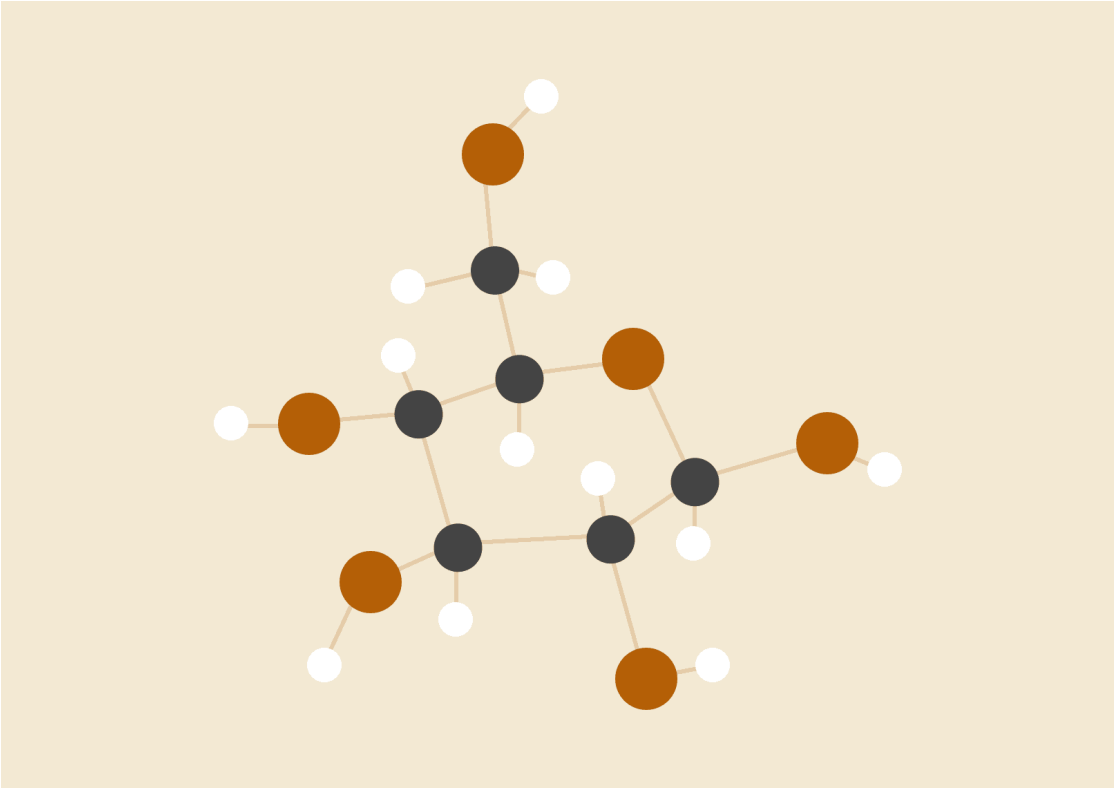
A Theoretical Research On Mosquito Behavior And Decisions In Different Aspects



Mia Lagunas and Daniela Lopez

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ABSTRACT

In the last 5 years researchers have built mosquitobrains.org, the first map of the female mosquito brain. The new resource may ultimately uncover the circuitry behind biting and other behaviors. But still the mind of the female mosquito and what drives their decision is still ultimately a mystery.

This study aims to determine if mosquito patterns are affected and or altered in different altitudes? Specifically higher ones. If the color of water as a variable affects mosquito breeding attraction? And additionally if clothing color as a variable affects mosquito biting behavior patterns? If so, what color captivates more significantly. Specifically ,it aims to research mosquito behavior and decisions in different aspects and circumstances to better understand the nature and persona of mosquitos.

To conduct this research we planned 3 different experiments in the course of 3 weeks. The first experiment was to determine Mosquito preference in altitudes. We created two bottled water traps with grass clippings. One was placed on the rooftop and the other in the garden of Danielas backyard. We observed these traps for 3 weeks. The second experiment conducted was to test the *Color Theory*. To test this hypnosis we created 3 different black bucket mosquito traps. Each bucket had a single dyed color *(the dye used was Chestnut hill food and egg dye)*; the colors utilized were black, red, and blue.Each trap used grass clippings as bait and were placed in different shaded corners of Mias backyard. We observed these traps for 3 weeks. For the final experiment to prove color biting preference we used our bodies as bait and wore different colored clothing and stood outside in our backyards from 2:30 pm to 3:30 pm everyday for 6 days straight. The first 3 days we wore light colors such as white, kaki, and pastel yellow. The remaining days we wore darker colored clothes such as black, navy blue, and red.

The results of experiment 1 *Altitude preference* showed that there were more eggs and larvae found in lower altitude garden traps. The results of experiment 2 *Color Theory* exhibited that the number of eggs and hatched larvae in the black dyed water was higher than in the red and blue. The amount of eggs and larvae in red and blue were roughly around the same. In experiment 3 *Color Biting* we saw more bitings on our bodies on days 4,5, and 6 the days we were exposed in darker colored clothing.

These results suggest that Mosquitoes do have a preference for select breeding habitats and in fact do have some type of neurological or logical system to find the best possible breeding site. Which allows us more insight into the mysterious mind of the female

mosquito and what drives their decisions.

Some suggestions to further pursue or further the experimentation in a series of the study in the case of experiment 3 *Color biting*, is to go out at different times of the day. Since in our experimentation we only went out in a select time, by doing this we can discover if time can be a variable. We can also get more detailed accurate results in the instance of Experiment 2 *The Altitude Experiment.* To achieve these results in the second trial we can measure the temperature of each altitude to note a difference. In this case temperature can also contribute as a variable affecting and changing the perspective of the results.

RESEARCH QUESTIONS

The questions created in this report were in service to the underlying understanding we were attempting to withhold, that being getting insight into the mind of the female mosquito and what drives their decisions and behaviors. These questions are fundamental and important to mosquito scientific interest. “Mosquitoes are perhaps the most dangerous animals in the world,” Omar Akbari, PhD, an assistant professor of entomology at the Center for Disease Vector Research at the University of California Riverside, told Healthline. “They are the primary vectors for major human diseases such as yellow fever, malaria, and dengue fever, which together infect hundreds of millions of humans worldwide and kill millions each year.”. If we are able to better understand the operation and reactions of female mosquitoes we are better equipped to handle mosquito borne disease outbreaks and ultimately drop the number of mosquitos in the public area. While in the midst of the research process we faced problems concerning the weather and traps. Since all the traps part of the research process were outside they were in a high risk environment with the problematic weather we saw in the testing period we lost traps and data but we were able to salvage most of the larvae and continue the process. Throughout this procedure we were able to gather a better and more advanced understanding of peculiar decisions female mosquitoes make in terms of breeding habitat giving us more insight to the enigma that are Mosquito Decisions.

INTRODUCTION AND REVIEW OF LITERATURE

Decision-making necessitates analysis and classification of information, which often assimilates reference to memory of what has been learned previously. As a result,

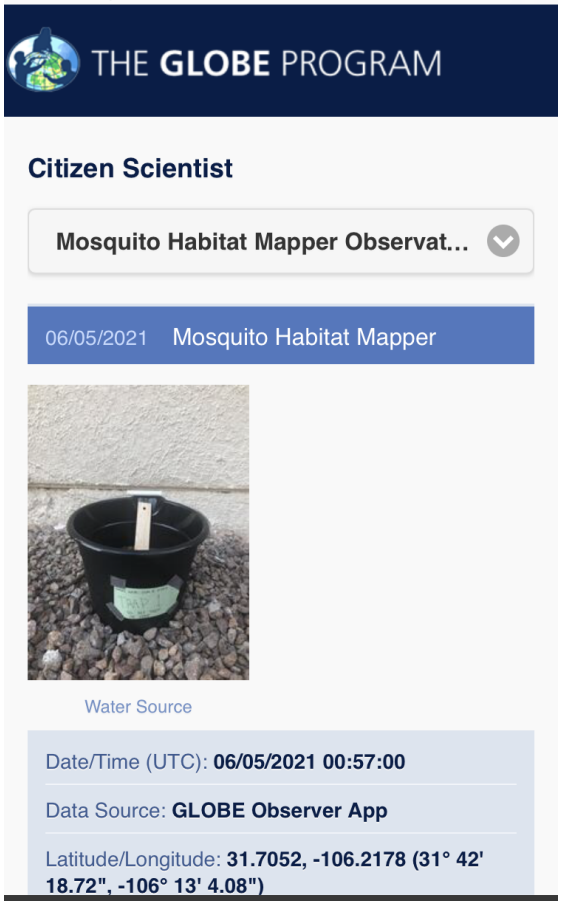
decision-making involves interlinking between many brain systems: sensory, sensory processing, learning ,memory premotor and motor systems. Effective decision-making is core to the stable operation of any behavioral system. We know this to be true in human and many insects brains but we are still in the unknown if the same applies to the mind of a female mosquito. Mosquitoes are trajectories that can lead to a dessaray of multiple infectious human diseases and use a variety of sensory cues such as humidity, visual and temperature to locate a human host. An Analysis by Olena Riabinina, Darya Task, Elizabeth Marr, Chun-Chieh Lin, Robert Alford, David A. O'Brochta & Christopher J. Potter (2016) concluded that The labellum (a part of the mouth of an insect) also contains gustatory neurons (Taste cells activated by taste substances that transmit chemical information to peripheral sensory neurons called gustatory neurons) which makes it possible that this region in the mosquito SEZ is a sensory integration centre combining olfactory and gustatory signals. In humans, the sensory integration of taste and smell gives rise to a perception of flavor. Whether this region in the mosquito SEZ underlies a 'flavor' centre remains to be explored. This discovery in this study proves that there is a neurological system that affects certain decisions and behaviors that mosquitos perform. However, despite this discovery we have yet not uncovered Whether the hawkmoth Orco+ proboscis neurons innervate the SEZ and thus implicate a common sensory integration centre between Lepidoptera and Diptera which remains to be determined. This is yet the first step to truly understanding the conundrum that is the mosquito encephalon. The Importance of understanding this is to find the emulsion that will lead to the control of mosquito outbreaks. If we are able to superintend the outbreaks of mosquitoes we would save millions of lives a year all over the world. The amount of deaths due to mosquito-borne diseases in sub-tropical countries could drop drastically. According to an article and empirical study conducted by Matan Shelomi (2017) ,we have been able to determine and grasp that the spread, or vector,of diseases such as malaria, yellow fever, dengue, chikungunya, West Nile Virus, and Zika virus, combined together can cause more deaths each year than war and homicide combined. Eliminating these diseases would save millions of lives, and eliminate much suffering and disease generated disabilities as well. An examination and review by Mosquito Joe, a company that specializes in a natural mosquito control treatment, discovered that Mosquitoes use their IR21a receptor, or heat-sensing antenna to locate their next blood meal. They were also able to reinforce our own data results that mosquitoes are attracted to black clothing. They were able to conclude this due to the liking of heat mosquitos exhibit. Since black, and other dark hues trap heat, we saw more biting behavior exhibits with these hues. Wearing dark colors also makes people sweat more, especially when combined with exercise. And mosquitoes love the excess CO2 released when you

perspire. The more carbon dioxide emissions you produce, the more bites you'll endure. Nonetheless, there is a lack of robust research of what truly drives the mosquito brain.

RESEARCH METHODS

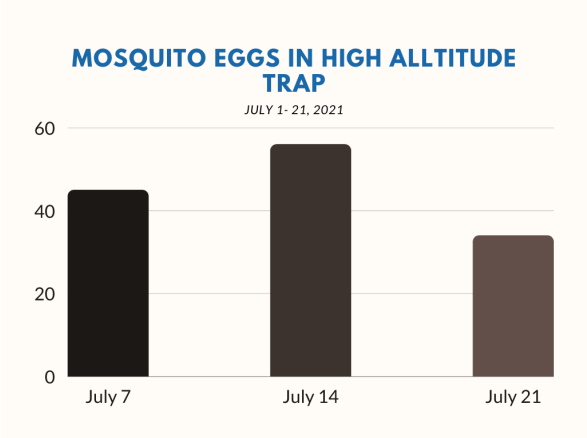
In order to gain more Insight into the possibilities of what drives the female mosquito brain we created a research plan. The Research Plan consisted of a 4 week time period. The first week was dedicated to research and planning. We (Mia and Daniela) had three, one hour Zoom meetings to collaborate and brainstorm the best possible approach to find the most accurate results. The first week we also took this time to freshen ourselves up on mosquito data we had collected on our personal traps. To determine a mean of expercations we could see in our experiments. We decided that the next 3 weeks July 1-21 was our trap time period. We agreed on 3 different experiments. This research included 2 study sites. Study Site 1 Danielas Backyard which would conduct Experiments 1 *The Altitude Experimen*t and 3 *Color Biting*. The second study site would be Mias Backyard which would partake Experiments 2 *Color Theory* and Experiment 3 *Color biting*. The area of study for study site one was a backyard located in central El Paso, Texas. A shaded area with trees, grass, and plants. There was canine life around the experiment area. The climatic behavior in this area is regularly dry, hot, and experiences little humidity. But due to the fast-paced monsoon season that came earlier and harsher than previous years as a result of climate change, this study site experienced high winds, hail, heavy rain, and high humidity, harsh desert weather, and wind storms. The area of study site two was a backyard in Far east El Paso, Texas. A mildly shaded area with rocks, soil, dirt, and woodchips. There was canine life surrounding the experiment area as well. The climatic behavior was more severe then in study site one and faced much more harsh desert climatic consequences due to study site two being in the outskirts of the City of El Paso. Study site two also experienced the harsh monsoon season that study site one experienced. For data collection of this mosquito behavior examination we used the *NASA GLOBE OBSERVER APP* to collect the number of eggs, larvae, and mosquitos found in the traps in the study sites. With the *NASA GLOBE OBSERVER APP* we were able to determine the most common mosquito species found in the study site traps were the *Aedes Aegypti* mosquito. The egg, larvae, and mosquito findings were manually recorded on a google spreadsheet as well as the mosquito biting patterns our body exhibited due to the experimentation our bodies endured as bait. We collected 3 samples for every trap in Experiments 1 *The Altitude experiment* and

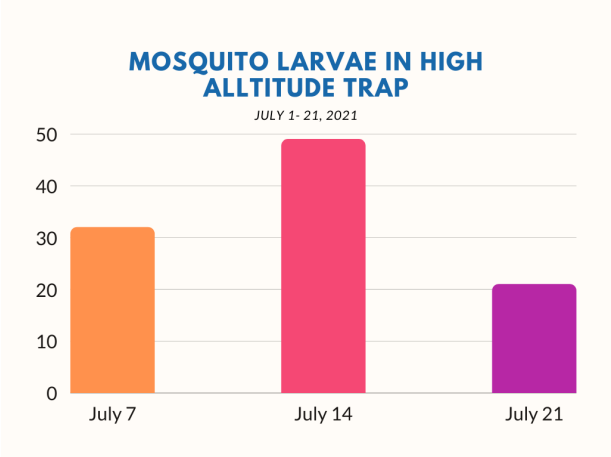
Experiment 2 *Color Theory.* Each sample was manually counted using a wooden stick used to test painting samples that was picked up at a local *LOWE'S hardware store* and the species was examined by a microscope provided by the *NASA SEES department* and confirmed by the *NASA GLOBE OBSERVER APP.* To analyze the data found we used simple addition to count the samples collected. To create the visualization of data we used multiplication and addition to calculate the mean of the samples.

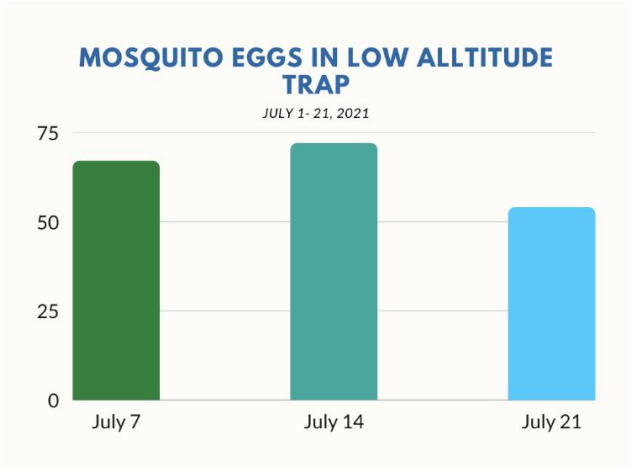


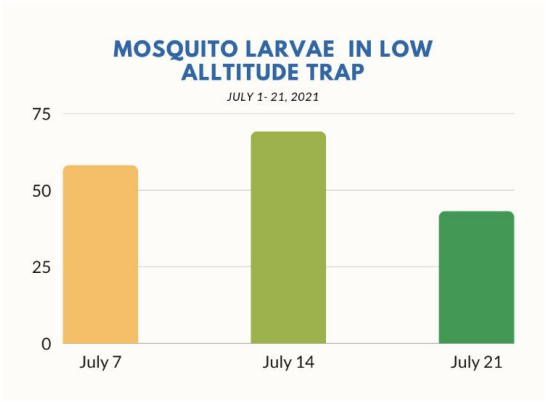
PERSONAL TRAP FOUNDED AT THE BEGINNING OF THE SUMMER 2021 THIS TRAP WAS LOCATED NEAR THE STUDY SITE 2 EXPERIMENT TRAPS AND USES THE SAME WOODEN TOOL TO COLLECT AND COUNT LARVAE AND EGGS

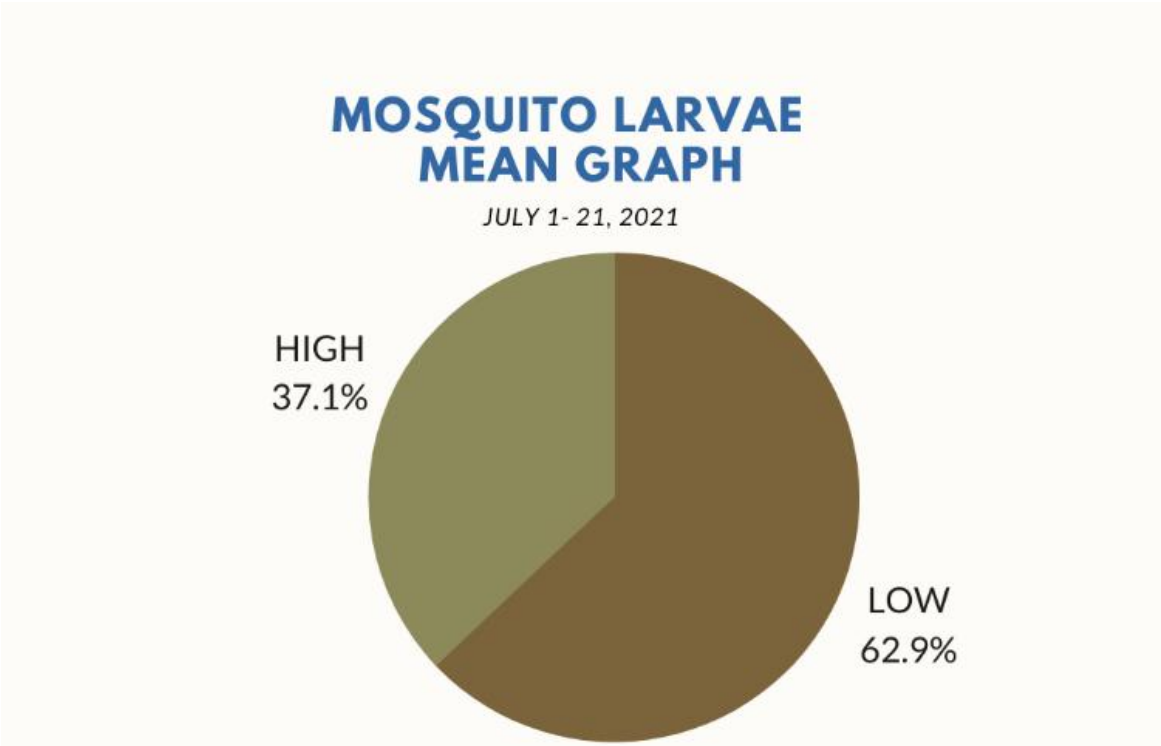
RESULTS

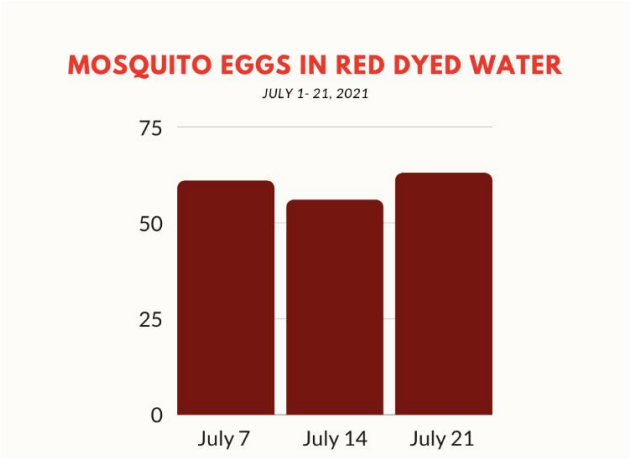

MOSQUITO EGGS IN HIGH ALLTITUDE TRAP
JULY 1- 21, 2021
60
40
20
0
July 7
July 14
July 21

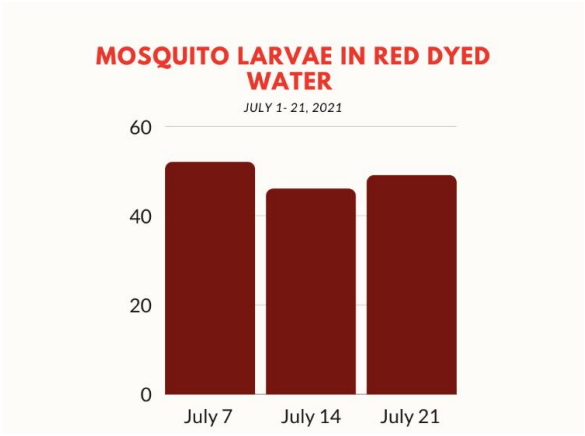

MOSQUITO LARVAE IN HIGH ALLTITUDE TRAP
JULY 1- 21, 2021
50
40
30
20
10
0
July 7
July 14
July 21

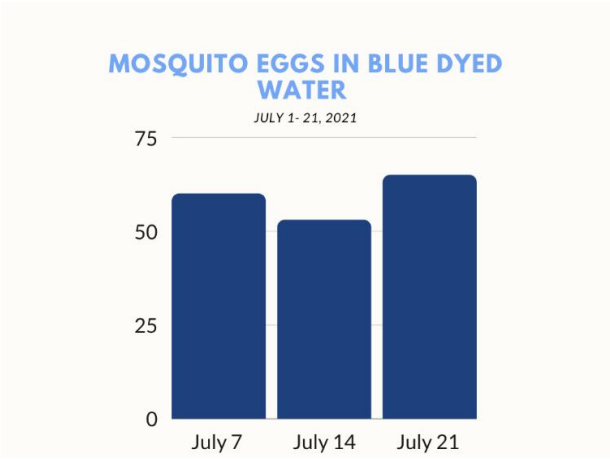

MOSQUITO EGGS IN LOW ALLTITUDE TRAP
JULY 1- 21, 2021
75
50
25
0
July 7
July 14
July 21

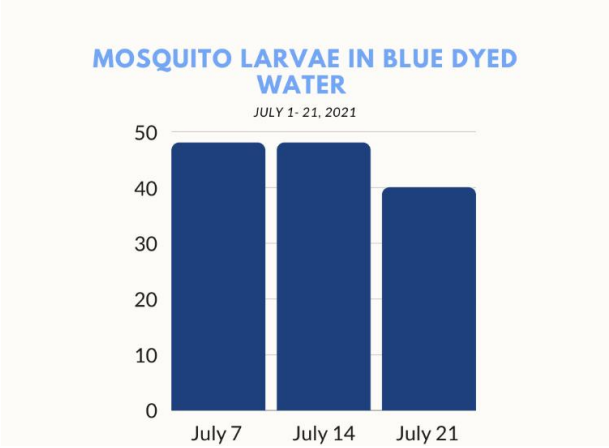

MOSQUITO LARVAE IN LOW ALLTITUDE TRAP
JULY 1- 21, 2021
75
50
25
0
July 7
July 14
July 21

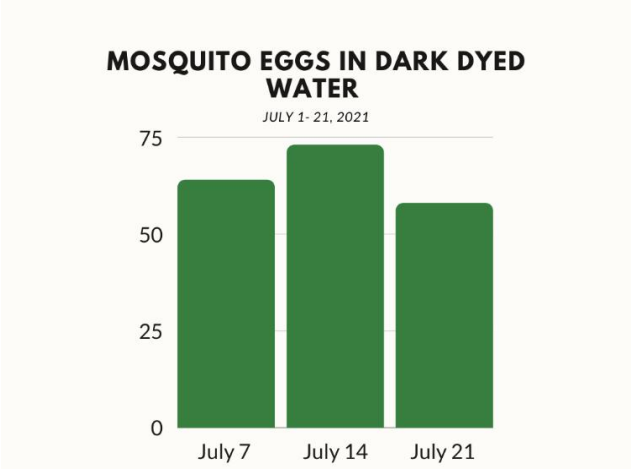

MOSQUITO LARVAE
MEAN GRAPH
JULY 1- 21, 2021
HIGH
37.1%
LOW
62.9%

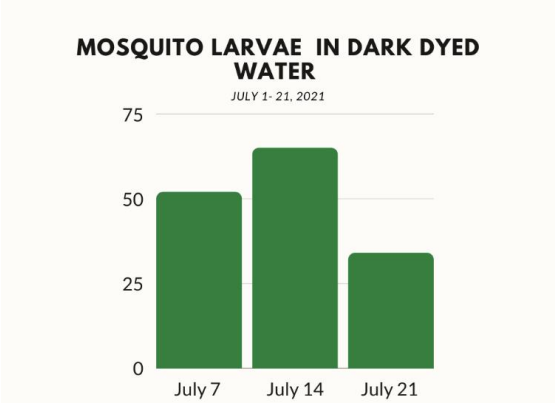

MOSQUITO EGGS IN RED DYED WATER
JULY 1- 21, 2021
75
50
25
0
July 7
July 14
July 21

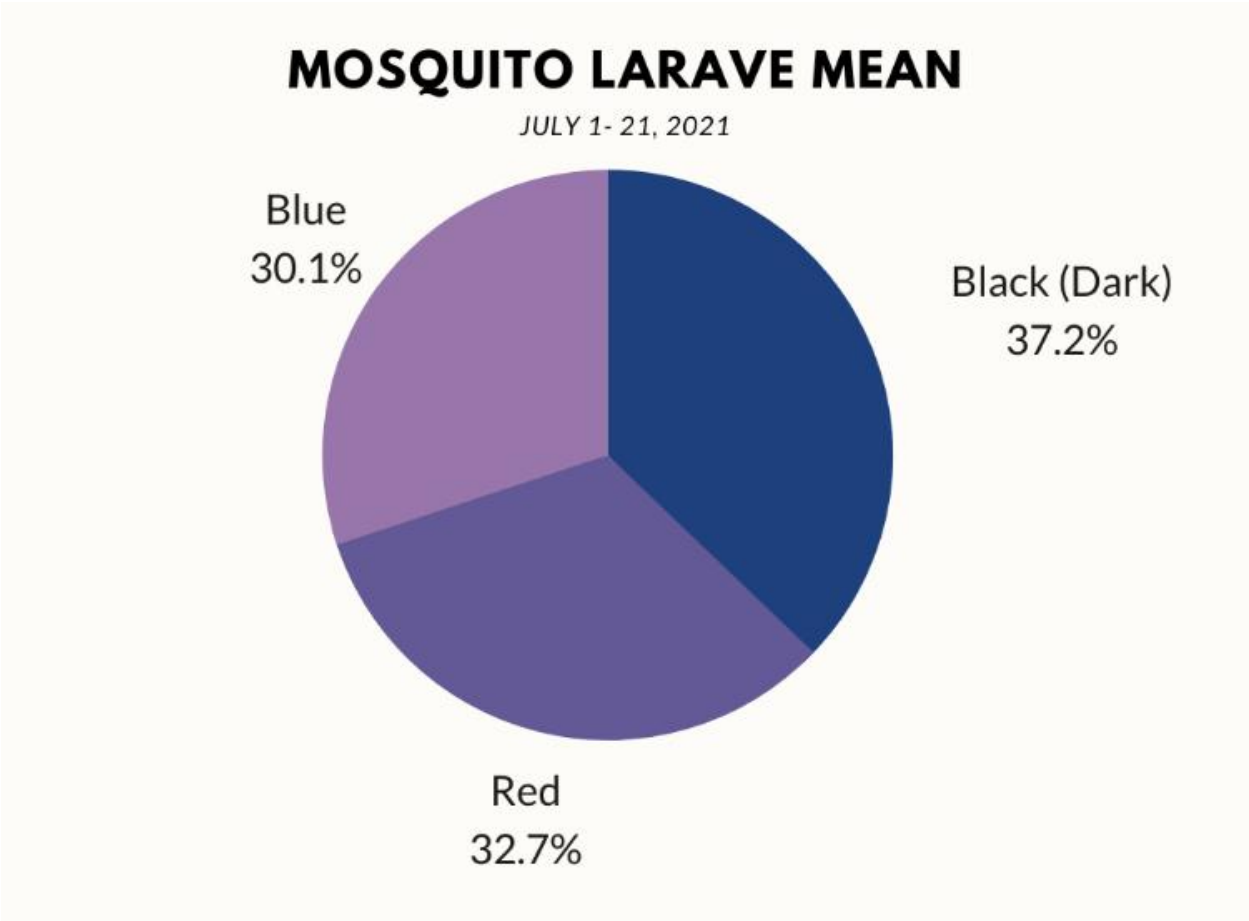

MOSQUITO LARVAE IN RED DYED WATER
JULY 1- 21, 2021
60
40
20
0
July 7
July 14
July 21

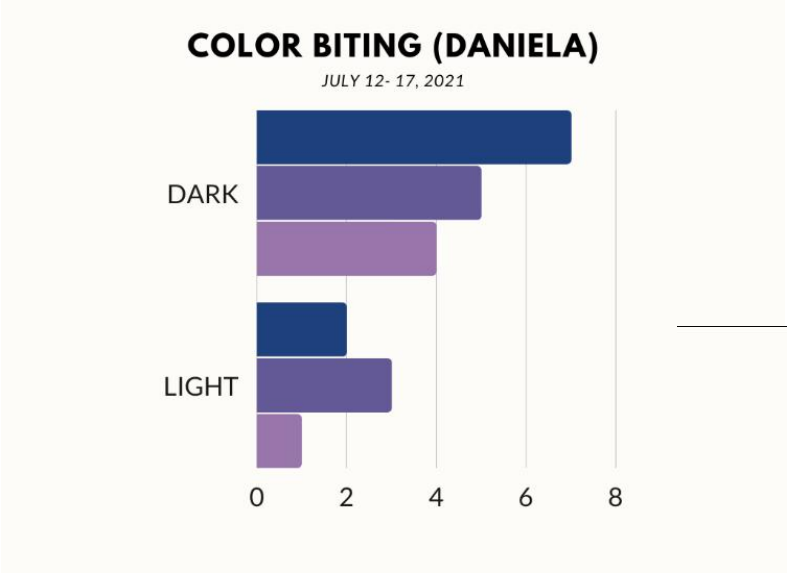

MOSQUITO EGGS IN BLUE DYED WATER
JULY 1- 21, 2021
75
50
25
0
July 7
July 14
July 21

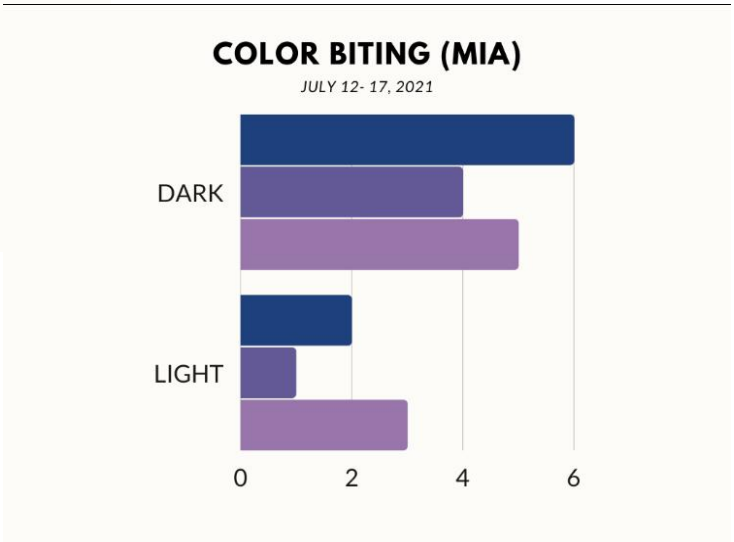

MOSQUITO LARVAE IN BLUE DYED WATER
JULY 1- 21, 2021
50
40
30
20
10
0
July 7
July 14
July 21


MOSQUITO EGGS IN DARK DYED WATER
JULY 1- 21, 2021
75
50
25
0
July 7
July 14
July 21


MOSQUITO LARVAE IN DARK DYED WATER
JULY 1- 21, 2021
75
50
25
0
July 7
July 14
July 21


MOSQUITO LARAVE MEAN
JULY 1- 21, 2021
Blue
30.1%
Black (Dark)
37.2%
Red
32.7%


COLOR BITING (DANIELA)
JULY 12- 17, 2021
DARK
LIGHT
0
2
4
6
8


COLOR BITING (MIA)
JULY 12- 17, 2021
DARK
LIGHT
0
2
4
6

GLOBE Visualization page

	WEEK 1 (July 1-	WEEK 2 (July 8-	WEEK 3 (August 15-21)	
How many eggs on roof trap	45	56	34	
How many larvae on roof trap	32	49	21	
How many mosquitos on roof trap	0	1	0	
How many eggs in low alltitude trap (ground trap)	67	72	54	
How many larvae in low alltitude trap (ground trap)	58	69	43	
How many mosquitos in low alltitude trap (ground tra	4	5	4	
How many eggs in dark water dyed trap	64	73	58	
How many larvae in dark water dyed trap	52	65	34	
How many mosquitos in dark water dyed trap	3	4	3	
How many mosquito eggs in red dyed trap	61	56	63	
How many larvae in red dyed trap	52	46	49	
How many mosquitos in red dyed trap	4	3	3	
How many mosquito eggs in blue dyed trap	60	53	65	
How many larvae in blue dyed trap	48	48	40	
How many mosquito in red dyed trap	3	2	2	
	M	D		
How many bites in dark colored clothes test #1	6	7		
How many bites in dark colored clothes test #2	4	5		
How many bites in dark colored clothes test #3	5	4		
How many bites in light colored clothes test #1	2	2		
How many bites in light colored clothes test #2	1	3		
How many bites in light colored clothes test #3	3	1		

MANUAL GOOGLE SPREADSHEET WITH THE EXPERIMENT DATA

The study conducted can support the conclusions that the mosquitos tested and analyzed in the Study site 1 (Danielas Backyard) and Study site 2 (Mias Backyard) found attraction to lower altitude breeding habitats in contradiction to higher altitude ones. Female mosquitoes also found further appeal to darker dyed water than blue, red, and naturally dyed water environments. We also concluded that we saw more biting behavior when wearing darker hued clothing in disparity to light bright hues.

DISCUSSION

With the found results of the study we were accepting towards the idea of learning more about different mosquito behavior in different circumstances. We were able to interpret the distinctive likings of what a female mosquito prefers for her breeding environment. When we discovered the common mosquito species attracted by our traps the *Aedes Aegypti* mosquito, and with further research we were able to determine that this certain species was attracted to darker collared hued containers and when rain floods the eggs environment their larvae cycle is fastned. Which can explain how we were able to salvage an adequate amount of larvae samples despite the flooding monsoon season the study sites and traps experienced in the analysis time period. After the extensive research and reading conducted after the sampling most of the studies and analysis other scientists and citizens have made were very similar in results to ours which can conclude that our experimentation was successful and can add support to the research questions and ideas explored in this study. Despite the success we like to believe we experienced there are still possible sources of errors we endured which we can improve. Such as the weather we experienced during our testing period. With the absurd and difficult weather our testing sites endured, most of our sampling was compromised and had to be salvaged. In spite of the weather, we were still able to retrieve a good amount of larvae but this caused a gray area to our data which impacted our results. In addition to improvement our study was very basic and generalized. For this study to be further tested and become more advanced we can use more technical and specific elements. Such as specific time periods of analysis of samples. More in depth look at the type of materials used such as the brand of plastic used in the water bottle, and black hued traps which can possibly be a factor of attraction to female mosquitos. With the results collected we were able to reflect on our hypothesis. For Experiment 1, *The Altitude Experiment* both Daniela and Mia hypothesised that the mosquitos in the study site

would prefer the lower altitude traps this hypothesis was correct. According to the data collected from the study the amount of larvae and eggs that were produced were higher in the lower altitude traps rather than the higher altitude traps. For support to the results collected the research conducted also showed that mosquitoes are attracted to lower altitude traps rather than higher altitude ones. In Experiment 2 *The Color Theory Experiment* Daniela hypothesized that the mosquitos in the study site would be more allured to the dark black dyed trap rather than the red and blue dyes trap. Mia hypothesized that the mosquitos in the study site would be more captivated by the red dyed trap rather than the dark black blue dyed traps. With the concluded results we were able to determine that more larvae and eggs were found in the dark black dyed water trap. Natali Ortiz Perea *A thesis submitted for the degree of Doctor of Philosophy School of Biological Sciences* (2018) analysis and experimentation also concluded with similar results using pond dyes on mosquitoes and other freshwater invertebrates. Danielas hypothesis of the experiment was correct in contrast Mias was not. In experiment 3 *Color Biting* Daniela hypothesised that we would see more biting behavior in the lighter hues of clothing, specifically white clothing. Mia hypothesised that we would see more traction in biting behavior in the darker hues, specifically blue clothing. With the finalized results collected and the added research of the article and analysis by Mosquito Joe we were able to conclude that the mosquitos in the testing sites were more attracted and created more biting marks in the darker hued clothing specifically black clothing. Danielas hypothesis was incorrect. Mias hypothesis was partially correct, the tested mosquitos were allured to the darker hued clothing but not specifically the blue clothing. We were able to understand that the reason as to why we saw more bite marks while wearing black and darker hued clothing was due to their IR21a receptor, or heat-sensing antenna. The color black is also a heat trapping hue which further explains the mosquito attraction.

CONCLUSION

By testing the effect of mosquito decisions and behaviors, this study established that the tested mosquitos in the study sites had a higher attraction to lower altitude breeding environments, more allurement to dark black dyed water habitats, and found dark hued more specifically black clothing more captivating for their human blood meals. We were able to reach these findings using the sampling data we collected in the weeks of July 1-21, 2021. We were also able to support our conclusive results with additional research and sources of other experimentations of scientists and citizens in the past decade. The findings collected in amassed of this observation put relevance to the greater idea of this

analysis. With the results concluded we can further pursue the studies, analyzation, and discovery of how mysterious the female mosquito brain really is. If we are able to better fundamentally understand what neurologically drives the attraction of mosquito breeding habitats we can better plan preventory elements and strategies to reduce the number of mosquitos found in the public. Author Jonathen Maberry is quoted for saying *"Know your enemy. The more you know about them, the less likely they can surprise you. And by studying them you might identify a weakness or vulnerability. "* As our environment is affected by climate change and habitats are being modified, the mosquito calendar has been altered and the mosquito season has been starting earlier and ending later. Mosquitoes have become one of our most powerful enemies to our health and environment. If we are able to know mosquitos and how they think and how they create their decisions and why they do it , we are able to create more advanced solutions to reduce the amount of mosquitos being born and can reduce the amounts of millions of civilians that are killed due to mosquito borne diseases. For this study to be further tested and become more advanced we can use more technical and specific elements. Such as specific time periods of analysis of samples. More in depth look at the type of materials used such as the brand of plastic used in the water bottle, and black hued traps which can possibly be a factor of attraction to female mosquitos. Throughout this exciting study process we were able to connect with a variety of project mentors. With their help we were able to improve our analysis and more accurately express our interest and expectations of data.

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GLOBE materials used

GLOBE OBSERVER APP

ACKNOWLEDGEMENTS

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This Project Included; Mia Lagunas and Daniela Lopez

Daniela Lopez contributed, designed, wrote, researched the study on "*Altitude Experiment*" and *"Color Biting"* and is credited on the creation and upkeep of the IVSS and AGU Posters. This research featured understanding of altitude landscaping, color attraction into biting behavior mannerisms and trap building. Daniela learned that altitude levels are one of the many decisions female mosquitoes make when choosing their selective breeding habitat. She also learned how to use Google Spreadsheets to record all the data collected.

Mia Lagunas contributed, designed, wrote, researched the study on "*Color Theory"* and "*Color Biting*". Mia is credited with the creation of the presentation slides, scientific abstract, and the Written Research Report. Mia learned that mosquitoes are highly selective to their breeding habitat. She also learned that the species Aedes Aegypti found in the study sites are very adaptable and prosper in the monsoon weather that was endured during the testing period. Rain floods allow the Aedes Aegypti larvae to transform before time due.

INTERNATIONAL VIRTUAL SCIENCE SYMPOSIUM VIRTUAL BADGES

Daniela and Mia have showcased the requirements to qualify for the IVSS Data Scientist Bade. We believe we have met the requirements because our study and report Includes In - depth analysis of our collected data as well as referenced data sources. We also disclose and reflect our limitations of our collected data and data process. In addition we provided insight on how our collected study data can be used to answer questions and or solve problems.

Daniela and Mia have showcased the requirements to qualify for the IVSS STEM Storyteller badge. Our report and study describes and shares this team's story. Our research In a creative literature style .We also showcased an in depth report reading exhibition with close friends, family, and community.