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International Center of Insect Physiology and Ecology
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Introduction

For my entire life I have lived on a farm in Harlan, Iowa. I was always interested in science, entomology, and medicine and always hoped that one day I would be able to use these interests to help others. I have graduated from Harlan Community High School and in the fall I will be attending Creighton University to major in both Chemistry and Biology in the pre-medicine program. When I was first introduced to the World Food Program I was really interested in the programs and opportunities that it offered, but I did not know how the program was going to fit with my interests and what I wanted to do in the future.

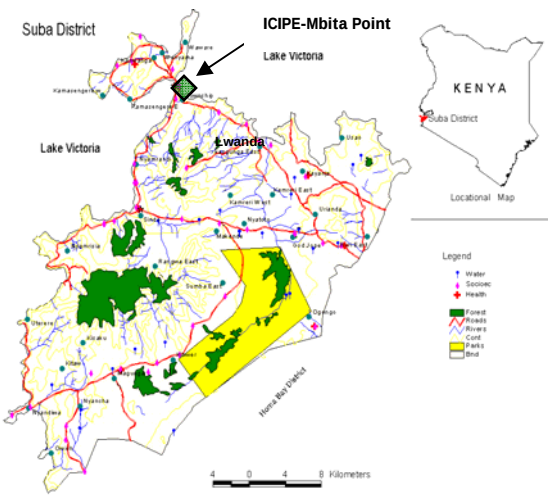
When I attended the youth institute in October 2006, I was amazed by the accomplishments of the interns who presented in front of me. As I listened, I thought how amazing it would be to experience that for myself. I have heard and read the facts of the issues that confront my world but I always wanted to actually experience it for myself.

As I completed the Youth Institute in October 2006 and began the interview process for the Internship program, I was still not sure if this was going to fit my interests. A few weeks later, I nervously opened the letter stating what my entire summer would be. To my pleasure, I discovered that I would be spending my summer in Nairobi, Kenya and that I would be studying malaria, its vectors, and how it affects Africa's food security.

I spent my summer in Mbita Kenya at the Thomas Odhiambo International Center of Insect Physiology and Ecology (ICIPE). ICIPE was established in the 70's with the intention to provide sites in the tropics to conduct research for managing pests and disease vectors. ICIPE is divided into 4 divisions: Human, Animal, Plant, and Environmental Health and I spent my internship studying under Dr. Manda in the Human Health division. ICIPE's mission is "to improve the well being of people of the tropics through research and capacity building in the insect science and its application." [1]

Kenya

Suba District



The human health department is focusing on the malaria vector. They have come to the realization that there is no "magic bullet" to stop the development and spread of the Plasmodium falciparum parasite, so they are working on multiple methods of control, such as predation of the mosquito with salticid spiders, prevention of attractant odors such as foot odor, and management of attractant and repellant plants.

There is a very strong connection between the research done in our human health division and the agriculture division. It is understood that without a productive healthy farmer, there cannot be a productive healthy farm. The malaria epidemic is so strong that it turns into even an issue of agriculture. The other issue between malaria and agriculture is the fact that mosquitoes prefer the man-made habitats developed for agriculture techniques. It turns out that the farmer depends on the agriculture techniques that the mosquito is dependant on.

I could not have been more pleased with my assignment in Kenya, as I finally saw the connection between malaria and food security. Scientists believe malaria was not a major health issue before the introduction of agricultural techniques[1]. The pools of water left behind by common agriculture practices are some of the best breeding sites for the mosquito. There lies the connection between agriculture and malaria. The malaria-carrying mosquitoes infect the farmer and causes financial and production hardships.

Along side the malaria project, I had a good friend who was studying the push pull project. He taught me a lot about their projects and his project. I learned about how the stem borer hurts the plant and how the parasitic striaga affects the maize. They are planting the napier grass around the plot of maize to either attract the stem borer away from the maize or to attract other insects that will attack the stem borer. This is the pull portion. They are also planting desmodium, a vine-like plant, between the rows of maize to kill the striaga and repel the stem borers away.

I also was able to learn about the tsetse fly program. The program is studying the relationship between the monitor lizard and the tsetse fly. They are trying to determine why the tsetse fly is attracted to the monitor lizard.

In Nairobi, I was introduced to different natural methods to generate income. The project includes using moth farming to produce silk and developing bee colonies to produce honey. This allowed me to understand all the missions of ICIPE to help the local communities.

Malaria Vector Experience

I began my work in the malaria vector project in the human health division of ICIPE. The primary goal of this program is to find practical control methods of the mosquito. My research was executed under the supervision of Dr. Manda.

My first few weeks at Mbita were spent getting familiar with the ins and outs of the mosquito. I was taught how to identify the different species of mosquitoes, which mosquitoes carry malaria, how to rear mosquitoes, and the life cycle of the mosquito. The mosquito species that I delt with most often were the culex, anopheles gambiae s.s., the anopheles funestus, and the monsonia, all having small variations from the others. Dr. Manda's program introduced me to the projects and goals they were working on and I helped out with their project. They were gathering mosquitoes out of homes, clay pots, and outdoors for a random testing on what type of plants mosquitoes feed on. Mosquitoes were smashed in a micro liter of water, then .5 micro liters was removed for testing if the mosquito was positive for glucose or not. Five milliliters of sulfuric acid was added to dissolve the mosquito in the water. The mixture would turn different shades of blue if it contained glucose. The darker the blue indicator, the more glucose was in the mosquito. Glucose is the only sugar found in plants and not humans, so if the mosquito contained glucose, then the mosquito was feeding on plants. I was able to perform this half of the experiment. The other half of the mosquito was saved for identification of the plant on which they feed. The test used was the gas-chromatography test. It matches the patterns of gasses allowed to pass through the unknown mixture with patterns from known mixtures.

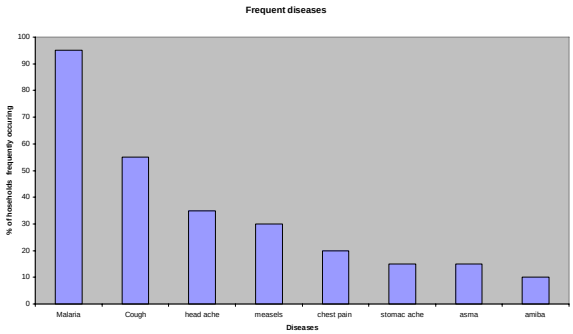
They also taught me how to identify the malaria parasite, plasmodium fanciparum and prepare slides with blood samples for examination. Plasmodium fanciparum is transmitted from one person to another by the anopheles mosquito species. There are several anopheles species including gambiae, funestus, and arambiansis. A mosquito is not born carrying malaria, but it must bite some one who has malaria. The parasite develops inside the mosquito for three to eight days, and then the parasite can be passed to another person. Once in the new host person, the parasite travels to the liver, where it multiplies and moves to the rest of the body. The parasite attacks the blood cells and kills them bringing a new disease to the person called anemia. I viewed several old blood samples containing the parasite to become familiar with the parasite, and then I got to actually try it out. Before I pricked someone else, I pricked myself to collect my first blood sample. I prepared the thick and thin slides and allowed them to dry. At the clinic I dipped the thin slide in methanol and allowed it to dry. After drying, both slides were placed in a blue dye for ten minutes to stain the blood cells. I observed the blood cells for a long time and then saw something familiar. It was that funny little ring structure with a black dot on it, plasmodium fanciparum. I thought that I must have done something wrong, so I asked one of the clinical doctors to check it out. I knew there was something wrong when he asked if this was my blood sample. The parasite was there but it was in such low numbers that they suspected that my anti-malaria pill was taking care of it. I have taken blood samples from several others to gain experience, but I did not find any positive results. In the clinic's lab, they allowed me to view blood slides from patients to look for the parasite.

Later in the trip, I was taught how to dissect a mosquito. We identified the organs but were particularly interested in the ovaries. Researchers are able to tell how many times the mosquito has laid eggs according to the different shapes and lengths of the ovary tubes. I can identify the halters, the falls wings for balance, the ovarials, both ovaries, the stomach, the malpighian tubes, and the spermatheca. The mosquito breeds once and stores the sperm in the spermatheca. When the spermatheca is dark brown it is fertile and if it is light than it is not fertile. Most of these organs are identified by pulling the last two segments of the abdomen away from the rest of the body.

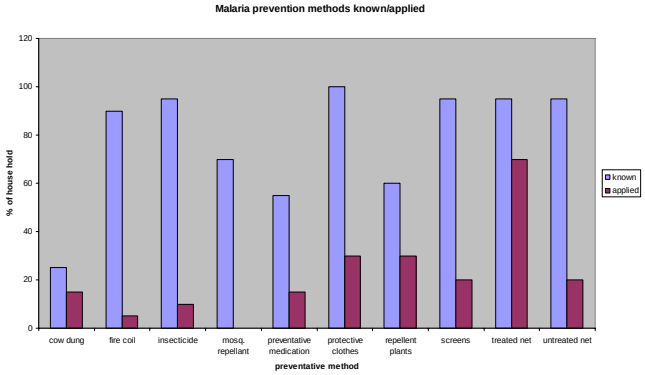
In the first phase of my research, Dr. Manda designed a questionnaire for me to interview locals accompanied by a translator about their knowledge of malaria and the mosquitoes, the preventative methods they used, and how malaria affects their families. This allowed me to get familiar with the culture and to help me determine what kind of study would be useful and practical for these local people.

Phase 1
Lwanda

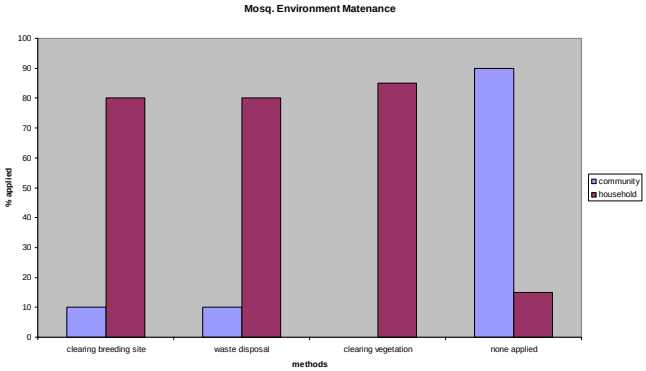
We interviewed twenty homes in Lwanda, rural setting, and twenty homes in Mbita, village setting. The homes were randomly selected from within our study area. Some errors in the data could have resulted in the translations from Luo, Swahili, and English or from the different interpretations of the questions from the translators of the interviewee. In Lwanda there were forty-eight people from the ages of twenty-one years or older, eighteen people from fifteen to twenty, fifteen children from ten to fifteen, twenty-six people from the age of five to ten, and twenty-four people from the age of five or less involved in our study. In Lwanda we observed the following:



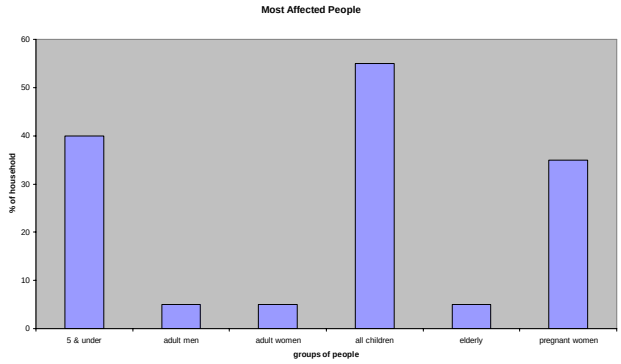
Stated above are the most frequently occurring diseases in Lwanda but also mentioned were tuberculosis, typhoid, diarrhea, eye problems, flu, teeth pain, vomiting, and a tumor.



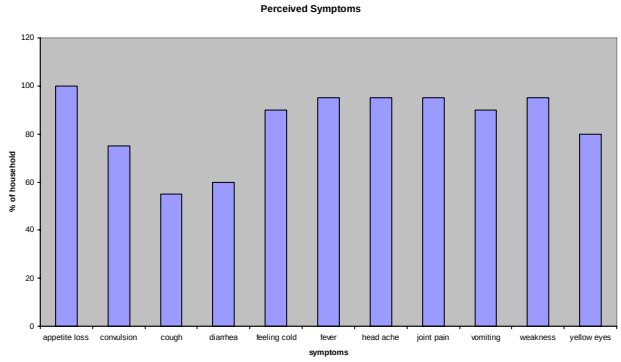
The graph above shows that many people know the preventative methods against the malaria vector but they use them very little. Many people stated that these methods are way too expensive or hard to find to be able to use. Also mentioned was the use of smoke to clear the mosquitoes from their homes. Eighty-five percent of the homes interviewed had a bed net and someone in the home was sleeping under it every night. Over half the nets were obtained from the clinic and a close second was purchased from the shop. Thirty percent had been using their bed nets for ten years or more and the remaining had been using a bed net for the last five years or less. They all mentioned that the bed nets were very comfortable. Most families had many children so not all were able to sleep under the net each night. If the nets were torn, sixty-five percent sealed the hole and the remaining replaced their net with a new one.



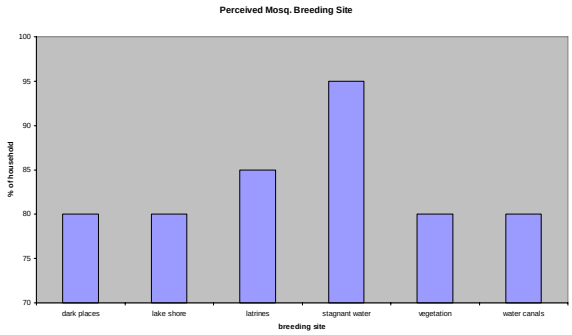
The graph above shows that most people clear mosquito breeding sites from around their home, but it also shows that very few people clear breeding sites from around their community. From what I observed, most large breeding sites were located along the lakeshore and in man-made pools of water around the community. The Tsetse fly was the most commonly mentioned insect harmful to a human's health in Lwanda apart from the mosquito. To prevent it, they kept their environment clean and used insecticides.



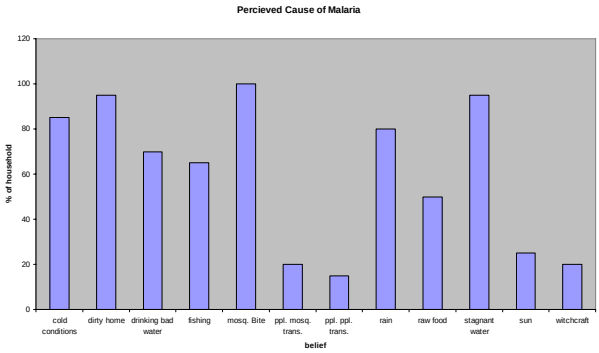
The graph above shows that young children, all children, and pregnant women are believed to be the most affected category of people according to the interviewed households. Also mentioned, were adult men, adult women, and the elderly. Previous studies show that pregnant women and children under five hold the highest risks to contract malaria.



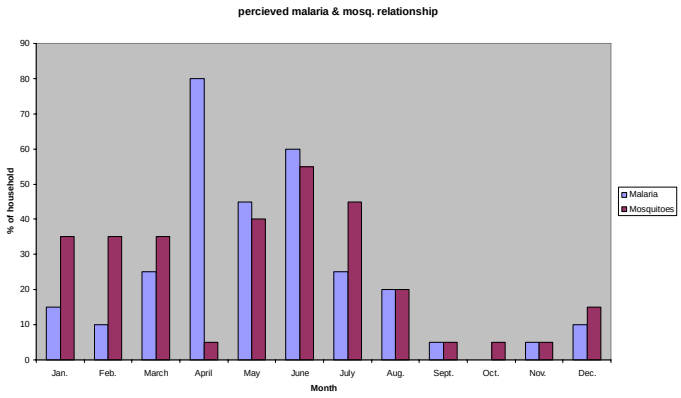
The graph above shows the perceived symptoms of malaria. Also mentioned was itchy skin. I observed that almost any cough or sniffle was immediately thought to be malaria. Sixty percent stated that someone in their family had or has malaria within the week of our interview. Most of the rest reported having malaria within the month. At the clinic, I found that about ninety percent of the people who thought they had malaria did not. The actual symptoms of malaria are fever, shaking chills, headache, muscle aches, tiredness, nausea, vomiting, diarrhea, and may cause anemia or jaundice.



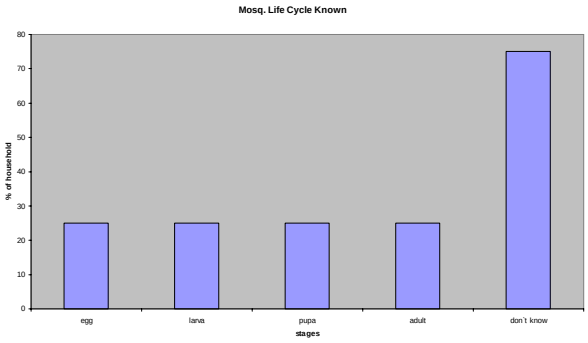
The graph above shows the interviewed household's perceived breeding sites of the mosquito. Few people in Lwanda understood where the mosquito comes from or is attracted to.



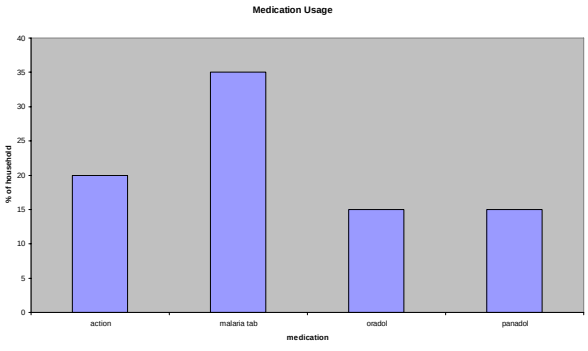
The graph above shows the perceived cause of malaria. Also mentioned was eating raw food, like mangoes, could bring malaria. The only cause of malaria is through the transmission of the malaria parasite, plasmodium fanciparum from one person with malaria to another by the anopheles mosquito species. The parasite has to pass through the mosquito because the mosquito acts as the host for the development of the protozoan. Once the parasites enter the host's bloodstream, it travels to the liver to multiply before returning back to the bloodstream to multiply inside red blood cells. The parasites burst from the red cells releasing large numbers of parasites into the blood plasma. This is what causes the fever associated with malaria. This entire cycle happens in approximately forty-eight hours, but can occur in only twenty-four hours. The free parasites are then able to infect any mosquito that feeds on the host. The mosquito releases the parasite into another host when it injects its sporozoites through the salivary glands into the host, and it contracts the gametocytes as the female feed on blood before laying their eggs.



The graph above shows the perceived months of when mosquitoes are abundant and when malaria cases are high. It also shows that, in most cases, they see the correlation between when there are more mosquitoes and the malaria cases are much higher.

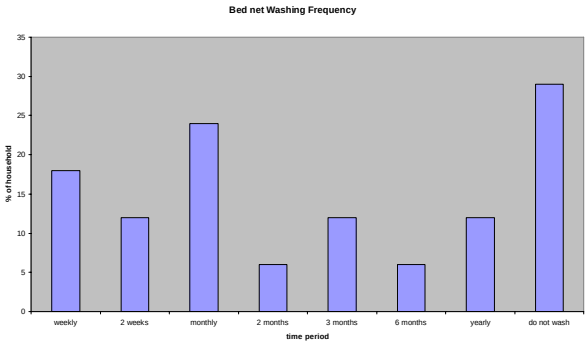


The graph above shows that most people do not know the life cycle of the mosquito. Many people stated that they learned about it in school, but do not remember any more. This could account for why many people did not find it necessary to clear stagnant water around their community.

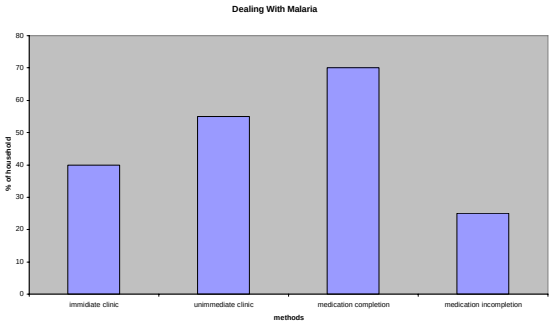


The graph above shows the medications most frequently used when they believe they have malaria. Also mentioned were fancidar, hedex, malaria qwin, and metacofal. If the medications are over-used, when they do not have malaria, it can result in the development of a mutated

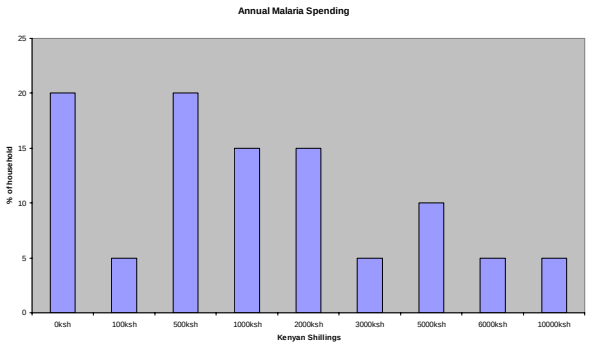
malaria parasite immune to the drugs. Some of these medications used for malaria are actually just painkillers. If malaria is not promptly treated, the loss of red blood cells from malaria may cause kidney failure, seizures, mental confusion, coma, and death. There is currently no malaria vaccine because the malaria parasite is a complex organism with a complicated life cycle and its antigens are constantly changing.



The graph above shows how often the bed nets are washed. This is important because if they are over washed, the treatment of the nets can wear off much faster, and if they are under washed they will loose their treatment and can gain attractive odors. The ideal amount of time between washing is six months with an application of insecticide. The net should also be dried in the shade instead of the sun to avoid damaging the insecticide on the net. Thirty-eight percent stated that they dry their nets in the sun; the other sixty-two percent dry their nets in the shade. Also, the mosquitoes are mutating into more resistant forms against the insecticides so we are looking for alternative types of control methods besides elimination insecticides.



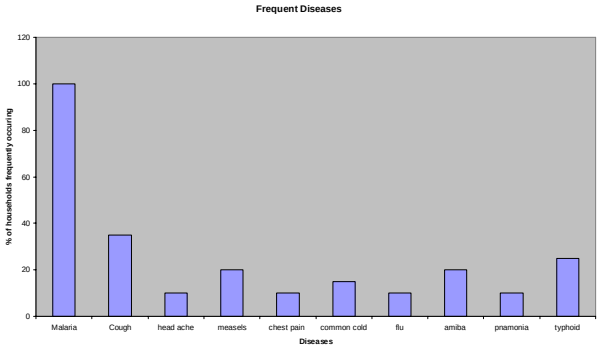
The graph above shows that many people wait to see if their symptoms get bad before they go to the clinic to be tested or receive treatment. Seventy percent stated that they did not use the local medical doctor and eighteen percent stated their treatment methods worked effectively for them. Also, most people complete the prescription but many people still stop taking the medication once they begin to feel better.



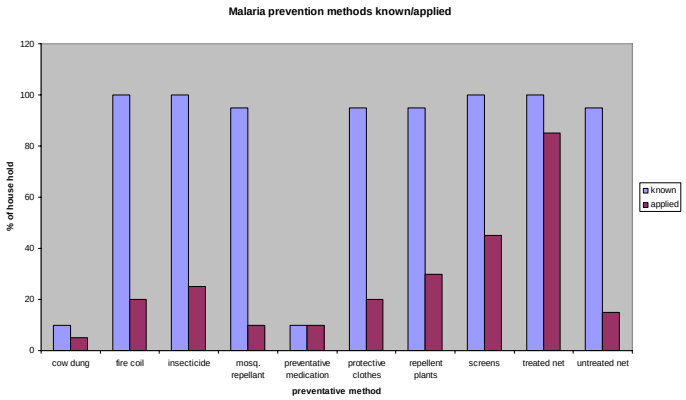
The graph above shows that these low-income families in Lwanda are spending a large amount of money on malaria each year. Every household also stated that malaria caused them to become very tired preventing them from fishing or working in their fields causing them to lose money. Most people live on food crops of maize, millet, vegetables, and fruit and perform fishing for their main source of income. In all the homes interviewed, there was no cash crop being produced.

Mbita

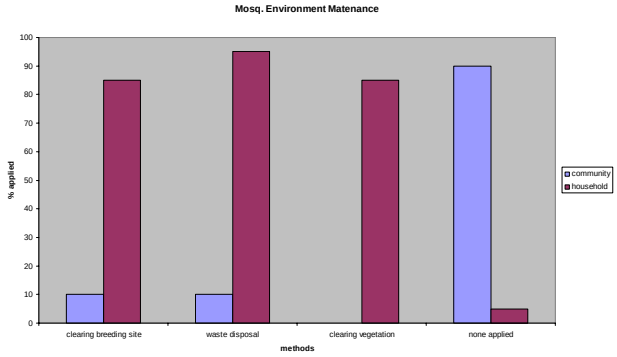
Mbita is the local town of approximately eight thousand people surrounding the ICIPE campus. It is one of the larger towns in the area and more people reported being employed or in business than in Lwanda. In Mbita there were thirty-nine people from the ages of twenty-one years or older, twelve people from fifteen to twenty, eleven children from ten to fifteen, fifteen people from the age of five to ten, and eighteen people from the age of five or less involved in our study. In Mbita we observed the following:



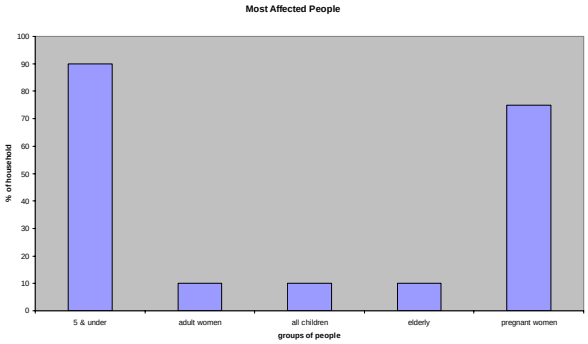
The graph above shows the most frequently occurring diseases in Mbita. Also mentioned was arthritis, diabetes, diarrhea, fever, and stomach ache.



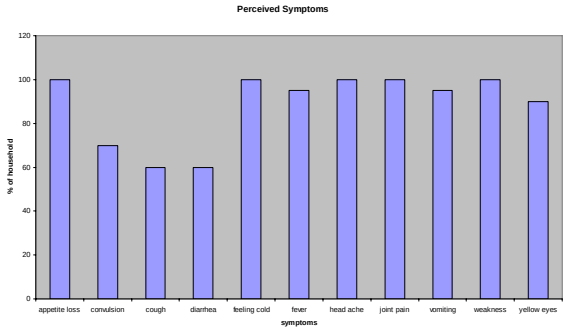
The graph above shows that many people know the preventative methods against the malaria vector but they use them very little. Many people stated that these methods are way too expensive or hard to find to be able to use. Also mentioned for applied preventative methods were disposing open containers, burning the neem tree, placing fish in water tanks, and allowing spiders to live in their home. All of the homes interviewed had a bed net and in almost all cases, someone was sleeping under the net every night. Three-fourths of the nets were obtained from the clinic and the rest were either purchased from the chemist or from the shop. Twenty percent had been using their bed nets for ten years or more and sixty percent had been using a bed net for five years or less. They all mentioned that the bed nets were very comfortable. Most families had many children so not all were able to sleep under the net each night. If the nets were torn, sixty-five percent sealed the hole and most of the remaining replaced their net with a new one, except for one person who continued to use it the way it was.



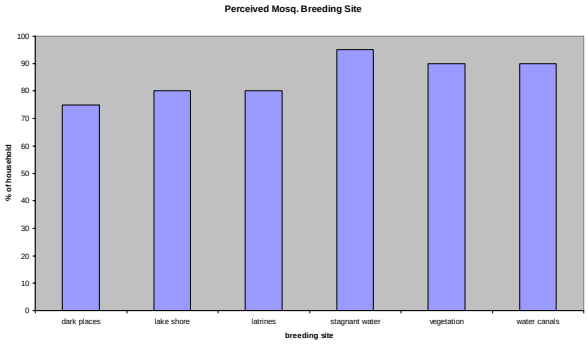
The graph above shows that most people clear mosquito breeding sites from around their home, but it also shows that very few people clear breeding sites from around their community. From what I observed, most large breeding sites were located along the lakeshore and in man-made pools of water around the community. Bees, houseflies, wasps, bed bugs, and the cici fly were most often mentioned as insects harmful to a human's health apart from the mosquito in Mbita. To prevent them, they kept their environment clean and used insecticides. Several people both in Mbita and Lwanda mentioned the butterfly as being a harmful insect to human health.



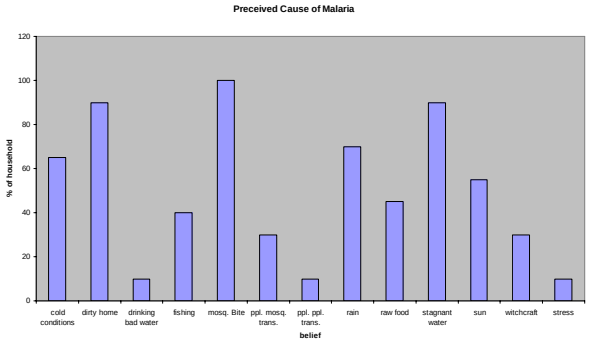
The graph above shows that the most affected category of people affected by malaria is children under five and pregnant women. In Mbita, it was better understood that it is mainly the children under five who are most affected by malaria and not all children in general.



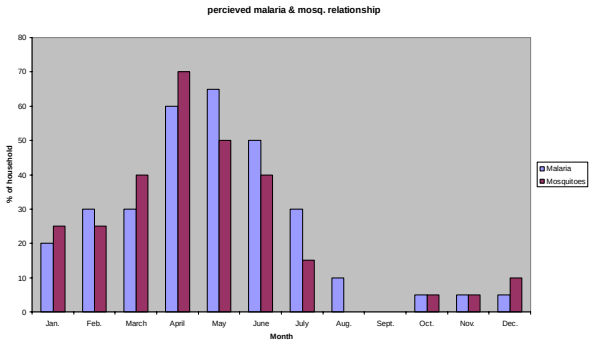
The graph above shows the most common perceived symptoms of malaria. Also mentioned were dehydration and extensive crying in babies.



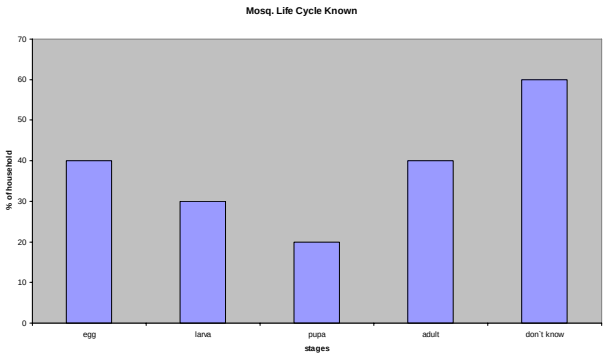
The graph above shows that most people in Mbita know the breeding sites and attractant areas of the mosquito. The percentages of people who know about these breeding sites in Mbita are much higher than those from Lwanda.



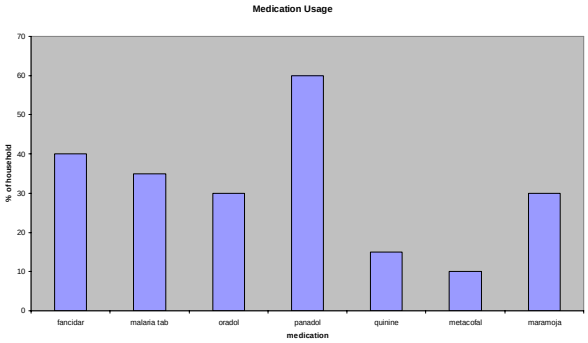
The graph above shows the most commonly perceived causes of malaria. Also mentioned was excessive alcohol consumption, body odor, and transmission from the pregnant mother to her unborn infant.



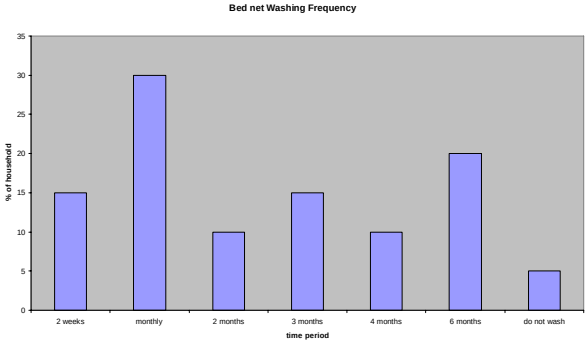
The graph above shows that, in most cases, people see the correlation between the number of mosquitoes present and the number of malaria cases. The months of the highest mosquito and malaria cases are the months of their rainy season. Some people based their answer on the period of their rainy season.



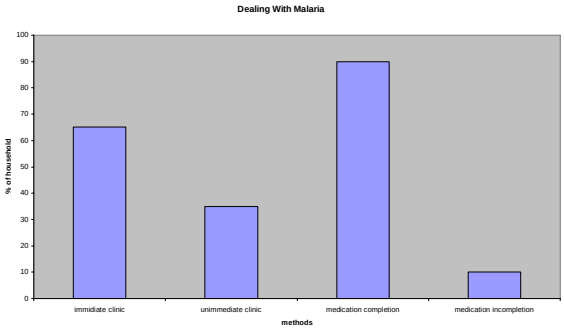
The graph above shows that most people don't know about the mosquito's life cycle but at least some people understand that mosquitoes come from the water. The knowledge of the mosquito life cycle is higher in Mbita than in Lwanda. Also mentioned by one interviewee was that the mosquito takes about seven days to emerge, the female needs a blood meal before she can lay her eggs, and the larva grow in several different instars.



The graph above shows the commonly used medications to treat malaria in Mbita. Mbita reported more medications used and better medications used than Lwanda. This is probably from the fact that ICIPE's clinic is located in Mbita. Also mentioned were action, amodiaquine, oroda, bruffen, cotexin, dawanol, and hedex. Some of these drugs are just pain killers and do not treat malaria. Even panadol, the number one drug used to treat malaria by the locals, is just a painkiller.

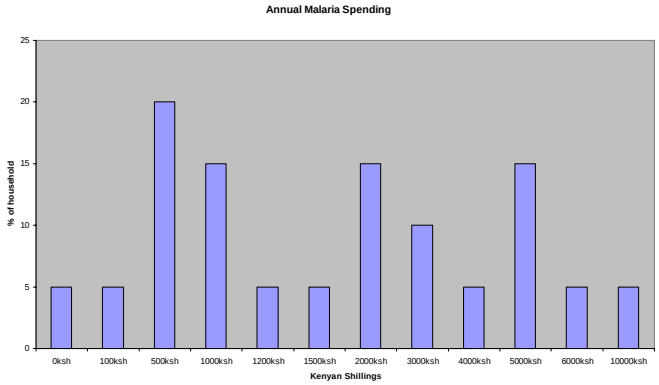


The graph above shows the washing frequency of the bed nets in Mbita. Most families over wash their bed nets, which washes out the insecticides. Thirteen percent dry their bed nets in the appropriate shaded area.



The graph above shows how people in Mbita deal with malaria. More people immediately go to the clinic when they feel ill in Mbita than in Lwanda probably because of the convenience of ICIPE's clinic. Eighty percent stated they did not use the local medical doctor either because it

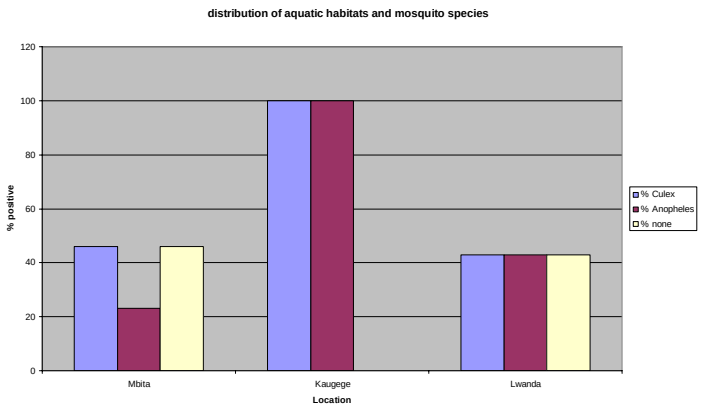
is too expensive or because they did not think it was anymore effective than their treatment. Sixty percent stated that their treatment method worked just fine.



The graph above shows the annual amount of money spent on malaria per household in Mbita. In Mbita, forty percent were in business, fifteen percent were employed, and seventy percent were using fishing as the source of income. Maize, millet, vegetables, and beans are the most common food crops in Mbita. Unlike Lwanda, sunflowers, watermelons, and vegetables were sold as cash crops for some families. In both Lwanda and Mbita, the main impact of malaria stated by each family is; it causes weakness, preventing them from working in their fields or at their jobs to earn an income or harvest food. Also mentioned was the fact that it made the mood in the family unhappy.

Phase 2

The second phase of my research, Dr. Manda and I designed a field experiment to determine how the mosquitoes' larva and pupa are affected by different unnatural water pollutants, the vegetation in their environments, the size of the pool, the type of the pool, and other invertebrates living in the pools. Twenty-two sites were analyzed for these factors. Two of these sites were from Kaugege, seven sites from Lwanda, and thirteen sites from Mbita. All three are located along the lake, but Kaugege has the densest population living right on the lakeshore.



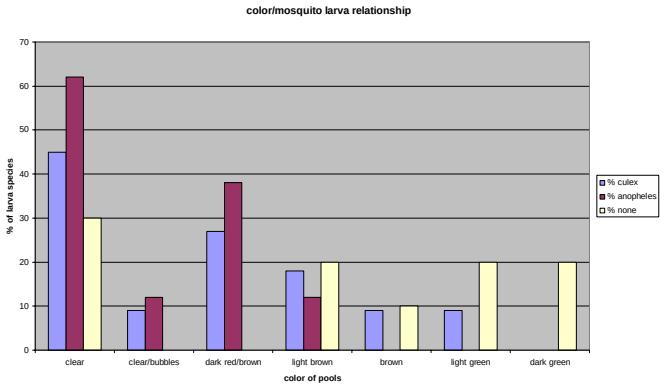
The graph above indicates the location frequency of larval habitats. A possible reason why Kaugege has such a high frequency of larval habitats is because of its close location to Lake Victoria. Many people are interacting with these breeding sites very regularly. This site would be a good site for further studies, followed by Lwanda.

The relationship between the mosquito larva and the pool type was found that all mosquitoes tend to lay their eggs in stagnant, shallow pools of water. Anopheles tended to be found in natural pools like: hoof prints, swamps, and pools located on the beaches, culex mosquitoes were also found in these areas but they also preferred man-made pools like: cement tanks and irrigation canals. The culex mosquitoes were found in a wide range of habitats, where the anopheles was only found in a few natural sites.

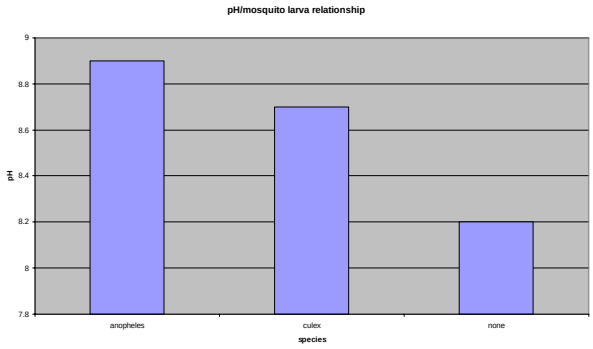
The pool size also plays a key part in attracting adult mosquitoes to lay their eggs. The anopheles mosquito was generally found in small pools but was also found in medium-sized pools. Culex mosquitoes were found to prefer the small and medium pools, but they were also found in large pools like creek beds. Few mosquito larvas were found in the large pools and no larvas were found in the huge pools. The culex mosquito seems to be the more hardy and adaptable of the two mosquitoes.

The vegetation found in and around the larval habitats was also found to play a part in the selection of the breeding habitat. Both preferred some grass or reed cover growing in the water. In sites where there was no vegetation growing, there was no larva found. Culex proved again to be the hardier of the two, because it was found in pools containing thick garbage and some algae. Anopheles tended to be found in sites clean of garbage with very little algae. In areas with heavy algae or water hyson, the mosquito larva was not found.

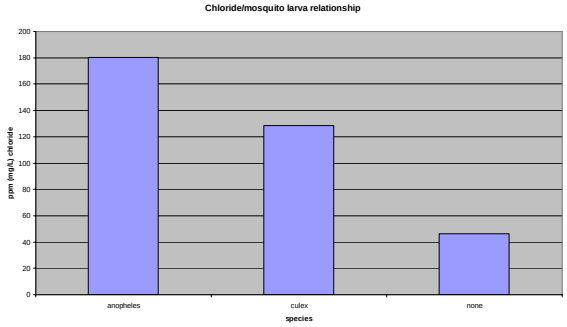
Invertebrates and other arthropods were other indicators of whether larva would be found and what species could live in the pool. When small red worms were found in the water, no larva was found in the same pool. Most commonly, black water beetles, red water beetles, and dragon fly nymphs were found living along side the mosquito larva. Other invertebrates and arthropods found to be living along side the mosquito larva were tadpoles, snails, water boatmen, and worms but they did not correlate with the availability of the mosquito larva.



The graph above shows that adult mosquitoes tend to lay their eggs in pools with a dark red/brown color or pools that are clear. Sites with the dark red/brown color could indicate some kind of nutrient in the water that the mosquito larva feeds on. The adult mosquitoes tend to stay away from pools with algae especially if the algae growth is thick. Culex larvas prefer the same colorations of water as the anopheles, but they can also survive in pools with some algae growth.



The graph above indicates very little evidence of a strong relationship between the pH of the water and the selection of the breeding site of the adult mosquito. The difference shown on the graph is too little to make an accurate conclusion. It does indicate that both types of mosquitoes perform well in relatively basic water pools. This test might be better performed on a larger region to analyze the relationship between acidic, neutral, and basic water pools.



Chloride is an unnaturally disposed of chemical, usually from sites receiving animal or human waste. Chloride levels over one hundred parts per million are relatively unsafe for humans, but the mosquito larva don't seem to mind. In fact the graph above shows that the mosquitoes prefer pools with high chloride levels. This could be due to the fact that the high chloride levels signify more human interaction. While in the field, I observed large amounts of human and animal waste next to the mosquito breeding sites. The data shows that the use of latrines will not only help with sanitary purposes but will also lower the larval numbers in breeding sites. The mosquitoes have developed a resistance to high pollutant levels to be able to live closer to the host human. Also tested were nitrate and nitrite levels, another unnaturally disposed of chemical, but no positive results were found. These levels usually come from added chemical fertilizers to local fields.

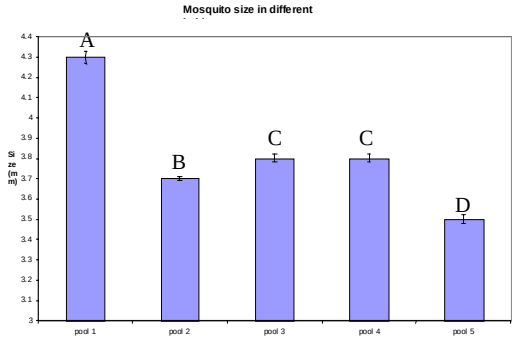
Phase 3

The third phase of my research was to determine how the surface area and amount of water in the anopheles gambiae's environment affects the growth rate from first instar to adult, the mortality rate between each instar, the adult size, the survival percentage from first instar to adult, the mosquitoes amount of energy reserves, and the reproductive fitness of the adult mosquito. The mosquito has an incredible rate of physical adaptation to its environment. The research will indicate how the mosquitoes' environment influences different traits developed by the same species.

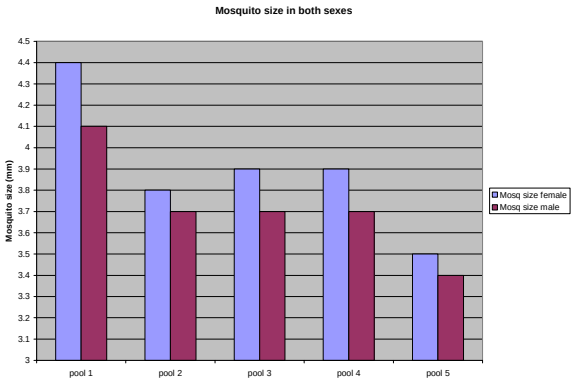
Procedure: Use several different containers that will allow different surface areas but are the same color. Place enough distilled water into each container to bring the water depth to eight centimeters. Do not add water, as the sun evaporates the water and do not change the water. Calculate the water's surface area in each container and measure the amount of water in each container that is used to bring the water depth up to eight centimeters. Make sure the temperature and lighting remain constant for all the environments. Place 400 first instar anopheles gambiae s.s. larva into each container and record the time and date of the mosquitoes' introduction into the environment. Feed each environment .0400 grams of fish food each day until they reach the third instar. Once at the third instar feed them twice per day in the morning, .0400g, and in the evening, .0400g. Record the date and time at which the mosquito larva begin to change instars and once the larva have completely changed the instar, calculate the mortality rate. After the pupa have emerged into adults, record the average time and date and keep the remaining mosquitoes in separate controlled environments. Kill ten adult mosquitoes from each pool ID right after they have emerged to use for the biochemical energy reserve test. Kill fifty more adult mosquitoes to measure the wing length. To measure the wing length, separate the wing from each mosquito and place on a glass slide with a drop of water. Use a micrometer lens to measure the length of the wing from the joint to the tip of the wing, not including the small hairs on the end of the wing. Keep the remaining alive adult mosquitoes separate in cages and feed them a 6% glucose water solution for three days. After the three days of sugar feeding, feed them a blood meal. Only allow one person to blood fed the same cage. Three days after the adult mosquitoes have been blood feed, separate individual mosquitoes into cages and place a small container of water into each cage. Allow the mosquitoes to lay their eggs into the containers of water and count the total number of eggs from each mosquito. This will show the reproductive fitness.

Legend

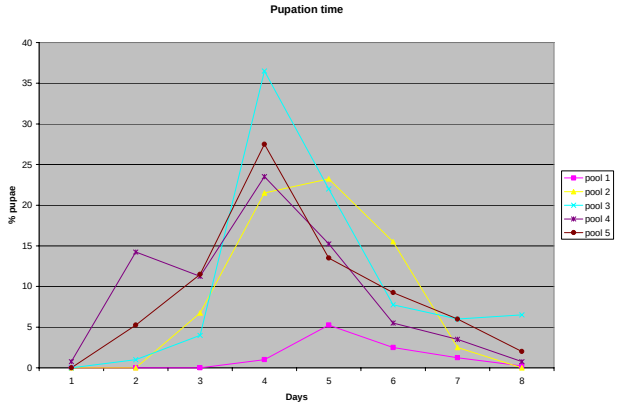
Pool ID	Surface Area cm^2	Volume (mL)
Pool 1	2,227 cm^2	15,700 mL
Pool 2	1256.6 cm^2	8,650 mL
Pool 3	572.6 cm^2	3,750 mL
Pool 4	346.4 cm^2	2,300 mL
Pool 5	70.9 cm^2	460 mL



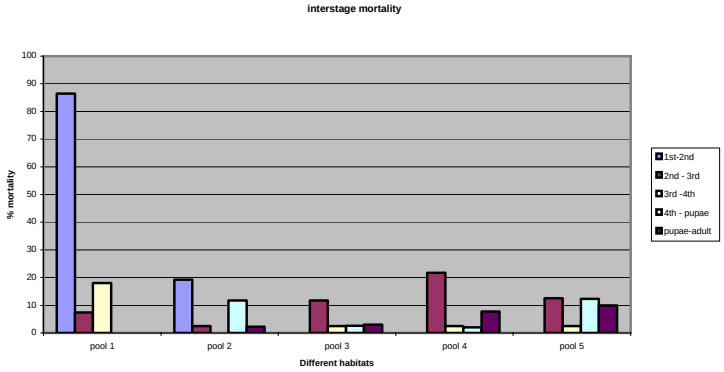
The average mosquito wing length (F=115.17, d.f.= 4, P< .0001) varied significantly in accordance with the pool's surface area. The graph above shows how the size of the pool affects the size of the mosquitoes. The larger the surface area of the pool, the larger the mosquitoes grew. The sizes of these mosquitoes were measured through wing length. Even in the larval stages, the mosquitoes reared in the larger pools were longer and skinnier, and the mosquitoes in the smaller pools were shorter and bulkier.



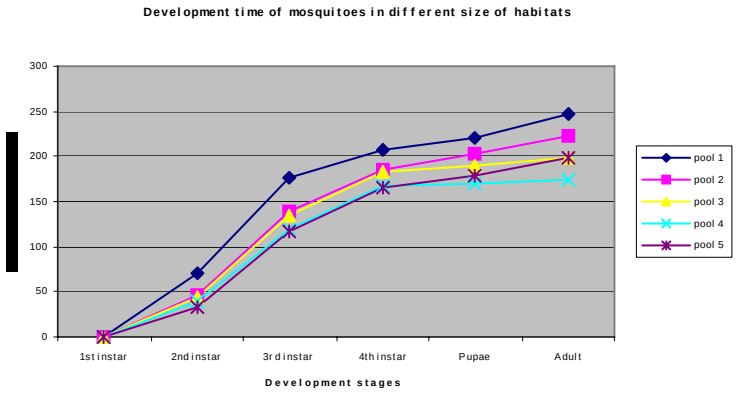
The graph above shows the correlation between the surface area of the mosquitoes' habitat and the adult mosquitoes' size, along with the relationship between male and female mosquitoes in different environment sizes. The female mosquitoes, the only sex that blood feeds, are usually larger than the male mosquitoes, which have been raised in the same environment.



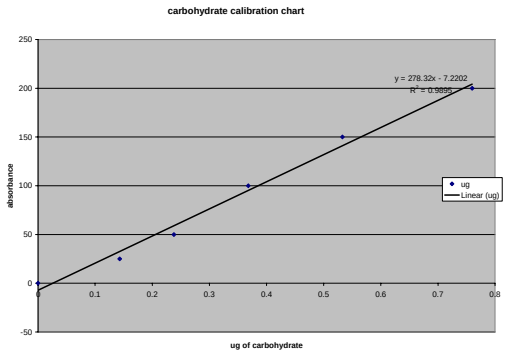
The graph above shows the relationship between the surface area of the mosquitoes' habitat and the rate of pupation. The larva in the smaller pools pupated earlier than the larva in the larger pools, but in all sizes of pools a majority of the larva pupated on approximately the same day. In the two smaller pools, more larvas began pupating much earlier. The patterns above show the anopheles gambiea's ability to rapidly change its body to match its surroundings.



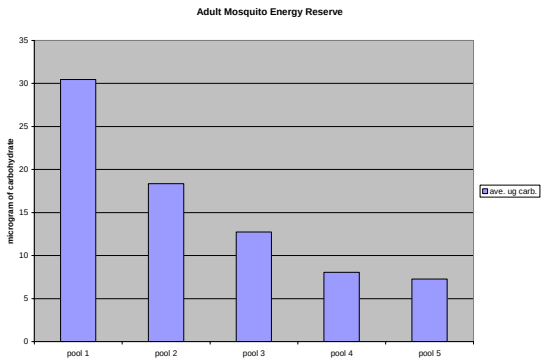
The graph above shows how the habitat size affects the mortality rates between each instar in the mosquitoes' life cycle. In the largest pool, the first instar mosquitoes had a very high mortality rate probably due to the fact that the tiny larva would have had a hard time traveling to the middle to get food and then back to the edge of the pool to rest. The smaller pools had a high mortality rate in the later instars of their life cycle. This is probably due to the fact that the smaller pools became much more polluted with the higher concentration of extra food in less water. Also, these smaller pools had a higher concentration of algae growing in them later in the experiment. The density of the mosquito larva in the smallest pool was so high that when the food was placed into the pool, the larva would fight over the food and most of it would sink to the bottom.



The graph above shows how the surface area of the pool affects the development time of the mosquito. The larger the pools' surface area, the longer it takes for the mosquito to develop. All five different pools indicated a longer development between the second and third instars. The last few stages of the mosquito lifecycle develop very fast. The smaller two pools follow the same pattern until the end probably because of the high concentrations of extra food and algae during the last couple stages of the mosquitoes' life cycle.



The graph above was used to calibrate a linear equation to use in analyzing carbohydrate levels in mosquito samples from each pool. The slope of the line allowed us to find the applicable numbers from the standards used in the spectrophotometer.



The graph above shows how the surface area of the mosquitoes' environment affects the energy reserves the mosquito has as an adult. Indicated by the graph, the larger the surface area of the mosquito larva's environment, the more energy reserves the mosquito has as an adult. This means that the mosquitoes from large environments will be able to travel further and survive longer to infect humans. A mosquito has to have more energy reserves to be able to travel from one person to another person instead of just feeding off of one person. Since the transfer of malaria comes from a mosquito transferring the parasite from one person to another, the data shows that large pools of stagnant water are more likely to assist in the transmission of the malaria parasite than the smaller pools of stagnant water. The stronger mosquito is more reproductively fit, more apt to bite several people, and lives long enough for the parasite to develop into the parasite that affects humans.

From my observation of the tested sites, many people keep their home areas very clean of stagnant water, but very few if any people clear stagnant water around their community, where all the large breeding sites are located. Through my research, it would be my suggestion to focus on clearing the larger pools of stagnant water around the community.

Conclusion

The major conclusion that I made from all three of my experiments as a whole is as follows: From the surface area energy reserve experiment, I found that larger pools of water produce stronger and healthier mosquitoes that are more likely to carry the malaria parasite from one person to the next. In the chemical breeding site analysis test, I found that mosquitoes prefer areas with high levels of chloride coming from human waste and human interaction. In the interview experiments, I found that there is no community level of breeding site leveling. People are very good at cleaning around their homesteads, but once they step out into their community they have no level of cleaning in their communities. I observed that the large and major breeding sites are located in and around the communities in public areas like the lakeshore and roadway culverts. These sites are perfect breeding sites for strong and healthy mosquitoes because of the large pool sites and high levels of chloride plus these breeding sites are not maintained. The locals seemed to know the basics of around-the-home mosquito management, but no one had any sense of community level mosquito breeding site management.

To say that this experience has just changed me and my views of my world would be the biggest understatement of the entire paper. There are few words that actually describe the experience, but I will attempt to describe this internship's impact on me. The labs, research, and projects were great to get my feet wet in the science fields I am interested in, but the entire experience here in Kenya is what really impacted my views of food security. I now realize that food security is not always an issue of food production and harvesting technology, but can be an issue of a culture having these tools at their fingers. In my research area, I saw a lot of potential. The implantations that are used on my farm at home could work great for them also, but one very big issue is in front of them. The issue of malaria!! Malaria is not just a human health concern, but it is an economic concern, a social concern, and an agriculture concern. On National Geographic's fact sheet of malaria, they listed malaria as a major agricultural issue and states that "malaria causes death and reduces the production of agriculture[4]." ICIPE is developing strategies to address the health of rural communities and the growing need for agricultural production. For example, in previous studies researchers found that rotating rice with soya not only eliminates excess water for mosquitoes, thereby reducing malaria infections, but also improves the soil and provides farmers with a high-value crop[3]. The basis of my research was to better understand the relationship between the community and the malaria vector. The lab data that I collected helped us develop new methods of feasible control methods. Nature will always keep a balance, so we cannot eliminate the mosquito, but we have to learn to live with it. There is an abrupt realization that issues of food security are huge and not an issue to be solved through agriculture alone, but can be solved through economics, health, and just about anything dealing with the ecology or physiology between humans and their environment. One hundred percent of the local people I interviewed were practicing agriculture for their main source of food or income.

I realized that the research I performed and helped with was important to the front of fighting malaria but was only a tiny portion of the entire battle against malaria and food security. The results of the program are being used for the development and public notification of new methods of malaria vector control.

I became very good friends with several graduate students. Some were studying economics, others engineering, and some sciences. I was so impressed by the projects they were working on and how much they were having an impact on the local area. Whatever field of study they were in, it could be used to benefit and help others. Students were making a difference in food and health security with their completely different majors. They really made an impression on me for my future college goals. They told me about all of the courses they received the most out of and the things that really helped them later in their training. But, the one thing that they all stressed the most was to study what you enjoy. It was made clear that if you really love what you are doing, you will be very good at it and others will benefit from what you do.

Cultural Experiences and Adventures

After nineteen hours of airtime, I arrived in Kisumu, Kenya. I thought the hard part was over, as I piled my things into the truck to go to Mbita ICIPE but I soon discovered the wild road conditions of Africa. I had heard that the roads were bad but the trip ahead was nothing short of exciting. The roads are dirt paths cut into the earth by extensive travel with large stones placed in the road to allow cars to pass even when it rains. For normal travel, however, it makes the trip quite bumpy and exciting. After a few hours of travel, we started going through large pools of water that came up over the tires, but did not faze our driver. As we continued on, we were stopped by some locals, stating that up ahead was a lot of water and the road was impassable, but we continued on. Up ahead was a "small river" crossing the road. Too far in the journey to turn around we decided to go for it. We plunged into the water and soon found the water to be too much. The water came up over the front hood of the truck and killed the engine. The locals pushed us out for a small price, and we started the engine back up but something was not quite right. A lot of black smoke was coming out of the exhaust and the truck had half the power. We stopped in several small villages looking for a small part but had no luck. With the truck at half power, the few hour trip turned into an all day trip. We arrived at Mbita ICIPE right as the sun was setting. Later that day, we found out that a river's banks had broken and we passed right before it got really bad. The water got much worse and swept away a vehicle, killing two people.

The nature was incredible, so I have been spending a lot of my free time collecting bugs and butterflies or fishing with friends for the Lake Victoria tilapia. The weather was perfect, even though I was located a few miles south of the equator. This was probably due to the fact that it is their winter. The tilapia is a major source of income and food for all the families around here. I caught nine tilapias and I had the guesthouse cook prepare two of them for me and I gave the rest to friends. The lake always has several small sailboats going from island to island casting nets for the tilapia or Nile perch. At night the lake becomes a town full of light as the boats head out to attract small fish called daaga. The fish are caught by net and then sun dried and sold in the market. The local wild animals are active so I have seen hippos, monkeys, and snakes as I explore around Mbita. Monkeys go tearing by the guesthouse as I eat breakfast, but they are too quick to get a picture of them. My room is right by the shore of Lake Victoria so I get to hear the hippos coming out on the beach at night to graze, they sound like old sows rutting in the mud. They are huge animals and don't seem to mind the locals, most of the time. I have heard some very sad stories of hippos killing people around here. On two of my field experiments, I came across a very poisonous snake called the black mamba. The locals killed the first one I saw so I took a picture of it as a child held it up proudly with his father. Shortly after, students killed a large python at their school. The Gembe hills around here are very beautiful. I have hiked up a few with friends. Some of the larger hills appear to be mountains to me. The locals gave me the name, Mr. Jagembe, meaning man of Gembe.

To describe the food here, I would not call it good but instead I would call it interesting. We eat ugaly, skumawiki, rice and either goat or tilapia everyday. At first I thought those things tasted awful, but by the end of the trip I could eat an entire plate of it. I would not order it from a menu if I had any other choices. I really enjoy their local samosa, mandazi, donuts,

pancakes, chapatti, bean soup, green grams, and even their vegetable pizza. Most of the foods are prepared with the local maize or millet flour with very few additives. The local produce is very good. I enjoy the local oranges, sugar cane, baby bananas, pow pow, passion fruit, pineapple, ground nuts, and coconuts.

I have met so many interesting people from around the world either people I worked with or just someone at a lunch break. I have developed many good friendships with locals but I also have very good friends from Switzerland, Canada, Sudan, China, Poland, and England. There are always many interesting people to talk with at lunch, either doctors, surgeons, engineers, missionaries, researchers, or even psychologists. I have learned a lot from just listening to what they are doing; let alone what I learn in my experiments each day.

I really miss all the great food from home, but what I really miss is all the small conveniences like water, electricity, which blacks out about 4-5 times per day, reliable internet, and motorized vehicles. It is very hard to spend a lot of money here because everything is really cheap, but your money can go really fast if you don't know the appropriate prices because everyone raises his or her prices for the white guy. I really enjoyed bartering for different souvenirs in the Maasai Market and other local markets. The U.S. dollar exchanges for about sixty-four Kenyan shillings. I always had to convert to understand if the price was fair or not. Most of the conversions made a lot more sense here than at home. Everything here dealt in Celsius and the metric system, which was very convenient and easy to work with.

There is a school located in the ICIPE campus, so I have spent a lot of time playing with the kids there. Of course they love "football" so we play on a dirt field with two sticks as the goal posts and the tall grass around the field as the out-of-bounds line. I also brought a frisbee, a collapsible kite, and a golf club with golf balls. They really enjoy trying out all the different sports, but they always come back to soccer. The ball I brought has been played with so much that the color has been kicked out of it. If I hadn't brought a soccer ball from home, they make balls out of plastic bags squeezed together then tied together with another plastic bag. They loved the small gifts I brought them like: balloon animals, pens, hats, and candies. The kids probably taught me the most words in Luo or in Swahili because the adults speak fluent English and I also learned words in Kikuyu and Maasai. The kids know English but were way more comfortable speaking in their native language. I picked up the basic words to greet people and just to be polite. I really enjoyed learning the different languages of the tribes as I traveled. I usually just tried to learn the words for hello and how are you.

Some of the bigger events that happened on my trip were: the tremors in Tanzania, visiting Nairobi National Park, the Maasai Mara game reserve, the Rift Valley, the Kenya National museum, and taking a boat ride on Lake Victoria to Unfangano Island and the Bird Islands. I enjoyed visiting caves on the islands with ancient paintings on the walls. I also enjoyed visiting an orphanage called Kibisum on Rusinga Island and hiking to the peak of Gembe Hill with my friends and eating our lunch on the top. Later, I cycled with friends to Rusinga Island to visit the Tom Mboya museum and to visit the archeological dig site where Louis and Mary Leakey discovered the first Proconsul skull complete with a face in 1949[2].

The Maasai Mara game reserve was my favorite park because of all the animals in and around the park and seeing the very traditional Maasai tribe. They still dress in their red robes, beads and have huge pierced ears and carry their spears. Most other tribes are trying to become westernized and wore old suits. I saw so many animals but the highlight animals were the giraffes, elephants, zebras, the wildebeest migration, cheetahs, lions including three babies, hippos, Cape buffalo, baboons, ostrich, and many species of antelope. At the lodge, the Maasai did three traditional dances for us and we fed the hyenas.

I also enjoyed attending a traditional church with a good friend every Sunday. They had me give the main lesson several times; and at the end of my stay, they gave me many nice handmade gifts including: gourd cups, gourd milk jugs, and an adobe pot.

The entire trip went by way too fast. At first, I thought two months was going to be a very long time but I still had plenty I wanted to do when it was time to go. I learned much more than just research here. I became very familiar with Kenya's culture. The news and politics are the discussion topics of choice and how they are going to elect Rieyla in December. I also learned that Kenyans run on a different time pace than I do. They are much easier going and relaxed and don't tend to mind if things are running an hour or three behind schedule. This experience you cannot get from a vacation or a short stay, but through developing friendships and visiting their homes I was able to understand their culture.

The best way to describe my experience in Kenya is to describe my luggage. I brought with me luggage from my home and I left most of it with friends and locals. Then, I filled my luggage with items from Kenya to bring back home with me. I know that I learned a lot on my internship in Kenya, but I also hope I left a little bit of what I know in Kenya. At the tourist locations, I realized how much more I got out of this working internship then just going as a tourist. I had a

skewed sense of understanding who the people really are until I got sick, lost weight and developed friendships with the locals and got a first-hand view of their daily struggles.

In the months following my return home, I have stayed in close contact with several of my friends from Kenya. One of my good friend's wives had a baby and named it Zachary after me! I am so glad to hear that I made such good impression on them because I know they have given me a great impression of them. I have found myself looking at the world in which I live with a completely different outlook. Questions fly in my head about the possibilities and what ifs as I compare and contrast my life style to theirs. The experience serves as a source of inspiration to me to make the most of my college education so that one day I can better serve my world.

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