Mosquito Trap

March 10, 2010

Team:
Jeff Theisen – Team Leader
John McGuire – Communicator
Courtney Krueger – BWIG
Ryan Nessman – BSAC

Client:
Dr. David Van Sickle
Department of Population Health Sciences

Advisor:
Dr. Chris Brace
Department of Biomedical Engineering

Abstract

It is important to be able to trap and analyze mosquitoes in order to determine what steps should be taken to prevent the transmission of the diseases they carry. Current mosquito traps require an incredible amount of time and tedious work for entomologists. A mosquito trap which implements remote transmittance of data could be extremely useful, as it would not only decrease the amount of work for entomologists significantly, but it could also provide real-time data of the environmental conditions when mosquitoes are entering the trap. Three additions to the current trap were taken into consideration: sensing (the ability to count the number of mosquitoes in the trap), communication (wirelessly transmitting the data) and differentiating and speciating the mosquitoes. Through research and evaluation of the design ideas, a GSM module will be used as the communication device, and audio frequency detectors were chosen to carry out differentiation and speciation aspects. Testing will be conducted on a laser trip wire and motion sensor to determine which method is most effective in sensing mosquitoes.

Problem Statement

This project is designed to apply a variety of electronic technologies to current light trap models of mosquito traps to improve their utility and ease of use and their potential to generate valuable, timely data for public health. In particular, we plan to integrate a variety of sensors to collect data on the local environment and on the trapped mosquitoes, and provide a means to remotely monitor and operate the device.

Background

General Purpose

Mosquitoes are capable of carrying deadly diseases, such as malaria, and transmitting those diseases to humans. This transmission has been a major health issue throughout the world; an estimated 300 million people are infected by malaria each year and over 3 million of these individuals die [2]. There are over 3,000 existing species of mosquitoes in the world today, but only a fraction of these are capable of spreading disease [6]. In an effort to control the mosquito's spread of disease, entomologists make use of mosquito traps, which allows them to monitor the populations of various species of mosquitoes [4]. Using the data received from the traps, entomologists are able to make accurate and informed decisions regarding mosquito control.

Current Traps

In an effort to receive the best data, entomologists make use of two popular kinds of mosquito traps, the gravid trap and the light trap. The light trap (shown in figure 1) attracts mosquitoes using carbon dioxide and light, while the gravid trap (shown in figure 2) attracts mosquitoes using swamp water. The different methods of attraction found within the traps are used to attract different species of mosquitoes. In the light trap, the carbon dioxide is emitted from a canister which is filled with dry ice, and the light is emitted from an incandescent light bulb [4]. In the gravid trap, the swamp water rests in a pan [3]. Aside from their method of attracting mosquitoes, the gravid trap and the light trap are essentially identical. Once mosquitoes are attracted to a certain point, there is a plastic tube which has a fan inside of it. The fan is turned on when the trap is in use, and mosquitoes are sucked through it and pushed through the cylinder and into a bag, where they stay. The bag's only entrance is through the cylinder, and the fan is powerful enough to keep the mosquitoes from flying out [3]. In order to keep larger bugs out of the traps, there is a mesh filter which is large enough to let mosquitoes pass through but stops the larger bugs. These traps are powered by a standard 6V battery, which typically holds enough power to run for one night. To use the traps, entomologists place them in a designated area late in the evening, where they run for the duration of the night. They then come and collect the traps in the morning, and proceed to hand count how many mosquitoes they collected. The entomologists then speciate each individual mosquito under a microscope, based on their scaling patterns on the abdomen and striping patterns on the legs. This allows the entomologists to receive the data that they need to make informed decisions.

Figure 1: Light Trap [7]

Figure 2: Gravid Trap [5]

Design Motivation

The overall motivation behind our project is to enhance the existing mosquito traps to make the process of trapping much more automated. Because entomologists have to individually count all of the mosquitoes that enter the trap and then individually speciate them under a microscope based on their scaling patterns, the process of mosquito trapping takes a vast amount of time. In one trap, there can be up to 65,000 mosquitoes in one night [1]. Usually, entomologists use multiple traps at once, so using the traps consumes an enormous amount of time, as scientists have to potentially speciate thousands upon thousands of mosquitoes. Despite the fact that entomologists usually take a subset of the data, which usually consists of about 2,500 mosquitoes, that is still an incredibly large number of mosquitoes to have to count and speciate [3]. Given this, the main motivation behind this project is to decrease the amount of man hours needed to accurately monitor mosquito populations within the area. Other problems with the current design are that it does not have temperature or humidity sensors, it has no way of communicating remotely, and that it has no way of establishing real time data. If these given problems were solved, monitoring the populations of mosquitoes would be made much easier and more effective, while the amount of man hours devoted to the monitoring would be significantly decreased.

Client's Requirements and Design Constraints

The client provided several specifications that the final design must meet. First among these, was that the device must be durable and rugged, and withstand weather and exposure. The trap will be operating in an outdoor environment; thus, it must be able to endure various weather conditions such as rain, wind, dirt, or dust. Current light traps are designed with an umbrella-like, protective disk on top, which will offer some shielding from the weather.

Another specification is that the device must reliably capture and count an accurate and valid sample of mosquitoes of interest. This is so that the trap can provide quality data to entomologists who make decisions based on this data. If the trap were to provide data that is not accurate or valid, this would be of little use to the entomologists. This data should be communicated remotely, in order to provide real-time information. Additionally, the trap should limit the number of other insects counted and captured, as the mosquitoes are the insect of interest.

Several operational specifications were also set, to ensure that the trap will be able to operate in a satisfactory manner. One of these is that the electronic additions must not diminish the length of trap operation. Current traps operate for the entire length of a night, so the device must be able to last for this amount of time. The designed device must also be relatively simple to operate, so as not to make it confusing or difficult for those who want to use it. Furthermore, the device could be designed as an add-on unit to current traps.

Finally, the client also provided several production characteristics. The device is relatively unrestricted in size and weight, except that it must be small and light enough to facilitate easy transportation to and from a mosquito collection site. The client desires just one prototype, which will operate alongside current traps this summer for comparison. Additionally, the budget was set at $1000 for development of this device; however, the cost of reproducing the final product should be significantly less. Current traps range from $90 to $300 plus the cost of batteries and chargers, which could easily add $100 [8]. The cost of the final device could be slightly greater than these values, as it will offer a more automated, efficient process of mosquito collection.

The formal product design specifications, which contains all of this information in a more itemized format, can be found in the appendix.

Design Alternatives

Through meetings with our client, discussions with entomologists, and team brainstorms, an enormous list of potential improvements was generated. Some of the proposed improvements include: regulating and automating the release of carbon dioxide, scavenging power through solar panels, killing mosquitoes as they enter the traps, incorporating temperature and humidity sensors, remotely differentiating mosquitoes from other bugs, remote control and retrieval of information, and many more. The team narrowed this list down to manageable set of priorities to be addressed in this semester. These goals reflect a desire to communicate useful data about the set of mosquitoes entering the trap, and does not focus on attraction methods or dealing with the bugs after they enter. The first priority is to accurately detect and count insects entering the trap. The second priority is to remotely communicate this data. Finally, the third priority is to improve the quality of data by potentially differentiating mosquitoes from other bugs or speciating the mosquitoes. After a brief summary of constant features of the design, the following sections of design alternatives will address these priorities.

Constant Features of the Design

There are a number of aspects to this design which were not considered with alternatives because they we relatively easy to decide upon. The first being the microcontroller implemented to interface and control the various electronic devices. For this, the client provided us with the

Arduino Diecimila, as seen in figure 3. This board has 14 digital input/output pins, 6 analog input pins, 16kb of flash memory, a clock speed of 16 MHz, and can be program easily using the arduino programming language. It optimally runs on 7-12 volts DC, although it can power by as low as 6 volts DC [9].

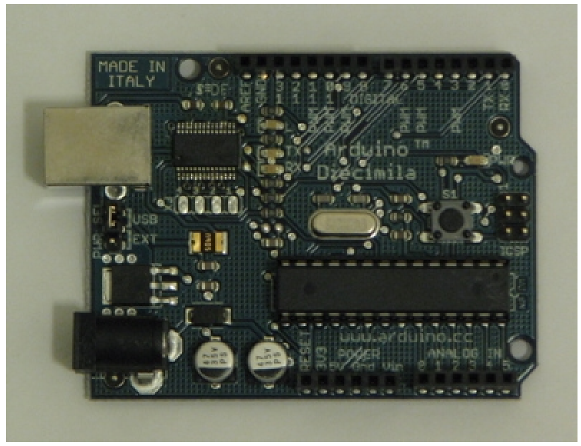

Figure 3: Arduino Diecimila [9]

The next constant feature is the waterproof case in which the electronics will be housed, thus keeping them safe from the weather. Although a final case has not been selected, several good possibilities have been identified, one of which is shown in the figure 4 below, which has inner dimensions of 5.79 x 3.11 x 2.4 in. [10]. The final decision will be made once the optimal dimensions needed to house all the electronics are know.

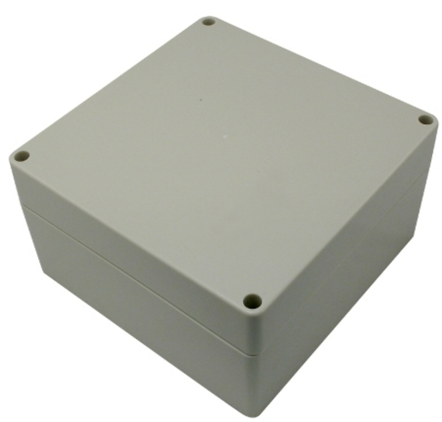

Figure 4: Waterproof plastic electronic enclosure [10]

The final constant feature of this design is the power supply. For this, the team will incorporate the battery currently used by the client to power the mosquito traps. These are 6V batteries with 10Amp-hours of battery life. This will make it easier on the client, because they already have the charger that works with this battery. As mentioned early, the arduino runs optimally on 7-12 volts; operating at 6 volts may cause the board to be unstable [9]. If, through testing, this is determined to be a problem, several approaches could be used to find a solution. The arduino could alternatively be supplied by two of these 6V batteries in series, effectively powering it with 12V. Additionally, similar 12V batteries can be purchased, though these would require a new charger as well [8]. As described in the client requirements section, the trap must operate through the entire night. Most of the electronics we plan to incorporate have relatively low power consumption; however, if additional battery life is needed, more batteries can be purchased from John W. Hock with battery lives of up to 20Amp-hours [8].

Design Aspect 1: Sensing

The first design aspect is sensing, that is, the ability to detect and potentially count mosquitoes once they have entered the trap. There have been methods used to count insects using sensing devices, including a laser trip wire and an infrared motion sensor. These two implementations will be tested and the method that is most effective will be used in the final design.

Laser Trip Wire

The first method examined was the laser trip wire. This device uses an infrared beam generated by a photodiode (figure 5), which is focused on a photo resistor. The photo resistor senses the infrared light from the laser, and a resistance is established. Once an object (in this case, a mosquito) crosses the beam, the beam is broken. This causes the resistance within the photo resistor to change. The change in resistance is transmitted to the arduino device, signaling that something has broken the beam [14]. The arduino would then be able to record and transmit the number of times the beam was broken, thus giving a count of mosquitoes.

The laser trip wire is advantageous because it detects a break in the laser beam, which could be caused by something as small as a mosquito. The main concern with sensing is the ability to detect and count mosquitoes, and this implementation has a large probability of being successful.

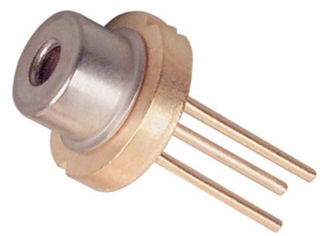

Figure 5: Image of a laser diode [18]

The main problem with this design is that, because it uses a single laser beam, it may not be possible to cover the entire area of the trap. It could be difficult to sense mosquitoes, as they could pass through the trap and not break the beam. It is possible, however, to implement a series of mirrors within the trap to reflect the beam, and increase the amount of space that it covers. Alternatively, the mosquitoes could be forced through a smaller passage, through which the laser passes, in order to increase the possibility of breaking the beam. One source of error, is that it is also possible for the beam to be broken by other insects, and potential debris that passes through the trap, which would result in and inaccurate mosquito count.

Motion Sensor

The motion sensor mechanism is able to detect the motion of infrared sources. The device uses a dome-shaped lens to detect infrared radiation, with an optical filter place behind it, as diagrammed in figure 6. The motion of an infrared source can be detected by these components through a transfer of heat from the source to the filter. The change in heat is transmitted through the device, and amplified to the output [15].

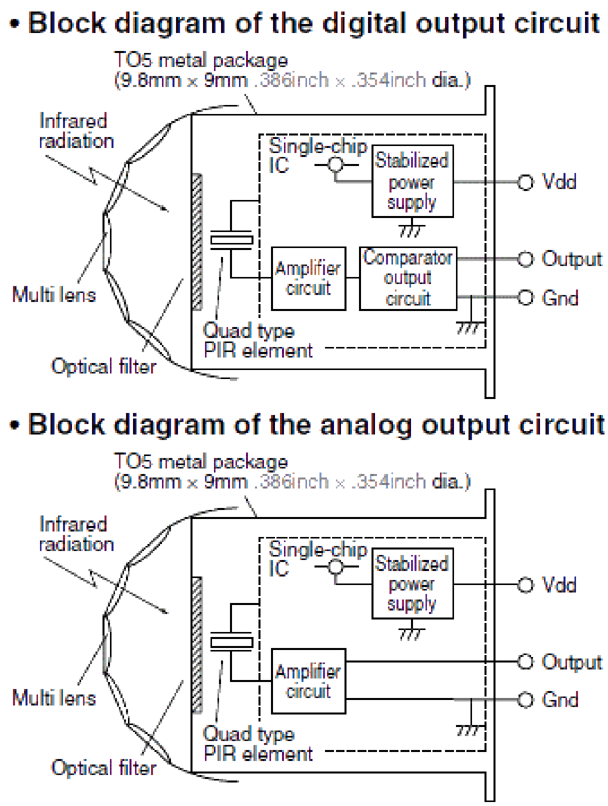

Figure 6: Diagram of the motion sensor mechanics [15]

The main advantage to this method is that it can cover a broad area, and can easily detect infrared sources within the trap. Mosquitoes emit infrared radiation, and could be detected using such a method.

The key disadvantage of this device is that it is designed to detect infrared radiation from a human source, which at normal body temperature radiates a wavelength of approximately 12 micrometers. The infrared radiation emitted by mosquitoes is around 6-8 micrometers, so the device would need to be modified in order to detect that wavelength. It is also uncertain as to how the device will react to multiple infrared sources.

Design Matrix for Sensing

The design matrix for sensing is not complete yet, as testing the parts has not yet been conducted. Three factors will be taken into account as to which method will be used:

effectiveness, ease of use with arduino, and cost. Each design will be given a rating based on their performance in each of the three categories.

The heaviest weighted criterion of this design is it's effectiveness, which is its ability to sense mosquitoes. Due to the need for a count of mosquitoes within the trap, it is essential to be able to sense the mosquitoes and produce a count. The laser trip wire and infrared motion sensor will be tested and their performance will be rated based on the ability to sense mosquitoes.

It is also essential for the sensing device to be compatible with the arduino microcontroller. In order for our device to transmit data, it must first pass through the arduino. In turn, it is essential for all electronic elements of the trap to be compatible with the arduino.

Cost always weighs in when considering the possible designs, as it is ideal to make the most inexpensive functioning prototype. The components for the laser trip wire cost $17.00, making it relatively inexpensive, as the components for the infrared motion sensor cost $44.24. Because the infrared motion sensor components cost $44.24, which is not expensive considering the budget of $1000, it received 8 out of 10 possible points. The laser trip wire components cost only $17.00, so it was awarded 10 out of 10 possible points.

Table 1: Design Matrix for Sensing

Considerations	Weight	Motion Sensor	Laser Tripwire
Effectiveness	70	TBD	TBD
Ease of Use with Arduino	20	TBD	TBD
Cost	10	8	10
Total	100	TBD	TBD

Design aspect 2: Communication

The second aspect examined for improving the mosquito trap was communication. In order to achieve the goal of transmitting real-time data from the trap, it is necessary to implement a device that can take the signals from the readings within the device and transmit them to a recording mechanism. Methods for transmitting data from an arduino exist, including a GSM transmitter, and wifi. These two methods were evaluated based on their effectiveness and efficiency within a mosquito trap.

GSM

The first possible method to be used in the mosquito trap was a GSM module. This device is commonly used in devices such as cellular phones for transmittance of data, live audio, and video recordings. GSM uses technology that transmits the signal to a satellite, where it is reflected to a destination specified on the transmitter. In this case, it would allow for the data from the trap to be transmitted to a receiver that is connected to a computer, where it can be analyzed [17].

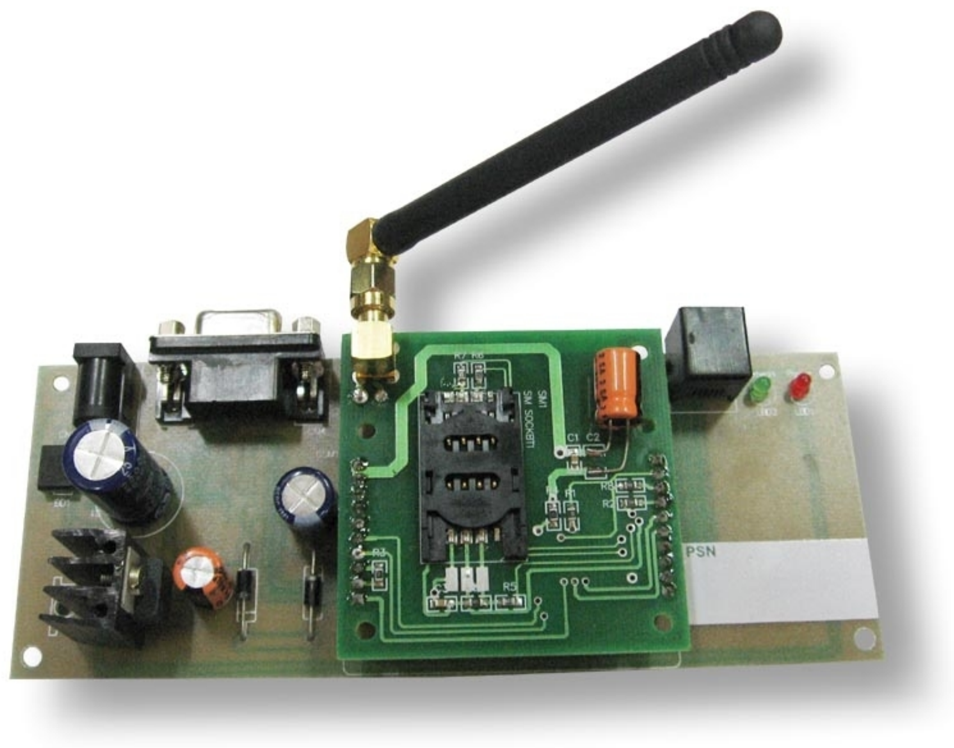

Figure 7: Image of a GSM transmitter [17]

GSM transmission is advantageous because it is a proven method of long-distance transmission. Devices such as cellular phones that have GSM modules are able to transmit signals from many remote locations, as long as there is GSM coverage in the area. It is common for GSM to have a large coverage area, as many cellular phone companies want their devices to be able to operate in the largest area possible. In the case of the mosquito trap, there are a number of wireless companies that have coverage in all the areas where the traps are placed. GSM is also easily compatible with the arduino microcontroller, and the mechanism comes fully capable of transmitting data, so no extra construction would be necessary.

The disadvantage of using GSM to transmit data is that it could be expensive. Wireless providers that facilitate the transmission of data require payment for the amount of data being transmitted. In the case of the mosquito trap, it would be necessary to transmit data and perhaps audio recordings from the device, and it could prove to be very expensive. It is undetermined exactly how much it would cost to transmit the data from the trap to a recording device, however a typical wireless provider charges about $40/month for unlimited audio transmission.

Wifi

The second option for transmitting data is wifi. Wifi is commonly used to provide wireless internet to a specified area. It allows for access to online transmission and reception of data, including audio and video. Wifi uses radio signals that can be analyzed and converted at both an internet source and the transmission device to allow for data transmission [16].

Figure 8: Image of a wifi transmitter [16]

The key advantage of using wifi is its cost-effectiveness. One flat rate would allow for unlimited transmission of data from the source. For an internet connection, a standard rate is approximately $20/month. A wifi receiver located on the device would come fully assembled, and would be easily implemented in collaboration with the arduino microcontroller, making it easy to assemble.

The main disadvantage of wifi communication is its range. Commercial wifi sources are designed to provide service to areas such as single buildings, and are not yet capable of having a range that spans a large area. Because the mosquito traps are sometimes set in rural areas, it would be very difficult to obtain wifi signals. It could be possible to establish wifi signals through an internet provider at areas where the traps would be used, however, this would be very costly.

Design Matrix for Communication

The design matrix for communication was based off of four aspects: cost, ease of construction, ease of use, and range. The wifi and GSM methods were evaluated based on their performance in those four categories.

The cost of transmitting data from the trap is important because the device should be as efficient as possible, and if the components of the trap are too expensive, it would be difficult to implement the design. The cost of GSM transmission of data would be in the area of $40/month for data transmission. This is fairly expensive but could be accomplished with the current budget for the trap, so it received 17 out of 25 possible points. Because wifi communication would cost approximately $20/month for data transmission, it received 22 out of 25 possible points, making it the method of choice in this category.

Both GSM and wifi communication would come fully assembled, making them almost effortless to assemble. Because they both would require such little effort, they each received 15 out of 15 possible points in the ease of construction category.

Ease of use is essential when determining which method of communication to use. The entomologists must be able to easily operate the devices and troubleshoot problems within the mechanism. Each communication method is fairly easy to use, as they are currently used in many transmission devices. Because both devices require a similar amount of knowledge to operate, they both received 25 out of 30 possible points in the ease of use category.

The final aspect examined in the design matrix was range. The range of the device was the key factor in deciding which device to implement, as it is essential for the device to be able to transmit data from the remote locations where the traps will be placed. Because GSM has the capability to transmit data from a large area of locations, it received 29 out of 30 possible points. Wifi fell behind in this category because it has a very limited range and can only be implemented in locations that have wifi connections. Because of its limited range, wifi received only 10 points out of a possible 30.

After the points were totaled, the GSM module came out on top, with 86 out of 100 potential points. Although it lost points in the cost category, it was not as crucial as the range aspect, in which it received the most points by far. Wifi received 72 out of a possible 100 points, mainly because of its lack of range, which proved to be the deciding factor in making the decision. Because GSM scored the most points overall, it was chosen to be implemented in the final design.

Table 2: Design Matrix for Communication

Considerations	Weight	GSM	Wifi
Cost	25	17	22
Ease of Construction	15	15	15
Ease of Use	30	25	25
Range	30	29	10
Total	100	86	72

<u>Design Aspect 3: Differentiation and Speciation</u>

For the purpose of counting and speciating mosquitoes, it is important that the trap is able to remotely differentiate mosquitoes from other bug and/or speciate the mosquitoes that are entering the trap. There are some insects that can enter the trap that are not mosquitoes, as they are a similar size to mosquitoes and can therefore get through the mesh openings. Although many of the other insects that try to enter the trap are too large to get through the mesh, there are still a fair number of insects that are very similar to mosquitoes that do not transmit disease and therefore are unimportant to the researcher. These insects vary in their population numbers during different times of the year, so it is not feasible to extrapolate the number of mosquitoes from the number of total insects caught. Under a microscope, which is the current method used by researchers to differentiate and speciate mosquitoes, it is very easy to recognize another insect that is not a mosquito. It is important to speciate the mosquitoes because different species of mosquitoes are capable of carrying diseases, while others are just considered pests. The information gathered by researchers about the numbers of different species of mosquitoes helps mosquito control groups determine if they need to deploy mosquito control methods, such as still-water draining or spraying.

There are three methods for differentiating/speciating mosquitoes. One method involves taking pictures of each entering mosquito. If this picture were to be sent to the researchers and it was of high enough quality, then they would be able to quickly and remotely differentiate and speciate the mosquitoes by looking at their scales, relative size, and leg bands. However, they normally view the insects underneath a microscope, so the picture that was sent would have to be very high resolution. In order to do this, we would need to obtain a very small, high resolution camera that took a picture when the counting sensor was set off. It might have to autofocus, although we would attempt to keep the insects in a small focus area by narrowing their entrance path considerably. The light conditions inside the trap would require a flash to be used. All of these aspects would make the picture method a finicky design to have to work with, and its accuracy might be limited by the quality of the picture that it would be able to take. The cost of this method would also be high because small, high-resolution cameras are expensive and would be likely to make the cost of each trap high.

The audio frequency method is based off of the fact that different insects, species of mosquitoes, and even the different genders of the same species of mosquito, flap their wings at a different frequency from one another. If the sound of their flight is recorded with a microphone and this data analyzed, strong correlations between frequency and species can be determined and used to speciate each mosquito. [12] For the best data, a short recording should only be saved and sent as a file to the remote computer if the count sensor is tripped. The computer can then further analyze the data to determine the frequency that was heard. Advantages of this method include the ease of implementability, the relative simplicity of construction, and cost. A microphone with a high enough quality for this function should be fairly cheap and easy to find. Some problems that will need to be worked out include filtering out the background noise from the wing beat frequency signal, but computer software or operational amplifiers should be able to do this fairly easily. This method has also been used in several other mosquito studies with very good accuracy [12].

The light frequency method works off of the same idea as the audio frequency method. A laser light is shown onto a photoresistor. When an insect is in the beam of the laser, the resistance pattern on the photoresistor changes and includes information about the frequency of the wing beats. Looking into this method however, it is apparent that there are a large amount of parts required, such as photomultiplier tubes and lenses, that would require large amounts of power and proper positioning, respectively. [13] This would make the setup unable to be applied to different kinds of existing traps. The software required by the computer would also be fairly complex. For these reasons, the light frequency method was not determined to be a feasible idea that we could implement within one semester's time.

Design Matrix for Differentiation and Speciation

In the end, we chose to focus on the audio frequency method for differentiating and speciating the insects that enter the trap due to its implementability, ease of data transmission, and differentiation ability. In the design matrix, all methods received low scores for speciation due to the assumption that it would be much easier to differentiate mosquitoes from other insects than to speciate the mosquitoes. A raw count of mosquitoes in itself would be very valuable to the researchers, even if we could not end up speciating the mosquitoes from one another.

Table 3: Design Matrix for Differentiation and Speciation

Considerations	Weight	Pictures	Audio	Light
Implementability	40	35	35	30
Data Transmission	10	2	6	5
Differentiation	30	29	28	15
Speciation	20	6	7	5
Total	100	72	76	55

Final Design

In the final design, depicted in figure 9, the mosquito will be attracted to the trap from a distance due to the emitted carbon dioxide and attracted further by the incandescent light bulb. It will be sucked up by the force of the fan, through the mesh, and will be blown down a tube into the holding container. On its way down the tube, it will be counted with the counting sensor, and the frequency of its wing beats will be recorded by a microphone. The count and frequency data will be sent with arduino through the GSM module to the computers at the entomology lab where it can be further analyzed. All of the electronic parts will have waterproof casing to protect them from the outdoor elements. They will be further protected by a rain shield that is placed on top of the trap. Design elements that have stayed constant are the use of the an existing gravid trap, a 6 volt battery provided by the client, an incandescent light bulb, and the use of existing carbon dioxide generation methods.

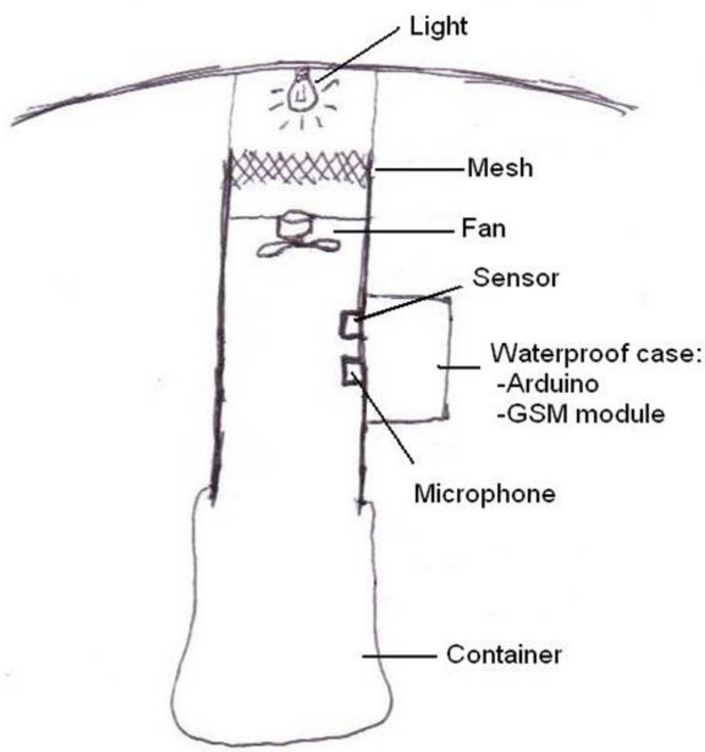

Figure 9: Final design for the mosquito trap. A mosquito will enter from a hole not shown near the light.

Future Work

In the time that we have in the rest of the semester, we plan to test the audio frequency differentiation/speciation method on real mosquitoes. With the mosquitoes, we will also test the counting sensors - the laser trip wire and the motion sensor - to determine which is more accurate and better for this application. We will be hooking up the arduino to the GSM module and determining how to send and receive data with these pieces of hardware. We will also be ordering any additional parts if we discover that we have a need as problems arise in construction of the trap design.

References:

1. AMCA traps. (2005). *AMCA*, Retrieved from http://www.mosquito.org/mosquito-information/traps.aspx

2. Gorman, Christine. (2004). Death by mosquito. *Time Magazine*, Retrieved from http://www.time.com/time/magazine/article/0,9171,1101040726-665039,00.html

3. Guidance for use of the cdc gravid trap. (2005). *Gravid Trap Instructions*, Retrieved from http://chppm-www.apgea.army.mil/ento/westnile/main/TabC_GuidelinesGarvidTrap

4. Milda: mosquito light traps. (2008). *Milda Light Traps*, Retrieved from www.milda-cevre.com/en/diger-urunlerimiz

5. Mosquito monitoring and surveillance. (2008). *State of Connecticut*, Retrieved from http://www.ct.gov/mosquito/cwp/view.asp?a=3486&Q=414712&mosquitoNav=%7C

6. Mosquito solutions. (2008). *Mosquito Facts*, Retrieved from http://www.control-mosquitoes.com/

7. Norfolk county mosquito surveillance program. (2008). *Mosquito Monitoring Program*, Retrieved from www.massnrc.org/ncmcp/surveillance.htm.

8. Price Sheet and Order Form. (2010). John W. Hock Company. http://www.johnwhock.com/buy/index.htm

9. Arduino Diecimila. (2010). Arduino. http://arduino.cc/en/Main/ArduinoBoardDiecimila

10. Plastic Enclosures and Electrical Connector Enclosures. (2010). PacTec. http://www.pactecenclosures.com/

11. Hendricks D. (1983). *Method for sampling flying insect populations using low-frequency sound detecting and ranging in conjunction with a biologically active chemical/pheromone.* US Patent 4410967

12. Raman, D. R., Gerhardt, R. R., & Wilkerson, J. B. (2007). Detecting Insect Flight Sounds in the Field:
Implications for Acoustical Counting of Mosquitoes. *American Society of Agricultural and Biological Engineers, 50*[4], 1481-1485.

13. Shaw, J. A., Repasky, K. S., Carlsten, J. L., Spangler, L. H., & Hoffman, D. S. (2009). *Optical detection of oscillating targets using modulation of scattered laser light.* U.S. Patent 7,511,624.

14. Features and Specifications of Laser Tripwires. (2010). Tripwire Enterprises. http://www.tripwire.com/it-compliance-products/te/specifications/

15. MP Motion Sensors. (2009). Panasonic. http://www.mouser.com/panasonicnapion/

16. Embedded Systems. (2009). Amtel corp. http://embedded-system.net/

17. GSM Module. (2010). Nenomart. http://www.nenomart.com/catalog/product_info.php?products_id=171&osCsid=5amb7out9vs98mtrpirepv6v27

18. Laser Diode. (2010). Digikey Corp. http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=67-1500-ND

Appendix

<u>*Product Design Specifications*</u>

February 12, 2010

Function

This project is designed to apply a variety of electronic technologies to current light trap models to improve their utility and ease of use and their potential to generate valuable, timely data for public health. In particular, we plan to integrate a variety of sensors to collect data on the local environment and on the trapped mosquitoes, and provide a means to remotely monitor and operate the device.

Client Requirements

- The mosquito trap should be durable and rugged
- Withstand weather and exposure
- Reliably capture and count an accurate and valid sample of mosquitoes of interest
- Mechanically limit the number of other insects counted and captured
- Must not diminish length of trap operation
- Relatively simple to operate
- Could be designed as add-on unit to current traps (rather than an entirely new trap)

Design Requirements

1. <u>Physical and Operational Characteristics</u>

   a. *Accuracy and Reliability:* The device must produce meaningful mosquito population data, so it should accurately and reliably measure the quantity of mosquitoes entering the trap.

   b. *Life in Service:* Must last at least overnight, preferably the device should last considerably longer to minimize human effort.

   c. *Shelf-life:* The shelf-life should be nearly indefinite so that it can be used over many seasons, although certain components may need to be recharged/replaced (e.g. batteries, CO2 cartridges, etc.)

   d. *Operating Environment:* The device will be used in an outdoor environment; it should be able to withstand rain, wind, dirt, dust, and other common outdoor conditions. It will have minor protection from the environment from the current trap design which has a circular "roof".

   e. *Safety:* The device must be not put the user in any danger. Potential sources for danger include: electrical components, mechanical aspects, and pressurized gases.

   f. *Ergonomics:* The device must be designed to allow the user to easily set up the trap for data collection and access the mosquitoes collected

   g. *Size:* The device should be small enough to facilitate easy transport to a mosquito collection site, but is otherwise unlimited.

   h. *Weight:* The device should be light enough to facilitate easy transport to mosquito collection site, but is otherwise unlimited.

2. Production Characteristics

a. *Quantity:* One prototype should be constructed.

b. *Target Production Cost:* Up to $1000 for development, but the final design should cost significantly less The device will potentially save much time in setting up and collecting data, so it can be more costly than other models.

3. Miscellaneous

a. *Standards and Specifications:* The device must produce meaningful data as compared other mosquito traps.

b. *Customer:* The primary customers are our clients; their main concern is to produce a mosquito trap that requires less human effort to operate, while maintaining a valid collection of data.

c. *Competition:* There are many mosquito traps available, but few, if any, are capable of real-time data acquisition and remote operation.

d. *Priorities:* Due to a wide variety of potential improvements, the following priorities have been established to guide the process:

1) Establishing a method of sensing or counting mosquitoes

2) Integrating this method with a means of remote control and access of data

3) Integrating a means of differentiating mosquitoes from other insects or, ideally, speciating the mosquitoes.

4) Improving upon other aspects of the trap, such as mosquito attractants, power sources, a variety of environmental sensors, a means of killing mosquitoes upon entry, or many more.