A Senior Project

presented to

the Faculty of the Dairy Science

California Polytechnic State University, San Luis Obispo

In Partial Fulfillment

of the Requirements for the Degree

Bachelor of Science

by

Jerred Davis

March, 2012

Table of Contents

List of Tables

List of Figures

Abstract

The objective of the study was to survey and monitor mosquito presence to be used in an attempt to identify the sources of breeding and, to determine what application compound is needed to apply on areas of stagnant water to reduce the amount of mosquito breeding. The traps that were used to collect the mosquitoes were CO_2 and gravid traps, which have their own distinct ways of enticing the mosquito. It is important to locate the trap in covering shade, as this is where the mosquitoes will be resting during the day in the summer. The following day the traps would be picked up and taken back to the lab for analyzing and sent to a testing facility to determine if the mosquitoes contained disease. If there were high numbers of mosquitoes in the traps the lab supervisor would determine if further surveillance was needed to find the breeding source. Pesticide applications are applied on the breeding site and are done on a regular basis to reduce the amount of mosquitoes in a specific area. The number of mosquitoes captured was representative of those mosquitoes in the surrounding vicinities. Throughout the summer there was only one incident found on the five dairy farms where there was a spike in mosquito numbers. The West Nile virus was found early in the summer and continued to linger throughout the last surveillance dates. The high spike in mosquito numbers was an indication of a new breeding source which was taken care of because the next test date indicated a dramatic decline in numbers. The results allowed for tracking of the West Nile carried by the mosquitoes and when there are higher numbers of mosquitoes, typically it is a necessity to reduce the amount in attempt to decrease disease. If the breeding sources were minimized and kept under control to diminish the amount of possible breeding, the possibility of the disease spread would reduce. For further analysis, steps including pesticide application amounts would

increase the reliability of what is happening on the dairy farm. Tracking of weather conditions and wind speeds would also allow researchers to determine how far the mosquitoes are traveling to the surveillance traps.

Introduction

Surveillance of mosquitoes is detrimental to determine whether there are positive signs for disease and to locate the breeding sources is a sure way to reduce the numbers of mosquitoes spreading the disease. Mosquito surveillance consists of using traps to catch mosquitoes in which are then analyzed and tested to determine signs of disease. Generally, when high mosquito counts are found the breeding source can be assumed close to the trap location, and if there are low numbers it may indicate that there are few mosquitoes traveling to the trap location because they have already found an adequate source to breed. There are different techniques to use when surveying for mosquitoes such as finding the right amount of shade to shelter the trap and also serves as a cool place where mosquitoes tend to rest during the hot summer days. After the analysis of the mosquitoes the supervisor would tell the technician to search for additional breeding sources in the area or to go and recheck the sources which have been marked sources previously.

The study consisted of going to five different dairy farms located in the Central Valley to survey for mosquito breeding and apply pesticides on a regular basis in attempt to reduce the amount of disease spread by mosquitoes. Because mosquitoes only spread disease during the summer months it is important to survey multiple times throughout the summer to make sure the number of mosquitoes are not increasing and finding new breeding sources. Applying pesticides are important to decrease the amount of

mosquitoes and if this is not properly done there are huge risks for disease to be spread if the pesticide evaporates or becomes inactive. It is important to check weekly that the breeding sources are controlled and not producing potential deadly pests.

The objective of this study was:

1. To survey and monitor mosquito presence to be used in an attempt to identify the sources of breeding and,
2. To determine what application compound is needed to apply on areas of stagnant water to reduce the amount of mosquito breeding.

Literature Review

The Mosquito is Born

Mosquitoes have been around for over 100 million years which have been divided into over 3,000 species that vary from one to the other (Sharon and Lanzaro, 2005). They have learned to adapt to different climates and get there blood source (blood-meal which provides the eggs with protein) from hosts such as frogs, mammals, and many retrieve from birds (Figure 1). The mosquitoes do not survive on blood; simply the female mosquito needs the blood-meal to develop her eggs, which is usually around 100-300 eggs per egg raft (Reisen et. al., 1989). An egg raft is merely a raft where the eggs stay until ready to become larvae (Figure 2). The mosquito stages start with the egg which transform into larvae (Figure 3) where then they become pupa then emerge into the adult mosquito. The mosquito feeds on nectar, where as the larvae and pupa stages survive on organic matter in the stagnant water until fully grown. The female mosquito has a ridged proboscis to penetrate human and animal skin were her bite usually goes undetected until

the itchiness sets in, whereas a male mosquito has a proboscis, but it does not have ragged edges for biting. No invention, including mosquito traps, foggers, pesticides, candles, or DEET, works consistently well on each species of mosquito. "Bug zappers" rely on ultra-violet light to attract and are ineffective to reduce mosquito bites and kill many harmless insects as well. Mosquitoes can be carriers of malaria, yellow fever, and West Nile Virus (WNV). In the United States, mosquitoes spread several types of encephalitis. Mosquitoes find blood hosts by scent, sight and heat. Mosquitoes can smell our scent, especially the carbon dioxide (CO2) when one exhales which is a key signal a blood-meal is near (Cooperband and Carde, 2006). Being that there is so much CO2 present in the atmosphere; mosquitoes respond to higher concentrations, especially when the CO2 is combined with host-odor, which then they follow the scent upwind (Allan et. al., 2005).

Figure 1. Blood-meal being suctioned through the proboscis (Gathany, 2006).

Figure 2. Mosquito laying an egg raft (personal photo).

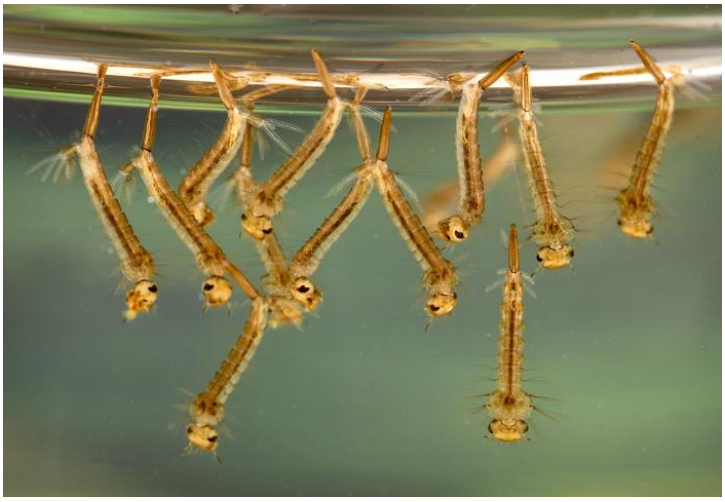

Figure 3. Mosquito larvae (Gathany, 2003).

Visual Characteristics

When examining a mosquito it is important to look at the mosquito's abdomen which has distinct markings that make it possible to tell which species it belongs. To distinguish from the two types of mosquitoes dealt with, the Culex tarsalis and the Culex quinquefasciatus, it is necessary to understand the characteristics (Table 1). The Culex tarsalis mosquito is distinct by its white median band on the proboscis, white bands extending the tarsal joints, white horizontal stripes on the segments of the middle legs, and dark 'chevrons' or triangle looking characteristics on the ventral portion of the

abdominal segment (Sharon and Lanzaro, 2005). The Culex quinquefasiatus mosquito is one of the most common, if not the most common members of the genus Culex. The Culex quinquefasiatus mosquito is brown with cross bands on the abdomen which have no white bands on their legs and their abdomen is smoothed at the tip (Reinert, 2010).

The Home of the Mosquito

Larval mosquitoes originate in a diversity of aquatic habitats. Mosquito larvae of the genus Culex are usually found in habitats that are permanent, including vegetated lake and river boundaries, natural ponds, rice fields and agricultural ponds, wastewater treatment ponds, and septic tanks (Figure 4) (Apperson,2002). Culex tarsalis larvae establish themselves in many types of newly created or occasionally enriched freshwater environments that are relatively less enriched than those inhabited by Culex quinquefasciatus (Smith and Shisler, 1981). Culex quinquefasciatus larvae are often found in environments with a high concentration of organic matter (Kline, et. al., 2006). They appear in areas of polluted water; dairy ponds, catch basins, and residential sources, which is why this mosquito is also named, "the house mosquito," being it is located around rural populations (Table 1).

Figure 4. Larvae in a dairy lagoon (personal photo).

Table 1. Mosquitoes of Tulare County

(Mosquito chart broken down by species, habitat, blood meal, and disease significance given to the employees at Delta Vector Control District)

DELTA VECTOR CONTROL DISTRICT

MOSQUITOES OF TULARE CO

	SPECIES	MOST COMMON LARVAL HABITATS	ADULT PREVALENCE (POTENTIAL)	SOURCE OF BLOOD MEAL	DISEASE OR PEST SIGNIFICANCE
Ae	Inland floodwater mosquito *Aedes vexans*	Irrigated pasture; woodland watercourse	Spring, summer	Humans and large	High pest significance, secondary vector of WEE
	Aedes melanimon	Duck club ponds, irrigated pastures and fields	Spring, summer, early fall	Large mammals Humans	Secondary WEE & primary vector, High pest
	Irrigated pasture mosquito *Aedes nigromaculis*	Irrigated pasture and alfalfa fields	Spring, summer, early fall	Large mammals Humans	High pest significance
	Western treehole *Aedes sierrensis*	Treeholes, tires, man-made containers	Spring (March-May)	Small mammals Humans	Dog heartworm vector High pest significance
An	*Anopheles franciscanus*	Sunlit pools; pools along receding streams associated with algal mats	Late summer and early fall	Small and large Rarely bites man	Low to moderate Occasional pest
	Western malaria mosquito *Anopheles freeborni*	Clear seepage, water in algal laden pools	Moderate summer	Large mammals	Low to moderate Malaria vector
	Woodland malaria *Anopheles punctipennis*	Cool, shaded, grassy pools rivers, streams, and creeks	Late spring and summer	Large mammals including man	Malaria vector Moderate significance
Cx	Tule mosquito *Culex erythrothorax*	Ponds, lakes and marshes with tules and cattails	Spring, summer, fall	Birds, humans, small	Localized pest Moderate significance
	Southern house mosquito *Culex quinquefasciatus*	Polluted water; dairy ponds, basins, residential sources	Spring, summer, fall	Birds, humans, large	Primary or secondary and WNV; High pest
	Foul water mosquito *Culex stigmatosoma*	Polluted water; dairy ponds, sewer ponds, log ponds	Spring, summer, fall	Prefers birds	Secondary SLE vector Low pest significance
	Western encephalitis *Culex tarsalis*	Fresh water sources; agricultural, commercial,	Spring, summer, fall	Birds, mammals,	Principal SLE, WEE, WNV High pest significance
Cs	Cool weather mosquito *Culiseta incidens*	Shaded, clear, natural or sources; rivers/artificial	Spring, fall	Large mammals Humans	Localized pest Low pest significance
	Winter mosquito *Culiseta inornata*	Sunlit pools or man-made duck clubs, irrigation	Spring, fall	Large mammals Humans	Localized pest Low pest significance
	Culiseta particeps	Shaded clear pools with algae	Spring, fall	Large mammals Humans	Localized pest Low pest significance

Vector-Borne Disease

Mosquitoes tend to be most active during dusk and dawn and are drawn to the shade where it is cooler during the day. It is recommended that when setting the traps to place them in the shade so that it mimics the area where mosquitoes would most likely breed being that the water will not evaporate. The frequent diseases associated with the Culex tarsalis are Western equine encephalitis and West Nile virus, which have high pest significance (Kaufman et. al., 2005). The most common disease for the Culex quinquefasciatus mosquito would be West Nile virus and is ultimately the most prevalent contributing to the disease to humans as it exists in the yards of it hosts. Being as these two types of mosquitoes are of high pest significance, working for the Delta Vector Control District allowed the opportunity to survey the two and what type of mosquito is most established at dairy farms in the Central Valley. A recent study has shown that as population of cities and towns grow, they lead to agricultural practices being closer to rural environments which increase human contact to mosquitoes in surrounding areas (Kline, et. al., 2006). In Florida, as in many other parts of the United States, the dairy industry is being suffocated by rapid urbanization, which results in increasing human contact with mosquitoes breeding in and around the dairy environments and the need for mosquito control (Kline, et. al., 2006). Mosquitoes see the illumination of the cities and find themselves searching for blood hosts which can contribute to additional disease. Dairies further away from the city are less susceptible to mosquito problems if water sources are kept managed. The arrival of West Nile virus has increased attention in mosquito control around the home and on small acreages, and in personal defense from mosquito bites. It is complicated to foresee the long term importance of West Nile virus

in the United States. Western equine encephalitis, a closely linked mosquito-borne disease has been in the country for many years, although usually at low levels. This, joined together with the surveillance that West Nile virus tends to be spread by significantly more mosquito species than the other encephalitis viruses found in the United States, makes it probable that this new disease is here to reside.

The Reduction of Milk Quality

Mosquitoes are not only harmful to humans but to cattle as well, which mosquitoes have contributed to the loss in milk quality and milk production. An experiment was carried out in South Bohemia, were there was a repellent used against the blood sucking mosquitoes for pastured dairy cattle. The average milk quality in the cattle decreased by 6.2%, the milk fat content by 11.8%, and after the milk was converted to average fat content of 4%, the difference in milk qualities between treated and untreated animals was 9.7% (Minar et. al., 1979). As the size of dairies as well as cities grow its important to realize the effects they construct and make sure they aren't harming the environment, animals, and ourselves. There are many sources of potential breeding on dairies such as water troughs, lagoons, furrows, and man-made objects such as the tires that hold the plastic down for the silage piles.

Surveillance of Mosquitoes

When surveying for mosquito larvae breeding a white ladle or "dipper" (90 ml, 3 X 8 X 7 cm) are used and placed into sample bags that are taken back into the lab to determine if the mosquitoes are building resistance to pesticide if once applied previously or to identify the species once the larvae have emerged (Mendoza et. al., 2008). Surveillance of the adult mosquito can be obtained in various ways of trapping by using

alternative traps such as light traps, carbon-dioxide (CO_2) traps, and gravid traps. The light trap is a device that only catches mosquitoes at night when the light sensor goes off when it becomes dark, which the light attracts the mosquitoes as well as other insects to be caught and examined each and every week. Inside the trap there is a solid pesticide that kills the insects which can make it hard to analyze because they "dry out" causing the colors to fade and the insects to lose their fullness. The gravid and CO_2 traps are much more efficient in that they are both an overnight trap that just requires a 6-V battery to operate and only attract mosquitoes themselves, no other insects that need to be separated. These two traps are useful because they keep the mosquitoes alive and just simply trap the mosquitoes.

Pesticide Use

There are some potential breeding sites that cannot be eliminated or periodically emptied such as fish ponds, water gardens, and reserve tanks. These can be treated with larvicides or pesticides to eliminate mosquito larvae before they emerge from the water as adult mosquitoes. Pesticides that are normally used inside dairy lagoons to reduce the amount of mosquitoes are Bacillus Thuringiensis Israelensis (BTI) (Figure 5). Bacillus Thuringiensis is a natural organic soil bacterium used as a biological pesticide or bacterial disease for insects and is safe to people and non target species, such as wildlife. The insecticide has unusual characteristics which make it useful for pest control in certain situations. There are several strains that will infect and kill insects, which why it has been developed for insect management. There are certain strain of the bacteria that were developed to control of fly larvae (Israelensis) which are used for mosquito larvae, black flies, and fungus gnats (Cranshaw, 2008). Bacillus Thuringiensis are susceptible to

degradation by sunlight and being the middle of summer when the mosquitoes are most active it is necessary to spray multiple times per week at times. Most formulations persist on plant life less than a week following application, which is important to go back often and check if there is breeding occurring to reduce the numbers of mosquitoes.

Figure 5. Pesticide Application (personal photo).

Pesticide Application

To control mosquito larvae, formulations consisting of the israelensis strain are placed into the standing water of mosquito breeding sites. For these applications, the pesticide usually is created as granules or solid (sand like particles), measured release rings to increase persistence (Tucker and Emmel, 1991). Rates of use are determined by the dimensions of the water source. Perform applications shortly after insect eggs are anticipated to hatch, such as after flooding due to rain or irrigation. Bacillus Thuringiensis Isrealensis persistence in water is longer than on sun-exposed plant surfaces, but reapply if favorable mosquito breeding conditions last for several weeks.

Other Treatments

There are other sources of treatment to be used such as permethrin, pyrethrin, cypermythrin, and resmethrin which are all types of marketed products to cut down on pests (Cranshaw, 2008). Control Districts use pesticide oil called Agnique, which would cover the top layer of the water source to prevent mosquito larvae from essentially breathing and would kill them. The last type of mosquito control the Delta Vector Control District provides are the mosquito fish which eat mosquito larvae. The fish reproduce at a very fast rate which allow for a body or source of water to be biologically controlled and can be maintained self sufficiently (Figure 6) (Locua et. al., 2009). Many times residents would come into the district and pick up these fish for their ponds and water troughs.

Figure 6. Mosquito Fish (Partin and Stewart, 1981).

Objectives

The experiment in which the project took place was comparing the numbers of two separate species of mosquitoes between two types of traps to be able to determine when pesticide applications should be applied on five different dairy farms. The overall process taken are to 1) survey the surrounding areas for potential breeding sources 2)

prepare and place the mosquito surveillance traps in correct locations 3) retrieve the traps the following morning for analysis 4) separate the mosquitoes into species and gender 5) wait for results from the virus testing lab 6) analyze whether pesticide application is needed and 7) apply pesticide if needed. Dairy farms as well as other agricultural locations are very important in the protection to reduce the amount of standing water to diminish mosquito breeding. If the farms could cut down the amount of mosquitoes being breed it has the possibility to decrease the amount of disease and virus spread throughout the city. As stated earlier cities are growing and becoming somewhat of a "pest" to the agricultural practices. The urbanization of humans increases the chance for mosquitoes to find their blood source which will only fuel the mosquitoes and continue to have the diseases and viruses that are continuing to be problematic.

Materials and Methods

Data Collection

Data from five dairy farms were collected from June 14th until September 19th. The dairy farms were located throughout Visalia, California and were visited on a semi-monthly basis for an examination and surveillance of mosquitoes to determine if there was a need for pesticide application. The surveillance included two types of traps that were to target different types of mosquitoes that were harmful to the dairy cow, other wildlife, and humans. The first trap used was a trap known as a CO_2 trap (Figure 6), which consists of 7-8 pounds of dry ice in a gallon container which looks like a paint container. The CO_2 is what attracts the mosquitoes because it mimics any mammals respiratory output. The container is hung from a 6ft stake where there is a battery and fan

which acts as a vacuum to pull the attracted mosquitoes down into another container where the mosquitoes are "trapped." The second trap known as the gravid (Figure 8), is very different than the first in that it has a tray of stagnant water or "infusion" which at the Delta Vector Control District created using 5oz of brewer's yeast and 10oz of rabbit chow mixed in a 50gal drum of water, which ferments for a week to allow a scent that is attractive to the foul water mosquitoes (Kline, et. al, 2006). A tackle box looking piece of equipment which contains a vacuum to allow the mosquitoes to be captured over the water making sure there is about a half inch of air between the infusion and the vacuum. There is also a battery inside the equipment which makes the vacuum run. This type of trap is looking for mosquitoes that have a blood-meal which they have deemed from a host and are looking to lay their eggs in the form of an egg raft (White et. al., 2009). The mosquitoes which try to lay their egg rafts in the infusion will be pulled up through the vacuum being trapped.

Figure 7. CO_2 Trap (personal photo).

Figure 8. Gravid Trap (personal photo).

The types of mosquitoes that are located in the CO_2 traps would be majorly Culex quinquefasciatus and the Culex tarsalis mosquito, the gravid will also attract the Culex quinqufasciatus if the water is "new" or polluted and will also draw in the Culex tarsalis if the water is fresh or is becoming "older." The traps would remain overnight at the dairy for approximately eighteen hours, then would be picked up and taken back to the lab at the Delta Vector Control District for further analysis. The data included the date, time, location, male or female, type of mosquito, pesticide used, and application date. Based on the amount of mosquitoes located in the traps the biologists would make a decision to go ahead and apply a pesticide (Figure 9). Many times the application date was not the same as the surveillance date which would result in higher mosquito counts varying week to week. The application of pesticide required a safety test to be passed and how to properly mix the pesticide. When the pesticide was applied it would be measured in how long it took to apply, how much pesticide was used, and where the pesticide was applied. Many times the application was applied weekly or semi-monthly depending on the effectiveness the time applied before.

Figure 9. Mosquito analysis (personal photo).

The type of pesticide most commonly used on the dairies was Bacillus Thuringiensis Israelensis which is a bacterium found naturally in soils. Since 1982, it has been used successfully worldwide as a biological pest control agent to combat mosquitoes and black flies (Cranshaw, 2008). The relationship between surveillance date and application date is very important to understand because the mosquitoes can affect hosts quite rapidly.

Data Processing

The data from the five dairies were collected and brought back into the Delta Vector Control District for analysis to be separated into species and then counted into "pools" of fifty to be sent to UC Davis to determine if the mosquitoes contained the West Nile Virus. To put the mosquitoes into the "pools" the district would use the dry ice to "put them down," which would basically give a fast freeze so the insects would stay workable to analyze the blood-meal they possess. An ordinary freezer would burst the insides of the mosquito and would damage and skew the results sent to be processed at

UC Davis. There were many variables that could have affected the results when trapping the mosquitoes such as the battery power becoming low overnight, weather conditions (melting of the dry ice, rainfall, and wind speed), and animals disrupting the traps. The data from the different test days for the five dairies were analyzed on a unified scale located on a graph, which allowed for consistency and accuracy of processing the data.

The dairies Jacobus Degroot Dairy, Milk River Dairy, B&D Dairy, and Faria & Sons Dairy were visited five different times throughout the summer, and the last dairy, Palm Dairy, was visited on four occasions. The analysis was based on the location of the surveillance trap, what species were caught, male or female, and both the date of surveillance and application of pesticide. When processing the data the district would get the results back either the next day or the day after depending on shipping. The only time this process is ever done is through the months of April to October, as this is the time when mosquito numbers for the West Nile virus get high.

Results and Discussion

The results that were searched were to test for mosquitoes which contain the West Nile virus around dairy farms. West Nile is most prevalent during the summer months and only tested for during the months of June through October. The results indicated in June, no West Nile was found, but as the summer progressed there was an increase. The virus was found on all five of the dairies as well as in residential areas. The Delta Vector Control District receives the results in about a day or two after the mosquitoes are sent to UC Davis for testing. The District has recently been privileged to build a facility or laboratory on the premises which will allow for the testing for West Nile virus (Figure 10). The building will be a biosafety level 3 (BSL-3) laboratory which will allow

microbial testing along with testing for infectious diseases. There are different levels of laboratories that allow for different types of testing such as a BSL-2 lab used to test for insecticides. The BSL-3 lab will consist of four different rooms 1) BSL-3 lab 2) BSL-2 lab 3) insectary and 4) a main lab where the analysis of the mosquitoes will be completed. Both the BSL-2 and BSL-3 rooms are negative pressure rooms, but are not connected to prevent cross contamination. Having the ability to test for a vector-borne disease will allow for faster and more in depth results at the facility. Based on the results found, there is no correlation between the amount of mosquitoes and positive cases for West Nile. There can be one single mosquito positive for West Nile and in turn can affect the entire pool being tested.

Figure 10. Biosafety Level 3 Laboratory construction (personal photo).

The placement and temperature of where the traps are placed are very important for proper surveillance. If the temperature was high and the trap was not under any type of shade the dry ice for the CO_2 trap would dissolve and the infusion for the gravid trap

would evaporate. During the day the mosquitoes try to get away from the heat and will find themselves flying towards more shaded areas. The locations for shade on a dairy are very limited making surveying for mosquitoes difficult. Being that there is much more shade at some of the dairies the district came to the conclusion that this could be a reason for the higher numbers. Another possibility for higher mosquito numbers could be the effectiveness of the infusion for the gravid trap. The infusion usually goes inactive in about two weeks where it doesn't attract the mosquitoes with the scent any longer making the trap ineffective (Allan et. al., 2005). The district found out that the containers in which the infusion was in began building algae that could have been affecting the infusion as well.

The total number of mosquitoes on the Jacobus Degroot Dairy was 120 for all the surveillance dates throughout the five times visited over the summer, were 60 mosquitoes were collected in the CO_2 trap (Figure 11.1) and 60 mosquitoes were found using the gravid traps (Figure 11.2). The Milk River Dairy was found to contain 284 mosquitoes during testing and 247 mosquitoes were found using the CO_2 during traps (Figure 12.1) and 37 mosquitoes were found with gravid traps (Figure 12.2). B&D Dairy was the following dairy that was visited which contained 219 mosquitoes with 165 mosquitoes being accumulated from the CO_2 trap (Figure 13.1) and the gravid collected 54 mosquitoes (Figure 13.2). Faria and Son's Dairy had 209 total mosquitoes and gathered 173 from the CO_2 trap (Figure 14.1) and using the gravid which trapped 36 mosquitoes (Figure 14.2). Palm Dairy was the final dairy visited only four times and contained 84 mosquitoes having 53 being trapped from the CO_2 (Figure 15.1) and 31 mosquitoes accumulated using the gravid traps (Figure 15.2). The results of the mosquito numbers

were indicative to finding were the West Nile was originating; however the problem grew at a rate that was tough to keep up with. The breeding sources were vast and sometimes very hard to find if they were too diminutive to see, and having the variability that the mosquitoes as well as many of its hosts can fly place to place. The number of mosquitoes in the CO_2 traps are much higher than the gravid traps because the CO_2 trap attracts mosquitoes looking for a blood-meal and the gravid attracts those mosquitoes that already posses a blood-meal. The Culex quinquefasciatus mosquito is the most prevalent at all the dairies which is closely related to the residential areas as well.

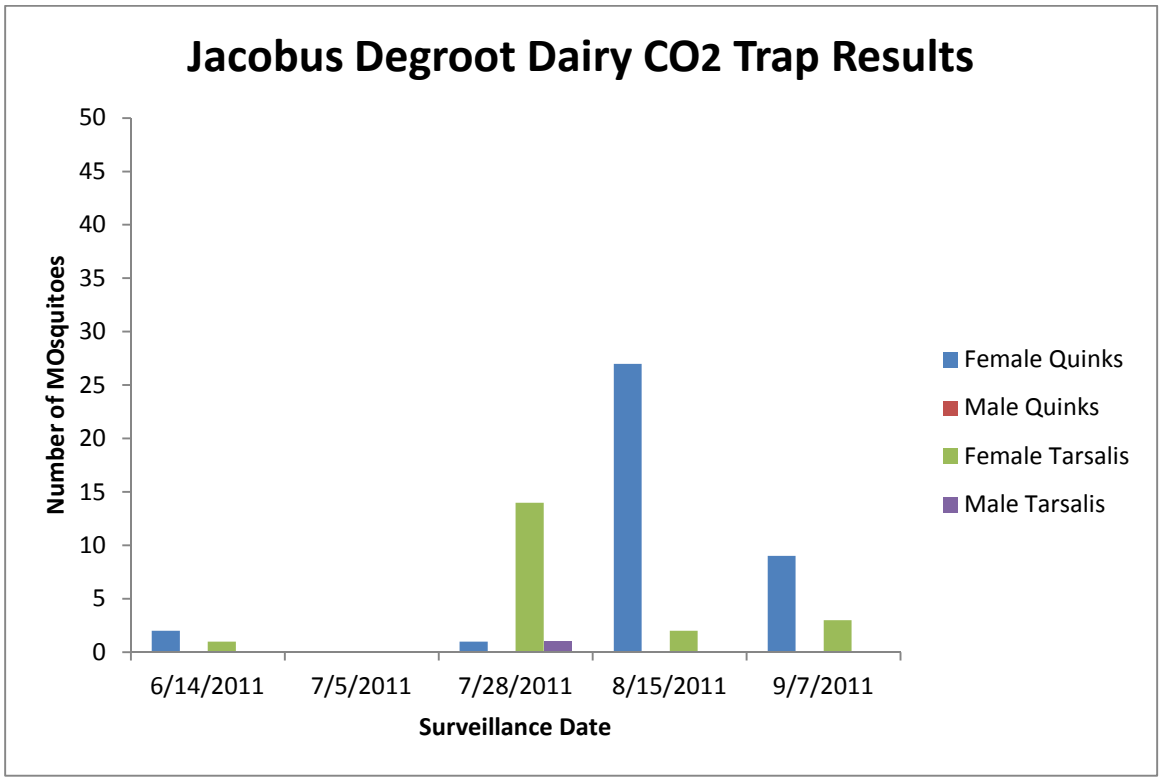

Figure 11.1. Jacobus Degroot Dairy CO_2 Trap Results.

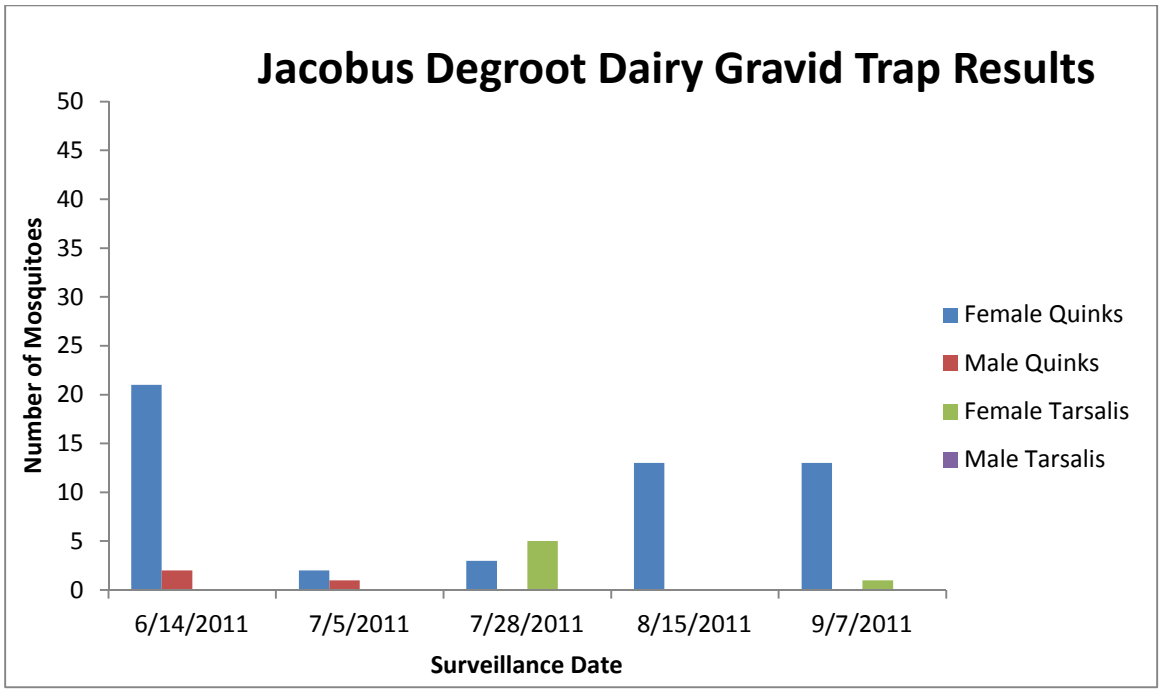

Figure 11.2. Jacobus Degroot Dairy Gravid Trap Results.

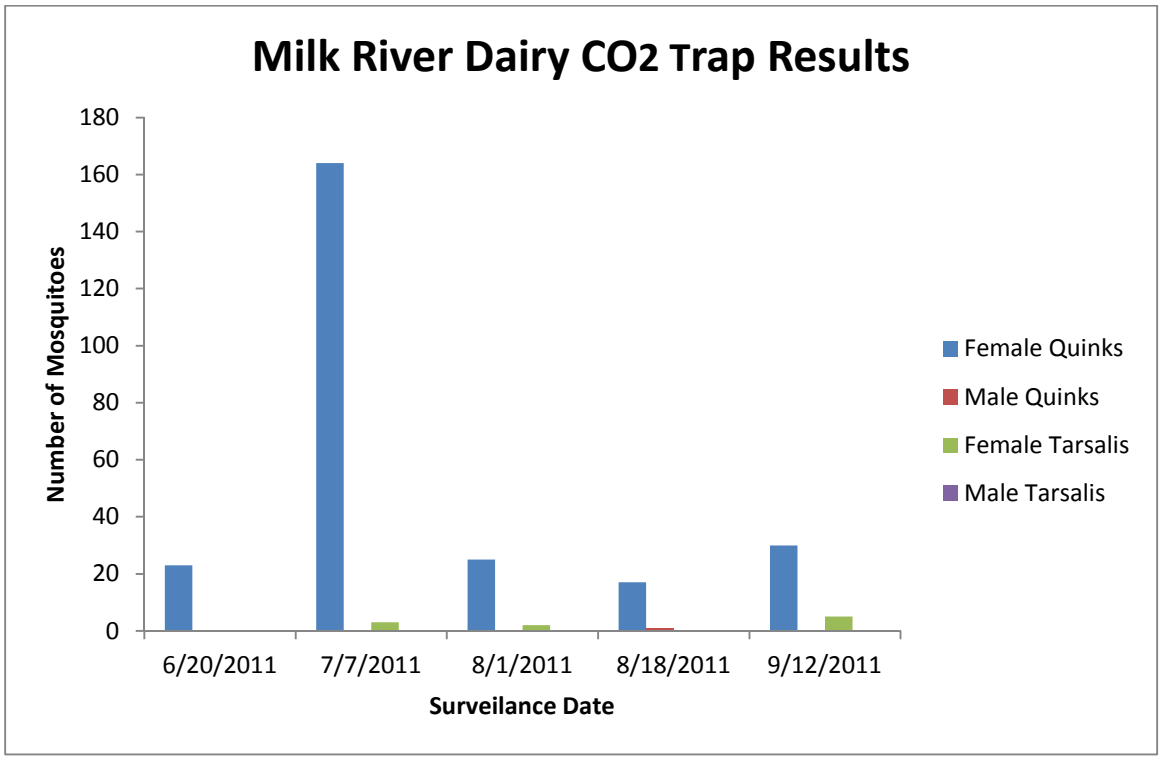

Figure 12.1. Milk River Dairy CO_2 Trap Results.

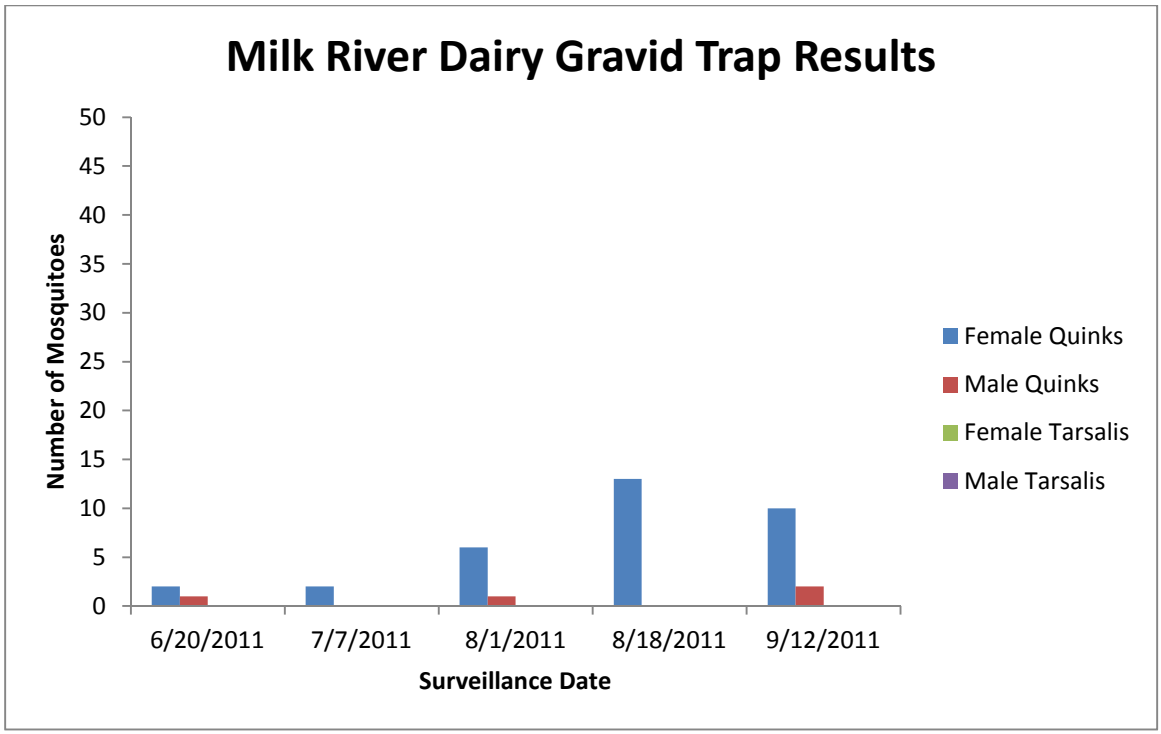

Figure 12.2. Milk River Dairy Gravid Trap Results.

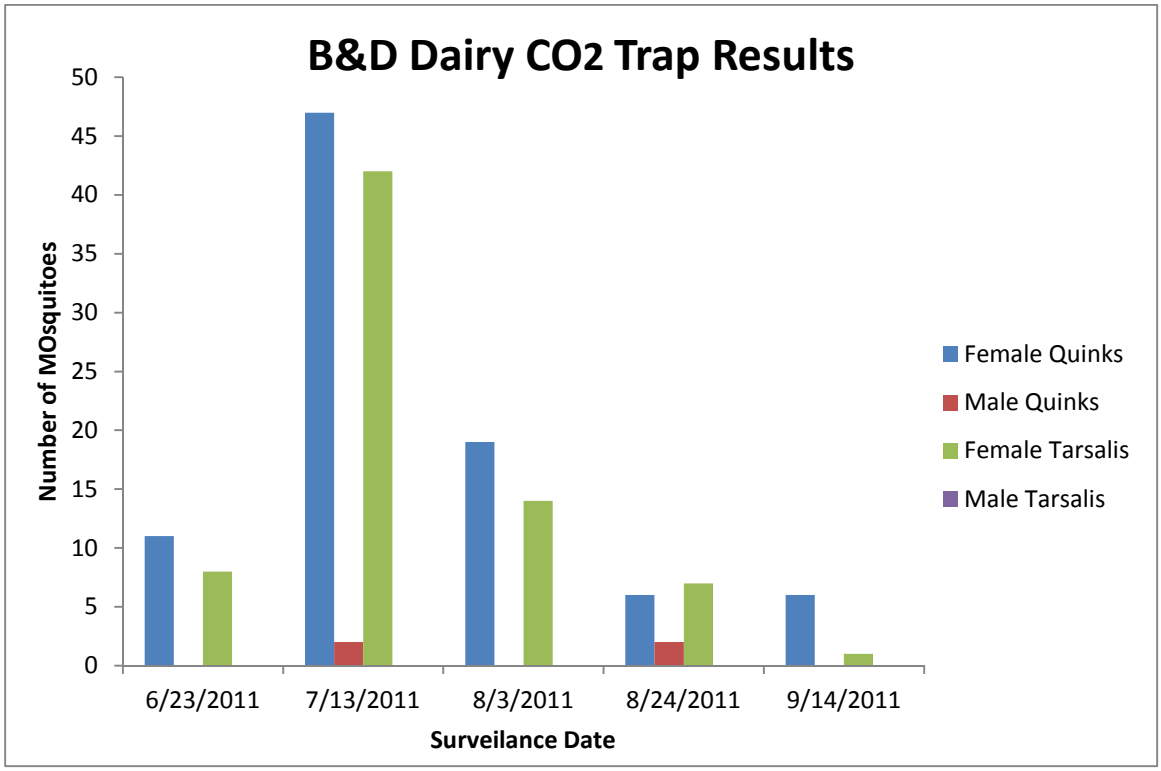

Figure 13.1. B&D Dairy CO_2 Trap Results.

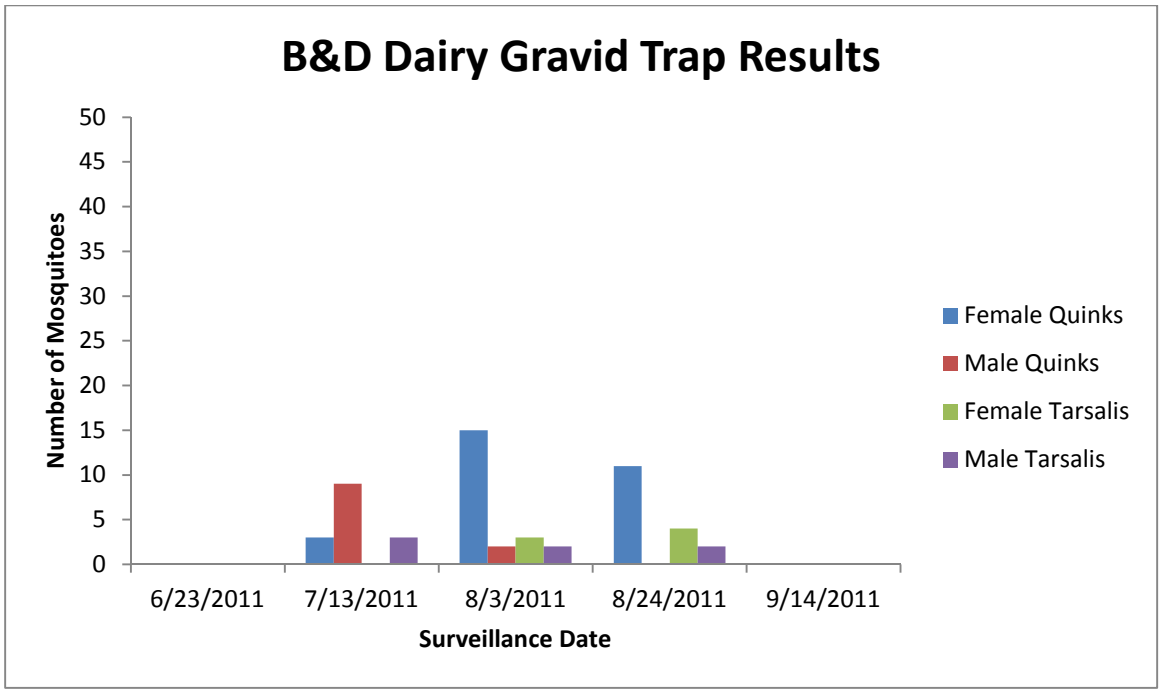

Figure 13.2. B&D Dairy Gravid Trap Results.

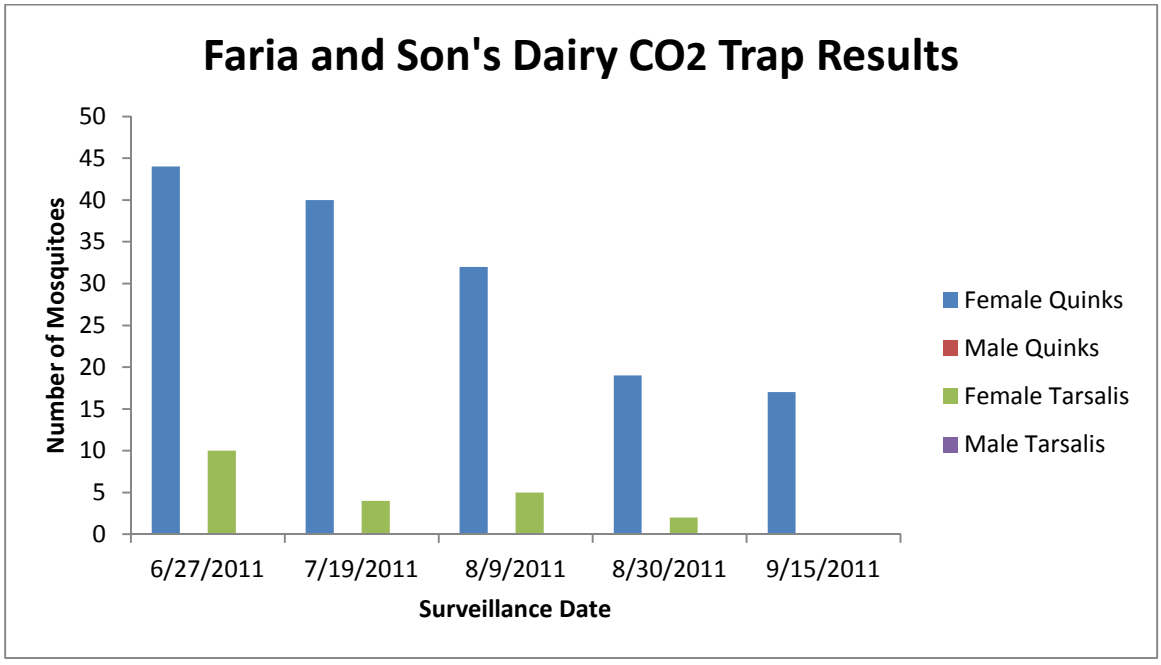

Figure 14.1. Faria and Son's Dairy CO_2 Trap Results.

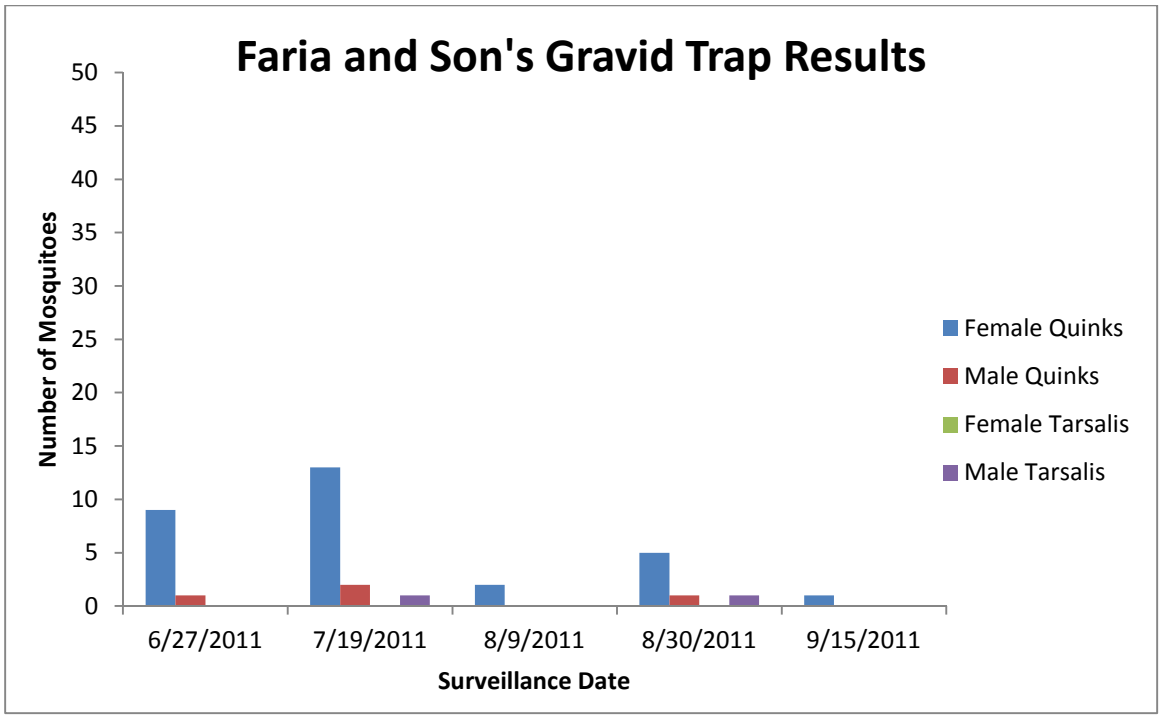

Figure 14.2. Faria and Son's Gravid Trap Results.

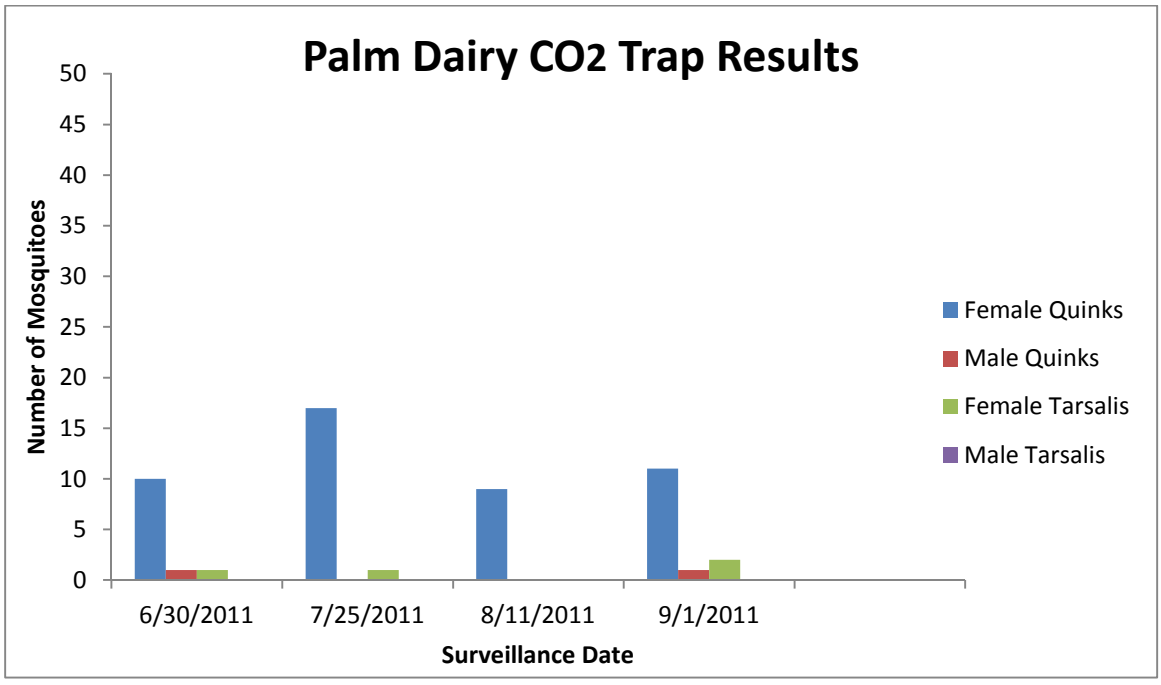

Figure 15.1. Palm Dairy CO_2 Trap Results.

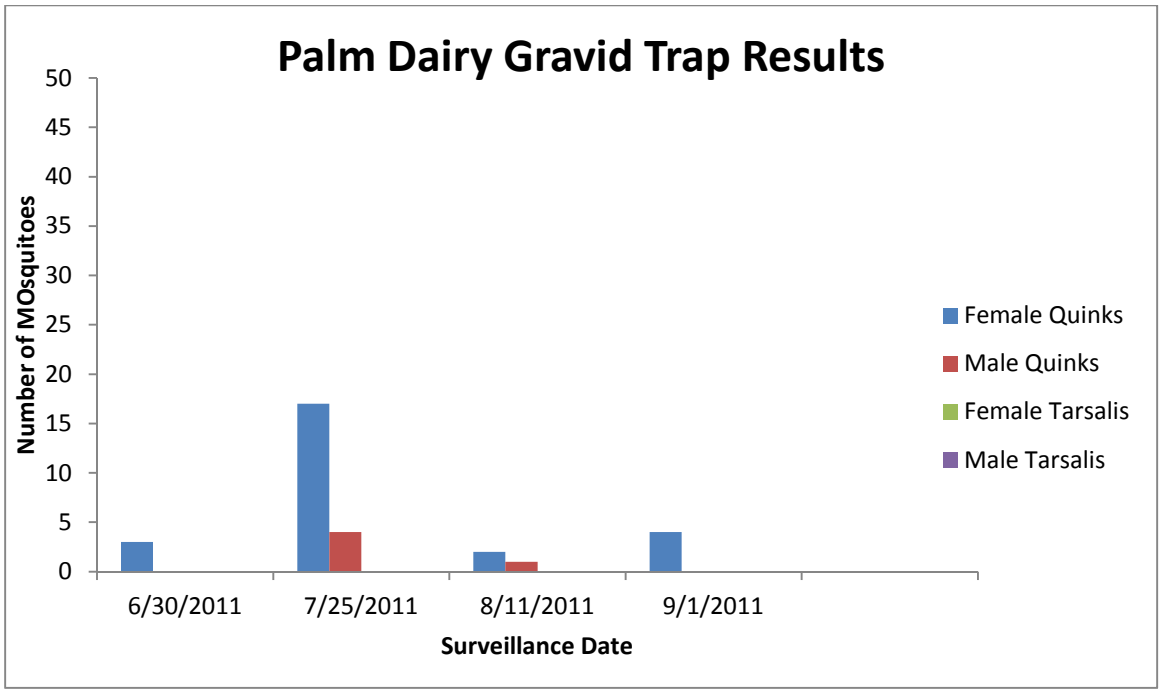

Figure 15.2. Palm Dairy Gravid Trap Results.

The results show that there was a mosquito breeding problem surrounding multiple dairies as well as a vector-borne disease at each of the dairies. The dairy containing the most mosquito numbers was Milk River Dairy with a total of 284 mosquitoes. This number is not reflective to the amount of positive mosquitoes for West Nile virus as only fifty mosquitoes are put into a pool for proper testing. There could be one mosquito in the pool that could make the entire sample become positive for disease.

The CO_2 trap will generally trap additional mosquitoes because there are more mosquitoes searching for blood hosts rather than individuals that already contain a blood-meal. Having the numbers higher in the CO_2 trap is the better of two evils in that many blood host have not been bit, however the mosquitoes are looking for meals making it more susceptible to being bit and potentially receiving a vector-borne disease. Reducing the numbers of mosquitoes transporting a blood-meal is ideal in cutting back the possibility for disease. Usually spikes in mosquito numbers indicate a new breeding

source were the technicians will go out and look for sources that need attention around the surrounding area. The gravid traps are much lower in mosquito numbers because many mosquitoes are having trouble finding blood sources. Being that there are few mosquitoes in the gravid traps indicates that the technicians at Delta Vector Control District have a good understanding of when to apply pesticide and are finding breeding sources. The traps are both designed to attract the female mosquito which is why there is not nearly the amount of male mosquitoes as there are flying around elsewhere. The male mosquito will follow the female mosquito around; therefore on occasion will result in finding the male in the trap. There are many more mosquitoes of the species quinquefasciatus due to the amounts of breeding sources that are rich in organic matter and fewer tarsalis because the breeding sources are not as enriched with fresh water. Mosquitoes have been on the planet for millions of years and trying to get rid of all the mosquitoes is something that is just not feasible, for this reason that is why there are mosquitoes captured each and every day. There will always be mosquitoes captured unless something has malfunctioned with the traps such as the battery power being low or some other reason that intrudes with the trap.

After careful observation recognizing that the weather and days of higher wind speed were all factors that need to be accounted for when expecting surveying results. Noticing that on days when the weather was very humid the mosquito numbers tended to increase possibly due to higher respiration from animals, but the study was not done with this recorded data. A mosquito can travel very far to reach its host to obtain a blood-meal and on days of high wind speeds a mosquito can travel up to a few miles (Miller, 2005). The dairies that were observed were from the West, North, and East sides of Visalia

(Figure 16). The Jacobus Degroot Dairy was located right behind an industrial plant where there was limited shade throughout the day making it less appealing for the mosquito to want to fly next to the traps (Figure 17). Having the traps where they were located was not as appropriate as we would have liked, but we still received results that were similar to others that were shaded. Milk River Dairy was probably the most ideal spot to place a trap as it was right next to an orange orchard with massive amounts of shade for mosquitoes to hibernate during the day (Figure 18). Citrus trees seem to be the best place to attract mosquitoes due to the shade they provide as well as the water that runs throughout the furrows. The other dairies have very little foliage for shade to provide to the mosquitoes and are not as far away from the city as the Milk River Dairy. B&D Dairy was along a very small river that is surrounded by large oak trees which provide large amounts of shade for the mosquito to rest, but the mosquito tends to be attracted to areas that are enclosed with shade (Figure 19). Faria and Son's Dairy was the dairy that was very close to residential areas as well as Jacobus Degroot Dairy, but Faria and Son's was located next to an olive orchard making it easy for mosquitoes to relax during the day (Figure 20). There was also a ditch that ran very close to the dairy making all the elements in which the mosquito needs to survive and flourish. Palm Dairy is located east of Visalia next to a park with trees positioned throughout with a ditch that runs by the dairy as well (Figure 21). The dairy on the other hand does not necessarily have a lot of foliage to allow for mosquitoes to take cover. Although many of the dairies didn't have sufficient amounts of shade to provide for the mosquitoes, the traps that had limited shade were relatively consistent with the traps that supplied shade.

Shade plays a major responsibility for mosquito surveillance as well as other factors such as weather, when pesticides are applied and how much. The wind speed plays a huge role in how far a mosquito can travel making it easier for mosquitoes to journey to their host (Schreiber et.al., 1987). The study completed had not taken into account the weather and wind speeds which can make days of surveillance much higher than others. If further studies were to be done recommendations would include the highs and lows for temperature to see what the ideal temperature would be for trapping mosquitoes. The limitations of not knowing what collecting days were very hot can potentially diminish or increase the amount of mosquitoes. To go beyond tracking temperature other studies should include the time of day when pesticides were applied as well as the amount of pesticide. Using the techniques utilized as well as several suggestions it would provide a much improved possibility for tracking the first sign of disease.

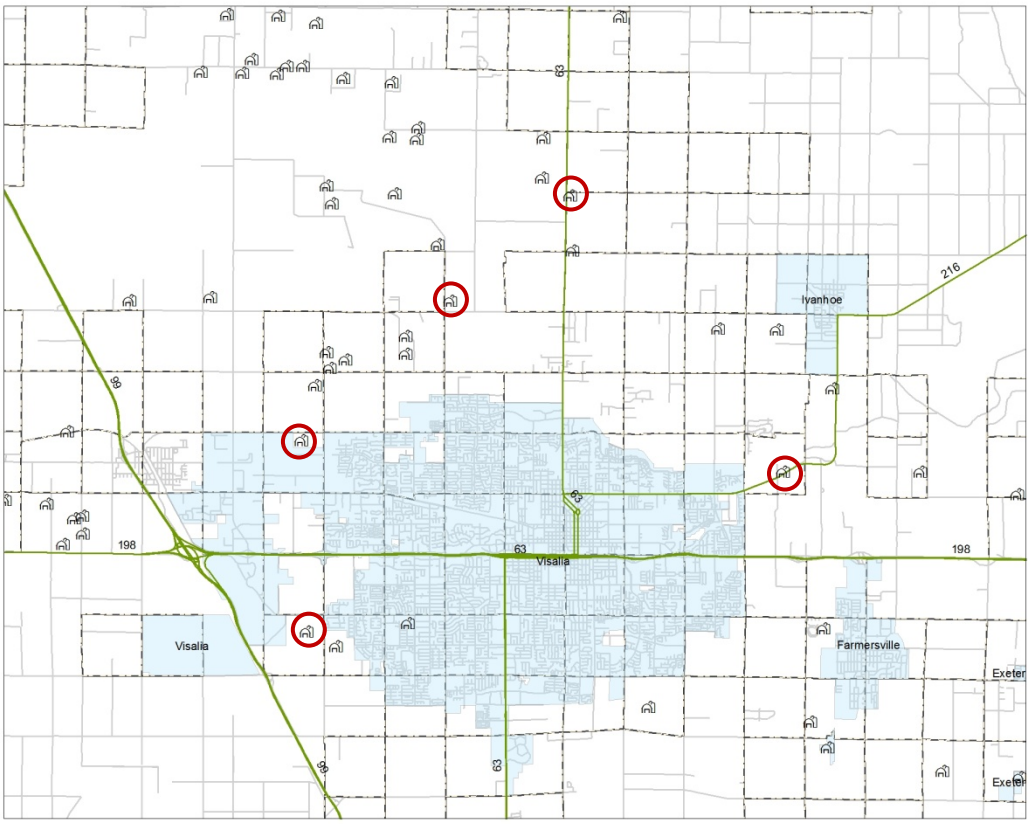

Figure 16. Five Dairies Surveyed (Trap locations throughout Central Valley).

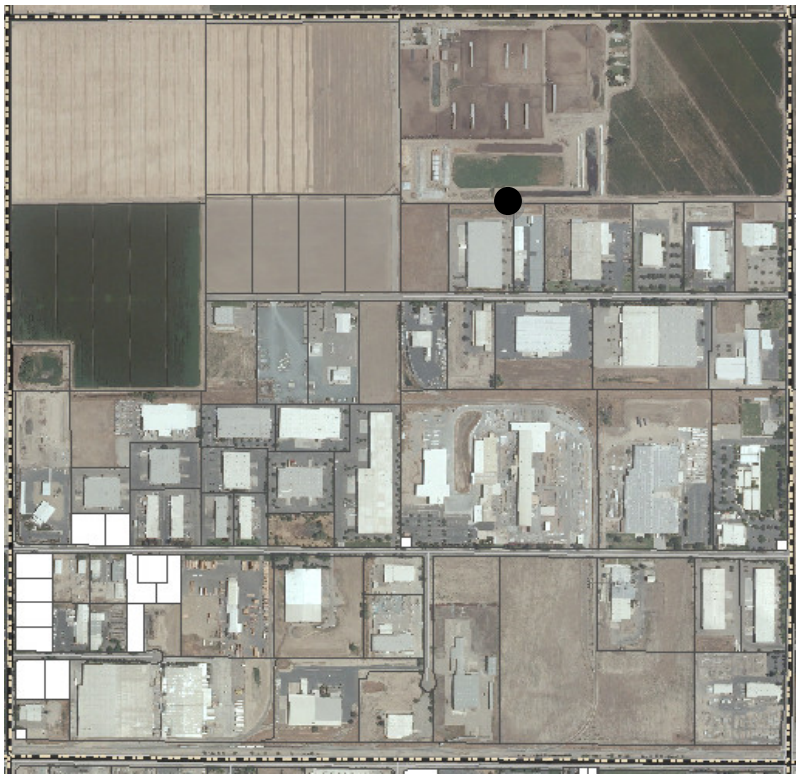

Figure 17. Jacobus Degroot Dairy Trap Location (Black Dot shows trap location).

Figure 18. Milk River Dairy Trap Location.

Figure 19. B&D Dairy Trap Location.

Figure 20. Faria and Son's Dairy Trap Location.

Figure 21. Palm Dairy Trap Location.

In conclusion, surveying mosquitoes gave the opportunity to analyze whether the treatments being applied were effective or if the mosquitoes were becoming resistant to the pesticide. Having only five dairies to trap mosquitoes made it much easier to collect data and to analyze the species and test for disease. The data collected was very helpful in attempt to reduce breeding sites because spikes in mosquito numbers indicated a breeding source near the trap location. It is inevitable to get completely rid of mosquitoes but if one can carefully work in attempt to reduce numbers of mosquitoes to decrease the amount of disease being spread. In the end, the five traps were very similar with the number of mosquitoes trapped on different test dates without further analysis such as weather conditions and measuring pesticide amounts.

References

Allan, S. A., Bernier, U. R., and Klien, D. L. (2005). Evaluation of oviposition substrates and organic infusions on collection of Culex in Florida. *Journal of the American Mosquito Control Association.*, *212*(3), 268-273.

Apperson, C. S. (2002). Host-feeding habits of Culex and other mosquitoes (Dipera:Culicidae) in the Borough of Queens in New York, with characters and techniques for identification of Culex mosquitoes. *Journal of medical entomology.*, *39*(5), 777-.

Cooperband, M. F., and Carde, R. T. (2006). Comparison of plume structures of carbon dioxide emitted from different mosquito traps. Comparison of plume structures of carbon dioxide emitted from different mosquito traps. *Medical and veterinary entomology.*, *20*(1), 1-10.

Gathany, J., (2006). Center for Disease Control and Prevention. Identification Number 9261 [Photo]. Gathany, J., (2003). Center for Disease Control and Prevention. Identification Number 4048 [Photo]. Retrieved on http://phil.cdc.gov/phil/details.asp.

Kaufman, P. E., Harrington, L. C., Waldron, J. K., and Rutz, D. A. (2005). The importance of agricultural tire habitats for mosquitoes of public health importance in New York State. *Journal of the American Mosquito Control Association.*, *21*(2), 17-176.

Kline, D. L., Patnaude, M., and Barnard, D. R. (2006). Efficacy of Four Trap Types for Detecting and Monitoring Culex spp. in North Central Florida. *Journal of medical entomology* , *43*(6), 1121-.

Locua, V., Fillinger, U., Lindsay, S. W., Majambere, S., Lucas, M. C., and Green, C. (2009). Role of Fish as Predators of Mosquito Larvae on the Floodplain of the Gambia River. *Journal of medical entomology.*, *46*(3), 546-556.

Mendoza, F., Cabrero-Sanundo, F. J., and Ibanez-Bernal, S. (2008). A standardized sampling method to estimate mosquito richness and abundance for research and public health surveillance programs. *Bulletin of entomology research.*, *98*(4), 323-332.

Minar, J., and Lamatova, Z. (1979). Losses in milk qualities of dairy cattle caused by mosquitoes and horseflies and reduction of such losses due to use of diethyltoluamide repellent. *Folia parasitological.*, *26*(3), 285-.

Partin, B., and Stewart, J., (1981). Centers for Disease Control and Prevention. Identification Number 3814 [Photo]. Retrieved on http://phil.cdc.gov/phil/details.asp.

Reinert, J. F. (2010). List of mosquitoes (Diptera: Culicidae) with published illustrations and/or descriptions of first-instar larvae. *European mosquito bulletin.*, *28*, 194-207.

Reisen, W. K., Meyer, R. P., Milby, M. M., Pfuntner, A. R., and Webb, J. P. (1989). Mark-release-recapture studies on culicine mosquitoes in southern California during 1988. *Proceedings and papers of the annual conference of the California Mosquito and Vector Control Association.*, *57*, 67-.

Schreiber, E. T., Mulla, M. S., and Chaney, J. D. (1987). Population trends of adult mosquitoes on southern California dairies. *Mosquito control research, annual report.*, 52-53.

Sharon, P. L., and Lanzaro, G. C. (2005). Managing Mosquitoes on the Farm. *Section 10: Dairy Operations.*, Retrieved from http://anrcatalog.ucdavis.edu/pdf/8158.pdf.

Smith, C. M., and Shisler, J. K. (1981). An assessment of storm water drainage facilities as sources of mosquito breeding. *Mosquito news.*, *41*(2), 226-230.

Tucker, J. C., and Emmel, T. C. (1991). Detailed Record Mosquito control pesticides: ecological impacts and management alternatives: proceedings of a Conference held on January 18, 1991 at the University of Florida, Gainesville, Florida. *Conference on Mosquito Control Pesticides: Ecological Impacts and Management Alternatives.*, *28*, 108. Retrieved from http://web.ebscohost.com.

White, S. L., Cyr, T., and Bueno, R. J. (2009). A Comparison of Gravid and Under-House CO2-Baited CDC Light Traps for Mosquito Species of Public Health Importance in Houston, Texas. *Journal of medical entomology.*, *46*(6), 1494-1497.