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Mosquito Abatement Monitoring: West Nile in Los Angeles County

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## Abstract

West Nile virus (WNV) has become established across the U.S. with heightened activity causing significant human illness. Monitoring methods to predict the risk of human infection are urgently need to initiate timely preventative measures and justify the expense of implementing costly or unpopular control measures, such as aerial spraying or curfews. This research outlines several ways to further improve the productive power of monitoring mosquitoes. These results demonstrate that mosquito monitoring provides a valuable public health tool for assessing the risk of human arboviral infections, allocating limited public health resources, and justifying emergency control actions.

A key challenge has been identifying a monitoring method that would signal impending human infection and be reliable enough to be used to justify expensive control efforts. The results show that standardized mosquito monitoring provides strong predictive power to signal human WNV infection up to several weeks in advance and is a valuable tool for public health officials. Given the 2012 WNV epidemics, the most promising find is that high values of the risk index have extremely high negative predictive value and strong positive predictive value. This suggests that waiting to take costly actions to control WNV when vector risk indices are low will nearly always be prudent, and taking costly actions to control WNV when risk indices are high is strongly warranted. It is worth noting that determining “high” and “low” values of vector indices required analyses of data from the area where control actions are being considered.

The results provide guidance on the most effective way to estimate the prevalence of vector infection by using mosquito trapping and testing data, which can be challenging for arboviral monitoring because of the very low prevalence frequently observed. If local trapping efforts yielded too few mosquitoes to accurately estimate prevalence, then the vector index should be calculated by using prevalence estimates for each mosquito species from regional or statewide trapping efforts for that week. In contrast, if trapping efforts over a 2-week period within a single county produce sufficient numbers of mosquito pools to adequately estimate WNV infection prevalence, then a vector index using a 2-week estimate of prevalence can be used to predict human infection up to 3 weeks later.

The results suggest that, the link between WNV entomological risk and human risk is strong enough that predictive relationships are not obscured by unmeasured variation in these other factors. They also suggest that even a single set of mosquito traps placed in each county can provide useful information for allocating disease control efforts. The findings indicate that active entomological surveillance provides a robust and valuable method to determine the risks of human infection with arboviruses like WNV. Resources to support these efforts and the trained personnel required to carry them out should be reduced by budget tightening. To do so in an era of environmental change and rapid international movement of vector-borne pathogens could be perilous.

The goals or objectives of the project is to provide an overview of mosquito monitoring, how it works, the different types of trapping that can be used, its effectiveness on eradicating

WNV, and the application of insecticides. The application involves a tedious and well documented way on how these pesticides are used. The project also outlines how community agencies, residents, and county officials work together to resolve the issue of WNV.

Although West Nile in Los Angeles County has decreased in recent years, there is still substantial work that needs to be completed. This includes improvements in Mosquito Control Measures, documenting and filing reports, and using fewer insecticides and more natural methods of controlling mosquito populations.

### Mosquito Abatement Monitoring: West Nile in Los Angeles County

The purpose of providing monitoring is to locate the transmission of the disease, to contain it, and to provide assistance to communities in combating the outbreak. Its main objective is to eradicate the virus and prevent new cases by educating the public. Surveys should be conducted in many languages but primarily in English and Spanish since it is the second most popular language in L.A. County. Providing surveys in many languages aids immigrants in being informed of West Nile and in making wise decisions or choices that will prevent future outbreaks. Surveys also help the community by determining which treatment options are available, such as, spraying pesticides or using natural methods. Natural methods involve catching and releasing the predators or enemies of mosquitoes. This includes ladybird beetles, dragonflies, and mosquito-eating fish.

Vector Disease Control International or VDCI is proposing a mosquito control program that provides for a fixed service offering that includes Mosquito Monitoring and Surveillance as a base program. Additional services that can be added are larval management and adult mosquito control. Mosquito Monitoring and Surveillance and Larval Management are best priced on a fixed price for the full season. If the city decides to employ adult mosquito control spraying, it proposes that service be priced on a per mile sprayed basis as those series are performed.

The California Department of Health Services has set up a special tip line where residents can report dead birds in their areas. The department also informs each neighborhood by distributing pamphlets on the warning signs of West Nile and how it is transmitted

The Compton Creek Mosquito Abatement District is an independent special district committed to protecting the public's health, safety and welfare from mosquito-borne diseases. In 1927, the residents of the City of Compton, realizing that mosquitoes were having an adverse effect on their lives, elected to form the District and alleviate the problems with mosquitoes. Now covering 12.5 square miles and protecting close to 125,000 citizens, the District is funded through tax dollars and provides free services for mosquitoes and all of the other related items involved in mosquito control.

By educating the public about the need to act before this problem worsens, the District plays a vital role as a source for the latest information about treatment options, it offers practical and accessible materials to give residents the guidance they want and the peace of mind they have a right to enjoy.

Since the beginning of time, mosquitoes and the life destroying diseases that they transmit have bewildered and provided much consternation for man. It wasn't until about 200 years ago that the causes of the deaths of so many people were connected to mosquitoes and to provide a history of the Compton Creek Mosquito Abatement District, one must look at this

discovery and the relation to the District to fully understand the history of the District and its objectives. It was in the late 1800's that Dr. Walter Reed and associates identified mosquitoes as the vector of malaria and yellow fever. The discovery was not only important to the workers of the canal, but to Californians as well because some of them had contracted malaria. Not only were mosquito a nuisance, they carried diseases as well.

In California, mosquito abatement activities in the early 1900's were focused on controlling the mosquito that carries malaria and reducing the number of nuisance salt marsh mosquitoes. Before 1915, mosquito control in the state was financed by subscription and donation. In 1915, a bill was passed through the legislature and signed by the governor that provided for the formation, organization and financing of mosquito abatement districts. This bill is known as the Mosquito Abatement Act.

In January 1927, flood waters coming from the Compton sloughs, the Compton Creek Flood Control Channel was then called, inundated large sections of Compton, particularly on the west side of town and the area resembled a lake.

After the spring floods subsided, mosquitoes in huge numbers appeared and the people couldn't enjoy the evenings. Citizens demanded relief and plans for the Mosquito Control District developed. On June 21, 1927, the Compton City Council adopted a resolution asking the County Board of Supervisors to include Compton within the proposed District.



The District's first Trustees were Mr. Ernest Spurlock, a prominent insurance agent who was appointed by the City of Compton and A.H. Cox who represented the City of Long Beach. Mr. Jim McDonald was the main driving force to create this District and the two Trustees named him the District Superintendent. The first location of the District was located at the home of Mr. McDonald.

The passing of Mr. McDonald in 1957 was a turning point into acquiring a permanent site for the District's Headquarters; another was that the old site was on the proposed site of the Artesia Freeway. In 1957 Mr. Wayne Wallace was named Superintendent of the District to fill the vacancy left by Mr. McDonald.

In 1958, County Counsel rules that the Board would have to be increased to five members. One of the members appointed was Mr. Torval Hanes, a longtime resident of Compton. Mr. Hansen was a Trustee until his resignation in October 1961, when the Board named him Superintendent of the District upon the passing of Mr. Wallace in October 1961.

In 1961, the District moved to the property in which it currently resides to this day. Seeing how mosquito control was evolving and expanding, the Board elected to remove the existing building and replace it with the building that currently exists today. Mr. Hansen served as District Manager of 10 years until his passing in May 1971, when Mr. Gabriel Alvarado, who was the District's Inspector-Operator, was asked to also perform the daily functions of the District Manager. Mr. Alvarado was named District Manager in 1974.

Many new technologies for mosquito control were being formulated and utilized during this time. Mr. Alvarado was able to incorporate many of these new techniques, pesticides and methods into the District's mosquito control program, keeping it current with the items and by using new safer pesticides that were not harmful to the environment or to any other animal or insect found in the state. In 1988, Mr. Alvarado retired and the District's Inspector-Operator, Mr. Mitchel Weinbaum, was asked by the Board to perform the daily functions of the District Manager. In 1989, Mr. Weinbaum was named District Manager and he currently holds this position.

### **Prevention of West Nile**

Mosquitoes typically bite when the sun sets. It is recommended to wear long pants and long sleeved shirts. Also, use insect repellent with DEET in it. Place the repellent on the skin that is not covered by clothes. The DEET in the insect repellent keeps mosquitoes from biting. Mosquitoes lay their eggs and grow in standing water. It only takes 7 days for a mosquito egg to hatch and become an adult mosquito. Remove standing water and empty water out of buckets and old tires including flower pots and toys. Change water every few days from pet bowls and bird baths. Install reliable and sufficient screens on windows and doors. Screens will prevent mosquitoes from coming in.

West Nile virus is now found throughout California. Dead birds are a sign that West Nile virus is in the area. Birds like crows, ravens, and jays get very sick and can die from the

West Nile virus. The public cannot contract West Nile virus from touching a dead bird. To monitor the spread of the virus, the State is tracking dead birds. People should worry about West Nile virus because it can lead to death. The symptoms occur 3-15 days after a mosquito bite. People who feel sick may feel like they have the flu. They may have: fever, headache, body aches, and rash. Some people who contract West Nile virus become very ill and die. Most people who have gotten really sick have been about 50 or older, but everyone needs to be aware of mosquitoes, and keep them away.

### **Mosquito Monitoring and Surveillance**

This primarily includes identifying set locations the city as trap sites that are set and collected by VDCI on a weekly basis. These samples are collected by field personnel, sorted by species, sent to the labor for disease testing, analyzed by a staff entomologist, and results delivered to the city as soon as possible.

These results provide a trend of data to understand the mosquito populations throughout the season, determine disease risks, and to provide information regarding proper control methods. Typically mosquito borne disease will appear in mosquito pools in advance of human cases of disease. It is this proactive monitoring and subsequent control that can reduce and prevent human outbreaks of disease.

### **Larval Management Program**

Larval Management is the process of first identifying breeding locations throughout the city. Once breeding areas are known, those areas are mapped and then visited regularly to inspect for the presence of mosquito larvae. When larvae are present, each area is treated to control the mosquito populations before they hatch. The proposed program includes a larval management crew one day a week for the whole mosquito control season. Additional crews can be added as requested by the city.

### **Adult Mosquito Control**

Adult Mosquito Control can take many forms which are detailed in the following sections. Should the city decide to employ adult mosquito control it will recommend truck-based Ultralow Volume Spraying ULV. This method employs safely using EP registered products that can control mosquitoes during their peak activity periods. Pesticides are mixed and spray equipment is calibrated so the proper application rates are applied. The technology includes variable flow control, driver assisted navigation, full treatment recording, and GIS location for post treatment review and reporting.

### **Overview of Mosquito Monitoring and Surveillance**

The cornerstone of any successful mosquito control operation is its surveillance program. VDCI uses the most up-to-date and widely accepted surveillance tools available to the industry. Proper identification of mosquito species and knowledge of their bionomics focuses control efforts on the areas of concern. Many different surveillance tools can be used

to develop a clear picture of mosquito problems, including CDC light traps, gravid traps, landing rates, egg surveys, Ovi traps and dipper counts. VDCI's staff is experienced in all aspect of mosquito surveillance. Two of the appropriate surveillance methods will be used to develop a true picture of the current mosquito population dynamics with this information. An effective and efficient control plan will be implemented.

### **Adult Mosquito Surveillance**

Surveillance of adult mosquitoes should include several methods of collection to sample for nocturnal, diurnal, and crepuscular species. Adult mosquito surveillance helps to elucidate the mosquito distribution density and species composition throughout the control area. Furthermore, it can provide direct evidence of an increased risk of contracting mosquito-borne viruses. Two mosquito species found in an area are not attracted to the same trap type; therefore, the following combination of methods can be employed.

CDC Centers for Disease Control Miniature Light Traps are lightweight portable battery operated traps that are used to assess local adult mosquito population abundance. These traps are baited with dry ice, a source of Co<sub>2</sub>, to increase their appeal to host-seeking mosquitoes. CDC light traps are set bi-weekly throughout the contract period. CDC light traps will be the primary trap used unless it is determined that another trap type would yield more useful data.

Gravid traps are lightweight portable battery operated traps that use putrid water as an attractant for ovipositing mosquitoes. They are ideal for collecting *Culex* mosquitoes that oviposit in these habitats. Gravid traps will be set on an as needed basis.

Landing rates are performed by field staff and are instrumental in determining which species of mosquitoes are actively feeding on humans in an area. Inspectors may establish areas where they can expose themselves as bait and count the number of mosquitoes landing on them in a given time usually one to ten minutes. These counts will be conducted as needed am or pm.

### **Disease Monitoring**

The goal of VDCI's mosquito-borne disease surveillance program is to detect mosquito-borne viruses in local mosquito populations before sufficient amplification of a virus can occur. After a virus is detected, management practices can be discussed and implemented, thereby, reducing the number of infected mosquitoes and simultaneously reducing the risk of human transmission.

### **Response to Mosquito-borne Diseases**

Contact with local health agencies are maintained during the mosquito control season. Reports regarding the presence or infectious mosquito-borne diseases are made available to those agencies. Regular contacts are maintained with state and federal health agencies in

order to project possible regional health concerns. Any finding of local significance is immediately reported to the proper City officials in addition to the required routine reporting.

VDCI works closely with all of the appropriate agencies to implement the best response to any finding of mosquito-borne diseases within the city. The presence of mosquito-borne pathogens within the city, results in one or more responses or interventions by VDC only after consultation and discussion with the appropriate officials.

### **Public Education**

Public relations and education are an important part of VDCI's community involvement. VDCI have programs suited for civic, church, and school groups as well as government organizations. Their mission is that an educated public is extremely important to the successful implementation of any mosquito control program and their presentations and workshops can be tailored to any topic of particular interest or need. Press release can be issued to inform the public of the progress of the mosquito control program during the mosquito control season.

A proactive larval surveillance and treatment program can often mitigate mosquito and disease risks before the mosquitoes hatch and become adults. Additionally, larval treatments can alleviate the need for adult mosquito control and use of costly truck spraying and pesticide use. VDCI uses its proprietary mapping and database system to track larval surveillance and treatments to ensure maximum efficiency of treatments and optimal treatment timing.

The first step in larval surveillance is to survey the municipality and identify breeding areas. These areas are entered into a mapping database and given unique identification numbers. This takes significant time and effort on the part of VDCI, but it helps to form the foundation of data and information for a proper larval treatment program.

Larval surveillance is one of the most important aspects of a mosquito control program. With continuous surveillance of larval habitats, mosquito populations, surges can be predicted and often abated through the well-timed application of larvicides. Additionally, knowledge of mosquito-breeding sites can increase adulticide efficacy because these areas can be selectively targeted before adult mosquitoes disperse to nearby areas. Larval habitats permanent water, temporary pools, drainage ditches, septic ditches, catch basin, artificial containers and tree holes are inspected regularly and mapped into a GIS database using GPS technology.

Permanent water sites consist of habitat that remains inundated for an extended period of time. Examples of these sites would be lakes, rivers, retention ponds, swamps, etc. Permanent water sites are inspected on a routine basis throughout the mosquito-breeding season. These areas are capable of producing large numbers of certain species of mosquitoes.

Temporary floodwater is standing water that may exist for short periods of time after high water or rainfall. Examples of this type of habitat would include bottom lands, woodland pools, low areas drainage ditches, tire ruts, and depressions. Large numbers of mosquitoes can



be produced in a short period of time from these sites. These areas must be inspected for the presence of larvae as soon as possible after every substantial rainfall.

Artificial containers tree holes are considered one of the most troublesome problems faced by a mosquito control operation. Artificial containers may occur in many places and produce mosquitoes in every back yard. Anything that holds water can produce artificial container species. Old tires, cans, bottles, buckets, cups, pet water bowls, birdbaths, gutters, and swimming pools are some of the more common artificial containers.

Septic water habitats occur when water holding areas become polluted with high levels of organic matter. Examples of this type of habitat would include oxidation ponds, ditches with sewage discharge or run off from decaying plant or animal life. Septic water can often produce the largest number of mosquitoes per unit of area. *Culex quinquefasciatus* is often the most common species found in this habitat, and is also a primary vector for West Nile virus in the United States. Routine management to this habitat type and the control of arbor-viral vectors will be vital to the public's health.

Catch basins occur throughout urban areas and are capable of breeding numerous mosquito species. Of primary concern in these habitats again is *Culex quinquefasciatus*, the primary vector of West Nile virus. Although all catch basins may hold water at some point in time, not all catch basins are sites of prolific mosquito breeding. Improper drainage, poor

design, and amount of rainfall can all contribute to the number of mosquitoes produced in catch basins. Catch basins are assessed for mosquito breeding where appropriate.

### **Solutions**

VDCI uses products approved by the Environmental Protection Agency, EPA, for the control of larval and adult mosquitoes. These safe, effective insecticides can be delivered by means of ground or aerial application equipment.

### **Source Reduction**

Large scale drainage projects are important in reducing mosquito habitat. Although VDCI does not attempt drainage projects, they do work closely with local agencies in identifying drainage problems. VDCI also conducts neighborhood source reduction campaigns. VDCI'S technicians can conduct house-to-house inspections, as needed, to reduce the production of urban mosquitoes. They will educate homeowners on ways to identify and remove mosquito production sources to control backyard productions, as well as, how to help themselves and their families by using personal protection such as repellent, proper clothing and window screens.

### **Biological Control of Larval Mosquitoes**

Biological control of mosquitoes ranged from naturally occurring organisms such as birds, bats, fish, dragonflies, copepods and mosquito larvae, to artificially introduced organisms

such as *Bacillus thuringiensis var israelensis Bti* and *Bacillus sphaericus*. Although few of the biological control agents occurring in nature are available to mosquito control specialists, the introduction and replenishment of *Gambusia affinis* the mosquito fish affords good control in pools, ponds, ditches, and drainage canals. The most widely used and environmentally sound biological agent is Bti. This larvicide became commercially available in 1978 and has become the larvicide of choice by VDCI. Bti is available in liquid, granular, and time-release formulations and poses little threat of resistance development. When mosquito larvae are detected in an area, they are preferentially controlled through the application of Bti. Dependent upon the conditions present, granular, liquid or time-release Bti formulations may be applied.

### **Chemical Control of Larval Mosquitoes**

Chemical control of larval mosquitoes is carried out when and where biological control is not feasible. Altosid, an insect growth regulator IGR, can be used in any mosquito-producing area where extended control is desired. These areas can be treated on a 30-150 day schedule once positive production is found. Control of mosquitoes found in tire piles and catch basins throughout the city can be treated 30-day intervals using Altosid. Any use of non-biological larvicides is closely monitored and mosquito species exposed are tested for any evidence of resistance. Chemical larvicides may be used in briquette, granular, and liquid forms depending upon treatment needs and habitat type.

Larviciding is conducted using a variety of equipment and methods as follows: Pack applicators and spreaders are used where vehicle access is unavailable. Tire piles, swales, retention ponds, backyards, etc. can be treated with this type of equipment. Power sprayers and spreaders are mounted on all terrain vehicles ATV or trucks. The holding tanks carry from 15 to 100 gallons of larvicide. These mechanisms can be used with all types of larvicide and in most habitat types, such as ditches, swales, septic ditches, etc. Parks, golf courses and ball fields can be treated quickly when surveillance indicates the presence of mosquito larvae.

Aerial applications, if necessary, can be accomplished using a single engine aircraft when areas too large for other application techniques are encountered. Pastures, orchards, swamps, and inaccessible backwater areas can be quickly and efficiently treated with the proper utilization of air power.

### **Overview of Adult Mosquito Control Services (Solutions)**

A fully integrated mosquito control program encompasses all aspects of adult surveillance, disease monitoring, larval surveillance, and larval treatments. In addition to those important foundations of a proper control program, a fully integrated approach includes control of adult mosquitoes.

Control of adult mosquitoes is performed whenever it is determined that mosquito populations or disease levels have reached unacceptable levels. Surveillance, source reduction, larviciding, and public education are used to reduce the quantity and application

frequency of adulticides that are needed. However, the end result of integrated mosquito management is often the application of pesticides. The pesticides used are always as safe and environmentally friendly as possible. Additionally, VDCI always takes care to avoid developing resistance to pesticides in local mosquito population. VDCI will apply only EPA registered public health pesticides labeled for mosquito control such as deltamethrin, bifenthrin, resmethrin, permethrin, and natural pyrethrin.

Pesticides are mixed and spray equipment is calibrated so the proper application rates are applied. All hand-held, ATV-mounted, truck-mounted and aerial adulticide equipment is calibrated and droplet sized MMD tests are conducted routinely to ensure the most efficient kill rates with each application.

ULV Spraying is a technique developed specifically for mosquito control that utilized aerosol sprayers, designed and calibrated, to produce droplets that fall within a specific size range, to apply to extremely low quantities of pesticide within the control area. VDCI used only the most advanced hand-held, ATV-mounted, truck-mounted, and aerial ULV application equipment. All four vehicles are equipped with GPS tracking units capable of delineating the spray routed of each vehicle. Detailed maps, graphically illustrating the application data, can be produced after each spray operation. VDCI's larvicide trucks have the capacity to serve as adulticide vehicles as needed. Hand-held and ATV-mounted ULV adulticide equipment may be used to supplement truck-mounted equipment. Smaller areas such as residences, camps, golf courses, parks, and special events can be treated with handheld equipment. VDCI's aerial

adulticide fleet is second to none. The twin engine, fixed wing aircraft are capable of applying any registered adulticide over congested areas as required by the FAA. Their experience and success in urban mosquito spraying with aircraft is unsurpassed in the industry. In the unlikely event aerial application adulticide is required, VDCI can quickly respond to any request by government agencies to do so.

### **Residual Carrier Applications**

VDCI uses only the safest, public health approved methods and pesticides whenever they make residual adulticide applications. Backpack applicators or hand-held sprayers are used to apply these long lasting adulticides to vegetation, exterior surfaces of buildings, or virtually anywhere else that adult mosquitoes rest. When the adult mosquitoes land on these treated surfaces, they absorb the pesticide and die. Barrier treatments are an important part of VDCI's integrated mosquito control programs, especially in areas with high potential for disease transmission to humans.

### **Service Requests and Citizen Complaints**

The public is encouraged to call the VDCI's local office, toll free, with service requests. All complaint calls are recorded and used to help identify mosquito problem areas. Service requests are used as a secondary indicator of where mosquito populations are high and causing human annoyance problems. These calls enable VDCI to pinpoint localized problem areas, to target larval and adult control operations, and to increase overall control effectiveness. In

each instance of a call, a technician is dispatched to the area within 24 hours and all appropriate actions, ranging from removal of tires and other debris, applying larvicide when larvae are present, or making targeted applications of adulticide, are undertaken.

### **Service Option Pricing**

Full season, fixed –price, pricing includes services from April 15<sup>th</sup>-October 15<sup>th</sup>. Services are billed equally over six months beginning in May. Per-service pricing, such as adult mosquito control, will be billed monthly as services are performed. For example, if the city chose to have 3 weekly traps sites and the Larval Management program, the total cost would be for the season.

### **Mosquito Monitoring and Surveillance**

- Weekly trapping of defined mosquito control zones
- Species identification of all mosquitos to determine disease risk and breeding trends
- Testing of all mosquito pools for West Nile Virus and EEE
- Weekly reporting of findings from VDCI biologists and entomologists
- Consulting from VDCI in regards to control measures and NPDES permitting
- Coordination with California State and Mosquito Control Board and Department of Health

Fixed Price for Season includes 3 weekly Mosquito Traps

Fixed Price for Season Additional Mosquito traps per trap

### **Larval Management Program**

- Coordinate all Federal State and Local permitting and approvals as needed
- Initial municipal-wide survey of all mosquito breeding grounds
- Regular inspections of mosquito breeding areas
- Breeding areas treated as needed and as possible with consultation from city
- Breeding areas treated with environmentally friendly products
- All treatment areas recorded, mapped, and reported back to customers
- Use of VDCI proprietary database to predict activity and generate reports

**Fixed Price for Season includes one weekly crew**

**Fixed Price for Season Additional Larval crew, per crew**

### **Adult Mosquito Control Services**

- Coordinate all Federal State and Local permitting and approvals as needed
- Equipment management and calibration as required by laws and VDCI protocol
- Coordination with relevant city agencies regarding public communication
- Conduct Ultra Low Volume ULV applications as needed and approved by city
- All treatment areas recorded, mapped, and reported back to customers
- Use of VDCI proprietary database to generate reports



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