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Edited by
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A PRIMARY SCHOOL-BASED CURRICULUM FOR THE CONTROL OF NUISANCE AND VECTOR MOSQUITOES IN THE CARIBBEAN – A PRELIMINARY REPORT

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Introduction

The Americas, with special reference to those areas considered tropical and sub-tropical have for centuries been known as a fertile area for a plethora of vector-borne diseases. Among these are yellow fever and dengue fever (DEN), known to exist in the Caribbean for at least 200 years (Zinzer 1967). During the middle of this century, dengue was a relatively unknown disease in the West Indies. This was due in part to a major effort on the part of the Pan American Health Organization and its Member States to eliminate the vector mosquito, *Aedes aegypti* from the hemisphere. By the late 1960's and early 1970's all but two countries had eradicated the species, leaving only the United States and Venezuela as remaining strongholds for eventual reinfestations. By the late 1970's and early 1980's, programs for the elimination of the dengue vector species faltered and gradually *Ae. aegypti* was re-introduced. This process was repeated in country after country in the Caribbean until nearly all the territories, where it once had been eliminated, were reinfested. Only the Cayman Islands and Bermuda managed to remain free of the dengue vector.

With the increased significance of the vector species, dengue re-appeared in the West Indies as seen by the first pandemic caused by dengue type 1 (DEN-1) virus. The disease, clinically known in old literature as "breakbone fever", caused major epidemics in 1977 and 1978. It commenced in Jamaica and during the ensuing two years, swept virtually throughout the Caribbean, in both the windward and leeward islands, then spread to the mainland causing outbreaks in central and south American, and as far north as Mexico and into the United States (Anon. a 1979).

In 1981, the first major epidemic of the more serious form of dengue occurred in Cuba, not simply classical dengue, but dengue haemorrhagic fever (DHF) with shock syndrome. Dengue serotype 2 (DEN-2) was introduced, causing clinical symptoms with major haemorrhagic manifestations. This new disease phenomenon occurred in epidemic proportions with 344,203 cases of which 116,143 were hospitalized and 157 deaths reported (Personal communications, G. Guzman).

Caribbean country programs, previously devoid of the dengue vector during the period when eradication was popular, now had unacceptably high levels of *Ae. aegypti.* in most communities. All three phenotypes of *Ae. aegypti*, are found in the Caribbean, and apparently are effective vectors, transmitting the flavivirus, to susceptible individuals.

In many cases countries were ill equipped to face DEN and DHF outbreaks, and medical resources were stretched to their limits, being overwhelmed by the number of cases. Since 1981 a total of 23 countries in the Caribbean, Central and South America have experienced outbreaks of DHF and many more have suffered epidemics of classical dengue (see Table 1).

Development

It became clear by the mid 1980's that government public health services charged with the responsibility of carrying-out pest and vector control in the Caribbean were unable to keep the levels of *Ae. aegypti* sufficiently low to prevent outbreaks of dengue. Leaders in the field of public health and health education called for additional resources to be made available to combat the scrourge of DEN and DHF.

Therefore, it was accepted that there should be a sharing of responsibility for vector control not only between ministries of health and environment, and public health departments, but also with non-health sectors departments such as ministries of education, communities, and even families and individuals. The latter two being most important in terms of their contribution to the provision of breeding sites for *Ae. aegypti* in and around residential dwellings.

In addition, it was recognized that public schools had a vital role to play in teaching youth, the rising generation, about effective environmental hygiene practices. Students could become agents for change with respect to being taught to apply correct environmental health principles about the prevention and or elimination of breeding places used by the dengue vector species in and around schools and homes.

In 1985, a pilot project (Boss et al., 1998), funded by the World Health Organization (WHO), the Panel of Experts for Environmental Management (PEEM), the Pan American Health Organization (PAHO) and the local government of St. Lucia was implemented. The goal of the pilot study was, as determined by community leaders, to reduce the incidence of *Aedes* mosquitoes, rodents and to improve solid waste management practices.

Over a one-year period, two participating communities in St. Lucia, with guidance from the Ministries of Health and the Environment, and Community Development along with PAHO/WHO devised activities to accomplish the goal of no dengue mosquitoes, no rats and no garbage. The project at the community level involved action groups such as women's organization, youth sports clubs, elementary schools, and the private sector. Training was provided locally by the Ministry of Health for more than 30 individuals who became vector control volunteers in the two villages.

Each volunteer was taught communication skills in order to meet with neighbors about key environmental health issues. Over time villagers received multiple visits from the volunteers, they conducted knowledge, aptitude and practice (KAP) surveys along the lines of the goals of the project to reduce levels of the household mosquito, *Ae. aegypti,* eliminate rodent harborage sites and to stimulate interest in the public regarding good environmental hygiene. Two primary schools were involved using simple curricula materials about the dengue mosquitoes, rats and nuisance insects. Students participated in poster competitions, the writing and inacting of skits, and crafting of calypso lyrics about vermin. Local businesses contributed prizes and trophies.

Despite a dengue outbreak, which occurred in the capital city of Castries, St. Lucia during the year of the pilot study, not a single case of dengue was reported from the two pilot study areas. The villages were involved in clean-up campaigns resultantly removed more than 100 dump truck loads of rubbish. Families and individuals not only cleaned up their yards, but also painted their houses and water standpipes with increasing pride in their surroundings.

Source reduction principles were taught by the volunteers, including the covering of drums and barrels placed beneath gutters to collect rainwater, in which the dengue mosquito so freely breed. The elimination of tins, jars, tires, coconut husks, and miscellaneous discarded containers were encouraged, aimed at reducing well-known *Ae. aegypti* breeding sites. All vector control measures were carried out in the absence of larviciding with temephos sand-core granules, which normally are placed in water storage containers by the public health inspectors. Source reduction activities by the community resulted in a drop, in the commonly used *Ae. aegypti* house index, from the pre-treatment level of around 35% to less than 5%.

During the clean-up campaign, abandoned vehicles and discarded appliances were removed and dumped into one of the community's erosion gullies, then filled and leveled with dirt. Subsequently on that site a field for soccer was created. Impressed with the community's self-help initiative, the government erected a community center, a much needed and appreciated facility. Eventually the campaign was introduced island-wide, but with less outstanding results.

The Italian government, traditionally a strong supporter of vector-borne disease research, learned of the pilot project's success and eventually funded a 15 country project, as part of PAHO's Caribbean Cooperation in Health (CCH) initiative. The project was established along similar lines of the St. Luica experience with an integrated community-based vector control approach and included a primary school environmental health curriculum component as a means of trying to build in sustainability. The aim was to teach primary school age children about the importance of having an *Ae. aegypti* free environment around their schools and homes through the application of basic environmental sanitation measures.

As part of the integrated community-based vector control project, a Health and Family Life Education (HFLE) school module was developed by two of us (AW and MN), with support from the PAHO health educator[1] to address issues of environmental health and the reduction of pests and insect vectors. In 1994/95 nine counties of the 15 participating countries used selected elements of the HFLE environmental health curriculum module with the goal of reducing pests and insect vectors (see table 2).

During the summer of 1998, one of us (ABK) visited Barbados, the Bahamas, Grenada, St. Kitts and Nevis, St. Lucia and St. Vincent on behalf of PAHO. During the visits, meetings were held with officials from the ministries of health and environment and ministries of education as a follow-up of the primary school pilot project with respect to an expanded use of the curriculum on pests and insect vectors (HFLE) module to other primary schools. The results are as follows:

In the Bahamas during 1996/97 school year, all 14 of the country's "Family Islands" schools selectively used components of the HFLE curriculum nation-wide from Kindergarten to the 12th grade.

In June 1996, after the curriculum had been introduced throughout the education system, a Children's Environmental Summit was organized by the Ministry of Education and Training in Nassau with more than 100 children participating. The agenda addressed issues of concern to the children who engaged in debates, made presentations and held group discussions on a variety of topics ranging from solid waste management, environmental hygiene and insect vectors and pests to coastal pollution. In July of that same year, the Ministry of Education held an Annual Teacher's Workshop for maximizing student potential with the theme of "Quality Education". Among the courses taught was that of "Science-Vector Education". The latter was conducted in cooperation with PAHO and WHO for Teachers of Primary School Sciences, Family Life and Health Education.

In November 1996, workshops and community meetings were held on Vector Control Education in the Bahamas. The overall objectives being to: 1) strengthen the capacity of teachers to implement the School Health and Family Life Education curriculum module, "Reducing Pests and Insect Vectors" and 2) encourage greater awareness among the community on vector control education (Anon. b 1996).

Also in that year, a booklet was prepared containing samples of some materials produced by teachers and students who participated in vector control education lessons (Anon. c 1996). The document contained poems, songs, plays and crossword puzzles on mosquitoes, diseases, cockroaches and houseflies. One of the poems written by Raynell A. Kemp, an 11 year from the Nassau Bahamas Mabel Walker Primary School was entitled, "Pests and Rodents". It went like this:

Mosquitoes, Mosquitoes, everywhere
Why don't they just disappear!
Mosquitoes, biting, biting me
Roaches crawling all around
Rats biting dogs and cats
We need a pied piper in town
Come, boys! And come, girls!
Come, moms and dads!
Let's get together; its not hard
To change our world and make a cleaner place!
Community participation is the key!

---

[1] Ms. Pat Brandon, Health Educator, PAHO, Caribbean Program Coordinator's Office, Bridgetown, Barbados

For this to work we must agree
To clean the garbage from our streets
And make our yards all clean and neat!

In addition, visits were made by one of us (ABK) to at least two schools in each of the aforementioned islands to obtain an idea of how the environmental health module was accepted and adapted. Although most of the schools were not in session at the time (some of the visits were made in June and August), it was possible in September 1998 to access to some degree, what residual impact the environmental health (HFLE) curriculum may have had upon the school's environment. For example, at one school on St. Kitts/Nevis, the children had cleaned and leveled a rocky playing field, removing trash and large rocks, thereby making a place for soccer. At another school, students not only cleaned-up the grounds, but planted flowers to beautify the area. In other schools, posters and signs about nuisance insects and school sanitation were in use.

Conclusion

The significance of the application of the HFLE school curriculum in terms of an impact upon vectors of disease such as dengue is not yet verifiable. However, should the application of the environmental health curriculum for the reduction of pests and vectors be expanded in both primary and secondary schools throughout the Caribbean one can surmise that there eventually will be a change in attitude and perhaps patterns of behavior about the environment and vector mosquitoes such as *Ae. aegypti* in the West Indies. Hopefully such will translate into correct adult behavior regarding an abhorrence of mosquito breeding sites.

It is felt that in time that the correct application of the HFLE curriculum principles will bear fruit and impact upon the environment leading to a reduction in the breeding of mosquito pests and vectors. In the long run a combination of community participation and school curricula with a focus upon environmental health, as commenced with the CCH funded Italian Project, may prove to be more sustainable, effective and of greater value in disease reduction than traditional public health program's vector control activities. From experiences reported from the Bahamas and elsewhere, it has been seen that children, in public schools can be taught basic principles of environmental sanitation thereby increasing their awareness of environmental hygiene issues, which they find important. The ultimate goal of such an expanded environmental health teaching effort is to obtain result in the reduction of pests and vector mosquitoes breeding which occurs at present so freely within the urban environment. Such an educational program may in the long run have a positive impact in reducing vector-borne diseases such as dengue fever.

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Table 1. Dengue haemorrhagic fever occurrence in the Americas by country and year.

COUNTRY	1ST CASE OF DHF	1ST DHF EPIDEMIC
CUBA	1981	1981
SURINAME	1982	1993
MEXICO	1984	1995
NICARAGUA	1985	1994
ARUBA	1985	-
DOMINICAN REPUBLIC	1986	1995
COLOMBIA	1985	1990
ST. LUCIA	1986	-
EL SALVADOR	1987	1987
VENEZULA	1989	1990
BRAZIL	1990	1993
HONDURAS	1991	1995
FRENCH GUIANA	1991	1991
PANAMA	1995	-
GUADELOUPE	1995	-
GUATEMALA	1995	-
JAMAICA	1995	1995
BARBADOS	1995	1997
COSTA RICA	1995	-
DOMINICA	1995	-
ST. KITTS & NEVIS	1995	-
MATINIQUE	1995	-
TRINIDAD & TOBAGO	1997	1997

Table 2. List of countries participating in school-based, integrated vector control project for the control of *Aedes aegypti* for primary schools in the Caribbean.

NAME OF COUNTRY	STATUS OF PROJECT
BAHAMAS	Implemented nation-wide in 1997.
BARBADOS	Expanding beyond pilot school phase in 1998.
DOMINCA	Pilot project being expanded.
JAMAICA	Pilot project in two schools. Ministry of Education, considering expanding to all primary schools.
MONTSERRAT	Pilot project.
ST. KITTS & NEVIS	Pilot project being expanded to other school in 1998.
ST. LUCIA	Pilot project being expanded to other schools in 1998.
ST. VINCENT AND THE GRENADINES	Pilot project in 1995-1996 being expanded.
GRENADA	Being implemented in two pilot schools in September 1998.

ANALYSIS OF THE OCCURRENCE OF SAINT LOUIS ENCEPHALITIS IN THE MOAB MOSQUITO ABATEMENT DISTRICT IN 1998

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Introduction

The Moab Mosquito Abatement District encompasses 25 square miles of Moab, Spanish Valley, and the adjacent Colorado River corridor. It has major riparian areas associated with the Colorado River, Mill Creek, and Pack Creek and extensive sub-up and flood areas along the Colorado River. Flood irrigated pastures and tail-water are the major *Culex tarsalis* Coquillett sources. *Cx. tarsalis* is the only known vector of Saint Louis Encephalitis (SLE) in the District, and the larvae can be routinely found in the District from March through October.

Encephalitis surveillance using sentinel chicken flocks started in Moab in 1984. The Moab District suffered an outbreak of Western Equine Encephalitis (WEE) with two chicken seroconversions and two equine cases in 1993. There has been no other evidence of WEE since surveillance began, and there was no evidence of SLE until 1998.

Background

The 1998 encephalitis surveillance sentinel flock was established April 23 in west Moab at the same location it had been since 1993. Blood samples were sent to the California Viral and Rickettsial Disease Laboratory (VRDL) on May 28 and every two weeks thereafter into October. Only three mosquito bite complaints had been called in 1998 prior to July 2, and these were confirmed to be associated with *Aedes vexans* (Meigen) and *Anopheles freeborni* Aitken. *Culex tarsalis* numbers seemed higher than usual, but there seemed to be no cause for alarm. So, it came as a surprise when, on July 2, the District was notified by the VRDL that chicken number 5634 was positive for SLE from blood drawn on June 25.

1998 proved to be a uniquely early and puzzling year for SLE seroconversions. Only four sero-conversions were detected, and these were abnormally early and widely dispersed over three states (Table 1). The only other SLE virus activity detected west of the continental divide was from a *Cx. tarsalis* pool in Riverside County, California, in August (CDHS 1998).

The detection of SLE virus activity in the Moab District came in what seemed, superficially, a normal mild year for mosquitoes. Was 1998 unique in any significant ways? Did *Cx. tarsalis* populations differ significantly from prior years? And, were there any predictors of virus activity that could have been recognized earlier in the season?

Methods

Adult mosquito trap data were

examined to determine if 1998 adult female *Cx. tarsalis* numbers differed in any significant ways from previous years. No data exists from before 1992, and only two trap sites for the years since provided data over a long enough period to be useful. One New Jersey light trap was run at a site (Site T) 1.7 km south-southeast of the sentinel flock through the seasons of 1994 through 1998. Another was run at the sentinel flock site (Site W) for parts of 1993 and 1994, all of 1995, 1996, and 1997, and part of 1998.

The Site W trap had used a 75 watt bulb in 1993, 25 watt bulbs in 1994 through 1996, dry ice bait in 1995, and no light bulb or bait in 1997 and 1998. Experiments were conducted at the site in 1996 in order to determine how the light, carbon dioxide bait, and the chicken flock influenced the trap catch. Multipliers determined from the 1996 experiments were used to adjust the data so that all the Site W data could be graphed to the same scale. The trap was terminated July 3, 1998, so that it would not compete with and reduce the virus detecting sensitivity of the sentinel flock. A third trap that had been placed about 0.4 km southwest of the sentinel flock June 25 and maintained to October 6 was used to give an estimate for Site W for the remainder of the 1998 season.

The data for each trap for each year were converted to New Jersey Light Trap Indices (NJLTIs) by averaging the female *Cx. tarsalis* count for each day with the counts for the previous six days. Figure 1 shows the NJLTIs for Sites T and W for the period of April 1 to September 30 for all the years with usable data. Figure 2 shows the same data for the period April 21 through June 24. Figure 3 shows the cumulative NJLTIs for the same spring period. April 21 was chosen as the start for Figures 2 and 3 because 1994 data collection did not start until that date, and June 24 was chosen as the end because the SLE seroconversion was from blood drawn June 25.

Discussion

Figure 1 shows that, except for the 1998 peaks at the ends of April and May, 1998 was most similar to the other non-flood years 1994 and 1996. Like 1998, 1996 had generally higher NJLTIs through much of the spring. All three non-flood years, 1994, 1996, and 1998, had relatively low numbers after July 1. Unlike 1998, the flood years of 1993, 1995, and 1997 had generally lower NJLTIs through the spring and much higher numbers through July and August.

The spring of 1998 produced many more *Cx. tarsalis* than any other spring for the years studied. The peaks at the ends of April and May in Figures 1 and 2 coincide with the mowing of alfalfa hay fields that were in production in all of the years. These peaks indicate 1998 had much higher than normal resident populations by the end of April at Site W and at the end of May at both sites. Figure 3 shows that *Cx. tarsalis* production, as compared with any other year for the period beginning April 21, was about six times higher by the end of April at Site W and roughly twice as high by the end of May at both sites.

Each of the non-flood years, 1994, 1996, and 1998, immediately followed a high flood year. In addition, 1998 followed a relatively mild winter, and the combination may have allowed a higher than normal overwintering population to survive into spring.

The following combination of events may have set the stage for early virus activity in 1998: the Colorado River flooded to its 77th percentile in 1997;

Moab rain & flooding in September of 1997; the 1997 mosquito season persisted later than normal; the winter of 1997-1998 was abnormally mild; the spring of 1998 was abnormal, with a warm February, a wet and cool March, and a dry April; and, Mosquito District mosquito field personnel noted abnormally high numbers of *Cx. tarsalis* larvae through March, April, and May of 1998.

Abnormally high *Cx. tarsalis* activity was detected by the traps one and two months earlier than when the District was notified of the seroconversion on July 2. With only six years of data to base conclusions on, it is difficult to have any confidence that similar trap counts in the future are going to be a reliable predictor of virus activity. Special larvicide and adulticide measures initiated after July 2 may have quashed virus amplification and prevented human SLE cases in 1998. It is interesting to wonder if there would have even been a seroconversion if the measures had been applied a month earlier.

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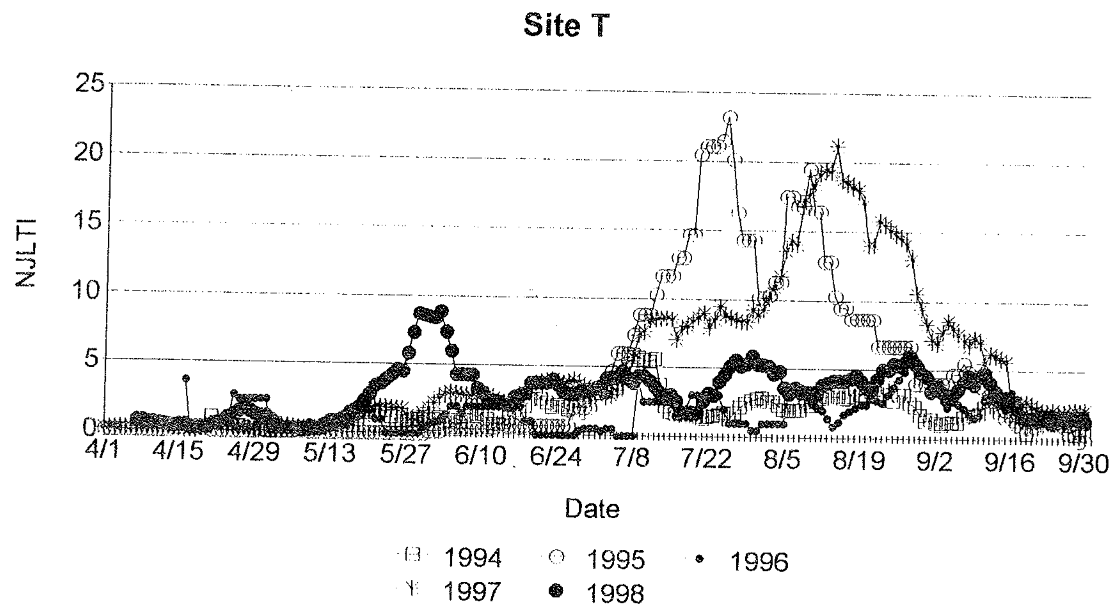
Table 1. Saint Louis Encephalitis seroconversions, 1998 (CDHS 1998).

DATE	STATE	COUNTY	CITY	NUMBER
April 17	California	Los Angeles	Harbor City	1
April 21	California	Orange	Irvine	1
May 12	Nevada	Washoe	Reno	1
June 25	Utah	Grand	Moab	1

Figure 1. *Culex tarsalis* New Jersey Light Trap Indices for Sites T and W for April 1 through September 30.



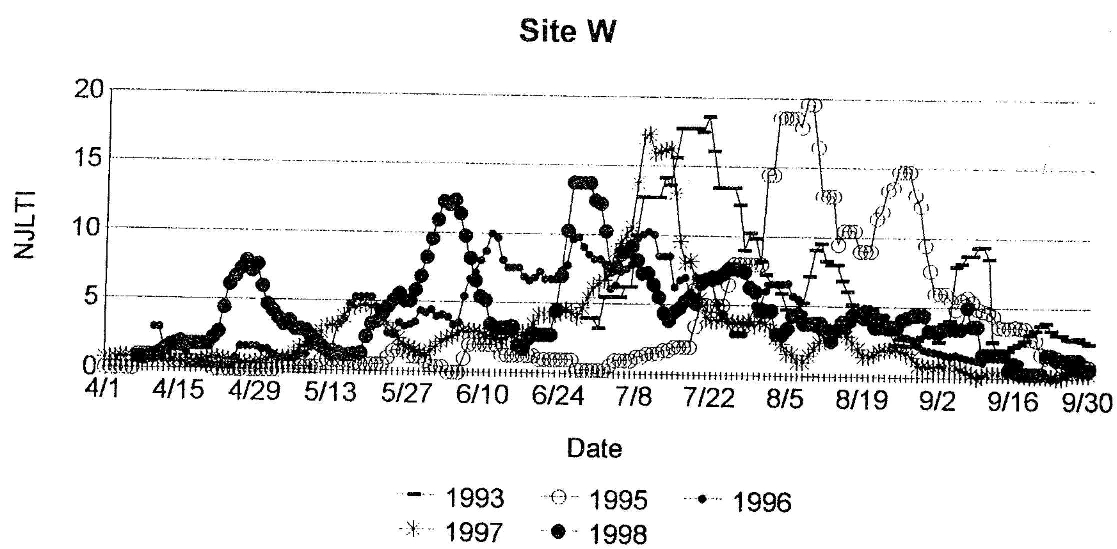
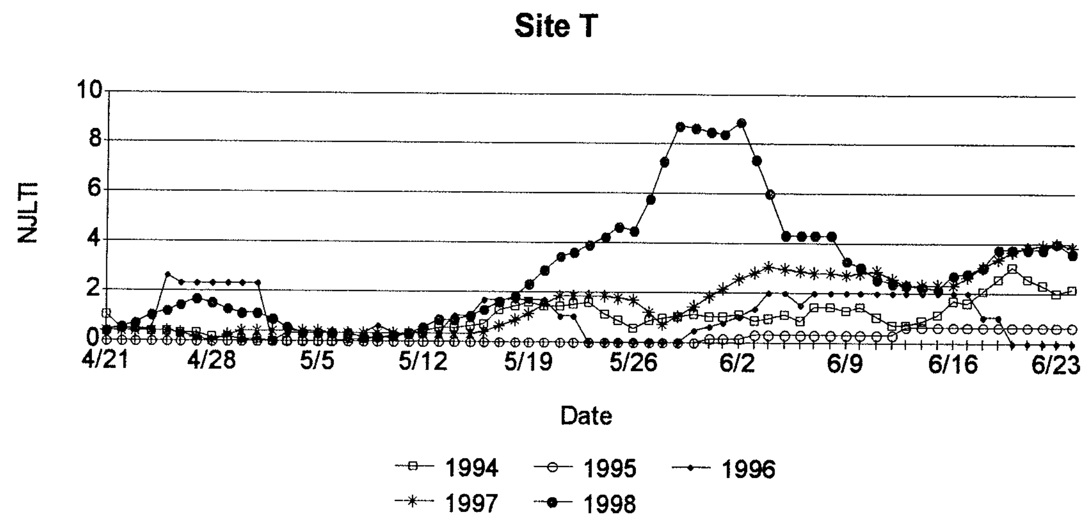


Figure 2. *Culex tarsalis* New Jersey Light Trap Indices for Sites T and W for April 21 through June 24.



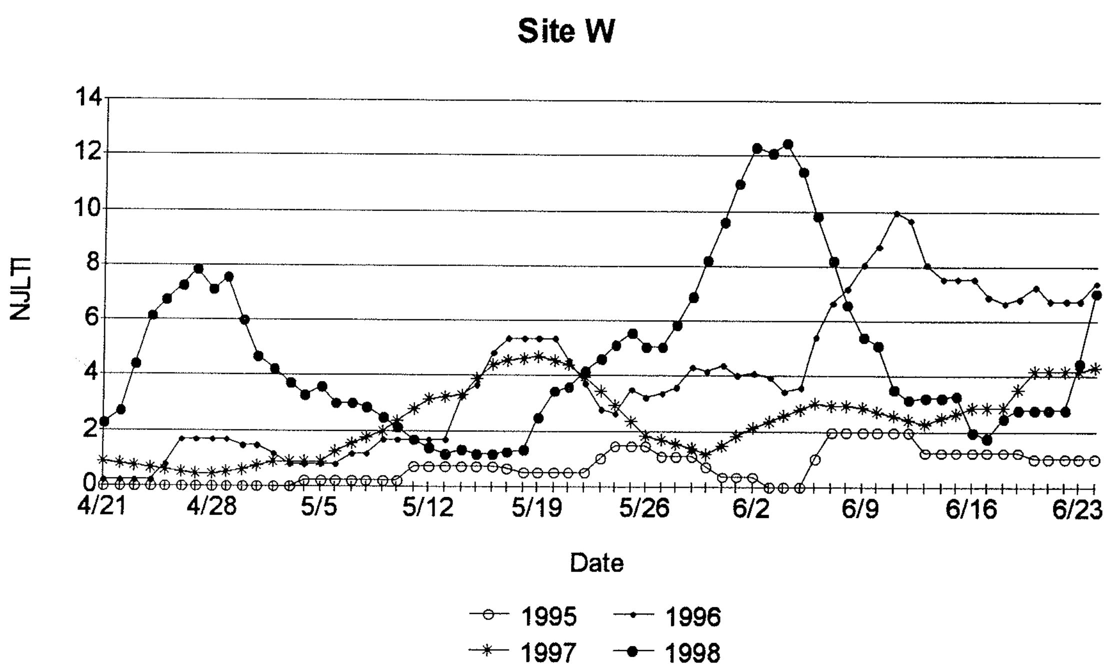
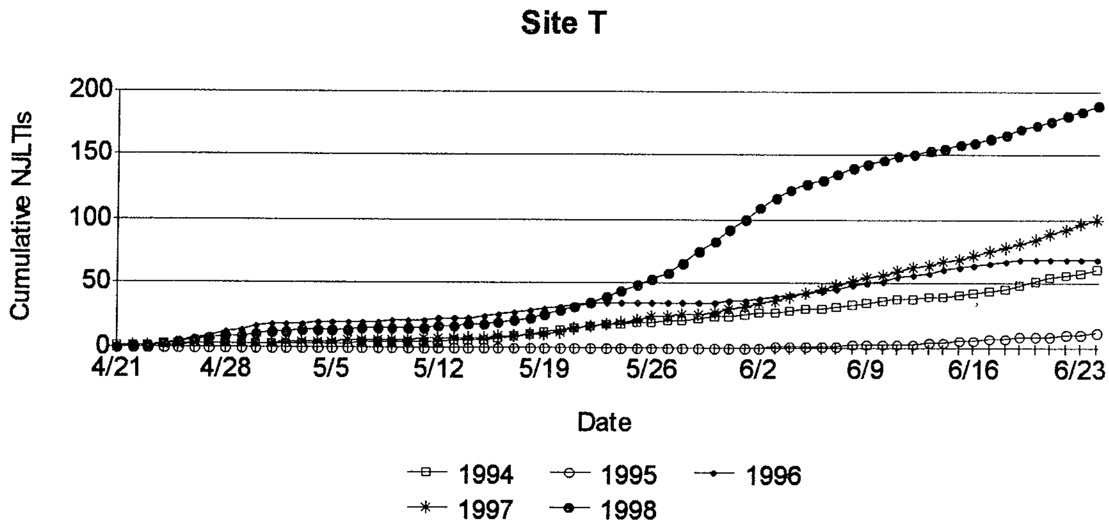
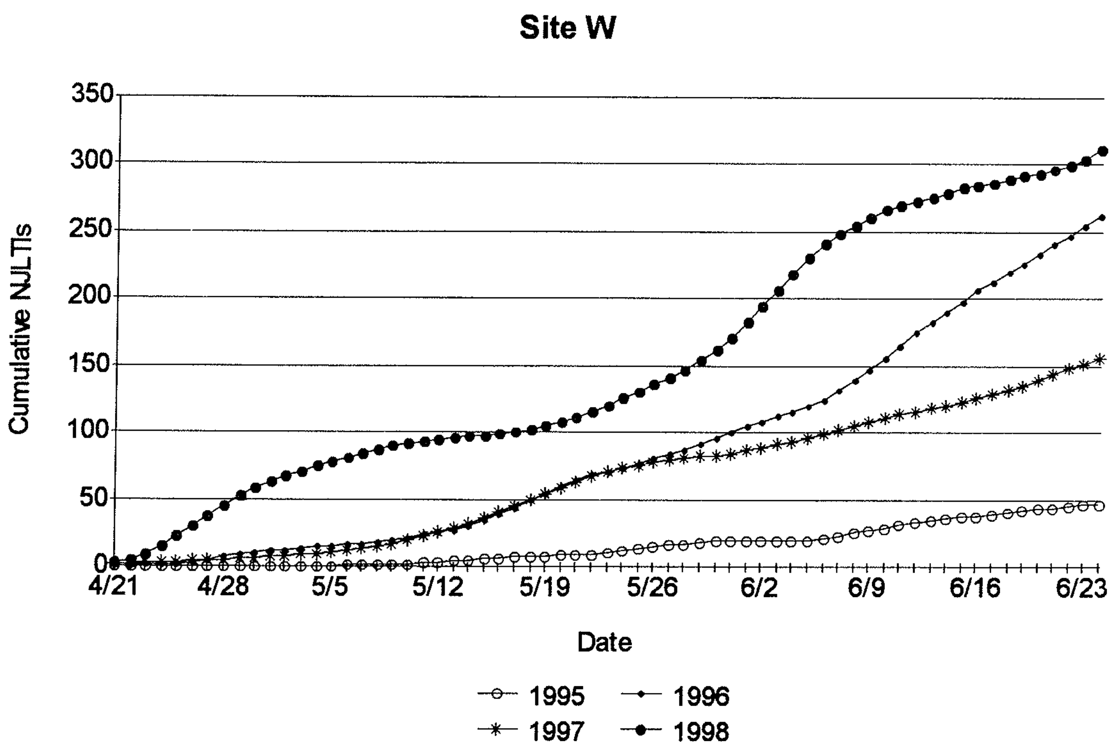


Figure 3. Cumulative *Culex tarsalis* New Jersey Light Trap Indices for Sites T and W for April 21 through June 24.





ARBOVIRUS SURVEILLANCE IN CALIFORNIA

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Abstract

Arbovirus surveillance in California is accomplished as part of a comprehensive vector-borne disease surveillance program operated jointly by the California Department of Health Services, the Mosquito and Vector Control Association of California, and the University of California. In recent years there has been a trend toward detection of high levels of viral activity, especially western equine encephalomyelitis virus (WEE) and St. Louis encephalitis virus (SLE) in the Central Valley, but fewer and fewer confirmed human disease cases. This has led to increased emphasis on human case detection. Using active surveillance approaches, a case of California encephalitis was uncovered that had been contracted in 1996 in Marin County. This represented only the 4th instance of a human illness caused by California encephalitis virus ever confirmed. Currently, a 5-year research program is underway by the University of California to incorporate modern surveillance technology into the program. The research is investigating 5 areas: (1) Improved human case detection; (2) Detection of enzootic viral activity; (3) Improved methods of estimating mosquito abundance; (4) Improved methods of analysis and reporting of surveillance data; and (5) Development of weather and climate models for prediction of risk to arbovirus infections in humans.

REPORT ON EQUINE INFECTIOUS ANEMIA CONTROL EFFORTS IN FREE-RANGING HORSES IN EASTERN UTAH

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Equine Infectious Anemia (EIA) is a viral disease of Equidae spread by biting insects. The virus attacks the red blood cells causing anemia in the victim. The disease may be manifest in an acute, subacute, or chronic form. Acute forms of the disease may cause death rates approaching 30%. In the subacute stages an animal may be able to survive recurring episodes of anemia. Chronically affected individuals show no clinical signs of disease but remain carriers for life, thus serving as a reservoir for others.

The principle vector is a member of the Tabanidae family, commonly known as the Horse Fly. The tabanid and other biting insects serve as mechanical vectors. Studies indicate that the virus may be able to survive on the mouth parts of the vector for distances of less than 200 yards. A horse fly can travel much longer distances, however, on the back of a horse.

In 1997, the State Veterinarian's office became aware of a possible reservoir of infection in free ranging equines in the Uintah Basin. A Ute tribal member had exceeded the capacity of a grazing permit he held with the tribe on tribal lands. The tribe had requested that he reduce his herd numbers and come under compliance. He had attempted on different occasions to gather the free roaming horses. As he tried to sell the animals he gathered, it was discovered that some of them were infected with EIA. At this point, Dr. Marshall, required all horses leaving the reservation be tested for the disease.

In the spring of 1998, the tribe established a deadline for the gathering of the trespassing animals. Any animals not gathered by April, 1998 would revert to tribal ownership. Arrangements were made with professional horse gatherers and 593 horses were gathered during March of 1998. The animals were gathered from various areas of the reservation. Testing of these animals determined that approximately 16% of them were infected.

Upon learning of the high rate of infection, the Ute Tribe requested the assistance of the Utah Department of

Agriculture and Food in testing their animals which were also being managed as a free roaming herd. It was the desire of the tribe to reduce usage of the range by horses and cattle to allow for the development of wildlife habitat. The tribe arranged for professional horse gatherers including helicopters. Blood samples were drawn by private veterinarians with some help from department veterinarians. The samples were delivered to the department laboratory for testing.

At this point it was felt advisable to gather and test wild horses grazing on BLM ground adjacent to the reservation. Fencing in the area is poor or non-existent and horses are free to roam at-will. A cooperative effort involving the Utah Department of Agriculture and Food, the BLM, and the Ute Tribe was begun.

The program was unique in participation and in scope. The tribe gathered animals at various locations along Hill Creek. Private herds were gathered at various locations along the Green River and near Touwave Reservoir. The BLM gathered animals in three different Horse Management Areas (HMA) as well as in an area known as Natural Buttes located outside the designated HMA. It was this last area near the confluence of the White River and the Green River that nearly all the infected animals were found.

A total of 1,361 horses were gathered during the period from March to June, 1998. All the animals were either tested or went directly to slaughter. It was found that 127 horses were positive for EIA. All the affected animals are believed to have originated from the Natural Buttes - White River area located at the confluence of the White River and the Green River where BLM and Tribal land meet. Approximately 50% of the animals in that area were found to be infected. The few positive animals found outside that particular area were felt to have been moved to those locations through the activities of humans. A breakdown of the distribution and ownership of the animals is presented in Table 1.

The BLM horses were subject to the provisions of the Wild Horse & Burro Act. Negative animals were returned to their respective Horse Management Areas (HMA). Exposed animals were retested after 45 days. Infected animals were required to be humanely euthanized and buried. Twelve of the positive mares had foals at their side. Eleven of those foals were also positive to the disease. It was felt that some of the foals may have obtained passive antibodies against the disease from the colostrum of their infected mothers, resulting in a "false positive" test. The possibility was that they may not actually have contracted the infection themselves, and that they may, in fact, test negative for the disease after 6-8 months, when antibody levels decreased.

It became necessary to hold the 12 mares and foals for a period of about 45 days until arrangements could be made for facilities to properly house the foals during this time. The infected mares and their foals were penned separately at approximately 600 yards distance from other animals. BLM officials sought the assistance of Steven Romney and the Uintah County Mosquito Abatement District in controlling possible vectors in the area. In a cooperative effort, adulticide ULV Malathion was applied with a standard fogger at the maximum legal allowable rate up to a level prescribed for control of stable flies. Application was approximately every 10 days.

The 12 foals are presently in a research facility in Oklahoma where their disease titers are being monitored.[1] Early indications are that the titers are decreasing. The 54 exposed herd members which originally tested negative were held for 45 days and retested. One was found to be positive and the remainder were released. The decision was made to release those animals rather than hold them under further quarantine period. Significant cost savings were realized as a result.

Program participants feel the horse gathering was a huge success. It has been characterized as an unprecedented cooperative effort. It is estimated that greater than 95% of the animals at risk were gathered and tested. Over 900 animals were removed, allowing rejuvenation of the range. The risk of disease to horse owners in the Uintah Basin has immensely decreased. Plans have already been discussed for gathering the horses in the risk area again next year to assess the success of the project. The contributions of the Uintah County Mosquito Abatement District are much appreciated.

Table 1. EIA Test Results - Uintah Basin - Utah - July 31, 1998.

LOCATION	PRIVATE HERDS	UTE TRIBAL HERDS	BLM HERDS	# POSITIVE ANIMALS
Hill Creek-		260/2		2
Touwave	36/4*			4
Tabayago			170/0	0
Agency Draw			50/0	0
East Bonanza	2/0		99/1	1
Natural Buttes-			107/53	53
White River	593/43	42/24		67
	631/47	**302/26**	**428/54**	**127**

[1] The 12 fouls eventually did test negative for E.I.A. and were offered for adoption by the BLM. Present BLM plans are to again gather and test the animals from the affected area during October, 1999. A sampling of Tribal animals gathered this spring was negative.

REPORT ON THE INCREASING INCIDENCE OF HEARTWORM IN NORTHERN UTAH

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Heartworm (*Dirofilaria immitis*) is a vector-borne parasitic infestation primarily of dogs, but cats and ferrets are also susceptible. The adult filarids live in the pulmonary artery and function to impair the circulation. Various mosquitoes of the genus *Aedes, Culex pipiens* and others have been implicated in transmission of the microfilaria in various parts of the country. Of particular note in Utah has been the existence of the tree hole mosquito *Aedes sierrensis* as a potential vector (Scoles et al., 1993).

Dr. Erekson, the former Assistant State Veterinarian, has addressed this audience previously concerning this problem (Erekson 1991). Dr. Erekson began keeping records on this disease in 1987. A decade of record keeping has seen the incidence of infection rise from a handful of cases to over 100 cases this year. Figure 1 shows the reported incidence of the disease from 1987 thru 1998, during which time the infection rate hovered around 30 cases annually.

In 1997, the reported incidence doubled to 67 cases. The number of positive cases reported in 1998 nearly doubled to 117 reported cases. Prior to 1998 there was only 1 reported case in Utah county. So far this year, there have been 6 cases reported from Utah county. Also new this year has been the report of 2 cases in cats. It has been noted in other areas where the infection has been introduced that the disease may go undetected or persist at low levels for several years until the number of cases seems to explode.

Ann Miller is our GIS coordinator at the Department of Agriculture and Food. She has prepared a map of the towns in seven northern Utah counties reporting cases this year. Using this technology it is possible to pinpoint problem areas. It will be noted that over two-thirds of the cases reported come from Davis and Weber counties. The infection rate in the area surrounding Hill Air Force Base is particularly high. It is postulated that the pets of military personnel may have been responsible for introducing the disease at some unknown time in the past. However, it was noted from the very first reporting, approximately 2/3 of the cases have occurred in native dogs.

A program of public education supported by the Utah Veterinary Medical Association has greatly increased the awareness, testing, treatment, and reporting of the disease in recent years. The data that we have accumulated provides possibly more questions than answers. It would seem important to identify all the possible vectors capable of contributing to the spread of this disease. This could lead to targeting certain areas and certain species of mosquitoes for control efforts. Some of this work has been done in Salt Lake City where they have attempted the control of the tree hole mosquito, *Aedes sierrensis* (Hatch and Dickson 1991). Also of interest is the identification of the species responsible for extending the range of the disease into Utah county. Is *Ae. sierrensis* active in that location, or are other vectors responsible?

In conclusion, let me say that the Utah Department of Agriculture and Food is very appreciative of the cooperative effort we have enjoyed with the mosquito abatement people over the years. Efforts to control not only heartworm, but also Equine Infectious Anemia, Equine Encephalomyelitis, and other diseases are best approached in a cooperative manner.

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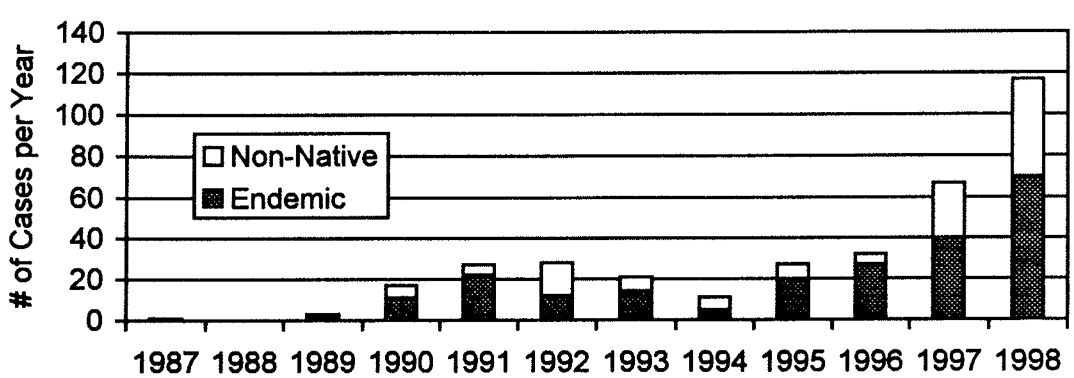
Scoles, Glen A., Sammie L. Dickson and Mark S. Blackmore. 1993. Assessment of *Aedes sierrensis* as a vector of canine heartworm in Utah using a new technique for determining infectivity rate. J. of the Am. Mosq. Control Assoc., 9(1):88-90.

Figure 1. Reported cases of heartworm in dogs in Utah.



THE BENEFITS OF AGNIQUE MMF®

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Box Elder County Mosquito Abatement District started applying Agnique MMF® on a very selective basis in the spring of this year. Applications were made in areas of 3 acres or less by hand equipment, at a rate of 0.2 to 0.5 gallons per acre. Initial applications were disappointing, but we were really just learning how to use this new product. We expected results within a few hours after application and even though we did find a few dead larvae, the reduction was not satisfactory. However when the operator went back to treat the same area approximately 24 hours later he found dead larvae in every dip including pupae. The kill was more than satisfactory. In some cases it took up to 48 hours to obtain satisfactory results. Agnique MMR® works well in heavier vegetation because of its spreading action. Water depth did not affect the results in our trials.

The greatest benefit that we realized was that Agnique MMF® has a broad application window being effective on first instar larvae through emerging adults. Good kills were achieved through all stages. We did experience a couple of failures. We believe these were due to the fact that on the one occasion Agnique MMF® was applied during a pretty stiff wind and enough material didn't reach the target area. The other failure occurred when it rained heavily within an hour of application. Weather conditions are important.

The fact that Agnique MMF® is non-toxic to humans and most non-target species was another benefit. It leaves an invisible film on the water and calms the water surface. Agnique is safe for use in waters containing fish or other runoff waters that enter fish bearing waters. It affects only target species at the water/air interface.

Agnique MMF® is effective at temperatures as low as 45 degrees or as high as 95 degrees plus. The cooler the water temperature the longer for spreading action to take place. This product is clean and easy to apply with little or no odor. It can be applied by backpack or cylinder type sprayer, power sprayer or by aircraft. We found that the residual can be up to three weeks depending on how much fresh water is entering the treated area. Ten days was the average residual in most of our treated areas.

The Bear River Bird Refuge Administrator issued the district an experimental use permit. This permit allows us to treat two selected areas in the refuge on a trial basis during 1998 with Agnique MMF®. Evaluations were made both by our district and the biologist employed by the refuge. As of this day, we have not received their evaluation on non-target insect damage. I really don't believe that any visible damage occurred to these other insects. We certainly couldn't find any in the survey that we conducted. In fact other aquatic insects seem to thrive in the areas treated including dragon fly larvae.

The State Water Fowl people have approved its use on the Salt Creek Area. The State Parks Superintendent has approved its use at the Willard Bay State Park.

The Box Elder District contains over 100,000 acres of irrigated pastureland, 81 private hunting clubs, the Bear River Federal Bird Refuge which now contains over 75,000 acres of which 35,000 acres is marshland and six State Water Fowl hunting areas. We need all the help we can get and Agnique is another weapon in our arsenal of mosquito fighting agents.

Bti is another one of our control agents and in most cases does a satisfactory job, however, the window of application is much smaller than with Agnique MMF®. We will have a place for both of these materials in our 1999 program. We feel that both of these products will do an excellent job for us in various applications. I know that some districts haven't experienced satisfactory kills. They should look at the equipment or nozzles they are using and weather conditions at the time of applications. Maybe because of costs, certain applications rates were too low. We know that the product works when applied properly. Maybe they don't wait long enough to evaluate the results, we made that mistake.

Agnique MMF® is an effective control agent in most types of applications however the cost has to be considered especially in low budget districts. We will not be applying it in all situations. We will be selective and will generally apply it to later instars and pupae and in areas 5 acres or less in size. It is important that you use the proper equipment with the correct nozzles for various types of application. This piece of equipment has the correct nozzle and works well in applying Agnique MMF® in most all situations. The cost of the sprayer wer use is approximately $100.00.

Check with my Assistant Manager, Gordon Wheeler concerning the correct nozzles and applying techniques. Van Waters & Rogers can also help you.

There is a training video that also gives you some hints on proper application techniques. It is available through Van Waters & Rogers.

VECTOLEX® OPERATIONAL EXPERIENCES AND FIELD TRIALS

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The characteristics, attributes and mode of action of Vectolex® CG were presented in this paper, followed by a summary of data from field trials and operational uses of the material in 1997 and 1998.

Vectolex® CG is a granular, biological mosquito larvicide that is based on *Bacillus sphaericus*, a naturally occurring soil bacteria. Vectolex® is highly specific in its' action against mosquitoes. It is very effective for the control of *Culex* mosquitoes, but recently has been shown to be quite effective on other species. One of the advantages of Vectolex® is that it is very effective in polluted waters, and often provides significant extended residual control. Vectolex® also has an excellent environmental profile due to its' low toxicity and specific action against mosquitoes.

The mode of action of *Bacillus sphaericus* is very similar to that of Bti in that the insecticidal components of the material consist of proteins that are non-toxic until digested by mosquito larvae. When Vectolex® is applied to the larval habitat, larvae ingest the proteins which are attached to the bacterial spore and encased in a parasporal body. The proteins are broken down into smaller toxic components by enzymes and the high pH that is found in the larval midgut. The proteins then exert their toxic effect upon cells of the midgut epithelium, causing pore enlargement and cell destruction. Fluids from the larval haemolymph then mix with midgut fluids, and the pH of the larval midgut is neutralized. As the larvae die, spores of *B. sphaericus* germinate and the bacteria grow in the larval cadavers. This is believed to contribute to the extended residual that Vectolex® often provides.

In 1997 and 1998, Abbott Laboratories obtained considerable information about the field performance of Vectolex® CG. This information was obtained both through field trials and close monitoring of operational uses in various settings.

Some of the highlights include 90 to 100% control of *Culex pipiens* and *Culex quinquefasciatus* for up to 35 days in sewage lagoon habitats. These results were replicated in studies in Washington, Louisiana and Connecticut. Similar results were observed at application rates of 5, 10, and 20 pounds per acre. Similar control of these species was achieved in septic ditches and dairy waste lagoons. However, residual control was more variable in these habitats ranging from one to five weeks.

A five pound per acre application resulted in 80 to 100% control of *Culex tarsalis* for more than 35 days in irrigation tail waters associated with center pivot corn circles in Oregon. More variable results were seen in irrigation run off in Utah with control lasting from 7 to 21 days. Tests against this species in duck clubs in California showed nearly 100% control for 28 days at 10 lbs. per acre. One application in duck clubs at 5 lbs. per acre resulted in similar results for 17 days (after which the site dried up). In another, initial control of 93% was achieved with control ranging from 100% to 63% for 17 days post treatment.

Vectolex® CG performed consistently well in catch basins in a variety of locations. Complete control of *Culex* mosquitoes was achieved for 21 days in catch basins in Oregon from applications of 0.25 tablespoon per drain. Residual control of thirty days or more was typical in catch basin studies carried out in Illinois, Michigan and Virginia.

A new label has recently been approved for Vectolex® CG that will expand its usefulness. A food tolerance exemption has been granted for *Bacillus sphaericus*. This will allow application of Vectolex® CG to rice, pastures/hayfields, citrus groves and irrigated crops. The label will also be expanded to include species of *Aedes, Psorophora* and *Anopheles* mosquitoes.

In conclusion, Vectolex® CG provided extended control of *Culex* mosquitoes in a variety of habitats. Residual control up to five weeks was achieved in many situations. Abbott Laboratories would like to thank everyone who contributed to gathering the information presented in this paper.

AQUA-RESLIN™ AERIAL FIELD TRIALS IN SALT LAKE CITY

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Introduction

In recent years the Salt Lake City Mosquito Abatement District (SLCMAD) has had an increasing number of inconsistent results in applications of aerially applied malathion. The exclusive use of malathion as an aerial adulticide for the past 30 years by the district brings up the suspicion, when all other explanations fail, that resistance may be the primary reason for failures. Field trials with malathion on caged adults (Hougaard et al, 1997), indicated that malathion was still very affective against *Aedes dorsalis*, but achieved poor results against *Culex tarsalis.*

In the spring of 1998, representatives of AgrEvo Environmental Health asked the authors if they would be interested in conducting some aerial field trials with Aqua-Reslin™. Aqua-Reslin™ is a synergized permethrin formulation, consisting of 20% permethrin and 20% piperonyl butoxide as the active ingredients. Aqua-Reslin™ is a unique ULV adulticide in that it uses water instead of oil as its carrier or diluent. Salt Lake City has very low relative humidity during the summer months, it was believed this would be a difficult challenge for a water-based formulation to reach the target mosquitoes before evaporation. In light of the failure of malathion against *Culex tarsalis* adults and the need for another adulticide, trials were scheduled for July of 1998.

Methods and Materials

Trials were scheduled for the third week of July when adult *Culex tarsalis* populations traditionally reach their peak abundance in the SLCMAD.

The aircraft used for the trials was a 1980 Cessna 188A spray plane. It was equipped with three Miconaire AU5000 mini-atomisers per wing. This aircraft had a speed of 110 mph while spraying. Aerial applications were made at a height of 100 feet above the ground giving an effective swath width of 500 feet. Using these variables, the spray system of the aircraft was calibrated to meet the desired flow rate, of 46 ounces of finished product per nozzle per minute. Labeled rates of this product range from 0.0015 to 0.007 lbs. permethrin per acre. A mid range of 0.0035 lbs. permethrin per acre was chosen for these tests since it would be a likely operational amount. To obtain this rate the Aqua-Reslin™ was diluted 1 part to 8 parts water. The finished product delivery rate was 2.5 ounces per acre. Droplets were collected at 6:30 a.m. the day prior to the trials, with the aircraft flying over Teflon slides on a battery operated device, spinning.

The afternoon prior to running the tests a test plot was laid out consisting of 9 wooden stakes, 1"X2"X4', placed in three rows with three stakes in each row. All cages were 500 feet apart. Each wooden stake had a straightened metal coat hanger attached with a screw to its top. The free end of the coat hanger was bent to hold the test cages.

Cages used to hold adult mosquitoes during the test were modified CDC resistance test cages. Essentially a 6 inch long, 1.5 inch inside diameter tube of fiberglass window screen, one end covered with a plastic ring and screen, the other end with the plastic CDC sliding device to allow transfer to clean cages with minimal stress to the test mosquitoes.

At sunset of the day prior to the tests four CDC dry ice baited traps were operated. Two were placed at the test site to get an estimate of the mosquito population size and variety before testing. The other two traps were placed near the SLCMAD offices to collect adult mosquitoes for the tests. The latter traps were collected at 4:00 a.m. the morning of the tests and brought to the SLCMAD laboratory. Adult mosquitoes were aspirated from the collection nets and put into the 9 test and 5 control cages. The cages were then placed in a styrofoam cooler for transport to the test site.

Control cages were placed in an open area approximately 2 miles up wind from the spray area. The other 9 cages were attached to the metal coat hangers at the test plot by 6:00 a.m. Glow sticks had been placed on and activated at each wooden stake making them easily located in the dark. A Teflon slide rotator was activated for collection of droplets during the testing.

The test plot was located towards the south end of a 2,000-acre block that was to be sprayed. Spraying began at 6:40 a.m., sunrise, July 22, 1998. The wind was from the south-southeast at 5-9 mph, gusting to as high as 12 mph. The first swath was made 2,100 feet to the south of the test plot with succeeding swaths perpendicular to the wind continuing north in the direction of the wind.

Approximately 15 minutes after the application mosquitoes from the test cages were transferred to clean cages for transport to the SLCMAD laboratory. Cotton balls dampened with a 10% fructose solution were placed on each cage to minimize post-treatment stress. At the laboratory, observations were made on the number of dead mosquitoes in each cage on an hourly basis.

The night following the test, the two CDC dry ice baited traps that had made pre-treatment collections were again operated to estimate post-treatment effects on the natural population.

Results

Pre-treatment droplet measurement showed a mass median diameter of 16.15 microns, with the smallest droplet at 4 and 35 microns being the largest. Droplets measured during the test yielded a mass median diameter of 16.20 microns with the smallest droplet being 4 and 22 microns being the largest.

The mosquitoes in the test cages consisted of *Culex tarsalis* (95%), *Aedes dorsalis* (4%), and *Culex erythrothorax* (1%). Upon transferring the test specimens to clean cages it was noticed that there were many dead adults within 15 minutes of spraying. Results of mortality are listed in Table 1. Mortality reached a very high rate with the first hour ranging between 91 and 100% in individual cages, with an over all mortality of 98.3% in the test plot cages. Mortality at one hour for all five control cages was only 1.3%. Mortality changed very little over the next 12 hours when the test was terminated. At 12 hours post-treatment, mortality averaged between 94 and 100% in individual cages, with an overall mortality of 98.6%. Control cages at 12 hours post-treatment had mortality ranging between 0 and 14%, with an overall mortality of 3.9%.

The two CDC traps that were operated at the test plot the night preceding and after treatment also showed a reduction in the wild population but to a much less dramatic result (Table 2). Of the four species *Aedes dorsalis* were reduced by only 31.5%, *Culex tarsalis* 67.2%, and *Culex erythrothorax* 94.7%. The overall reduction in the wild population at the test site was 58.9%.

Discussion

We found that Aqua-Reslin™ was very easy to work with and performed exceedingly well under the conditions at the time of these trials. Aqua-Reslin™ was very effective at killing both *Culex tarsalis* and *Aedes dorsalis* adults in the test cages. Mortality reached an extremely high level at one hour (98.3%). Once mosquitoes in the cages were observed to be 'knocked down', they did not recover. Collections using CDC dry ice baited traps before and after the field trial showed that the wild population also showed a reduction in both of these species but not to the same dramatic level. The total reduction in the wild population being 58.6% as compared to the 99% mortality in the cages. Both the test cages and trappings have problems that cause these differences. Even though adult mosquitoes were transferred to clean cages within 15 minutes of the fly-over, they are still exposed to droplets of insecticide that have become attached to the test cages. CDC traps like all trapping devices merely give an estimate of the population and can be affected by a myriad of factors. The test area was located along the Jordan River which runs through Salt Lake County, forms the boundary between Salt Lake and Davis counties, flows through marshlands and eventually becomes part of the Great Salt Lake. It has been observed over the years that mosquitoes such as *Culex tarsalis* and *Aedes dorsalis* that breed in the marshes follow the river like a highway in their movement to seek a blood meal. Therefore, post-treatment catches may be higher due to immigration of new adults.

The droplet measurements made both before and during the tests showed that not only are the droplets reaching the ground, but are of a very consistent size. Measurements were made from droplets that were captured on Teflon coated slides. It was noted that the droplets were remarkably uniform in size and shape. This was especially impressive due to the near prohibitive winds, 5-9 mph, during the test.

It was hoped that this test would give some insight as to the ability of a water based ULV adulticide to reach the ground under conditions of very low humidity. Relative humidity was at 52% during the trial. While this is high for the Salt Lake City area, it may considered relatively low in other areas.

Acknowledgements

The authors wish to thank AgrEvo Environmental Health for suggesting these aerial tests and providing the Aqua-Reslin™, Jing Zhai, Peter Andersen, and

David Sykes of AgrEvo Environmental Health for observing and helping during the trials, and to the staffs of both the Salt Lake City and Davis County Mosquito Abatement Districts who gave up a lot of sleep to make sure this trial was done properly.

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Table 1. Number of Adult Females in test cage that are dead or knocked-down and % mortality. Test cages had approximately 95% *Cx. tarsalis*, 4% *Ae. dorsalis*, 1% *Cx. erythrothorax.*

Cage #	Total #	1 Hour		2 Hours		3 Hours		4 Hours		6 Hours		12 Hours	
		#	%	#	%	#	%	#	%	#	%	#	%
1	33	32	97.0	33	100	33	100	33	100	33	100	33	100
2	35	35	100	35	100	35	100	35	100	35	100	35	100
3	25	25	100	25	100	25	100	25	100	25	100	25	100
4	52	52	100	52	100	52	100	52	100	52	100	52	100
5	27	27	100	27	100	27	100	27	100	27	100	27	100
6	32	29	90.6	30	93.8	30	93.8	30	93.8	30	93.8	30	94
7	49	48	98.0	47	95.9	47	95.9	47	95.9	47	95.9	47	96
8	68	68	100	68	100	68	100	68	100	68	100	68	100
9	35	34	97.1	35	100	35	100	35	100	35	100	35	100
Total	**356**	**350**	**98.3**	**351**	**98.6**	**351**	**98.6**	**351**	**98.6**	**351**	**98.6**	**351**	**99**
Control													
1	20	0	0	0	0	0	0	0	0	0	0	0	0
2	35	0	0	4*	11.4	5	14.3	5	14.3	5	14.3	5	14.3
3	39	2	5.1	0	0	1	2.6	1	2.6	1	2.6	1	2.6
4	36	0	0	0	0	0	0	0	0	0	0	0	0
5	25	0	0	0	0	0	0	0	0	0	0	0	0
Total	**155**	**2**	**1.3**	**4**	**2.6**	**6**	**3.9**	**6**	**3.9**	**6**	**3.9**	**6**	**3.9**

* The cotton ball that had been dipped in 10% fructose and placed on top of this cage had not been properly squeezed out which allowed a drop of fructose in the bottom of the cage in which 4 adults were trapped.

Table 2. CDC dry ice baited light trap catches at the test plot the night before and after treatment with Aqua-Reslin™.

	Pre-treatment			Post-treatment			
Species	**Trap 1**	**Trap 2**	**Total Pre-**	**Trap 1**	**Trap 2**	**Total Post-**	**% Reduction**
Ae. dorsalis	6,048	6,472	12,520	4,760	3,810	8,570	31.5
Cx. tarsalis	3,296	3,712	7,008	1,464	834	2,298	67.2
Cx. erythrothorax	2,368	1,632	4,000	128	84	212	94.7
Cs. inornata	3,104	1,704	4,808	392	240	632	86.9
Ae. nigromaculis	0	0	0	0	24	24	(100)
Total	**14,816**	**13,520**	**28,336**	**6,744**	**4,992**	**11,736**	**58.6**