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Due to subtropical ecology and ample mosquito populations in south Florida, the Florida Keys Mosquito Control District (FKMCD) and Florida Department of Health (FDOH) have long been concerned with the reintroduction of tropical diseases, such as dengue, yellow fever, and malaria, and the introduction of new diseases, such as chikungunya. Not only are the climate and local vectors concerns in case of this reintroduction, but the number of international visitors the islands receive every year also adds to the possibility of one of these arboviruses surfacing. To combat this possibility, there is a domestic surveillance program that now includes 23 inspectors throughout the Florida Keys. These inspectors perform environmental assessments of homeowners’ properties on a daily basis, as well as inspections of storm drains and sewage treatment plants. Each inspector has a “hot-spot” list that includes properties of greatest concern in their particular area. These are visited on a monthly basis. Other properties are visited due to service requests and/or door-to-door sweeps of problem areas. The domestic program is the first line of defense against the disease vectors of primary concern, particularly *Aedes aegypti*, which transmits dengue fever, yellow fever, and chikungunya.
Following increased rainfall beginning May 2009, there was a significant increase of *Ae aegypti* in Key West. To combat this growing population, truck-mounted ULV machines were used on a nightly basis throughout July. In addition, aerial adulticide missions were flown approximately every other week throughout June and July.

Early September 2009, Monroe County Health Department and FDOH were notified of a New York resident diagnosed with dengue fever soon after traveling to Key West and passed this information on to the Florida Keys Mosquito Control District. The infection was later confirmed as DENV-1. The traveler had stayed at a guest house in a residential area in what is known as Old Town, Key West. The premises and surrounding properties were surveyed for standing water and hand-held ULV foggers were used to treat all vegetation, under homes and porches. A number of containers were found holding larvae, including plastic containers, plant trivets, bromeliads, and a swimming pool under construction. Standing water was either dumped or treated appropriately with larvicide. Not all standing water was eliminated in order to prevent female *Ae aegypti* in the area from moving to find oviposition sites. Use of mechanical aspirators resulted in the capture of four individuals at the initial site, which were then sent for testing to the Florida Department of Health, Bureau of Laboratories. At this point, aerial adulticide missions were increased to every other day over the area of main concern, and truck missions continued as well. Domestic inspectors returned to the area on a daily basis, treating with hand foggers as necessary. Mid-September, another possible infection was identified in Key West, in a residence over a mile from the first case. Again, FKMCD immediately responded to the area and a number of both larval and adult *Ae aegypti* were found. Some larval habitats in the area included a bird bath, fountain, light fixture, bromeliads, and a flat rooftop. Use of mechanical aspirators resulted in the capture of 16 individuals at the site. Hand-held foggers were used to treat all vegetation, under homes and porches in a two block radius. Aerial missions began covering all of Key West, instead of only a small portion, continuing every other day.

Because this problem appeared to be more widespread, a door-to-door environmental assessment campaign was implemented in Key West beginning on September 15. There were 20 to 26 individuals participating on any given day, and all individuals were placed in teams of 2. Each team was given a map of their area of responsibility, a data sheet to record if larvae were found or if they were unable to find any.
to enter the property, treatment materials for both larval and adult mosquitoes, sample jars for larval collection, mechanical aspirators for adult collection, and information about both mosquito breeding and dengue virus for the homeowners. Every property on the islands of Key West, Stock Island, and Key Haven was either inspected or marked as “unable to enter.” By pooling all inspectors, the first sweep was completed in approximately two weeks. At the same time, FDOH was developing methods for identifying further cases and determining the extent of the outbreak. Local physicians were encouraged to consult with the health department on any patients that were suspected of having dengue and submit samples to the state or CDC.

During this time, one confirmed and one possible case of dengue fever, both at the same residence in Old Town, were identified and the earlier possible second case was confirmed negative. At this point, the District focused all man-power in Old Town, Key West. Door-to-door assessments throughout the area on three different occasions were continued and lasted another three weeks. Larval samples were collected during all assessments; multiple breeding sites at one location were combined into one sample jar. All samples were returned to the laboratory and identified to species by entomological technicians; all samples collected were *Aedes aegypti*. Throughout the six week campaign, inspectors collected a total of 1,101 larval samples, which coincides with the total number of Key West, Stock Island, and Key Haven properties on which mosquito breeding was found. Of the 3,206 containers found, 13.3% were plastic containers, 12.9% were plant trivets, and 7.3% were five gallon buckets. One of the more interesting larval habitats found was in the bottom portion of a Mosquito Magnet® trap on Key West!

In addition to collections made by inspectors with mechanical aspirators, BG Sentinel Traps were placed in high interest areas known to have large populations of *Ae aegypti*. Traps were placed in the field between 2 and 3 pm and recovered between 10 and 11 am. All *Ae aegypti* collected were pooled by location and shipped to the FDOH Bureau of Laboratories, Tampa, where they were RT-PCR tested for dengue virus. A total of 313 pools were collected and tested from September 10 to November 18, 2009; of those, 2 pools tested positive for the virus. Collections of *Ae aegypti* are ongoing, and testing is still being performed on all *Ae aegypti* collected.

Late September FDOH, Monroe County Health Department, and CDC collaborated to perform an epidemiologic investigation of the outbreak. The first step was a medical record search at the Lower Keys Medical Center and two area primary care offices. The search was based on discharge diagnoses consistent with dengue infection. 211 records were examined for likelihood of infection. Six records were identified as possible cases and the patients were contacted. All were willing to supply a blood sample, and four were confirmed as recent dengue virus infections.

The second stage of the investigation was a seroprevalence survey. A random sample of 911 households within one kilometer of the confirmed cases was selected based on the known flying distance of *Ae aegypti*. All residences were visited by an interviewer, a phlebotomist and a member of mosquito control staff and each individual was asked to provide a blood sample and answer questions about risk factors for mosquito-borne illness. The survey yielded 240 individuals from 170 households who were willing to participate. Laboratory testing at the CDC Dengue Branch in Puerto Rico identified 8 confirmed and 5 presumptive recent dengue infections, representing 5.4% of the sample. This rate of infection is higher than those identified in other recent United States outbreaks on the Texas-Mexico border.

When serosurvey results are combined with individuals identified...
by physicians and the medical record search, there were a total of 22 confirmed cases with onset dates ranging from July to mid-October; see Figure 4. Symptoms experienced by these individuals included fever (22/22), headache (17/22), body pain (17/22), joint pain (15/22), rash (13/22), eye pain (12/22), vomiting (5/22), blood in urine (3/22), diarrhea (3/22), and petechiae [micro-hemorrhages] (2/22). Ages ranged from 22 to 73 and 73% of cases were male. Geographic location of the cases is shown in Figure 5. Most were located in Old Town, Key West; however, a family of three in Key Haven was also affected.

Unfortunately, control of mosquito-borne disease is always a challenge. Throughout the outbreak, a number of different approaches were used by mosquito control to reduce the disease vector populations. These methods ranged from aerial adulticiding to dumping artificial containers. Overall success of these measures differed. Adult control was best accomplished by hand-held ULV machines. With these machines, inspectors were better able to treat mosquito resting areas, including vegetation, underneath porches, and especially underneath houses. Even though this was the most successful method for controlling adult mosquitoes, larval control is the key to Ae aegypti population control. Because it is impossible for FKMCD to be everywhere at once, it is extremely important that the public be involved in any larval habitat reduction campaign. Numerous press releases went out and inspectors gave information to almost all residents in Key West. However, there were still a great number of households that continued to provide ideal larval habitats week after week. Public involvement is the critical factor in the success or failure of any Ae aegypti control program. Both the District and Monroe County Health Department are emphasizing public outreach in the immediate future. It is hoped that the combined efforts will provide enough information to begin to change the behavior of residents at problem households and help prevent future outbreaks.

Other challenges for adequate control of dengue fever include the lack of a vaccine and the free movement of people from endemic areas into the Keys, providing the opportunity for repeated introduction. Still, as of this writing, there is no indication that the outbreak is ongoing and no transmission has been documented later than mid-October. This success is likely due in large part to swift action by mosquito control and the health department. The United States is also fortunate in having high quality water and waste management and good housing with air conditioning and screening, all of which contribute to reducing transmission. At this point, our focus is on prevention and surveillance. Only time will tell whether dengue will return with the warmer weather and rain.

Figure 5: Map showing confirmed Key West cases of dengue fever.
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2009 marks the 20th anniversary of the American Mosquito Control Association’s (AMCA) Student Paper Competition. Since 1989 AMCA has encouraged students to attend annual meetings by providing student members the opportunity to present a selection of their research in the form of a competition. Beginning 1998, winners of this competition receive the Hollandsworth Prize, which honors AMCA member Gerald Hollandsworth; see Figure 1. The Hollandsworth family provides financial support for the award. The AMCA contributes part of the prize money from various contributors each year. Dr Roger Nasci, currently with the Centers for Disease Control in Fort Collins, CO, was the original organizer of the competition. In 2003, the honor of organizing and moderating the competition was assumed by Dr Roxanne Connelly, an extension medical entomologist with the Florida Medical Entomology Laboratory and a previous competition winner.

THE HOLLANDSWORTH PRIZE

Education and efforts to increase interest in vector control have long been goals of the West Central Mosquito and Vector Control Association (WCMVCA). After successfully hosting the AMCA annual meeting in Denver in 1988, funds were available to establish a scholarship program. The proposed scholarship was aimed at college and university undergraduate and graduate students. The primary purposes of the scholarship were to promote student activity and interest in the WCMVCA and to encourage academic study and research in the area of vector biology, control, and vector-borne disease.

In 1989 a scholarship was established by the Executive Board and the membership at the annual meeting of the WCMVCA in Laramie, WY. The scholarship program was developed by Chester Moore of Colorado and Kenneth Minson of Utah. Up to two scholarships were made available for one undergraduate and one graduate student studying in areas of public health entomology, vector control and other closely related fields.

The scholarship idea was strongly supported by Gerald Hollandsworth, a member of the executive board and past president of WCMVCA. After Gerald’s death the Association voted that the scholarship be known as the Gerald Hollandsworth Memorial Scholarship.

Gerald graduated from Oklahoma State University with a major in Biological Science. He began his public health career in 1962-1964 at the Oklahoma City Health Department, Oklahoma City, OK, working in the housing and nursing homes programs in Environmental Health. From 1964 to September 1988 he was employed by the Pueblo City-County Health Department in the Environmental Health Division. His positions included general field staff, supervisor, and acting division director. However, his favorite environmental work was with zoonoses, including mosquito and vector control.

Gerald was an active member of many professional organizations: Colorado Environmental Health Association; National Environmental Health Association; Colorado Public Health Association; WCMVCA, serving as President in 1986 and Executive Board member; and AMCA, assisting in hosting the 1988 national convention. He was credentialed as Registered Sanitarian (RS) in 1966 in Colorado. He also obtained his National Environmental Health Association registration as a Registered Environmental Health Specialist (REHS).

When Gerald was not busy with environmental health issues, he could be found fishing, hunting, gardening, cooking, watching movies, or enjoying the outdoors. Since Gerald was married to a Public Health nurse, Public Health was a family matter. Gerald was...
a devoted family man with four children and six grandchildren at the time of his death on September 24, 1988.

Ted Davis, retired Colorado Department of Public Health and Environment summed up Gerald’s commitment to Public Health and WCMVCA: “...Gerald made a positive contribution to the Association through his years of service on the Executive Board and especially as President... he was always the hard working professional...From Gerald we have learned about gentle, positive attitudes, doing the best we can, going that extra mile when necessary and reaching for something extra when the going gets rough. We can be an extension of those qualities Gerald exemplified when we put forth the effort to do as he would have done...” For this commitment, WCMVCA wished that the scholarship retain its identity as the Gerald Hollandsworth Memorial Scholarship.

Funding for the scholarship was supported by the money received from hosting the national convention (nearly $8,000), donations from members, and accrued interest income. Gerald’s widow, Jane, has been a faithful contributor to the scholarship fund and has been included in all decisions regarding the scholarship.

The WCMVCA continually sought to expand the impact of the scholarship and upon learning that AMCA had established a student paper competition awards program in 1989, the WCMVCA committee approached AMCA about using the Hollandsworth Award as part of the student competition. AMCA agreed to include the scholarship in their awards program while continuing to identify the award as the Gerald Hollandsworth Scholarship. The goals of the scholarship remained the same. An additional goal is to encourage student participation in the AMCA national meeting. Thanks to the efforts of Sammie Dickson of Utah and other WCMVCA members, this has proved to be a very logical and successful move.

The scholarship is listed as the Hollandsworth Prize in the AMCA Student Paper Competition. AMCA also provides additional funding for the scholarship. Currently the AMCA contact person for the scholarship is Dr Roxanne (Rutledge) Connelly, the 1998 recipient of the scholarship. The WCMVCA point person for the scholarship is Sammie Dickson.

STUDENT COMPETITION WINNERS

The winning student of the AMCA’s first paper competition in 1989 was Scott Willis. At the time, Scott was working on a master’s thesis at McNeese State University under the guidance of Dr Roger Nasci. Scott presented his thesis work for the competition on Aedes albopictus population density and population structure in Southwest Louisiana. Scott would go on to become the Assistant Director for Calcasieu Parish Mosquito Control in Lake Charles that same year, where he now oversees all aspects of mosquito control operations. When asked about advice for future participants of the competition, Scott advised “keep things simple and relate the significance of what you have learned.” Indeed, the quality of the presentation and articulation with which the participants communicate their research to the judges are major factors in deciding a winner.

Another competition winner who continued in the vector-borne disease profession is Rosemarie Kelly. Rosemarie was enrolled in a PhD program at the University of Massachusetts in Amherst with Dr John Edman. In 1992 she presented her winning paper “Multiple transmission of Plasmodium gallinaceum during serial probing by Aedes aegypti on several hosts.” After graduation, Dr Kelly became a Public Health Entomologist for the Georgia Division of Public Health. She currently works on arboviral surveillance in Georgia, and is a board member of the Georgia Mosquito Control Association. She commented that the AMCA’s student paper competition is an “opportunity to speak at a national meeting in a non-threatening forum and to gain recognition for your work while still a student.” Such an opportunity is valuable to students in any discipline. Non-threatening feedback is important for any aspiring professional, as it allows them to hone their research and presentation skills while celebrating the strength he or she already possesses. Furthermore, recognition for excellence within a field of study can only stimulate further professional growth.

In 1995, Glen Scoles won the competition with his paper titled “Vectors of Canine Heartworm in St Joseph County, Indiana.” At the time he presented his paper, Glen was a PhD student with Dr George Craig at the University of Notre Dame. After graduation, he began a post-doc position at Yale and the Plum Island Animal Disease Center. Glen is currently a Research Entomologist with the USDA-ARS Animal Research Unit in Pullman, WA, studying tick-borne pathogens of livestock such as Babesia equi and B caballi in horses, and Theileria parva in cattle. When asked about the value of the AMCA’s student paper competition, Glen commented “The things I learned about presenting talks at meetings while participating in student paper competitions have been
invaluable. I see so many ‘older’ scientists, even people who are quite senior and well respected, who could use some pointers on how to present. If these folks had been able to take advantage of student paper competitions to hone the craft of presentation, we would all be subjected to fewer disorganized and overtime presentations by people who ought to know better.”

The presentation skills garnered from participating in student paper competitions like the AMCA competition provides countless benefits. Research presented confidently and concisely leads to a clear communication of ideas and improves the overall quality of scientific discourse within and among fields of study. Scientific arguments can then be reviewed on their merit rather than lost as a result of a poor presentation.

Dr Laura Harrington won the competition in 1999 with a paper titled “Human Blood Feeding Imparts a Fitness Advantage to the Dengue Vector, Aedes aegypti (Diptera: Culicidae).” Like Dr Rosemarie Kelly, Dr Harrington was then a PhD student with Dr John Edman at the University of Massachusetts in Amherst. Currently, she is an Associate Professor of Entomology at Cornell University, where she studies the behavior and ecology of the mosquito vectors for West Nile and Dengue Fever.

When Sarah Hamer (formerly Sarah Yaremych) won the competition in 2003 for her paper titled “American Crows and the West Nile Virus: Movement, Mortality, and Mosquitoes,” she was working on a MS degree at the University of Illinois. While at Michigan State University, the Michigan Mosquito Control Association recognized her outstanding performance by awarding her the William J Lechel II Memorial Scholarship for her tick research. In commenting on the AMCA’s student paper competition, Sarah relished the opportunity for feedback when fielding questions from the audience. She states: “I was honored to participate in this competition that received such a great audience. The questions I fielded after my presentation, both formal and informal, helped me to identify areas of particular interest to the audience that I could expand upon in future presentations.”

Jennifer Armstead won the Hollandsworth Prize in 2007 for her paper “On the Competition Occurring Between Aedes albopictus and Aedes japonicus in Northern Virginia.” That same year, she completed her MS from the University of Florida with Dr Phil Lounibos. Currently, Jennifer is continuing her graduate studies at the Johns Hopkins University School of Public Health. She offers important advice to future contestants: “Keep it short and sweet!”

Over the 20 competitions that have been conducted, winners and honorable mentions have come from 23 different Universities; see chart on page 17. During this time period, University of California, Davis, has produced the most winners with 4 taking the top prize, and 6 honorable mention recipients. There have been 2 international winners, one honorable mention from University of Mainz (Germany) and one from University of Zurich (Switzerland). For the first time, in 2008, a high school student, Emily Bick, participated in the competition.

JUDGES AND AUDIENCE MEMBERS

For each competition, there are 3 to 5 judges, and these volunteers vary from year to year depending on the location of the meeting and the Universities and agencies represented by the students in the competition. There is typically a mix of agencies represented by the judges including mosquito control agencies, health departments, industry, military, government, and academia.

The judges are provided guidelines and score sheets to use during the presentations. They meet after the session to decide on the top paper(s). In recent years, they have been given the option of also awarding an honorable mention prize. The criteria set forth in the guidelines emphasize presentation skills including organization and delivery, effective use of time, clarity and intonation, visual aids, and explanation of the problem.

Dr Vicki Kramer, California Department of Health Services, who has participated as a judge in the past, advised that in her opinion “the strongest presentations... provided clear study objectives, a conclusion slide, and discussed the relevancy of the research to advance public health. Students should be sure not to crowd their slides with too much text or complicated charts and tables as this detracts from the key points they are trying to convey.”

Dr Mike Turell (USAMRIID) attends the session every year and commented “to be honest, most of the talks by the students were better given and more interesting than many of the talks given by the more seasoned professionals. This is always a great session.”

2009 COMPETITION

The judges who volunteered their time and expertise for the 2009 competition were Dr Henry Lewandowski, Chatham County Mosquito Control; Commander George Schoeler, US Navy; and Dr Don Shroyer, Medical Entomologist at the Indian
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<td>SCOTT WILLIS</td>
<td>McNeese State University</td>
<td>Calcasieu Parish Mosquito Control</td>
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<td>ANDREA BROWN</td>
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River Mosquito Control District. AMCA greatly appreciated their contribution to the competition.

Two University of Florida graduate students won prizes for their scientific presentations in the AMCA Student Paper Competition held during the 2009 Annual Meeting in New Orleans, LA. They competed with 7 other students on Wednesday, April 8; see Figure 2.

Ms Alexandra Chaskopolou, a PhD student in Entomology with Dr Phil Koehler, won the Hollandsworth Prize, given to the student with the best overall presentation; see Figure 3. She received a certificate and $2,000 for her presentation entitled “Efficacy and Non-target Effects of Aerial Adulticiding Utilizing Modern Guidance Technology Against Rice-land Mosquitoes of Greece.” Alex has been working with Manatee Mosquito Control District while preparing for her research in Greece.

Ms Stephanie Larrick, MS graduate student with Dr Roxanne Connelly at the University of Florida, won Honorable Mention in the contest and received a certificate and $1,500; see Figure 4. Her presentation, “A Novel Way to Test the Traveling Capacity of Larvicides,” was based on a project she worked on last year at the Florida Medical Entomology Laboratory. Stephanie defended her research in May 2009 and started a PhD program in August 2009, working on ants at the University of Florida.

The Hollandsworth Prize was presented to Alexandra by the current President of the WCMVCA and Mosquito Control Crew Supervisor from the City of Laramie, Mr Keith Wardlaw, during the Awards Banquet; see Figure 3. Congratulations to two excellent speakers and good luck to them in their studies!

**FUTURE OF THE STUDENT PAPER COMPETITION**

The number of students attending the AMCA annual meeting and entering the competition has increased over the last several years. It is imperative that employers, faculty, etc, continue to support student attendance at the annual meeting. Participating in the student competition gives students the opportunity to perfect their skills, to gain experience in speaking in front of colleagues,
and the chance to meet potential employers. The 2010 AMCA annual meeting will be in Lexington, KY. Previous participants, including those who have won the competition, are eligible to compete as long as they are still in school. Students who wish to participate in the competition must be enrolled in school at the time of the submission of the abstract and they must be members of the AMCA by the time the meeting starts. Please make plans to attend the competition during the AMCA annual meeting. It’s not too early to start planning for the 2011 competition, which will be in Anaheim, CA. Watch the AMCA website for the call for papers.
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Black flies (Diptera: Simuliidae) are notorious pests of humans and animals throughout the world. Thankfully, here in the southeast, black flies are a relatively minor pest compared to mosquitoes, ticks and other biting flies. Most of our black fly problems in the southeast involve nuisance species of the *Simulium jenningsi* species group, which usually just swarm about our head and face. In many parts of the world, black flies are a much more serious problem. In Africa, Mexico and Central and South America, black flies transmit the filarial nematode *Onchocerca volvulus*, which causes onchocerciasis or river blindness, as it is commonly called. In addition, people in many parts of the world deal with aggressive, human biting species whose bites produce intense itching, swelling, pain and bloody welts.

Black flies are closely related to mosquitoes, both being classified as Diptera, Suborder Nematocera. The primary difference between these two pests is that larval black flies develop in flowing water as opposed to the still water habitats of mosquitoes. Black fly eggs are laid on the surface of rivers and streams or on trailing vegetation, sticks or rocks along the edges of these habitats. After hatching, the larvae use silk glands to spin a pad of silk and attach to substrates in the water flow.

Typically, larval populations will be most abundant in areas of streams with higher water velocity. The selection of these areas as a preferred larval habitat is related to larval filter-feeding. Upon attaching to a substrate, the larvae will be suspended in the current, where cephalic fans filter food materials out of the passing water. Larval black flies are indiscriminate filter feeders, ingesting particles of 0.09-350µm in diameter. After completing seven instars, the larva spins a silk cocoon and molts to the pupal stage. The adult black fly emerges from the pupa in a bubble of air, hardens its wings and begins its aerial life.

The most effective technique for suppressing adult black fly populations is larvicide applications to the aquatic habitats where the larvae are developing. The primary material used for this work is the biological control agent, *Bacillus thuringiensis* subsp. *israelensis*, or *Bti* as it is commonly called. This naturally occurring soil bacterium produces insecticidal proteins during sporulation. When ingested into the alkaline conditions of the mid-gut of Nematoceran Diptera, the proteins are highly efficacious and fast acting. These proteins are formulated into bacterial based products that are used to suppress black fly, mosquito and chironomid midge populations throughout the world.

The University of Georgia Black Fly Rearing and Bioassay Laboratory is operated under the direction of Dr. Ray Noblet and Elmer Gray. Dr. Noblet has had a nearly 30 year relationship with, first, Abbott Laboratories, and now Valent Biosciences Corporation, conducting research related to *Bti* and black flies. As part of this research, his laboratory maintains the world’s only black fly colony. The colony was originally started at Cornell University in 1981 when eggs of *Simulium vittatum* cytospecies...
IS-7 were collected on vegetation from Flaxmill Brook in Cambridge, New York; see Figure 1. In 1991 eggs were sent to Clemson University where Dr Noblet’s laboratory was operating and the current version of the colony was established. The colony was moved to the University of Georgia in 1999 following Dr Noblet’s acceptance of the position of Department Head in 1997.

The primary components of the colony system are the nine aquatic rearing tanks; see Figure 2. Individual tanks form a closed circulation trough environment, to create an ideal larval habitat. Each tank consists of a 180 liter reservoir, a pump for circulating the water over a wooden runway and a compressor and cooling system that can be used to regulate water temperature. The pump moves water from the lower reservoir to an upper chamber where the water spills onto a runway creating an artificial stream environment. Strips of nylon screen are attached to the runway to serve as larval attachment sites and as a substrate to harvest large numbers of larvae in an undisturbed fashion; see Figure 3. Larvae are fed a mixture of soy bean meal and rabbit feed, which is ground dry in a household blender to a uniform consistency. The ground food material is washed over a 53 µm sieve and the resulting slurry is used as the larval food material. This food slurry is stored in tanks in refrigerators to prevent spoilage. Two small pumps are placed in each food tank. The first pump stirs the food slurry and the second pump injects the food slurry into the upper reservoir where it mixes with the tank water and flows over the runway where larval feeding occurs; see Figure 4.

After pupae are observed on the runway, typically around days 20-24, the rearing unit is covered with a lightly framed emergence hood. The emergence hood is covered with black cloth and plastic. This design facilitates adult capture and maintains a humid environment to support adult survival. All edges of the emergence hood are sealed with weather stripping to prevent adult flies from escaping. At the apex of the emergence hood is a glass funnel. This funnel is the only site where the emerging flies are exposed to light. Black flies are highly photo-tactic and migrate into tubing that is attached to the funnel. Mating occurs in this emergence tube and in a smaller, mating tube, where all of the flies that have emerged for the day are combined. Typically 4-5 of the 9 tanks that make up the colony will be at a stage where flies are actively emerging. Upon removal of the mating tube, the flies are released into a cardboard food
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Mosquito-borne pathogens are among the most important sources of human disease that cause morbidity and mortality worldwide. They include the viruses responsible for deadly outbreaks of yellow fever, Rift Valley fever, eastern equine encephalitis, Japanese encephalitis and dengue, and an assortment of other serious illnesses caused by the etiological agents of West Nile fever, St Louis encephalitis, Murray Valley encephalitis, Venezuelan equine encephalitis and chikungunya disease. Dengue viruses, of which there are 4 serotypes, cause an estimated 50-100 million new illnesses each year (and 25,000 deaths) while the latest chikungunya epidemic has lasted longer, affected more people, and occurred over a wider geographic area than any previous outbreak of the disease. Yellow fever outbreaks continue to occur sporadically in South America and Africa when either vaccination or vector control are inadequate. These outbreaks have been controlled by creating barrier zones of vaccinated people and by increasing the intensity of vector control. The threat of devastating outbreaks of yellow fever remains, as illustrated by continuing quarantine and vaccination requirements for international travel. The most devastating of all mosquito-borne diseases is malaria, which kills an estimated 1 million people annually, while infecting another 500 million. Although public health efforts have been able to reduce or eliminate vector-borne pathogens in many situations, some parts of the world have actually suffered increases during the past 30 years. A number of agencies have responded to this problem with much increased levels of attention: World Health Organization, Bill and Melinda Gates Foundation, President’s Malaria Initiative, Institute Pasteur, US Centers for Disease Control and Prevention, and US National Institutes of Health. However, morbidity and mortality due to mosquito-borne diseases is increasing.

Today, mosquito wars are being fought around the globe and on many fronts. Insecticide-treated bed nets are mass-produced and distributed to the hardest-hit malarious regions in Africa, India and southern Asia. Vaccines have been developed to protect humans and domestic animals against Yellow fever, Japanese encephalitis, Rift Valley fever and eastern equine encephalitis, with intensive ongoing research targeting dengue, West Nile virus, and malaria vaccine development. New skin and clothing repellents for personal protection against all biting insects are being developed, and insecticide and related application technology development is in full swing. Of these, the key component for protecting humans from mosquito-borne illness is the use of effective insecticides that quickly...
kill millions of mosquitoes before they can pass their pathogens to sicken or kill humans. Mosquito adulticides and larvicides are a key component of our assault, along with indoor residual spraying and insecticide-treated bed nets.

Unfortunately, mosquitoes are fighting back somewhat successfully by developing resistance to currently used mosquito adulticides. To date, at least 100 species of pathogen-carrying mosquitoes have overcome the effects of today’s limited arsenal of adulticides. We now have only 2 chemical classes of adulticides available for adult mosquito control: organophosphates (OPs) and pyrethroids. Malathion is one of our oldest organophosphate adulticides and the workhorse of this class. It was developed in the early 1950s for agricultural pest control and has been used extensively around the world as a mosquito adulticide since 1953. It is a cholinesterase inhibitor that impairs nerve cell transmission. Resistant mosquitoes have at least 3 biochemical processes for detoxifying this class of insecticide. Pyrethroid insecticides were developed in the 1970s as analogs of pyrethrum, a natural product of chrysanthemum flowers, known for its insecticidal properties for hundreds of years. Pyrethroids provide rapid knockdown of mosquitoes by binding to sodium channels on nerve cells and subsequently depolarizing them to stop neural transmission. Resistant mosquitoes are now capable of detoxifying pyrethroids by the above 3 biochemical processes and target cell insensitivity. Larvicides offer more target sites for killing immature mosquitoes, but increased tolerance or resistance has also been reported among different larvicide classes including the stomach poison Bacillus sphaericus, insect growth regulator (methoprene), and a commonly used OP (temephos) among some mosquito species.

With only 2 adulticide classes left to combat an increasingly resistant adult mosquito population and the pressing need for novel larvicides with new modes of action, a call has been initiated by the United States Department of Defense (DoD) and public health agencies to develop new classes of insecticides that are affordable and efficacious in killing mosquitoes, especially resistant ones. At the United States Department of Agriculture (USDA), several research units within the Agricultural Research Service (ARS) are actively involved in discovering and developing novel insecticides. These units include the Mosquito and Fly Research Unit (MFRU) at the Center for Medical, Agricultural and Veterinary Entomology (CMAVE) located at Gainesville, Florida; the Invasive Insect Biocontrol and Behavior Laboratory (IIBBL) located at Beltsville, Maryland; and the Natural Products Utilization Research Unit (NPURU) located at Oxford, Mississippi. Funding for much of this research is provided by the DoD’s Deployed War-fighter Protection (DWFP) Research Program, which seeks to develop insecticides with new modes of action for both military and civilian use. Discussed below are the insecticide research goals of these ARS units and the impressive results from their insecticide discovery programs.

Scientists at the MFRU are using high throughput larval screening techniques to evaluate thousands of candidate chemical compounds provided from industrial collaborators’ chemical libraries. This bioassay technique exposes mosquito larvae, usually the yellow fever mosquito Aedes aegypti, to a large array of candidate compounds. Five first instar larvae (24 hours old) are added to each well of a 24-well plate in de-ionized water (950 ml) to which larval diet (40 ml), DMSO (dimethyl sulfoxide, a substance used to stabilize candidate chemical concentration), and the test chemical itself are added; see Figure 1. Larval mortality is scored after 24 hour post exposure. Later, the most active compounds are tested under a wide range of concentrations to determine the lethal dose necessary to kill 50 and 90% of mosquito larvae. Hundreds of chemicals can be screened weekly using this system.

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larval assay described above, candidate compounds are then tested on adult mosquitoes to determine if they will make good adulticides. Three to five day-old adult female Ae aegypti are anesthetized for 30 seconds with carbon dioxide and placed on a 4°C chill table. A 0.5µl droplet of pesticide diluted in acetone is then applied to the dorsal thorax using a repeating dispenser; see Figure 2. After topical treatment, mosquitoes are kept in plastic cups and supplied with 10% sucrose solution for 24 hours before mortality is scored; see Figure 3. All chemicals are subjected to a primary screen at a concentration of 200 ppm. Active compounds from the primary screen are subjected to secondary and/or tertiary screening at 20 ppm, 2 ppm, and 0.2 ppm to determine lethal dose 50 and 90 percentiles; see Figure 4. Permethrin is used as the positive control to measure relative toxicity and acetone is used as a negative control to insure that mosquito death is due to the compound and not environmental circumstances. The strategy is to pass successful adulticides to industrial collaborators for registration, production, and marketing as mosquito control insecticides. An additional inducement for industrial production and marketing is the involvement of IR-4 (Interregional Research Project Number 4), a USDA sponsored entity that facilitates the registration of minor-use pesticides. Military entomologists can then assign national stock numbers to these products through the AFPMB's pesticide committee for inclusion into military stock systems.

To date, MFRU scientists have examined over 2,000 compounds. Of these, over 200 showed high activity as a mosquito larvicide, of which 28 show high adulticidal activity. MFRU chemists are also collaborating with chemists at the University of Florida to examine the USDA historical archives of insecticide data by quantitative structure-activity relationship (QSAR) modeling to predict and synthesize new insecticides. This approach was used successfully to predict and synthesize efficacious repellents. Another source from which larvicides and adulticides can be developed is from existing insecticides already registered for use against other pests, such as the bioactive ingredients found in products registered to control other insect pests. In early 2009, 19 registered insecticides with different modes of action were tested against mosquito larvae and adults. Results indicated that 3 relatively new insecticides (ie, fipronil, spinosad, and imidacloprid) show good larvicidal and adulticidal activity, compared with that of permethrin. DWFP is now seeking product development with pesticide manufacturers through the USDA’s IR-4 process to provide rapid and inexpensive registration of proven insecticides for new insect pests. For example, fipronil is the active ingredient in Maxforce® FC Roach Killer Bait Gel, a common cockroach control product used by pest control professionals in urban environments. Under the IR-4 process, mosquitoes are added as a target pest and industry then develops a product for use in the mosquito control market.
The Invasive Insect Biocontrol and Behavior Laboratory (IIBBL) seeks to develop insecticides from naturally-produced plant toxins. The goal of the IIBBL, funded by the DWFP, is to discover and develop public health pesticides and repellents for control of disease vectors, a key component of ARS’s National Program 104 and the DWFP Program.

Development of new toxicants that provide novel modes of action or that have other properties desirable for efficacy, safety, and commercialization is based on molecules with high vapor pressure. When novel toxicants are developed, they are less susceptible to enzymatic detoxification by insects and can be developed as new, fast-acting insecticides, while insecticides with current agricultural registrations can be adapted for use against blood-sucking arthropods.

The key thrust of IIBBL’s approach involves QSAR-based modeling of fast-acting pyrethroid insecticides to predict and synthesize novel compounds of a similar structure based on their known enzymatic

Figure 5: Comparison of mosquitoes surviving after 14 minute exposure to a permethrin Fire-Resistant Army Combat Uniform (FRACU) sleeve (top) and after 4 minute exposure to a FRACU sleeve treated with a fast-acting insecticide.
detoxification mechanisms in disease-carrying insects. New classes of compounds with optimized physiochemical spectrums will be then explored to develop a second generation of fast-acting insecticides. Some of these new compounds have the potential to be used on or in clothing, such as in collaborative research with MFRU scientists to find faster acting insecticides for use with military uniforms; see Figure 5. Simultaneously, IIBBL is evaluating pesticides with current agricultural registrations for their ability to control medically-important arthropods. Classes of candidate compounds obtained from existing chemical libraries and commercial sources are being screened for bioactivity via high throughput bioassays against a laboratory strain of *Ae aegypti*. Promising compounds are evaluated against additional taxa of mosquitoes and other blood-sucking arthropods including sand flies, ticks, and bed bugs, using a variety of laboratory and field bioassays. A key feature of this thrust is to evaluate laboratory toxicity in disease vectors to at least 96 hours post-exposure, since shortening the life span of a disease vector could possibly break the cycle of transmission and thereby be of great utility in vector control programs. Additionally, IIBBL scientists test, evaluate, and develop products for control on food hosts (vertebrate hosts such as cattle) and resting and breeding sites (residual and ovicidal treatments, respectively).

Research at the Natural Products Utilization Research Unit (NPURU) is concentrated in discovering natural products with insecticidal qualities from native plants. Emphasis is in finding mosquito adulticides, larvicides and repellents. NPURU scientists investigate both plant compounds and derivatives (modification of these compounds) in hopes of “enhancing” the strength of naturally active repellents and insecticides. Under the DWFP program, NPURU efforts have resulted in several potent larvicides and a repellent that is three times longer lasting and more potent than DEET.

NPURU is currently investigating terpenoid compounds common to American and Japanese Beautyberry (*Callicarpa americana* L and *C japonica* Thunb, respectively) for the repellency activity of callicarpenal and intermedeol, determined by NPURU scientists to be the responsible agents. Callicarpenal may well serve as a possible substitute for DEET, as ongoing tests with mosquitoes and ticks indicate that it is as effective as DEET and may be better tolerated by DEET-sensitive individuals.

The discovery and development of novel compounds that kill mosquitoes is a long-term and expensive endeavor, with final registration dependent upon the successful completion of a large battery of EPA-mandated tests. This testing ensures that new compounds are not only effective against mosquitoes, but that they are safe when applied to aquatic habitats or in the air and produce minimal adverse risk to human, animal, and plant health. Although the DoD-USDA ARS insecticide development program is only five years old, results obtained thus far indicate that several compounds with new modes of action have shown promise for development into future public health mosquito control products. On the horizon are new products with unique modes of action that will aid mosquito abatement and public health programs to control both larval and adult mosquitoes, especially those tolerant or resistant to older insecticides routinely used over the past 50 years.
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Effective mosquito control is critically important to reduce the transmission of debilitating human and animal diseases. For example, in zoo facilities, diseases such as avian malaria, West Nile virus, St Louis encephalitis virus, and many others may result in debilitating illness and even death.

Parrot Jungle was a roadside tourist attraction that opened its doors in 1936 about 15 miles south of Miami. This privately owned park featured a parrot show and had a small animal collection. My tenure as the horticulturist at Parrot Jungle began in 1976 where my role was maintaining the extensive collection of ornamental plants that filled the park’s 14 acres.

Over the years, I’ve used various chemicals for controlling plant pests. For mosquito control at the park, newer insecticides were used as older products lost their effectiveness. Indeed, one of the most challenging aspects of mosquito control is the intrinsic capacity of mosquito populations to change under selective pressures, such as occur during the heavy usage of a specific insecticide (Linser et al. 2007) thereby producing resistant mosquito populations.

In 1988 I became the director of horticulture of Parrot Jungle when it was purchased by a new owner and the animal collection was greatly expanded. This new position enabled me to begin working on the development of an Integrated Pest Management (IPM) program involving the use of beneficial insects, a more judicious use of insecticides, and better cultivation techniques. I had already some success with the control of spider mites on musoid plants, such as bananas and plantains, through cultivation techniques (Shimonski 1991). I was learning that insect control needed to be based on scouting, understanding the behavior and ecology of the particular insect pest and only spraying on an as-needed basis. Insecticide use seemed to eliminate susceptible individuals leaving resistant individuals to reproduce, passing on genes associated with resistance mechanisms to their offspring.

Parrot Jungle was eventually relocated and a new much larger park was built from a bare site in the City of Miami. In 2002 the 18 acre Parrot Jungle Island opened and upon its five year anniversary in 2007 the name was changed to Jungle Island to more accurately reflect the expansion of the animal collection and shows.

In 2005 I began a mosquito larval control program at the park, one of the strategies that I developed for the park’s membership in the EPA’s Pesticide Environmental Stewardship Program.

The need for this program came about because of several reasons. First, there was a successful Integrated Pest Management and Plant Health Care program in place that had allowed this newly built park to establish lush landscape throughout 18 acres without the use of insecticides or commercial fertilizers. However, adulticiding was still being performed for mosquito control on a daily basis and may have adversely affected beneficial insects, impacting an important element of our IPM program. Second, a large collection of bromeliads that numbered in the thousands was a featured part of the landscape. Unfortunately, the majority of the bromeliad species had phytotelmata where mosquito larvae could successfully breed. Phytotelmata are water collections found in leaf axils of numerous plant species, such as many bromeliads or the large ornamental bracts of the Heliconia inflorescence and even the water-holding pitchers of insectivorous plants.

Figure 1: The Green-winged Macaw, *Ara chloroptera.*
It was necessary to fog the park at least once a day in an attempt to control mosquitoes. Fogging was done every morning at sunrise before employees started the first shift at 7:00 am. Outdoor insecticidal aerosols must drift in order to be effective. Great care had to be taken so the fog would not enter the animal exhibits or pass over any bodies of water. The insecticide application was difficult to control since most mornings had at least a slight breeze and there are many buildings and exhibits throughout the park that blocked movement of the fog cloud. Ultimately this method of control was not very effective. Employees and visitors to the park would often be annoyed by mosquitoes throughout the day, and security guards at night.

In early 2005 I invited Dr George O’Meara from the University of Florida Medical Entomology Laboratory to walk through the park to give me some insight as to the possibility of a mosquito larvae control program that would complement our existing IPM program for plants. Dr O’Meara noted that the mosquitoes on the 18 acre site were most likely from the site itself since the park was actually on an 86 acre island between downtown Miami and South Beach.

A weekly mosquito larva sampling program was started on the bromeliad collection at the park. Since beds of bromeliads consisted of single species, the plan was to identify the sampling locations as individual plant species and then randomly collect, identify and count any mosquito larvae collected in each location. I also identified the species of mosquitoes that were breeding in the bromeliads.

Once the locations of the mosquito larvae were identified a group of biochemicals would be tested on the bromeliads and larvae. Prior to implementing this program, my previous experience with larval control on bromeliads had been disastrous. The chemicals had been very phytotoxic and the bromeliads burned and died. This time, however, a variety of different larvicides would be used including:

- **Bti** - *Bacillus thuringiensis* var *israeliensis*
- **Bs** - *Bacillus sphaericus*
- **Altosid®** - methoprene, an insect growth regulator
- **Arosurf® MSF** - a monomolecular surfactant film
- **Agnique® MFF** - a monomolecular surfactant film
- **Garlic Oil**

My hope was that environmentally safe methods of mosquito larvae control could be identified that were easy to apply, effective and safe for the bromeliads, the human applicator and the zoo animals. As with the other IPM components used at the park, I also wanted to make this program cost effective and eco-efficient, since the cost of this program would ultimately determine its success.

Within two months I had identified three mosquito species that were common in the bromeliad phytotelmata – *Aedes aegypti*, *Culex quinquefasciatus* and *Wyeomyia vanduzeei* – and two species found only rarely in these plants – *Cx nigripalpus* and *Wy mitchelli*.

I tested six biochemicals on the bromeliads. The 2 monomolecular films both burned and killed the bromeliads, and could no longer be used. The garlic oil was sprayed full strength directly on the foliage of several species of bromeliads that had been washed out (no larvae left in the leaf axils) as a repellent with no apparent effect. Larvae were found in the leaf axils within a week.
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The Bti, Bs and Altosid all proved successful in controlling larvae with no apparent damage to any of the bromeliad species. Success was determined during the sampling the following week. If no larvae were found in bromeliads that had been treated previously, the treatment was considered a success. These three products were applied to the bromeliads by using a homemade shaker made from a half gallon plastic bottle with holes punctured in the bottom.

I also tested the Bti, Bs and the Altosid on the three mosquito species in plastic containers. All three products successfully controlled the mosquito species. The Bti and Bs usually killed all larvae within 24 hours. Since the Altosid acts as an insect growth regulator and prevents adult emergence, results could not be determined for up to a week. This became an issue when the bromeliads would be sampled weekly. The larvae would have to be collected and stored for up to a week to determine if the Altosid was working. Eventually in the interest of efficiency Altosid was no longer applied to bromeliads.

One other species of mosquito was collected offsite and tested with the three previous mosquito species. This was *Deinocerities cancer*, the crab hole mosquito, whose larvae develop in water in the burrows of the native blue land crab, *Cardisoma guanhumi*. The larvae were collected at the Montgomery Botanical Center in Coral Gables, one mile from the original Parrot Jungle and about 15 miles from Jungle Island. This species of land crab lives in holes that it digs down to the water table. Since the original Parrot Jungle had hundreds of land crab holes onsite and nearby and since the main blood host of *De cancer* is birds (the majority of the animal collection at this park was birds), I thought it would be enlightening to test this mosquito in the same manner as the others. The Bti, Bs and Altosid were all effective in killing *De cancer*.

After two months of sampling larvae and testing biochemicals it appeared that mosquito larvae were being effectively controlled in the bromeliad collection. There was less of a mosquito problem in the park, but often the action threshold was still being met. The action threshold was four mosquitoes landing on my pant legs within two minutes of walking into an area of the park.

The main source of mosquitoes in the park turned out to be the 20 storm drains located on the property. To collect the larvae in the storm drains I used a five inch wide brine shrimp net on a 10 foot long PVC pole. The pole would be lowered into the drain, five sweeps would be made to collect the larvae. The sampling was done once a week concurrently with bromeliad sampling. There are different sized drains that hold between 70 and 90 square feet of surface water.

Only two species of mosquito were found in the drains: *Ae aegypti* and *Cx quinquefasciatus*. In some drains, *Cx quinquefasciatus* seemed to number in the thousands. I began to test Bti, Bs, methoprene and the MMFs in the drains. All of these bio-rational chemicals work to some extent. After three years I have come to use Bti, Bs and the MMFs for storm drain control on a rotational basis because I would like to reduce the likelihood of resistance being developed in the local mosquito population. Methoprene is not used in the storm drains for the same reason it is no longer used on the bromeliads; the mosquito larvae would have to be collected and stored for over a week to determine efficacy.

Once the storm drains were brought into the weekly sampling and biochemical testing programs, we no longer approached the action threshold. Since August 2005 it has not been necessary to spray for the control of mosquitoes.
at Jungle Island. This is significant considering I had been spraying to control mosquitoes almost daily since 1975 – first at Parrot Jungle and then briefly at Parrot Jungle Island.

It has been very important to scout for adult mosquitoes on an almost daily basis. I have been continuously challenged whenever the action threshold has been approached. The breeding flock of flamingos builds their nests on an island in the main lake onsite. During breeding season the island is kept flooded so that the birds can maintain their nests of mud. We now let the island dry out every few days to kill the Cx quinquefasciatus larvae that are present. Automatic animal watering basins, aquatic reptile housing, and anything that can hold water for a few days needs to be inspected and cleaned on a regular basis. I have found that sanitation is also a very important component of an effective and comprehensive mosquito control program. The success of Dr William Gorgas with the control of the yellow fever mosquito, Ae aegypti in Havana and the Panama Canal in the early 1900s shows chemical control is not the only method that needs to be considered for the control of mosquitoes. Sanitation and sound construction methods to remove man-made sites for water retention may be more critical in many instances than the use of chemicals (Martin 1947).

This mosquito larvae control program has been very successful, and cost effective. The park saves about $7000 a year in chemical and labor costs. Implementation of an IPM program that does not require aerosol spraying is an advantage because beneficial insects are not being impacted, therefore the populations of insect predators can establish themselves on the site. Invasions of plant pathogenic insects are maintained below action and economic thresholds. A recent invasion by the fig whitefly at Jungle Island has been under the control of an established population of insect predators. I do not believe this would be possible if aerosol adulticiding, which would negatively impact beneficial insect populations, was in place for the control of mosquitoes at the park.

ACKNOWLEDGMENTS

There are many people that patiently encouraged me and answered my numerous queries. I am very grateful to Dr George O’Meara from the University of Florida, who first told me that this control program could be successful and has always answered my never ending e-mails. Candy Brassard of the EPA’s Pesticide Environmental Stewardship Program constantly encouraged me to work through all the little problems and helped immensely. Larry Elworth, the Executive Director of the Center for Agricultural Partnerships generously provided me with a grant (and much insight) to run this program. Valent BioSciences Corporation via Peter DeChant donated the Bti and Bs. I am indebted to the owners of Jungle Island and the staff of Montgomery Botanical Center for the use of their facilities. Lastly, I want to thank my many interns who became quite adept at collecting larvae out of bromeliads.

REFERENCES CITED


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305-400-7218
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Figure 4: The author collects mosquito larvae from a storm drain, with his assistant, a young Emu.
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As we in the mosquito control profession prepare to enter the second decade of the 21st century, a number of formidable problems are poised to challenge our capacity to provide those vital mosquito control services on which our public depends. Historically, technological advances, adherence to sound science, the enviable work ethic of mosquito control professionals, and a supportive populace provided enough slack in the system to absorb the onslaught of environmental activist harassment. Unfortunately, those with agendas profoundly inimical to ours are now utilizing their considerable economic clout to achieve their ends through the courts. This entails significant expenditures for legal counsel, but is deemed worthy of the ultimate goal (in my opinion) – the dismantling of our profession as now configured. The activist community is banking on the success of placing the intricate, multi-faceted exercise of integrated mosquito management methodologies by government and private individuals in the hands of a legal system ill-equipped to understand its complex scientific underpinnings and unwilling (or unable, in the case of the Clean Water Act) to interpret these methodologies in a cost/benefit context.

It’s as if activist groups have discovered a new and increasingly powerful regulatory toy with which to challenge pesticide use and are determined to use it in more and more creative ways to achieve their aims – whatever the consequences. One need only witness the acerbity with which “endocrine disruptors,” unrealistic endangered species protections and “inerts” disclosure have been discovered and doggedly pursued to realize that the list of prospective environmental insults, real and imagined, with which to badger our profession are well nigh limitless.

The three most prominent problems noted above will exert an even greater impact upon our association in light of their tie-in with the Clean Water Act (CWA) permitting issue now confronting us. Let’s take a quick look at each one.

**ENDOCRINE DISRUPTORS**

Environmentalists are beginning to push for increased protection of waterways from contamination by chemicals thought to have the potential to either mimic or block normal endocrine functioning, supposedly leading to developmental and other health effects. This comes at the same time that the US Environmental Protection Agency’s (EPA) Office of Pesticide Programs and Office of Water are attempting to harmonize the different risk assessment methodologies used for the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and CWA. The Center for Biological Diversity (CBD) is asking EPA to establish or revise national water quality criteria for certain reputed endocrine disrupting chemicals (EDC) and chemical classes “to reflect the latest scientific knowledge about their impacts.” In its petition, CBD cites new studies ostensibly depicting the harmful effects EDCs are having on water quality, fish, aquatic invertebrates, wildlife and humans. Water quality standards already exist for chlorpyriphos and diazinon, two of the targeted chemicals. According to the Office of Water at EPA, a “water quality criterion is a level of a pollutant or other measurable substance in water that, when met, will protect aquatic life and/or human health.” There is no cost/benefit analysis associated with the criterion or whether it can even be met with current technology. However, CBD states that existing standards “are not strong enough to protect against endocrine disrupting harm. It is now known that infinitesimally small levels of exposure may cause endocrine or reproductive abnormalities, and current regulatory levels are insufficient to protect against water quality impairment.” Indeed, CBD acknowledges that regulating these substances might pose a unique challenge in that they may defy the typical ‘dose makes the poison’ paradigm in standard toxicology. The petition also states that, “the timing of the exposure is highly critical to the outcome of the exposure (with fetal or early post-natal exposure being the most detrimental due to their potential permanent effects); EDCs act at environmentally relevant doses with complex dose-response curves and the effects of EDCs may not be limited to the individual but can be transmitted to subsequent generations via the germ line.” We can thus expect our products to undergo a whole new layer of regulation based on laboratory studies uncontrolled for phytoes-
trogens and any other number of confounding variables unknown at this time. In fact, the terminology the petition uses to demand revision of long-standing regulatory practices to accommodate EDCs is eerily reminiscent of that underlying the precautionary principle. This is an open-ended issue, with staggering unpredictability of consequences. With detection methodologies becoming increasingly refined, there is no doubt that EDCs will eventually be found everywhere, and there will be no reliable means to tease out the actual effects of those associated with public health pesticides from background effects of caffeine, birth control pills, etc. Nonetheless, you can be assured that activists will, in due course, call for severe restrictions or elimination of pesticides thought to exhibit these properties—and they’ll use the language of the CWA to accomplish it.

EPA, which has been mandated to develop and implement an EDC screening program, has listed 73 chemicals that are to receive a tier 1 scrutiny by the Agency. The list does not, in EPA’s view, reflect any presupposition that the products are endocrine disruptors, but merely that they represent chemicals in widespread use. The products of interest to mosquito control are:

1. Ciferluthrin
2. Cypermethrin
3. Dichlorovos
4. Imidocloprid
5. Malathion
6. Permethrin
7. Piperonyl Butoxide
8. Resmethrin

The methodologies involved in determination of EDC status is in its infancy and will probably undergo significant improvements in accuracy and predictive value in the coming years. In the meantime, we can do our best to ensure that the science employed is sound, for the implications are vast. Look for the constellation of putative effects from EDCs to undergo considerable change in the coming years, with any number of developmental or mutagenic defects becoming easily attributable to EDCs, despite the real cause.

**ENDANGERED SPECIES ACT**

A presentation at a recent Pesticide Program Dialogue Committee EPA implementation of their Endangered Species Protection Program centered on the recent National Oceanic and Space Administration Fisheries Service (NOAAFS) Biological Opinion on malathion effects on salmonids. It appears that NOAAFS disregarded EPA comments tendered on behalf of the draft opinion. The Agency took the Biological Opinion to task on the following issues:

**Lack of Transparency**

EPA could not determine what methodology NOAAFS used to collect information. In addition, EPA was puzzled as to why some data that it had made available to NOAAFS was utilized and some was ignored. Furthermore, there appeared to be no clear rationale supporting how NOAAFS reconciled conflicting information in their assessment.

**Flawed determinations of jeopardy**

NOAAFS determines species jeopardy based on the probabilities of species extinction or persistence of the populations that comprise the species. Yet, their Biological Opinion acknowledged severe limitations in their probabilistically derived risk assessments due to lack of data, non-normal data distributions and quality assurance/control. In addition, NOAAFS recognized that these limitations, coupled with the inherent complexity of the proposed action, produce an unquantifiable degree of uncertainty that compromises the reliability and validity of the assessments. Nonetheless, NOAAFS uses this methodology to evaluate risks to salmonids. Go figure.

**Status of Species within Evolutionarily Significant Units (ESU)**

The Service appears to draw conclusions based at a species level rather than contemplating risks to specific ESUs. Neither does the Biological Opinion address whether a particular designated critical habitat could support the recovery of a given ESU. Furthermore, the Biological Opinion does not take into consideration the actual current status of the ESU in question. This is crucial in that many ESUs show increases rather than decreases in spawners and fluctuations and rebounds have been documented over the period where pesticides have been used in the area. Evidently, the populations demonstrate substantial survivability and recovery capabilities inimical to jeopardy status. Yet, the Service ignores this in their opinion.

Particularly egregious was the National Marine Fisheries Service’s (NMFS) proposed Reasonable Prudent Alternative (RPA) of a 1000 foot buffer for aerial sprays. This had to result from their specifically ignoring EPA’s disputation of NMFS’s use of a 30 foot above ground level release point for aerial adulticiding. This does not appear to meet the “sound science” platform of the new Administrator and that all should be vigilant in ensuring that faulty assumptions like this not be allowed to become precedent and further invalidate the modeling processes used by the services in their...
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attempts to comply with ESA. Be advised that EPA is not obliged to implement the RPAs noted in the Biological Opinion and, thankfully, they didn’t. The Agency reduced the buffers to 100 foot or more, with the actual width depending upon application rate, droplet size and water body size. As of this writing, EPA and NOAAFS are collaborating with the US Geological Survey on a new monitoring design. In addition, there are problems with harmonizing differing definitions of “best available data,” impacts of mixtures and inert ingredients, sub-lethal effects and what constitutes “likely adverse effects.” We’ll keep you posted on progress and potential impacts on our operations.

INERTS DISCLOSURE

On August 1, 2006, EPA was petitioned by the Northwest Coalition for Alternatives to Pesticides, Western Environmental Law Center, and the state of California to require that the identities of inert ingredients included in the formulation be listed on the pesticide label. The demands were quite expansive and EPA declined to immediately accede to a good portion of the petition, preferring to proceed cautiously in a potentially contentious environment. EPA did, however, agree that it has the authority, in certain circumstances, for limited disclosure of confidential information to medical professionals to aid in treatment protocols as promulgated in FIFRA Section 12(a)(2)(d), despite exclusion of disclosure of the identity and/or percent quantity of inert ingredients in FIFRA Section 10(d)(1). Indeed, even as early as 1975 in 40 CFR 156.10(g) (7) EPA had determined that “the Administrator may require the name of any inert ingredient(s) to be listed in the ingredient statement if he determines that such ingredient(s) may pose a hazard to man or the environment.” Furthermore, the Agency published a Federal Register notice (52 FR 13305) on 22 April of 1987 promulgating policies on regulation of pesticides containing toxic inerts. On December 23, 2009, EPA initiated rulemaking to expand public availability of inert ingredient identities, and is now accepting public comments to assist in establishing the scope and approach of the rulemaking. This is an incredibly “sticky wicket,” and will prove problematic to implement without opening the doors to abuse by activists. On one hand, EPA is concerned that consumers have access to the information needed to make informed decisions about the potential hazards posed by the pesticides they purchase. This is perfectly reasonable. However, the manner in which the toxicity of these inerts is disclosed to the public for them to make a reasoned decision is fraught with problems. For instance, is there a de minimis concentration below which a potentially hazardous inert would not be listed on the label? Unfortunately, EPA is not inclined to provide a de minimis factor, arguing that such a threshold might compromise market forces driving provision of less hazardous inerts in formulations.

The key issue, in my opinion, is whether disclosure of an inert on the label actually provides useful information to the consumer. How would consumers interpret and evaluate risk based on mere disclosure? This is critical, as you can imagine that ingredients requiring disclosure will be subject to gross exaggeration of their risks by activists over the Internet and in the courts.

ENVIRONMENTAL JUSTICE

It’s certainly arguable that the environmental justice agenda being pushed by the current administration and its majority allies in congress has provided the ideal medium in which an activist agenda can flourish and propagate – and so it has. “What do you mean you can’t build a perpetual motion machine? How could you possibly be against clean energy! You must be in the employ of Big Oil!” It’s difficult to effectively argue against that style of fallacious argument, especially in the 15-second sound bite format favored in today’s society. I’m actually quite mindful of the rationale, however specious, behind new initiatives investigating means to reduce pollution of our waters, identify and regulate “endocrine disruptors,” provide enhanced protection of endangered species, and institute public disclosure of inert ingredients in pesticides. Parts of all these measures have some real merit. Unfortunately, these problems can be all too easily demagogued by politicians intent on influencing the regulatory process for their own ends. This is particularly egregious when the legislative and executive branches of the federal government are of the same mind in the regulation of critical public health and agricultural sectors. Add in a public that all too often obtains its information from suspect Internet sites and widespread support for problematic legislation and environmental policy is the result.

In recent years momentum has been growing towards adoption of a hazards-based regulatory environment to replace the risk-based paradigm under which we have labored for so long. This could be disastrous if allowed to become an integral part of the regulatory landscape. Hazard-based assessment of pesticides is based on possibility of harm, whereas risk-based assessment is grounded in the probability of harm. Risk is far more complex,
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as it involves the use of chemicals in a real-world context, with its innumerable interactions resulting in infinite outcomes. This may seem a subtle difference, but is actually quite profound. Indeed, hazards can be found everywhere if one is looking for them outside of an exposure context. In fact, it could be said that all substances have at least the potential to be hazardous if used improperly. As a result, regulation of substances becomes politicized as a necessity, with those viewed favorably by regulatory establishment, e.g. “natural” or “exempt” products, given a pass, whereas synthetics become the object of increasingly burdensome and counterproductive scrutiny. With the continual refinement of detection methods, regulatory policy will become ever more restrictive and a reduction in available control program elements will be the inevitable result.

This hazard-based regulatory approach has its share of irony too. When enacted within a comprehensive mosquito control program, it can produce particularly pernicious adverse effects on those it claims to protect. Prescriptions to public health pesticide use on the basis of vanishingly small potential harm they pose often result in needless exposure of humans and animals to vector-borne disease. A preventive approach to public health at this point is thus suborned to the precautionary principle. That the most technologically advanced society on this earth in the 21st century would knowingly subject its citizenry to a manifest risk of preventable diseases based on theoretical exposures several orders of magnitude less than even remotely foreseeable in mosquito control operations is quite extraordinary – and a betrayal of the Enlightenment.

So, what must we do to bring a measure of rationality to this politically-charged regulatory atmosphere? First and foremost is to educate the citizenry at all levels through the media and educational institutions. Inform the children, teens, parents and educators so that they can further the message that properly practiced integrated mosquito management is the most efficient and least risky method to reduce the impact of mosquitoes on human and animal life. This presupposes a populace suitably skeptical about claims on all sides of every issue and fully qualified to evaluate risk in a cost/benefit context. Armed with an informed viewpoint, the citizenry can then compel their legislators to craft laws that reflect a coherent appreciation of the role risk plays in all human endeavors.

Probably the most effective means to communicate our message is to present it in a manner that affirms rather than challenges peoples values. Research has shown than individuals filter scientific evidence through a prism of broad cultural and moral outlooks. Thus, people who value personal initiative and who respect authority tend to be dismissive of evidence of environmental risks, which would threaten commerce and industry as entities they admire. Those ascribing to more communitarian values, on the other hand, tend to view commerce and industry as sources of inequality and pose unacceptable environmental risks. Researchers have termed this “cultural cognition” and it is something with which we contend daily. The fact that most of the public is not in a position to evaluate data themselves leads them to rely on experts, generally those which are perceived to share their values. Again, this seems quite logical. Those of a more egalitarian bent might thus look more favorably at mosquito control if our operations were seen to protect small children and wildlife and not just killing mosquitoes. We also need to identify and enlist the assistance of a wide variety of experts that support our methodologies. People will tend to look more openly at an issue when a credible expert or person of high stature in their own value peer group accepts the evidence. A public willing to openly weigh the risks, without cultural bias, is really the most for which we can hope. It’s our task, then, to identify the means by which we can promulgate our message without threatening the values of those whose support we seek.

It’s imperative, though, that the mosquito control profession go beyond educational outreach. Defend your program and don’t be shy about it. Don’t confuse acting professionally with tolerating abuse that tacitly threatens our profession, and, by extension, the health and welfare of our families as well. Remember and take pride in your profession’s pedigree. At core we are in the business of saving lives – and I can think of no higher calling.
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