Wing Beats magazine

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Lynn Haven, FL

GEORGIA MOSQUITO CONTROL ASSOCIATION

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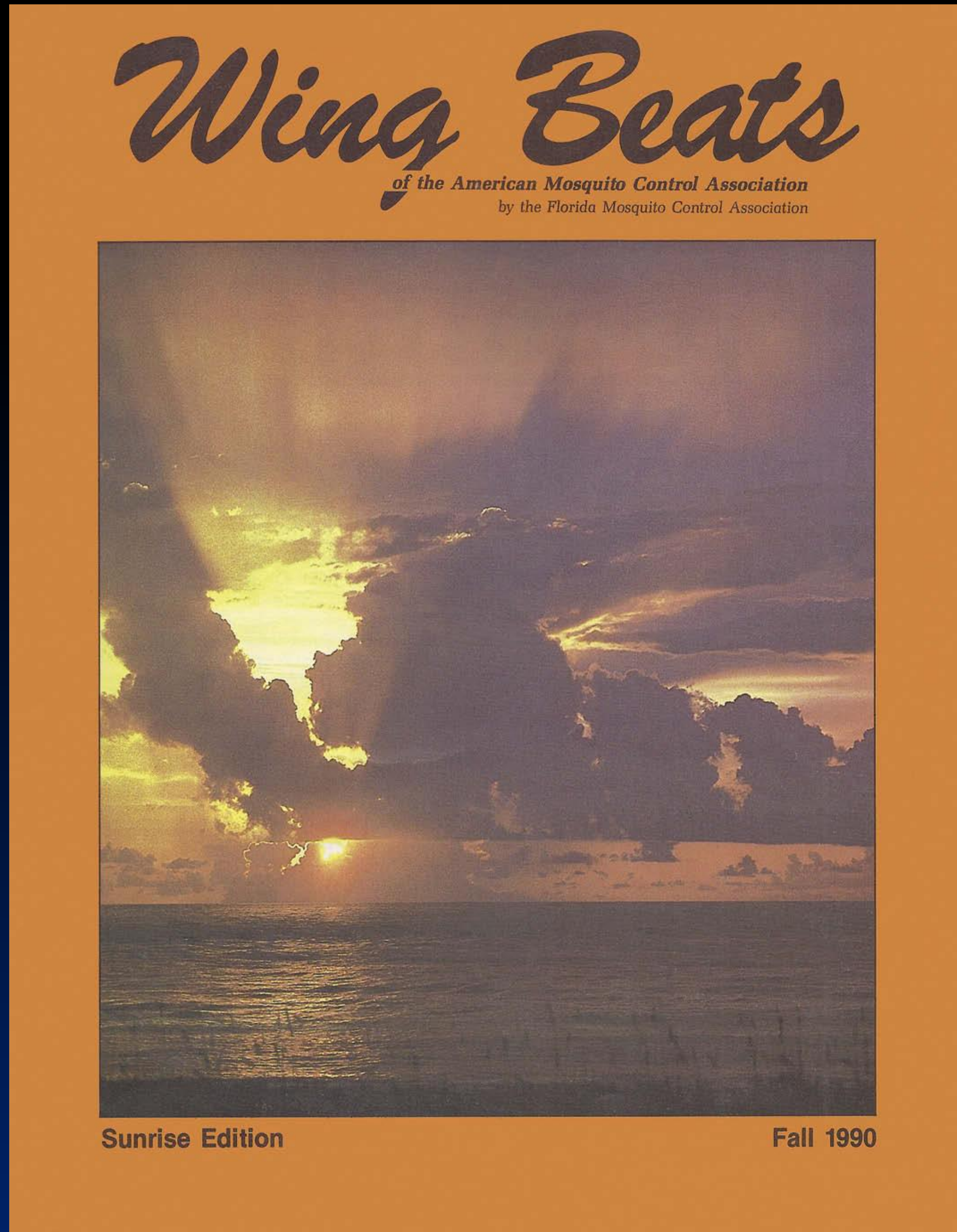
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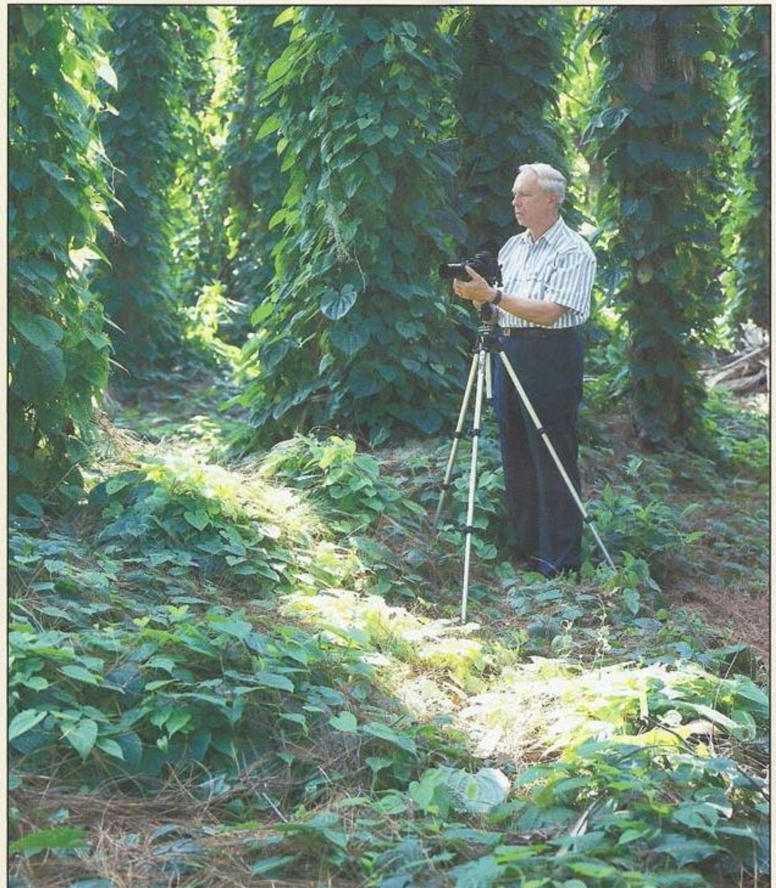

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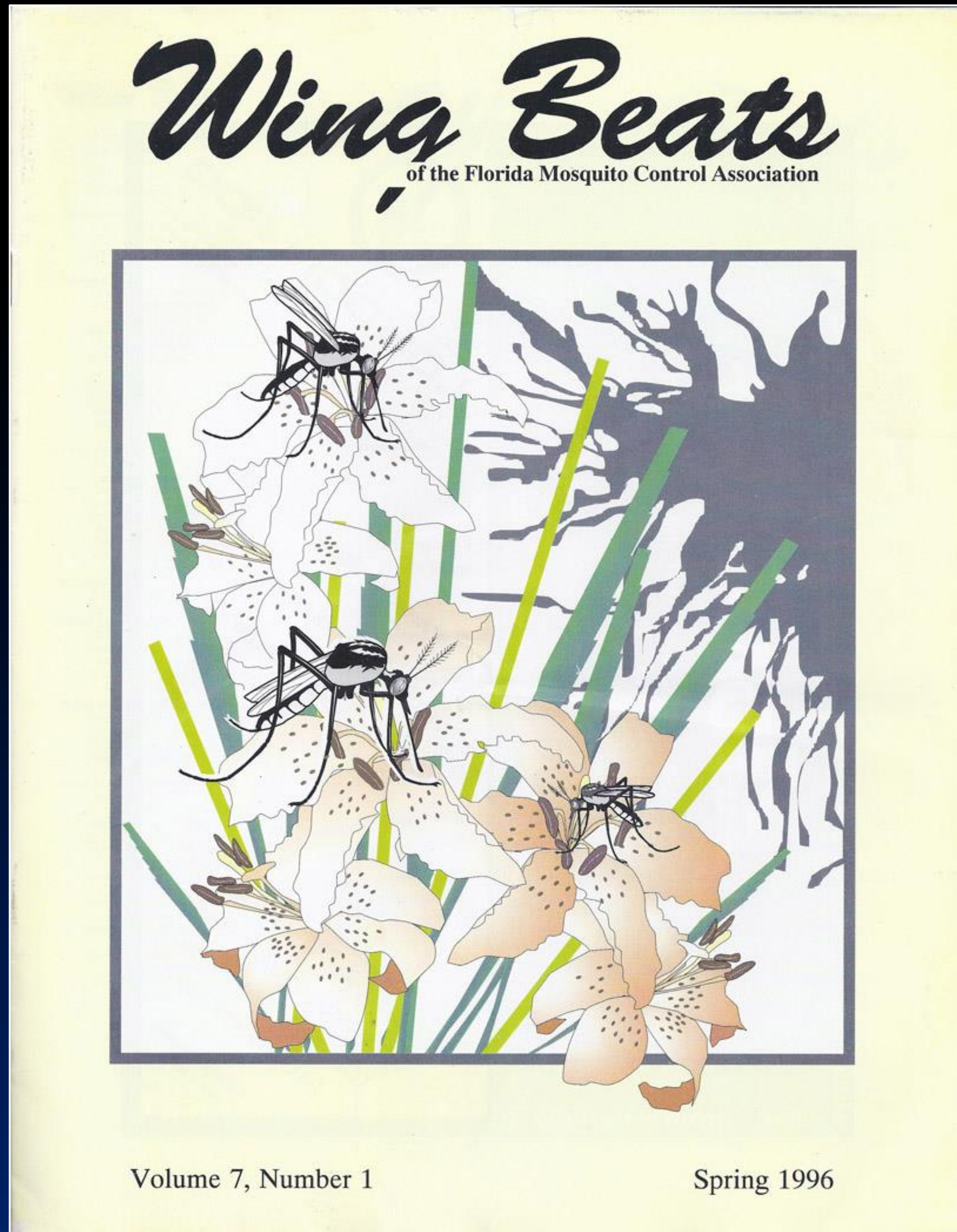
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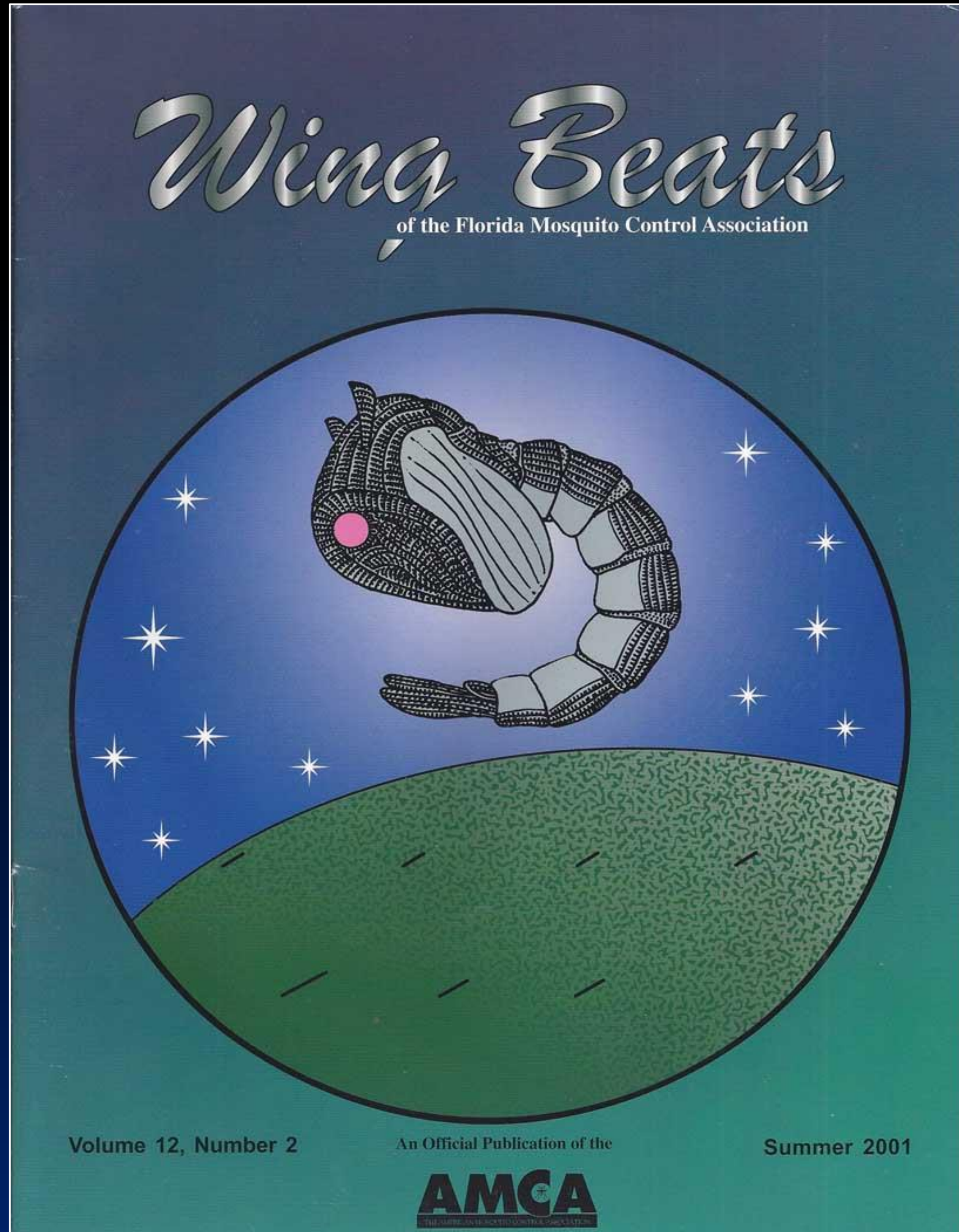
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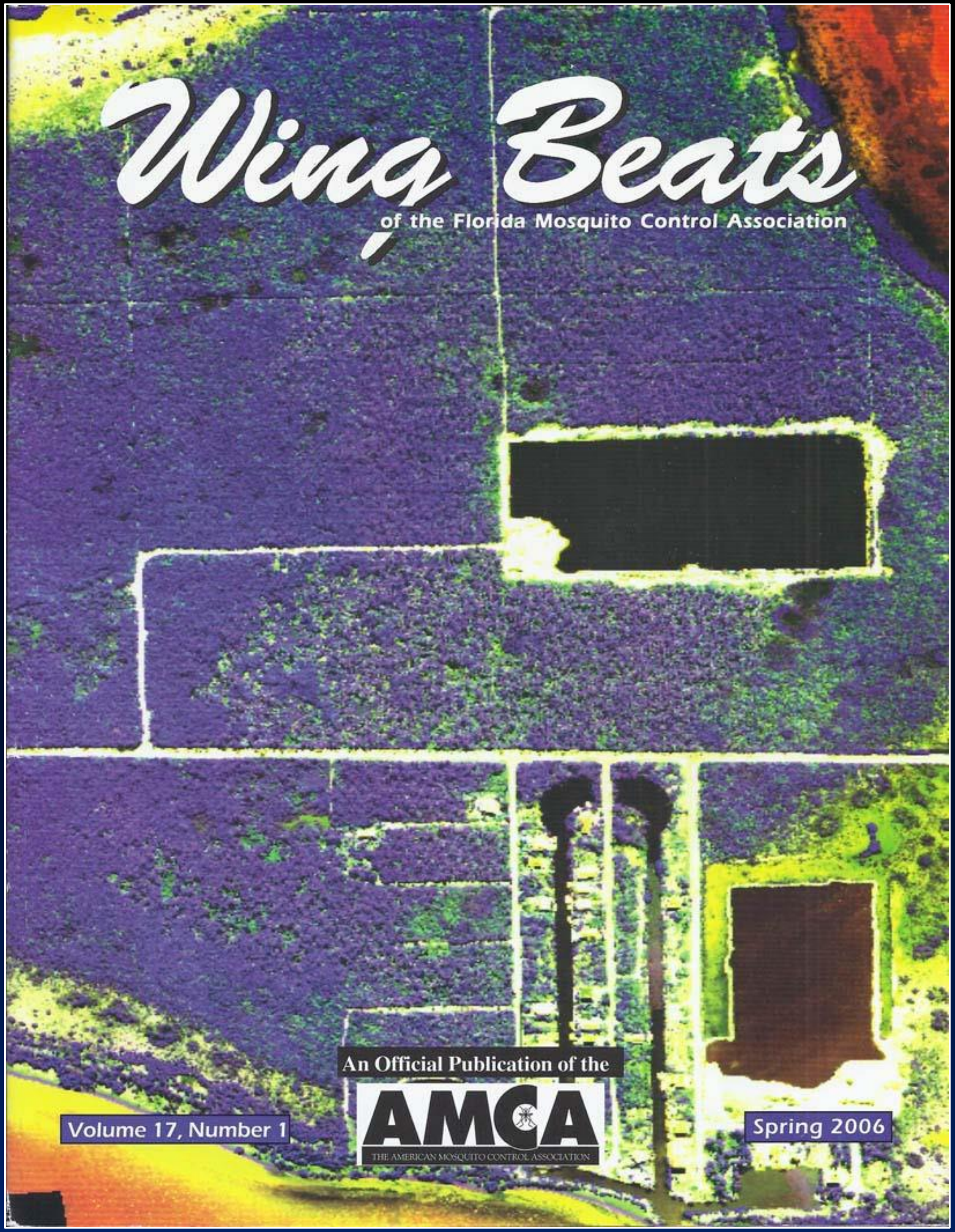
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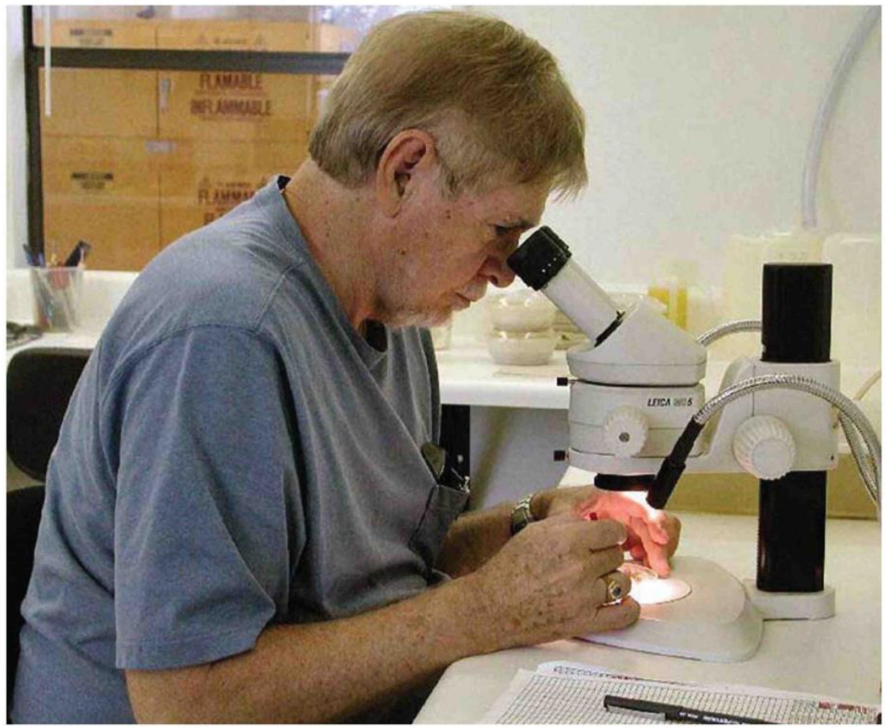

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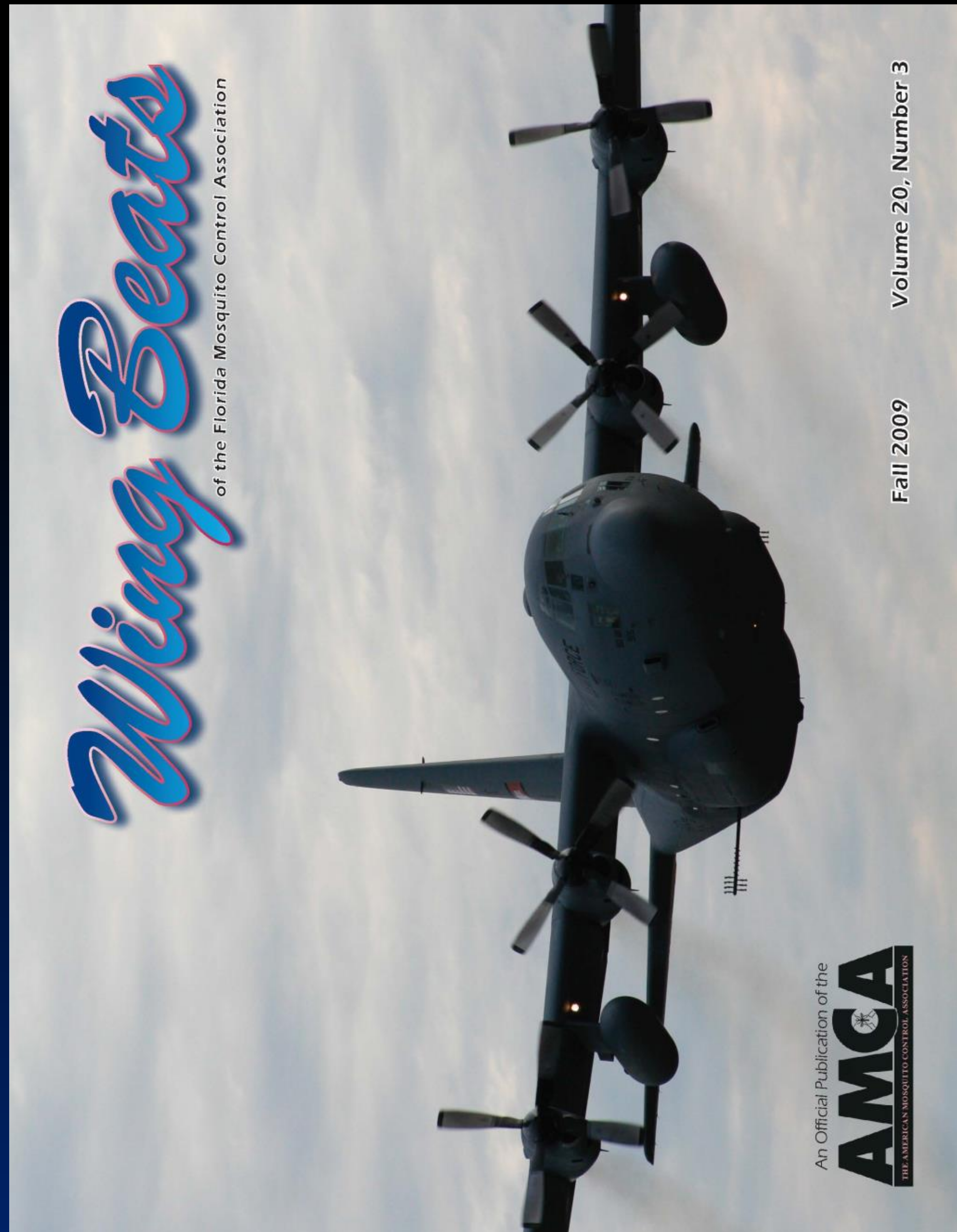
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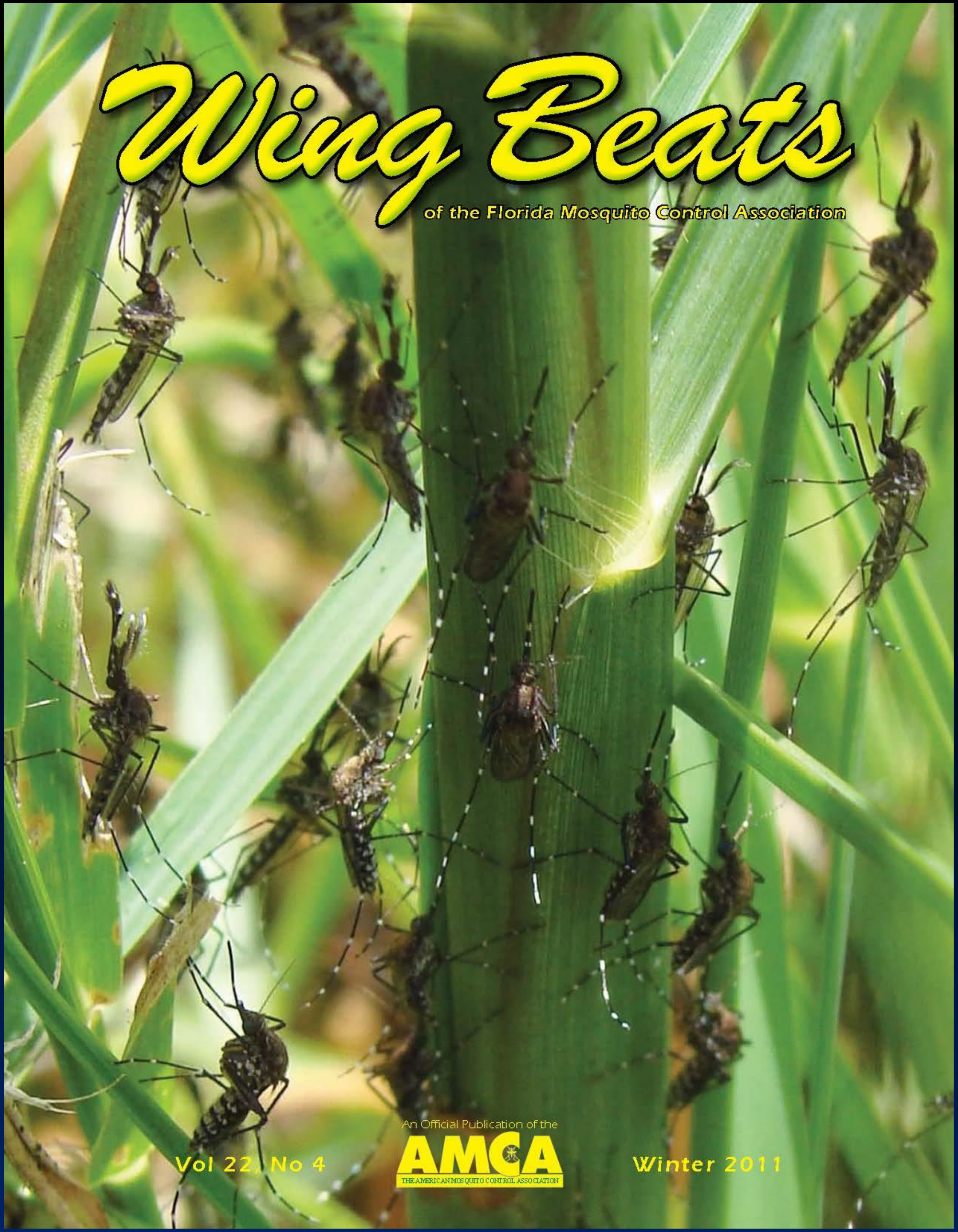
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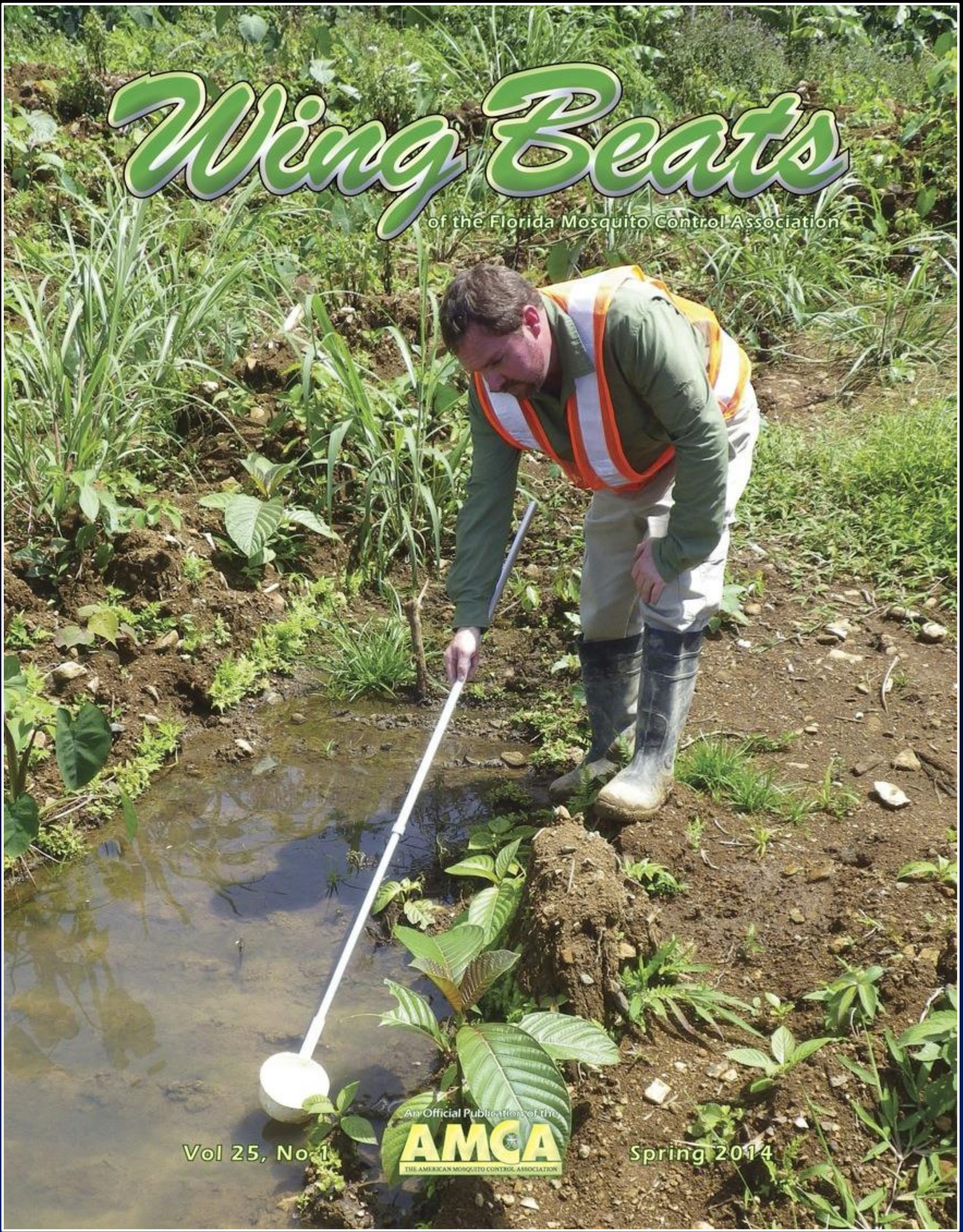
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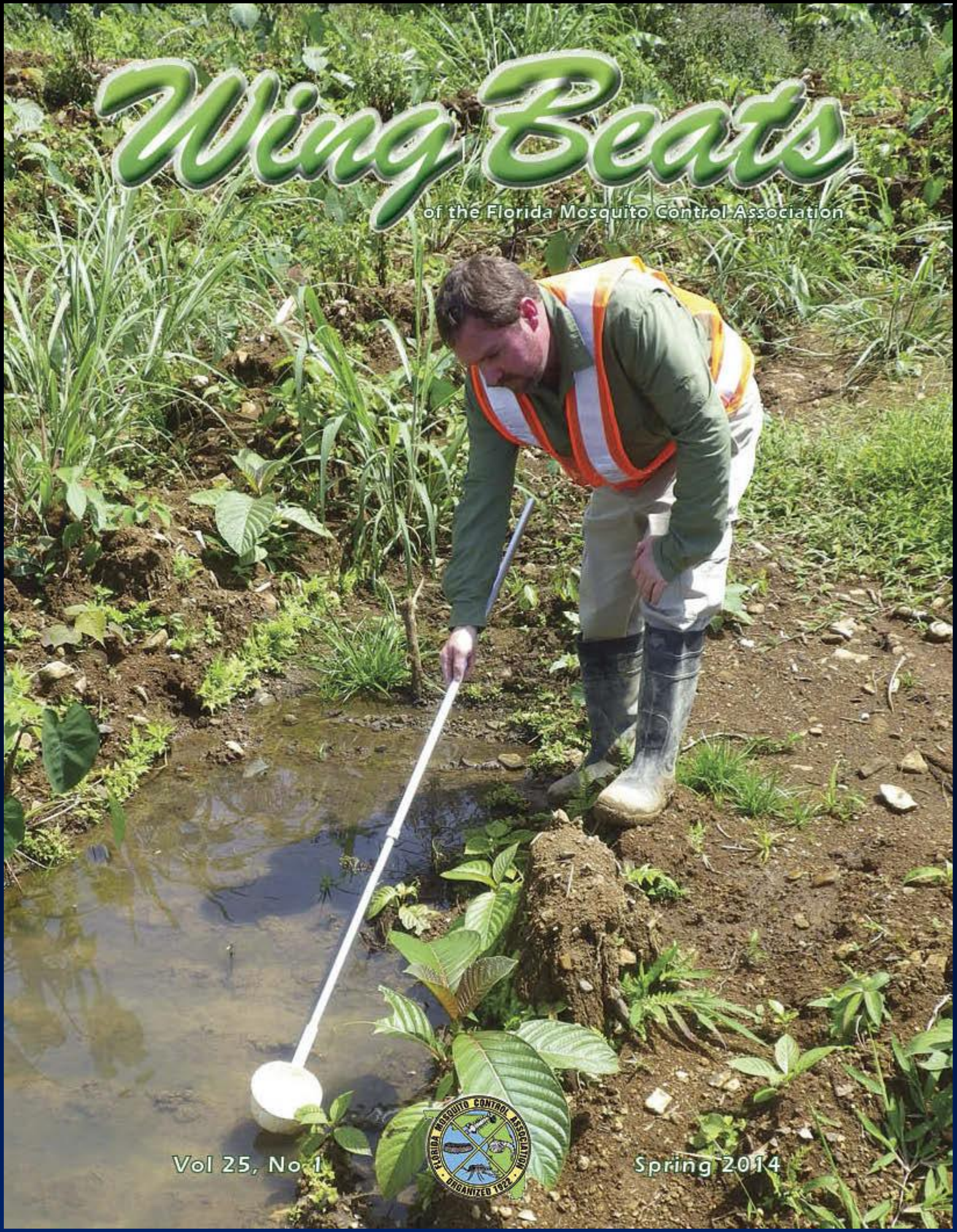
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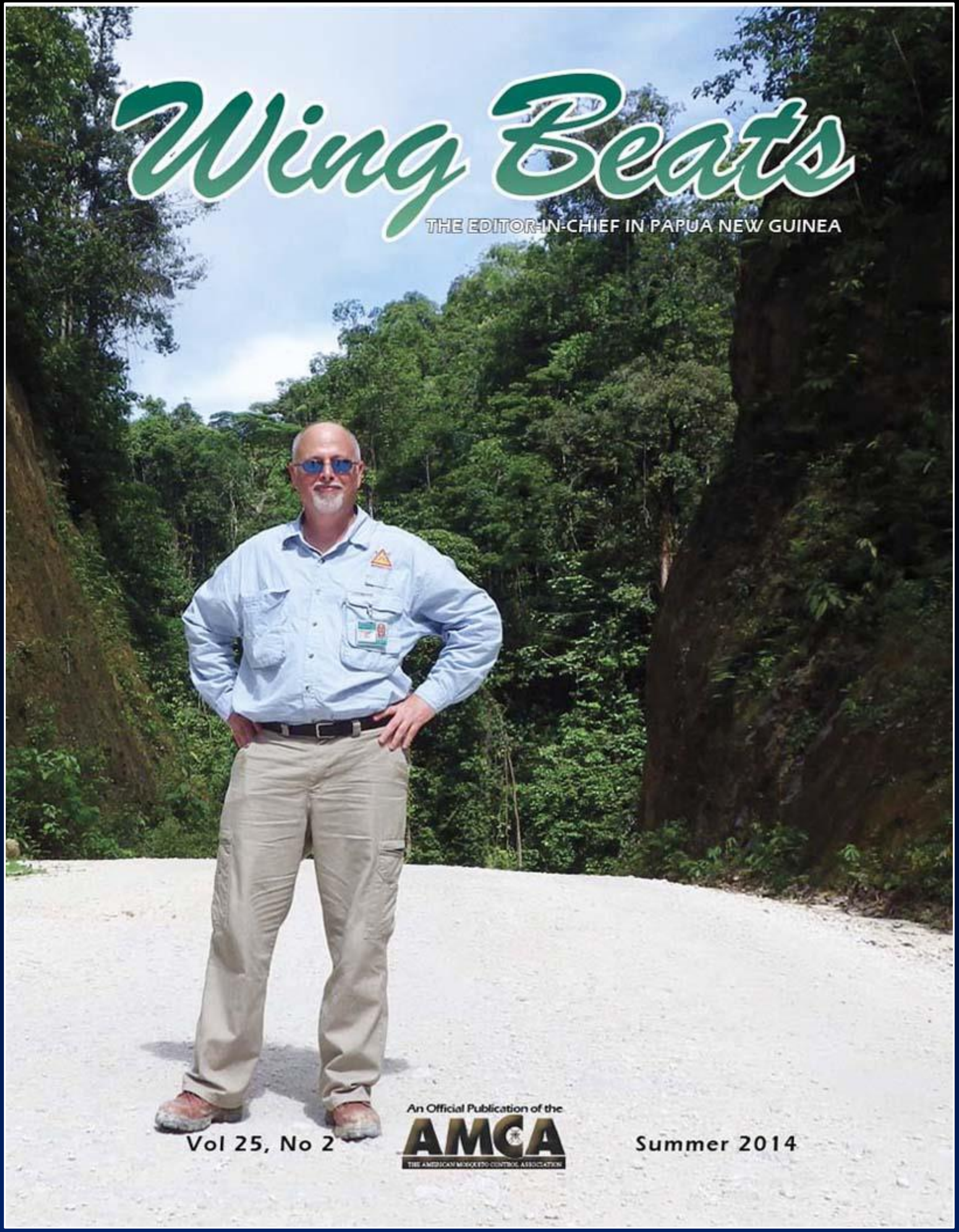
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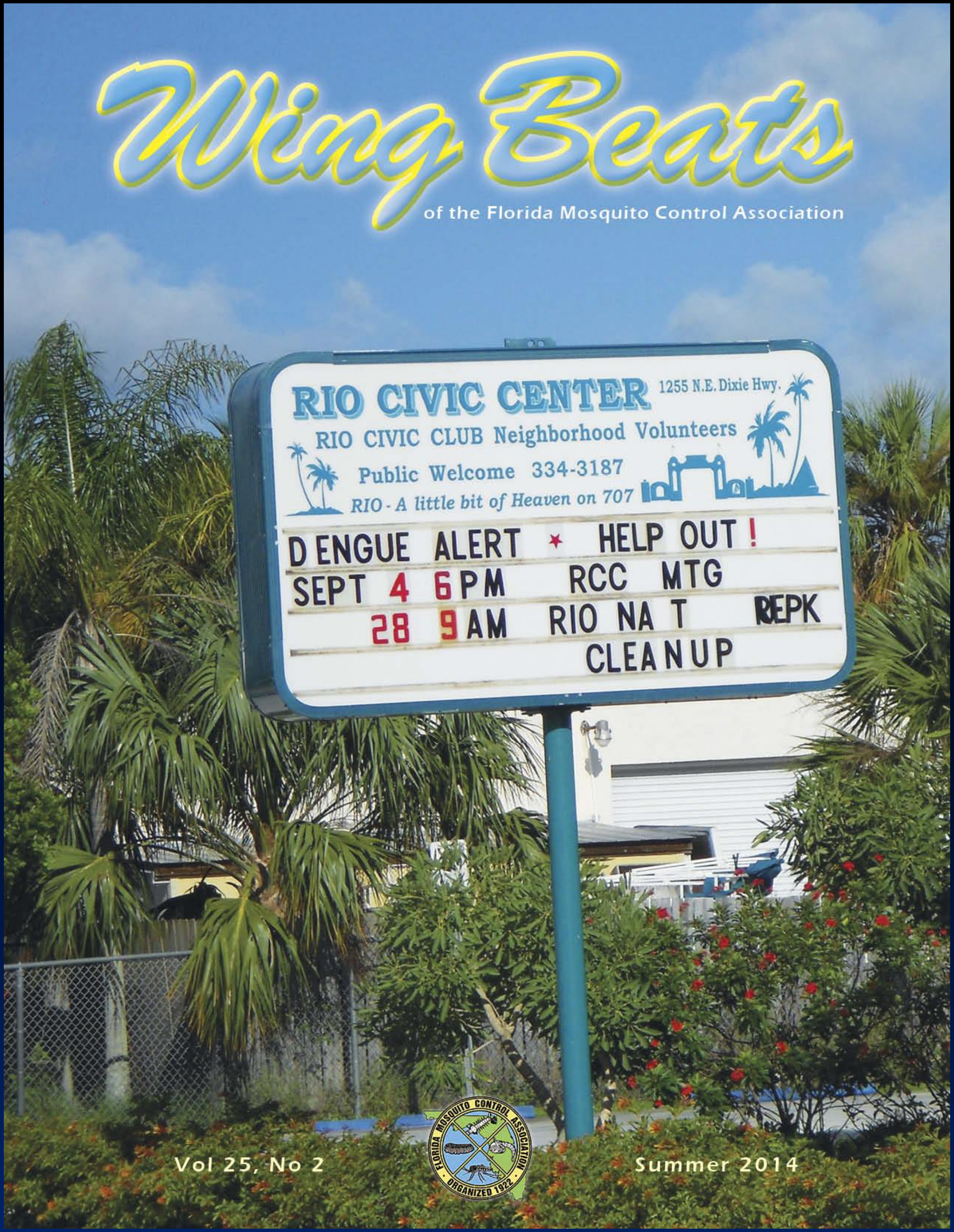
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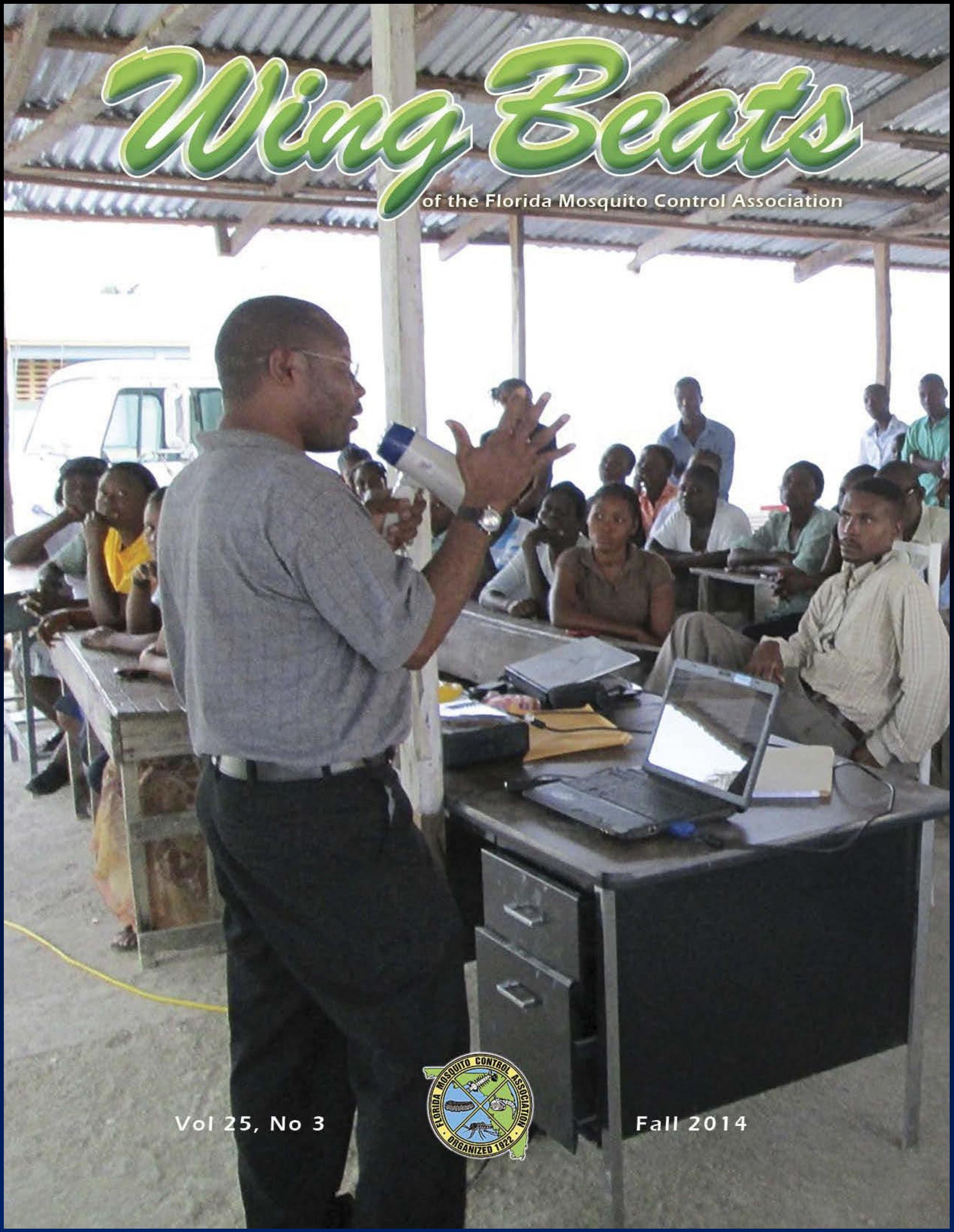
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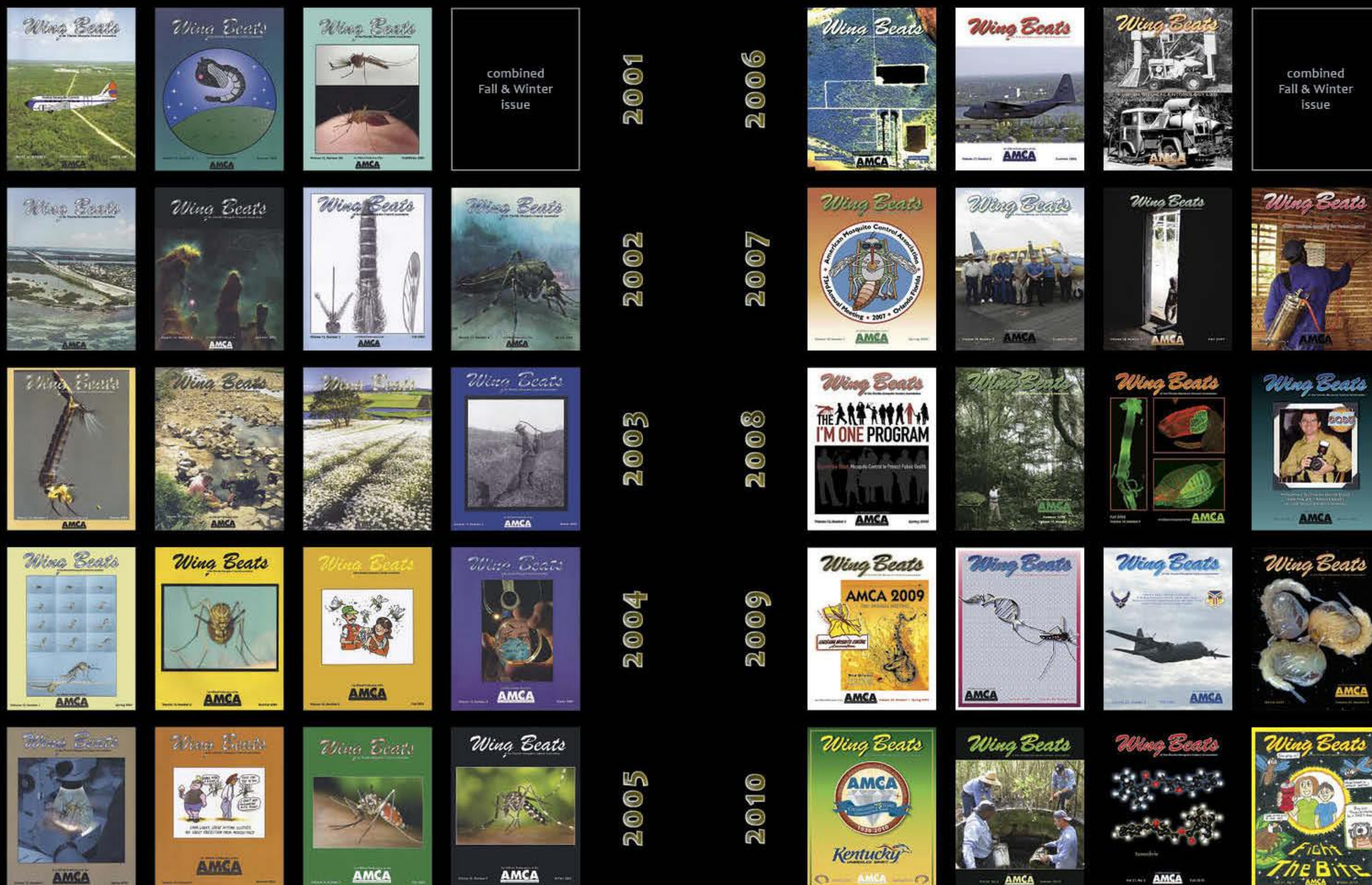
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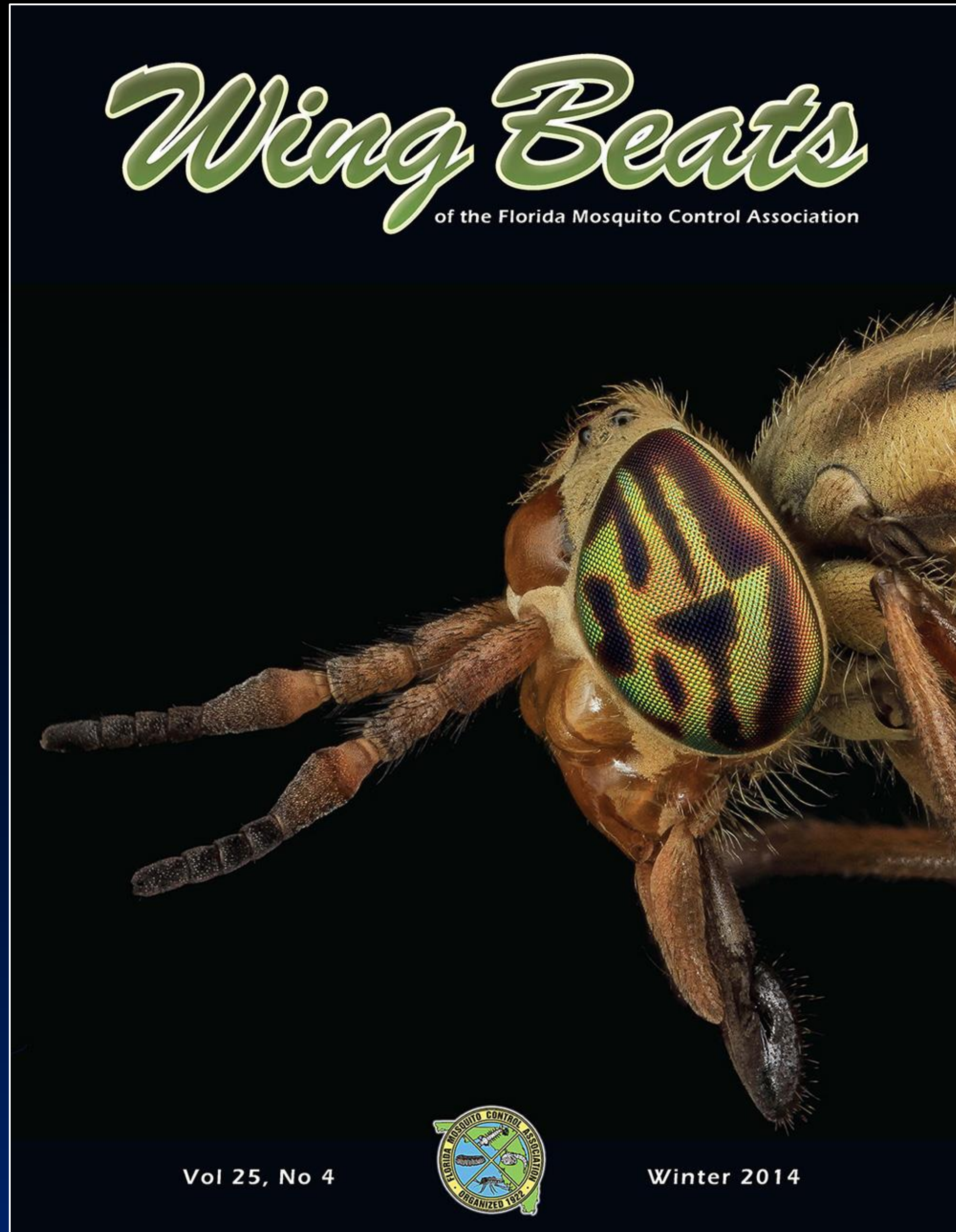
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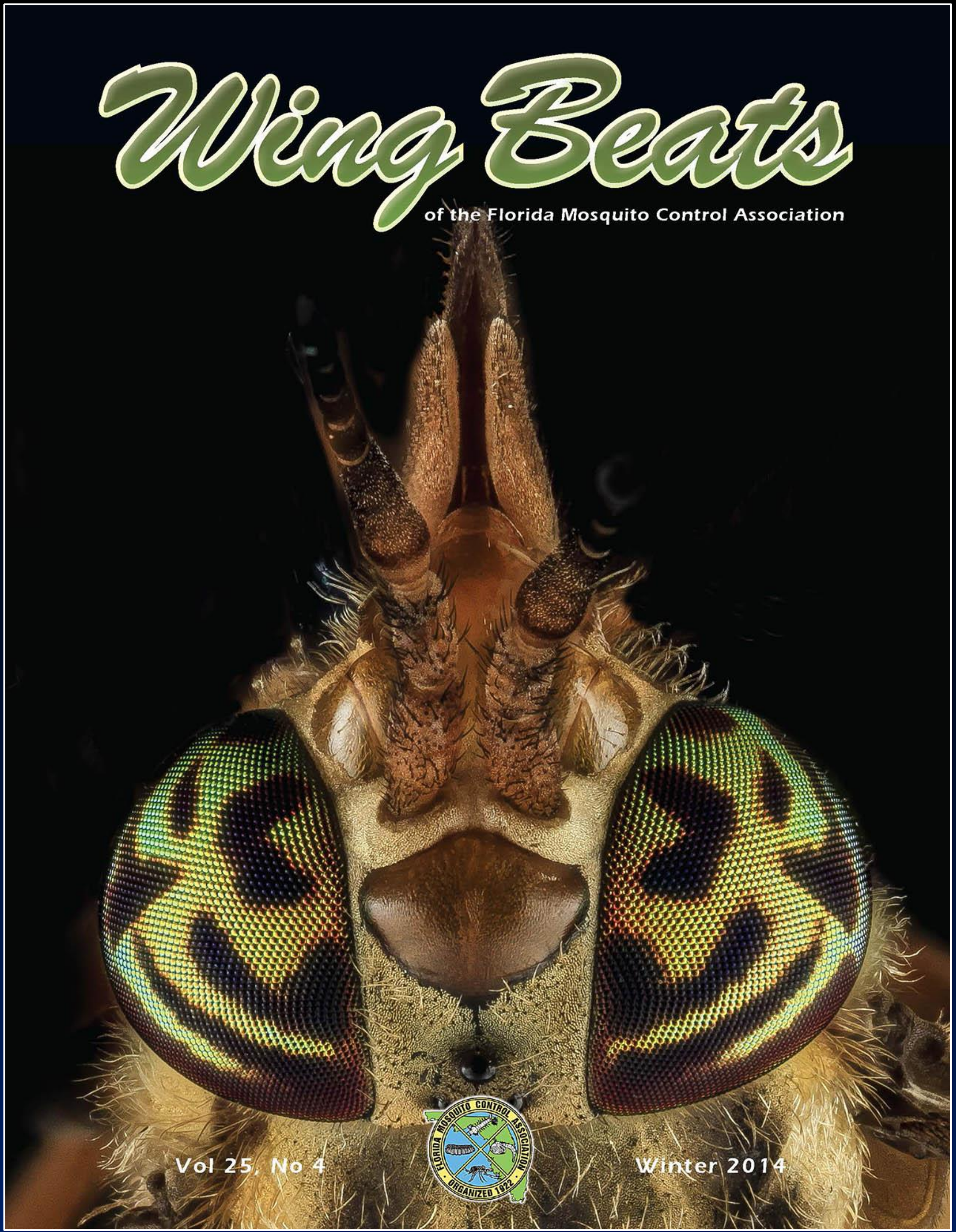
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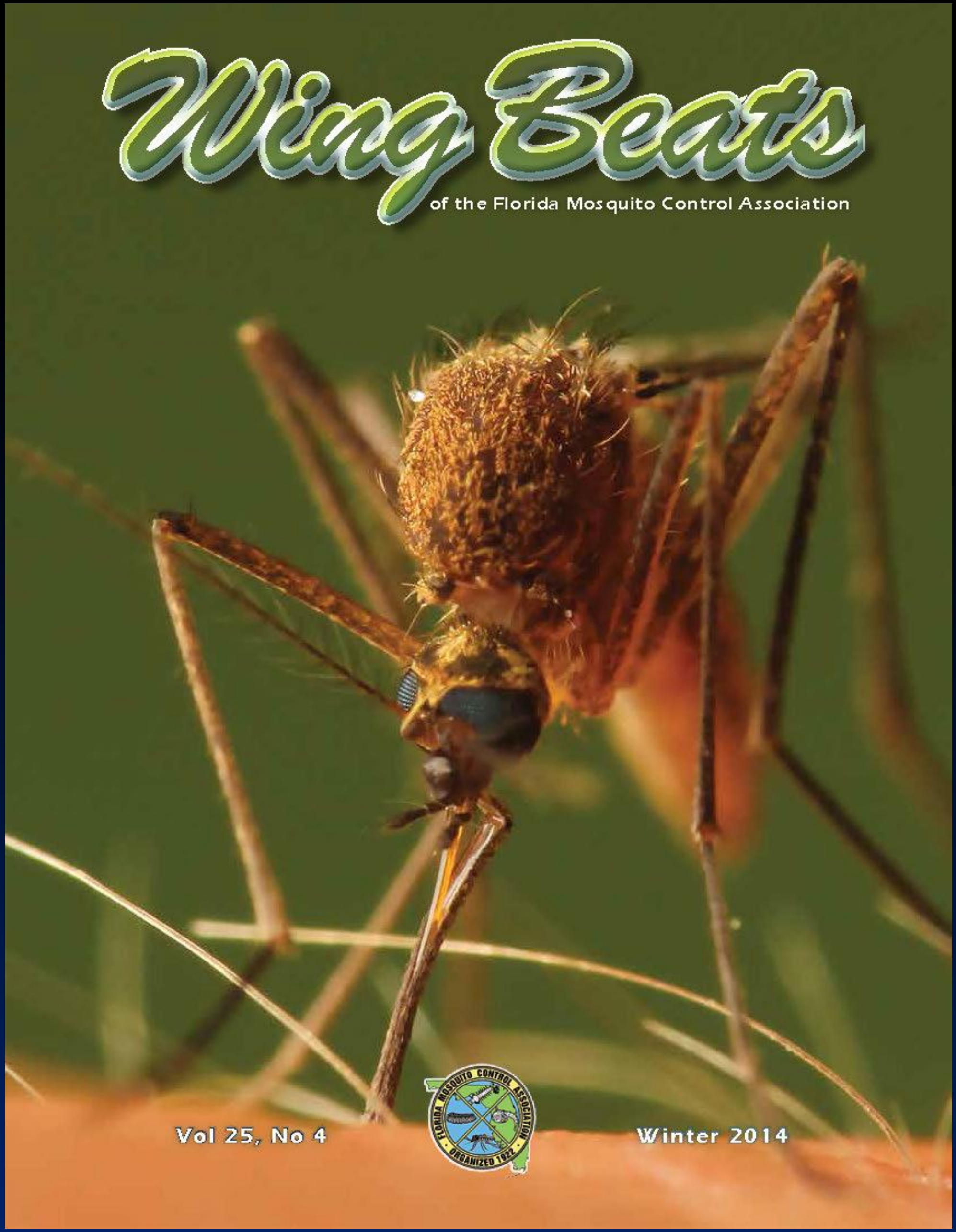
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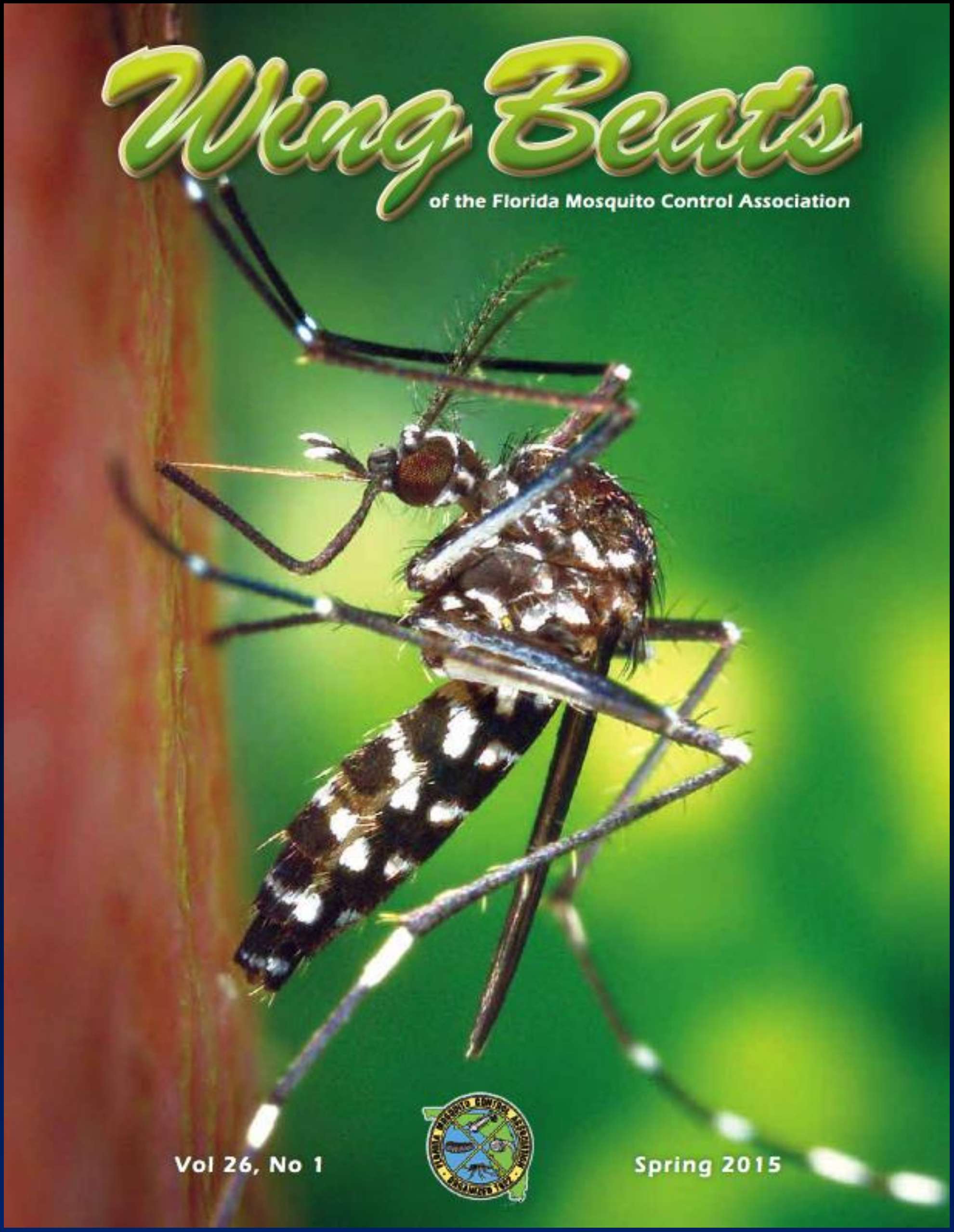
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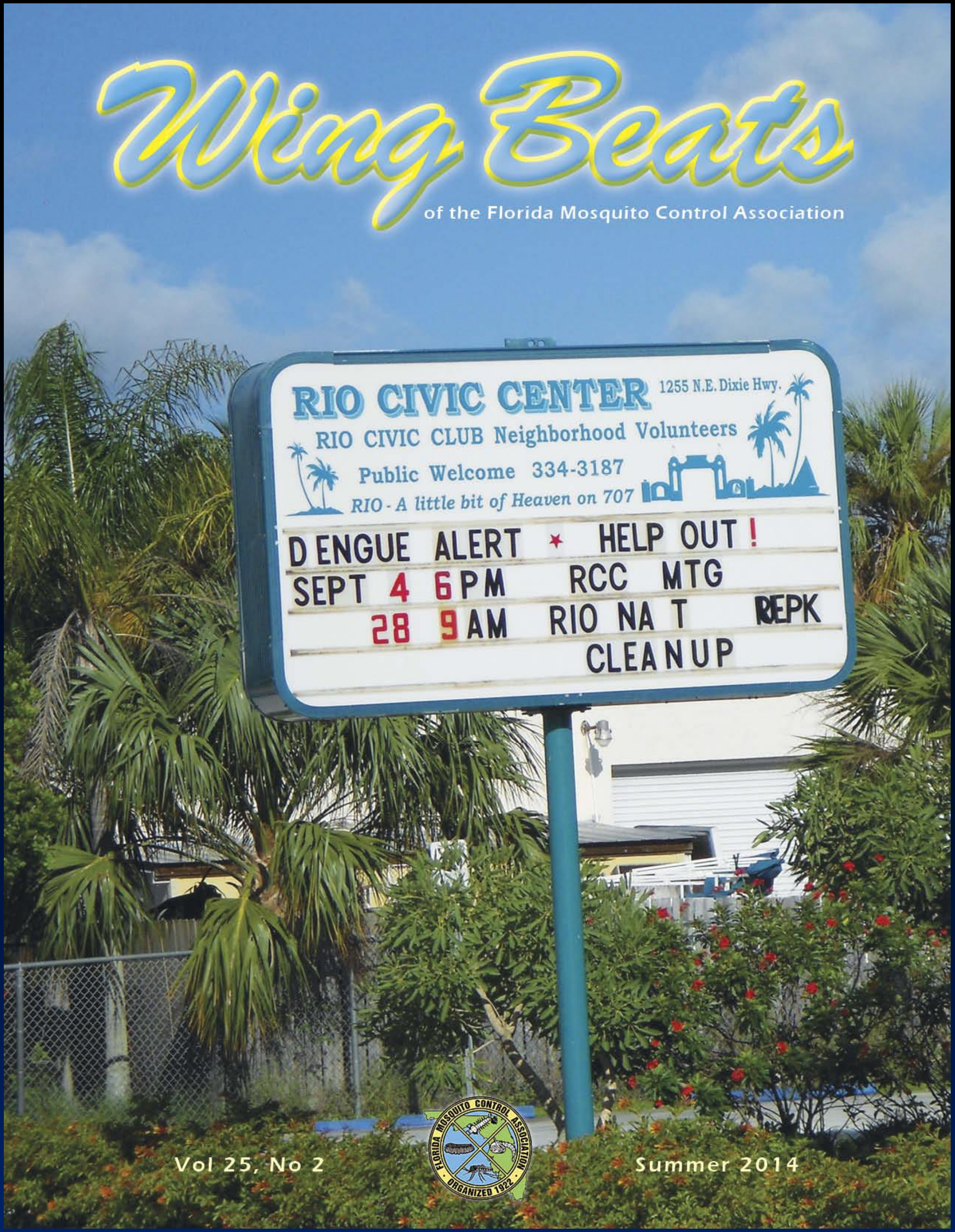
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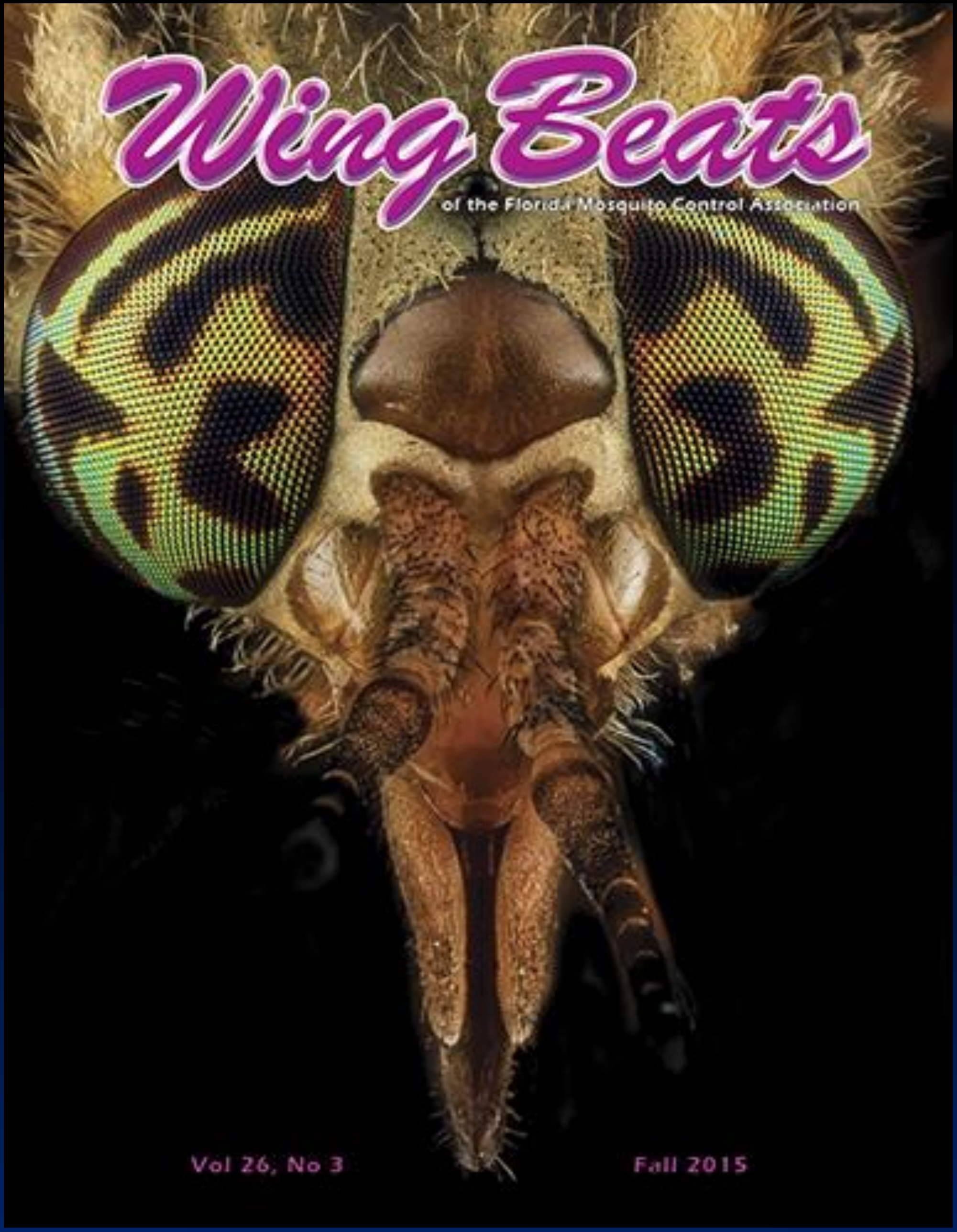
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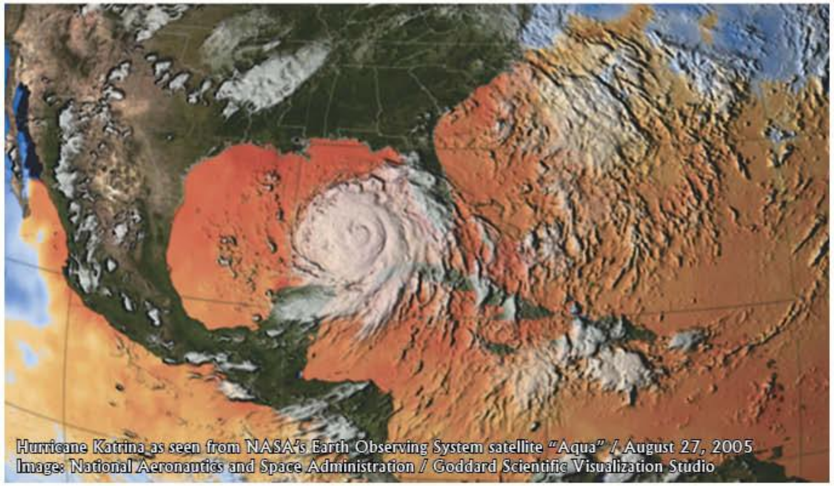
The Coming Storm by Rosemarie Kelly

Like many states, Georgia is vulnerable to tornadoes, hurricanes, flooding, and other natural and man-made disasters that can and have caused severe disruption of essential human services and severe damage to public roads, utilities, buildings, parks, and other facilities. Mosquito populations following water-related disasters can increase to a level that they become a public health risk, making the restoration of vital services to the citizens of the affected area both difficult and dangerous. Additionally, several mosquito-borne viruses circulate in Georgia each year that are capable of causing disease in humans and other animals. The most common mosquito-borne viruses in Georgia include West Nile virus, eastern equine encephalitis virus, and LaCrosse encephalitis virus. Saint Louis encephalitis virus has also been detected in Georgia in the past.

Because disaster events increase mosquito production sites and human exposure, the risk of infection with one of these mosquito-borne viruses could increase after a natural or man-made disaster. For example, after a hurricane, houses may be only marginally livable, and without power, windows would be wide open allowing mosquitoes access to the house. Recovery workers would be exposed to mosquitoes as they worked. And, even without the issue of disease transmission, increased numbers of mosquitoes biting would still constitute a public health problem. Recent studies done in hurricane-damaged areas indicate that natural disasters do increase mosquito density and that it is important that there be a rapid response capacity able to quickly and effectively reduce mosquito densities.

The potential for increased arboviral disease risk has not been realized, but this may in part be due to the impact of extensive control efforts following recent hurricanes.

In July 1994, tropical storm Alberto brought heavy rains to parts of Alabama, Florida, and Georgia. In south Georgia, rivers rose 44 feet above flood stage,



Hurricane Katrina as seen from NASA's Earth Observing System satellite "Aqua" / August 27, 2005
Image: National Aeronautics and Space Administration / Goddard Scientific Visualization Studio

SPRING 2008

Overview of Mosquito Control Programs in Chatham County, Georgia

by Henry B Lewandowski, Jr & Robert A Moulis

Chatham County is the most northern coastal county in Geogia, with a land area of approximately 438 square miles. Chatham County Mosquito Control has a staff of thirty, including one seasonal position and is fortunate to be an independent county department, reporting directly to the County Manager. This paper gives a functional overview of the program with a discussion of five services.

Chatham County uses an integrated pest management approach to mosquito control and obviously, surveillance is essential. Thirty-nine species of mosquitoes are known to occur in the county, of which only eleven are important nuisance species or disease vectors. *Culiseta melanura* (Coquillett) and *Culex quinquefasciatus* Say are the only two species from which we have isolated Eastern Equine Encephalitis (EEEV) virus and West Nile virus (WNV), respectively. Surveillance begins in our front office, where calls from our residents are individually plotted on a county map using different colored pins for each day of the working week. This map is used to locate trouble spots, as indicated by a cluster of pins. After a significant rain event, our staff's direct field observations corroborate the telephone requests for service, and there is little need to inspect each residence. However, during drier periods, staff members investigate many of the calls, suspecting artificial container species or other isolated situations that create a localized problem. The map is then used to plan both ground and aerial adult control missions.

Several hundred potential larval mosquito habitats have been identified and are treated with aircraft when necessary. There are at least 93 rain and tidally influenced larval sites on our barrier islands and hammocks totaling over 580 acres, over 6,200 acres of numerous inland, rain influenced, larval habitats, and more than 5,670 acres of dredge material containment areas along the Savannah River. These latter sites are used to contain the water and silt pumped out of the Savannah River to maintain the shipping channel. The total acreage of all our potential larval mosquito aerial targets is more than 12,000 acres. We have never aerially treated all that acreage after any rain or tidal event in our history. A significant weather event typically requires the treatment of 3,000 to 5,000 acres.

GPS technology is extensively used in our program, and particularly in the surveillance of aerial targets. Each larval site is assigned a unique identification number. Within 24 hours following a rain or tidal event, entomology technicians survey all such sites.

Fig 1: Entrance to Chatham County Mosquito Control administration building.

Improve Your Ground ULV Effectiveness
by Kern Walcher

The purpose of ultra low volume (ULV) application is to get a lethal dose of insecticide to the target insect over a wide area. To be successful in this endeavor, we have to take several factors into consideration:

- The concentration of the product selected
- The best way to get this concentration to the target
- The ability of our equipment to get the product to the target
- The restrictions on the label of the selected product
- The weather

A recent study of pesticides and mosquitoes (Pridgeon et al, 2008) has indicated that it would take 6.9×10^{-3} micrograms of a particular active ingredient (ai) per milligram of laboratory raised *Culex quinquefasciatus* females (with an average weight of 2.02 mg) to achieve an LD_{95}. The LD_{95} is the dose of toxicant at which 95% of test subjects die. The ai was permethrin, the most toxic to the target mosquitoes of the 19 pesticides tested, and the only ULV adulticide currently in widespread use.

Let us put this example in numbers we can easily relate to: the number of drops of a specific particle size it takes to deliver this dose, using a measured standard of unmixed 30% permethrin; see Figure 1, columns 1 and 2.

This information taken alone would seem to indicate the larger the particle the better because it contains more pesticide, and thus fewer hits to do the job. But, what about particle density in the target area? One ounce of a product spread over an acre gives this product density at the noted particle size. For illustration purposes, one acre 30 feet high is 40,468,725,396 cubic centimeters (cc); see Figure 2, columns 1 and 3.

Now that you have this information, smaller particles seem more likely to give the needed density for target dose, even though the need more hits. But, now we have to take into consideration the ability of the existing equipment to produce the particles we want. Tests of some of the more common ULV machines indicate they can produce $Dv_{0.5}$ at the following rates; see Figure 2.

The complexity of this problem should now be evident, but we have one more factor to consider, label rate of the formulation we intend to use. If we want a high particle density within the ability of our machines to produce the particle size we need for this particle density, we need these rates for one drop per cc; see Figure 3.

Now we can see a better picture of the complications involved. If we want particle density within the ability of our equipment to apply the pesticide and within the label requirement of ai per

Particle diameter in microns	Number of droplets for LD_{95}	Number of droplets per cc
8	174	2.73
10	89	1.40
12	51	0.81
15	26	0.41
20	11	0.17

Figure 1: Relationship between particle size, number of droplets required for an LD_{95} and droplet density.

Fluid ounces per minute	$Dv_{0.5}$ range in microns
3	9 - 11
6	10 - 13
12	19 - 25
18	23 - 28

Figure 2: Relationship between flow rate and range of droplet size.

The Demise of Small Mosquito Control Programs
by Rosemarie Kelly

For the most part, small programs do a very limited amount of mosquito control. Their budgets don't allow aerial application of mosquito control products and usually don't include mosquito surveillance. And these are often the first programs to be cut when counties face budget shortfalls.

Does it matter?

The Georgia Division of Public Health's (GDPH) arboviral surveillance program, which began in 2000 when West Nile virus (WNV) was spreading south from New York, includes mosquito surveillance and testing components. Within this program, most of the surveillance is done in urban areas where the risk of WNV transmission is highest.

Clayton County is a small, densely populated county located just south of Atlanta; see Figure 1. Their mosquito control program evolved from a spray-only program, which started in 1988, to a scheduled adulticide program, and then to a complaint-driven adulticide and larvicide program.

When WNV arrived in Georgia in 2001, Clayton County was the only one of nine metro Atlanta counties with a county-funded mosquito control program in place. The mosquito control staff worked closely with the local public and environmental health departments to reduce the risk of West Nile fever/encephalitis in Clayton County. When arboviral surveillance began in the county in 2002, mosquito control responded to every report of increased *Culex* mosquitoes with both adulticiding and larviciding.

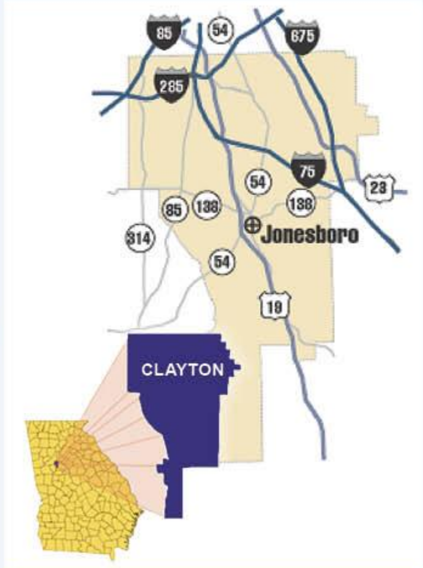


Figure 1: Clayton County, Georgia.

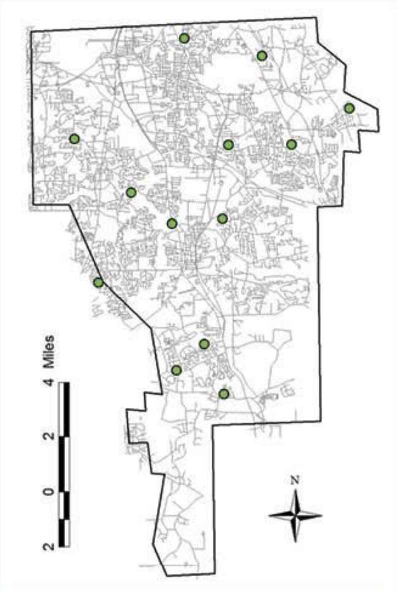


Figure 2: Clayton County surveillance sites.

FALL 2011

West Nile virus activity in Chatham County, Georgia during 2011

by Robert A Moulis, Henry B Lewandowski, Jr, Jennifer D Russell, Jeffrey L Heusel, Laura F A W Peaty, Daniel G Mead and Rosmarie Kelly

West Nile virus (WNV) was first detected in Chatham County, Georgia from dead birds during the 2002 mosquito season. In all, 23 wild birds, 9 mosquito pools, and a horse were found positive for the virus that year. In 2003 a total of 27 wild birds, 6 sentinel chickens, 67 mosquito pools, and a horse were found positive for WNV. Additionally, nine human cases were diagnosed in 2003, including one fatality. WNV was also confirmed in Chatham County during 2004, 2006, and 2007. WNV was not detected in dead birds, mosquito pools, or humans between 2008 and 2010. Two sentinel chickens initially tested positive for the virus in 2009, but follow-up tests were negative. In 2011 WNV was recorded in 214 mosquito pools from 18 different sites, and 10 human cases were confirmed within our service area; see Table 1.

Prior to the arrival of WNV, Chatham County Mosquito Control (CCMC) conducted surveillance and control efforts primarily for nuisance mosquitoes (*Aedes albopictus, Ae sollicitans and Ae taeniorhynchus*) and vectors of eastern equine encephalitis (EEE) (*Culiseta melanura* and *Coquilletidia perturbans*). However, during the 2002 season it became apparent that the primary vector of WNV in our region was *Culex quinquefasciatus*, a species of mosquito that was not targeted by our surveillance or control efforts. After the 2002 season, CCMC staff began a series of program modifications to augment our response to this newly emerging disease threat. Many of these program changes have previously been documented (Lewandowski and Moulis, 2008), although our approach is continuously re-evaluated and refined as staff learn more about WNV and its ecology within our geographic region.

Most important to our WNV surveillance program is the use of gravid traps throughout the county to better assess *Cx quinquefasciatus* populations. Prior to the WNV threat, traps used by CCMC consisted solely of CDC light traps. A substantially larger number of *Cx quinquefasciatus* adults were available for arboviral testing at the University of Georgia's Southeastern Cooperative Wildlife Disease Study by using gravid traps. We have found that this testing is one of the best tools available for the early detection of virus. We further devised a system of thresholds based on the raw numbers of *Culex* captured in traps, which allowed us to treat areas prior to or early in the amplification stages of the WNV epizootic cycle in advance of laboratory confirmation of virus.

Secondly, we moved away from ground ULV adulticide missions toward aerial applications, to provide "blanket" coverage of relatively large tracts of land in a very short time. We also began conducting missions closer to sunset, aligning with the peak activity of the local *Cx quinquefasciatus* population as indicated by timed collections in surveillance traps. Furthermore, we replaced malathion and permethrin-based products with naled adulticides, as susceptibility issues became apparent in our local *Cx quinquefasciatus* population. More recently (2011),

Sample Type	Year									
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Mosquito Pools	9	67	38	0	0	36	0	0	0	214
Wild Birds	23	27	0	0	0	1	0	0	0	0
Sentinel Chickens	0	6	0	0	0	0	0	2	0	0
Horses	1	1	0	0	0	0	0	0	0	0
Humans	0	9	1	0	1	0	0	0	0	10
Human Fatalities	0	1	0	0	0	0	0	0	0	0

Table 1: Occurrence of West Nile virus in Chatham County, GA 2002-2011.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CELEBRATING 75 YEARS
of Protecting Public Health
1935-2010
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THE AMERICAN MOSQUITO CONTROL ASSOCIATION
Vol 21, No 1
Spring 2010

SPRING 2010

2009 Dengue Outbreak in the Florida Keys
by Andrea Leal and Elizabeth Radke

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.

Figure 1: Interagency survey team (left to right) - Andrea Leal (FKMCD), Glen Gallagher (CDC), Pamela Mann (FDOH) and Lindsay Irwin-Weiss, a trainee from the Florida Keys Community College nursing program.

SPRING 2010

Figure 2: FKMCD inspectors Robert Lamontagne (left) and Andy Diaz look for *Aedes aegypti* larvae in a backyard water fountain.

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

Figure 3: FKMCD inspectors William Ryan (left) and Kristopher Hall go door-to-door to conduct premise inspections.

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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.

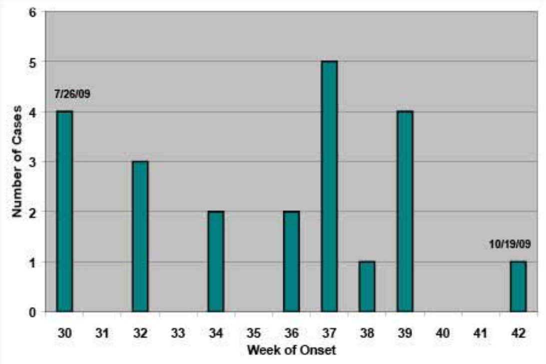

Figure 4: Dengue cases in Key West from July through October 2009.

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

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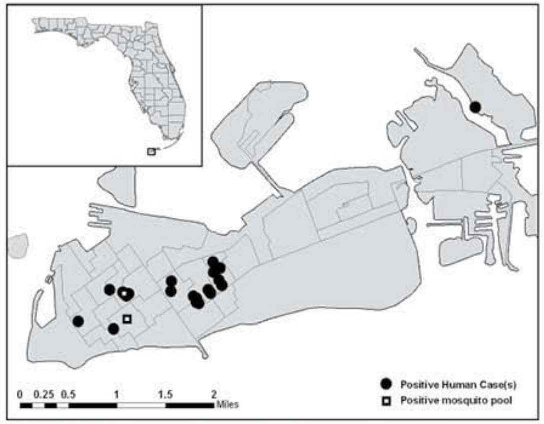

Figure 5: Map showing confirmed Key West cases of dengue fever.

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.

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The 20th Student Paper Competition of the AMCA
by C Roxanne Connelly, James Almasi and Jane Anne Hollandsworth

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.

Figure 1: Gerald Hollandsworth.

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

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The University of Georgia Black Fly Colony
by Elmer Gray

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

Figure 1: Adult female *Simulium vittatum*.

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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.

Figure 2: Aquatic rearing tanks.

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.

Figure 3: Larval black flies attached to nylon screen substrate.

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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container that has been modified with screening on one end. Cotton balls are soaked with distilled water and a 10% sucrose solution and placed against the screen to provide moisture and metabolic energy.

Oviposition occurs in a specially designed apparatus where water is trickled over a disc of green cloth with a light shining from below. The choice of green cloth is thought to be related to the trailing vegetation where this species often lays its eggs in nature. The flies are attracted to the moisture and light from below and lay their eggs on the moist discs of cloth. Sealed insect cages are placed over this apparatus and all of the mated flies from the previous week are released into the cages. The entire apparatus is covered with black cloth, again to take advantage of the adult black fly's strong photo-tactic behavior. Eggs laid on the discs of green cloth are used to initiate the next week's rearing.

Eggs, larvae and flies from this colony have been used by researchers throughout North America. Institutions where researchers have used material include the University of Georgia, Clemson University, the University of South Alabama, Auburn, Kansas State, Creighton and Brock University in Canada. Most recently, colony material has been used to study the transmission of vesicular stomatitis in animals, to develop the black fly genome, and in a variety of projects related to *Bti* efficacy. However, the colony's overall operation is scheduled so that larvae are routinely available for research related to Vectobac® 12AS product development research and quality control monitoring. To accomplish these tasks, a team of technicians and students maintain the colony 365 days a year. As a result, large numbers of black flies are produced during each rearing cycle for *Bti* assessments and a variety of research activities.

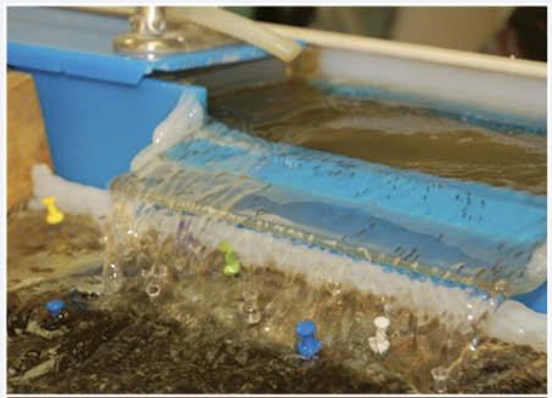

Figure 4: Black fly larvae attach where water flows out of the upper chamber to the runway.

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Departments of Defense and Agriculture team up to develop new insecticides for mosquito control

by David Hoel, Julia W Pridgeon, Ulrich R Bernier, Kamal Chauhan, Kumudini Meepagala and Charles Cantrell

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

Figure 1: Twenty-four-well plate bioassays used to expose first instar *Aedes aegypti* larvae to candidate chemical compounds for insecticide discovery. Five larvae are added to each well and observed for mortality after 24 hours.

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Integrated Pest Management in a Zoological Theme Park
by Jeff Shimonski

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.

Figure 1: The Green-winged Macaw, *Ara chloroptera.*

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 aces 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.

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From Where I Sit: Notes from the AMCA Technical Advisor by Joe Conlon

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 alacrity 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-

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PART 87:
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