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Hail from the Editor-in-Chief ................................................ 4
by Stephen Sickerman

Haiti after the 2010 Earthquake: Mosquito Education and a Meal Help Make a Difference ...................... 7
by Morel Jules

A Little Representation of a Big Problem: A Model for Teaching Mosquito Control .............................. 15
by Beth Carey Kovach

Malaria Capacity Building in Liberia: The US Navy Joins Forces to Defeat a Deadly Foe ....................... 25
by Cdr Peter J Obenauer, Lt Jennifer Wright, and Lt Joseph W Diclaro II

Climate change and mosquito control: An example with the Asian tiger mosquito ......................... 32
by Richard A Erickson and Steven M Presley

Smith – Lever Act of 1914 - the Law that Created Cooperative Extension ............................. 35
by Jack Petersen and Roxanne Connelly

From Where I Sit: Notes from the AMCA Technical Advisor ................................................... 40
by Joe Conlon

About the Cover: Morel Jules, a Haiti native and Larvicide Field Crew Chief at the Indian River Mosquito Control District, Vero Beach, FL, speaks to a group of citizens from L’eogane, Haiti, on November 29, 2012. He stressed prevention of filariasis by draining standing water to deter its primary vector, Culex quinquefasciatus. Photo provided by Morel Jules.

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Remember the excitement surrounding the approach of Y2K? If you’re old enough to recall the anticipation and apprehension as 1999 drew to a close and worldwide New Year’s celebrations ensued on the eve of 2000, you might also call to mind the purists who insisted that the New Millennium did not technically begin until January 1, 2001.

Such thoughts occurred to your Editor-in-Chief while preparing to celebrate volume 25 of *Wing Beats* magazine this very issue, and realizing that perhaps the true Silver Anniversary still lay a year away! Not one to waste a milestone, historic or otherwise, yours truly wanted to honor the editors, authors and artists of issues past, and so after many hours of preparation, this double gatefold cover came to fruition. Quite serendipitously, an excellent photograph submitted by author Morel Jules just a few months ago offered the ideal opportunity to complement the cover of this special issue.

Perhaps you’ve already noticed that the thumbnail-sized cover images spread across all 4 panels of the inside cover only cover years 1991 through 2010. The initial layout plans included every cover to date, but were compromised by space limitations of the printed page and available time of the editor. Because of their historical importance, larger images of Volume 1 were warranted, in your Editor’s humble opinion, and so below are pictured the covers from the premiere and sophomore issues of *Wing Beats*, circa 1990: the Sunrise Edition featuring a, well, sunrise over the Atlantic, and the second issue featuring John Beidler, often referred to as the Dean of Florida mosquito control, and deservedly so.

Changes have also been made to the publication’s interior; not a complete makeover, mind you, but the text and title fonts have been replaced with new, and we hope, easier to read typefaces. You were right, NR of MN! Your comments prompted a search through dozens of prospective copy typefaces to find the right one(s). Hopefully the rest of you will agree the new look is an improvement.

Rest assured that next year’s Fall issue, will indeed be recognized (again) as our 25th Anniversary (1990 – 2015) issue.
with all the additional Silver Jubilee celebratory bells, whistles and graphic embellishments one might hope for and expect, in a trade magazine on mosquito control - - all presented to you on time and under budget.

So while that commemoration is but a year away, let’s take a brief look at the contents of the current issue you now hold in your hands: We start off with Morel Jules, taking the first steps towards forming a much-needed Haiti Mosquito Control Association. Beth Carey Kovach explains how creating a small model of a home helps teach schoolchildren awareness of residential larval habitats. Peter Obernauer, Jen Wright and Joseph Diclaro describe how the US Navy is assisting mosquito control personnel in Liberia to control malaria. Jack Petersen and Roxanne Connely commemorate the centenary of Cooperative Extension, thanks to the Smith-Lever Act of 1914. Richard Erickson and Steven Presley look to a warmer future and what that might mean to the distribution of the Asian tiger mosquito and dengue. And as usual, AMCA Technical Advisor Joe Conlon gets the last word, this time on the subject of honeybees and other pollinators.

It is an honor and privilege – not to mention a tremendous amount of time and effort – to put together each quarterly issue of Wing Beats, and it’s always satisfying when we finally go to press. To my partners on the Wing Beats Editorial Desk and fellow editors, thank you for your continual good judgment and devotion to mosquito control and this magazine; to the many authors who have submitted manuscripts to Wing Beats, thank you for your submissions and for informing our readers of the good work that you perform; and to those in industry who have supported Wing Beats with your advertising dollars for the past 25 years, my great appreciation.

The editors encourage those of you who have not yet published in Wing Beats to consider sending us an article. Why not share what you’ve learned with your colleagues? So sit down, give it some thought, and work up the courage to follow through.

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Over the years, Haiti, which is one of the poorest and least developed countries in the world, has struggled with many problems including political upheaval, severe hurricanes, earthquakes, educational problems, and health issues including serious infectious diseases. In January 2010, Haiti suffered a devastating earthquake. Not only did it kill countless numbers of Haitians, it essentially destroyed the country as compared to its prior condition causing levels of misery making the residents’ struggle for progress seem pointless. It has created poor sanitary conditions, turning entire neighborhoods into mosquito and disease producing habitats. Education of the Haitian people about the link between diseases and poor sanitary conditions is critical.

Figure 1: A drainage canal in L’eogane, Haiti, where trash is trapped in the narrow passage.

Figure 2: Typical drainage system in the urban area of Haiti.
This is especially pertinent to mosquito-transmitted diseases.

As a native of Haiti, I traveled in March 2010 to my homeland to find that my family’s home was destroyed, a relative had been killed and several others were left severely injured. While I had been aware of their situation after the earthquake, seeing it was very different from simply knowing about it. Living conditions in most of the country included inadequate sanitation with virtually no shelter. There was no choice but for the residents to survive on contaminated food and water, further compounding the problems they were already experiencing.

Dengue and malaria are endemic in Haiti and anthrax is hyperendemic. Cholera, introduced post-earthquake, killed thousands of Haitians. Having worked at the Indian River Mosquito Control District since 1993, the mosquito situation in Haiti particularly interests me. Thirty-two mosquito species occur in Haiti and during my visit, in just one street, I found 5 species of mosquito larvae. They were in containers, small drainage ditches, a tree hole, and a small depression. The 5 species included: *Aedes taeniorhynchus*, *Ae albopictus*, *Ae aegypti*, *Culex nigripalpus* and *Cx quinquefasciatus*. Knowing the potential most of these species pose as competent vectors for dengue, yellow fever, St Louis Figure 3: Morel Jules gives a presentation on mosquito control practices in Port-Au-Prince, Haiti, November 24, 2012.

Figure 4: Morel Jules provides mosquito control education in L’Eogane Province, Haiti, November 29, 2012.
encephalitis, West Nile virus and filariasis, this discovery was heartbreaking. In fact, after describing the classic symptoms of dengue fever to my family and their neighbors – ie, fever, flu-like symptoms, rash, severe postocular headaches, joint pain – they remembered suffering such symptoms themselves.

Hoping to make a positive impact on my family’s immediate community, in short order, I organized a project, offering a good hot meal in exchange for helping me clean up my family’s street as a source reduction project. Everyone, from five year old children to their own grandparents, enthusiastically pitched in to do what they could to eliminate larval habitats. We picked up all the trash and debris, piled and burned it. To help eliminate stagnant water, we cleaned out ditches and started them flowing again. While we worked, I was able to teach everyone to recognize mosquito larvae, understand the mosquito’s role in disease transmission, and show them the long term value of source reduction from these cleanup efforts. The minimal cost of this potentially lifesaving exercise was the mere $100 that I spent on groceries. Everyone who participated was happy to enjoy the hot spaghetti and bread meal that I cooked for them.

This positive experience stimulated me to want to do more. In November 2012, the MEBSH de Cote Plage Baptist Church in Carrefour, Haiti, arranged for me to speak to their members and guests on mosquito control which is part of a plan I am developing to protect the health of Haitian citizens and visitors. While in Haiti, I visited the mayor’s office in Carrefour. The Fire Department and the mayor’s office welcomed the idea of establishing a mosquito control program in the country. However, everyone was temporarily locked in their position until an election takes place. I also visited with Congressman Elie Blaise (Carrefour) during a public meeting at which time I spoke to him briefly about the mosquito control proposal. He welcomed the idea, but time was too short to discuss details.

On November 21, I visited the University of Notre Dame in Saint Croix L’eogane and spoke with Dr Yves Bon Garson about my idea for establishing a mosquito control program in the region. Dr Bon Garson was very interested as he has been working with filariasis patients at Saint Croix Hospital. In fact, Dr Bon Garcon is a filariasis victim himself. At the end of our meeting, Dr Bon Garcon requested that I make a presentation for the people in the L’eogane region. I agreed and it was arranged for a week later.

On November 24 I spoke at the Baptist Church of Cote Plage 18 in Carrefour, to an interested group of 28 individuals consisting of professionals, community leaders and

![Figure 5: Interested Haitian citizens participate in a mosquito education program in L’eogane Province, Haiti.](image-url)
college students. On November 29 in Léogâne, I presented the mosquito control proposal to approximately 85 people outside the Capital. This region is especially appropriate because it has been severely affected by filariasis. Men, women and children excitedly received the information, asking when this program would begin. In an initial effort to help encourage their enthusiasm and reduce the numbers of mosquitoes within residences, several bug zappers that I brought to Haiti were handed out to them.

This proposal aims to introduce mosquito control in Haiti by three approaches: 1) education, 2) source reduction and 3) home inspections. To be effective, we propose to create a platform known as the Haiti Mosquito Control Association. In the initial phase, we will seek the endorsement from several stakeholders and relevant government departments in Haiti before moving forward. We now have a US employer identification number and continue to work on all necessary legal paperwork.

Because I have experienced such positive feedback from many Haitian citizens willing to support a mosquito control program, my future plans are to continue with educational efforts to expand and reach out to children in public schools, nursery schools, churches and non-government organizations. On subsequent trips I also plan to:

- Donate T-shirts with mosquito control messages to help promote the project (thanks to the Florida Mosquito Control Association);
- Distribute hand ULV sprayers to help reduce the local adult mosquito population;
- Hand out bug zappers to help control mosquitoes within residences;
- Continue reaching out to the Haitian government for their support.

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Figure 6: Morel Jules demonstrates an electronic bug zapper to help control mosquitoes within residences.
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Many mosquito complaints we receive, especially in dense residential areas, can usually be blamed on containers holding water that are found right outside the home. When routine inspections yield common container species, such as *Aedes albopictus* and *Ae aegypti*, it becomes a fun challenge to try to seek out their habitat(s) – as chances are the culprit is nearby. It always catches homeowners by surprise when they learn that they are creating prime mosquito habitat in places they’d never even thought to look. Usually the average homeowner assumes that mosquitoes arise from ponds, canals, and ditches – but rarely do they think about something as simple as the bottom lip of a flower pot, or the sunken-in tarp covering their boat. On a recent investigation I uncovered an underground cistern that was generating thousands of *Ae aegypti* literally just feet away from the customer’s lanai. It was the last place he had thought to look. Once we eliminated the source his particular case was solved, and all without the costly use of chemicals.

We wanted to find a positive way to get that message across to the residents of Charlotte County, Florida. Rather than expecting mosquito control to be solely responsible for their mosquito issues, we wanted to teach the community that they, too, play a very important role that begins with source reduction. We began a “Flip-it! Tip-it! So you don’t get bit!” campaign and created brochures pointing out various larval sites around the home, but we were met with very little enthusiasm on the matter. Somehow we needed a better approach.

During an elementary school Power Point® presentation, one slide in...
particular received a lot of hubbub. It was a new slide we had added, which was a simple clip art illustration of a home with various items in the yard which we'd show at the end of the talk. When we asked students to tell us where they thought mosquito larvae would develop, based on what they had learned during the presentation, they suddenly became extremely engaged, almost competitive, as they waved their raised hands and shouted out their answers excitedly. This happened again and again, and we knew that a great way to reach the community with this message could be through the kids, who were more than happy to take on this responsibility and be mosquito-seeking sleuths around their own homes.

Since this two-dimensional slide presentation visual was so exciting for the students, we decided to create a life-like model depicting all of the common places around the home that can raise mosquitoes. My co-worker, Brian Greig, and I set out to complete the task. We had a general idea of what we wanted to do; but what began as a pretty simple rough draft ended up blossoming into something more beautiful and complex than we originally imagined. Using a garbage can keychain and some toy truck tires as the scale for the rest of the model, construction began.

There were a few important criteria we needed to meet. It had to be lightweight for portability and covered for protection. We also wanted to keep it as realistic as possible. We used a piece of 3-inch styrofoam as the base and landscape features were carved out with a sander. The house began as a cardboard box, but gained little plastic windows, shake siding made from strips of veneer, shingles made from strips of sandpaper, tin foil gutters, and other accessories common to a modest home. A cotton ball tree was constructed, complete with a tire swing. The driveway was paved using sand and glue, and the yard was

Figure 2: The model home’s bird bath, flower pot, bucket, tires and a boat tarp are prime larval habitat.
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created with railroad model grass. We added as many details as we could, using clay to construct a small bucket, flower pot, beach ball, dog dish, and bird bath with crow (since, crows play an important vector roll as well). A spray paint lid became a kiddie pool and a green piece of electrical wire became a garden hose. Brian used his carpentry skills and constructed a beautiful wooden frame and a nearly seamless plexi-glass lid which he bent and molded using a heat gun. Most of the items we used were scrap materials found at home or around the shop, making the project very cost-effective.

The most challenging part of the project was figuring out what we could use to depict water – by far the most important component – without eating away at the foam and other materials. We made some test ponds and tried a fiberglass resin first. As long as the foam was coated with a thick layer of Elmers glue, the resin did not eat through it. But when it dried it turned a cloudy-brown and was full of ripples. Next we tried using pieces of acrylic dissolved in acetone. Although it dried nice and clear, it was always full of bubbles, no matter what technique we used. Finally, following the wise guidance of a hardware store employee, we were led to an epoxy resin called Enviro Tex Lite®. This worked out fantastically, drying crystal clear and virtually flawless.

Although originally intended for elementary students, the project has received a lot of interest from citizens of all ages! People admire the details of the model, which is the first thing to catch their eye, and they really seem to enjoy being able to spot the places where water can collect, often prompting responses such as “Wow, I never thought about that!” and following up with questions or ideas on the best ways to eliminate these potential larval sites. Whenever something generates any form of interest, no matter how large or small, it can most certainly be counted as a success.

Figure 3: The model home’s yard includes a kiddie pool, ornamental pond, dog dish and driveway culvert, all likely sources for mosquito larvae.
We intend to add some more items to our model as we brainstorm new ideas to improve upon what we have in order to further pique the interests of our children and citizens. So far, though, it has definitely become an asset to our educational arsenal as we continue to look for new ways. In a fun and creative way, it shows them that they, too, can make a huge difference when it comes to source reduction and mosquito control. And the best part is, a realistic model has no age limit for appreciation, making it a very versatile form of educational media.

Figure 4: Close-up views of some of the model home’s potential larval habitat, such as a leaking garden hose and flower pot with standing water.

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2014 MEETING ANNOUNCEMENTS

2 - 6 November • The 5th International Forum for Sustainable Vector Management will be held in Qingdao, Shandong, China. For more information, visit www.chinavbc.cn/forum/.

9 - 12 November • The 86th Annual Fall Meeting of the Florida Mosquito Control Association will be held at the Bonaventure Resort in Weston, FL. For more information visit www.floridamosquito.org/Events/Meeting.aspx.

2015 MEETING ANNOUNCEMENTS

13 - 15 January • The annual FMCA Aerial Short Courses (Fly-In) will be held at the Lee County Mosquito Control District in Lehigh Acres, FL. For more information, visit www.floridamosquito.org.

26 - 30 January • The 31st annual FMCA Dodd Short Courses will be held at the Hilton Orlando/Altamonte Springs Hotel in Altamonte Springs, FL. For more information, visit www.dodd.floridamosquito.org/Dodd/.

24 - 25 March • The 12th annual Arbovirus Surveillance and Mosquito Control Workshop will be held at Anastasia Mosquito Control District, St Augustine, FL. For more information, visit AMCD’s website at www.amcdsjc.org.

March 29 - April 2 • The 81st Annual Meeting of the American Mosquito Control Association will be held at the Hilton New Orleans Riverside, New Orleans, LA. For more information, visit www.mosquito.org/annual-meeting.

25 - 29 May • The 4th International Forum for Surveillance and Control of Mosquitoes and Mosquito-borne Diseases will be held in Guangzhou, Guangdong, China. For more information, visit www.mosquitosforum.net or www.asiansvemc.org.
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Malaria ranks among the top three important vector-borne diseases for the US military. In response, over the past five years, the Armed Forces Health Surveillance Center – Global Emerging Infections Surveillance and Response System (AFHSC-GEIS) and Department of Defense (DoD) overseas labs have conducted several projects aimed at enhancing or establishing hospital-based febrile illness surveillance platforms and conducting arthropod surveys (Fukuda et al 2011). The Navy Entomology Center of Excellence (NECE) in Jacksonville, FL recently collaborated with the US Naval Medical Research Unit No. 3 (NAMRU-3) and the Liberian Institute for Biomedical Research (LIBR) to deliver a two-week Public Health and Vector Control Course for 22 students from the Armed Forces of Liberia (AFL). The classes were directly aimed at teaching skills to control Anopheles gambiae, the primary malaria vector in Liberia. During the final two days of the course, students conducted an indoor residual spray operation (IRS) for barracks housing AFL soldiers. Large-scale IRS has remained the cornerstone of the World Health Organization (WHO) malaria control plan since the 1950s and is one of the four major components of the President’s Malaria Initiative (PMI) aimed at reducing malaria transmission (Hoel et al 2013).

Responding to a high incidence of malaria infections among US forces in 2010, NAMRU-3 and NECE have conducted six spray missions applying insecticides to the insides of various residences on two major military installations (Obenauer and Stoops 2012). The primary objective was to protect US Forces from being bitten by this highly anthropophilic, endophagic and endophilic mosquito species. Since its inception, no malaria cases have been reported from US active duty members of Operation Onward Liberty. The military barracks housing US Forces are now being treated by private contractors on a regular basis; however AFL barracks have been left untreated in part due to lack of training and support. As part of a larger component from the DoD Global Emerging Infections System (GEIS) funding, the past two years have focused on capacity building and “training the trainer” to sustain malaria control efforts among AFL members.

The recent course was a combination of classroom and field instruction covering basic insect taxonomy, general adult and larval mosquito identification, mosquito biology, vector-borne diseases, mosquito surveillance and control, insect toxicology, integrated pest management and personal protective equipment. Classes were held at the medical clinic on the Edward Binyah Kesselley (EBK) military base. Classroom sessions consisted of PowerPoint® presentations, small group discussions and exercises, while afternoon field sessions involved hands-on activities that reflected the previous classroom instructions; see Figure 1. The final two days of the course were dedicated to treating over ten AFL enlisted barracks with Demand® CS (lambda-cyhalothrin) using two types of sprayers. The majority of IRS applications in Liberia rely heavily on hand-compression sprayers, and while effective, this method is extremely labor intensive, especially given the number of buildings to treat on base. Therefore, AFL students were
instructed on how to operate and maintain Stihl™ backpack sprayers and the JQSX-12, an innovative backpack sprayer developed by Dorendorf Advanced Technologies LLC, funded by the Deployed Warfighter Protection Program (DWFP), that uses two compressed gas cylinders; see Figure 2. Both sprayers allowed the applicator to maintain a sustained tank pressure of 55 psi without having to stop and manually repressurize the tank.

Advanced preparation is essential for any successful spray mission. The class was divided into four teams consisting of a sprayer, a guide, a water/fuel/insecticide director, and one instructor, while the remaining students were urged to assist in the equipment transportation. The majority of AFL members live with their families, so the EBK base commandant instructed all family members to move their belongings before spray teams arrived; see Figure 3. This facilitated maneuvering throughout the buildings,

Figure 2: A student applies insecticide to the walls of EBK barracks with a JQX-12 compressed backpack sprayer.

Figure 3: Liberians living on EBK military barracks removed their furniture and belongings in preparation for spray teams to treat the inside of their homes.
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Figure 4: Students and instructors pose with their spray equipment for a quick photograph after treating over 240 rooms onboard Camp Edward Binyah Kesselley, Monrovia, Liberia, April 2014.

prevented any inadvertent property damage, and lessened the likelihood of anyone coming in contact with the insecticides. Moreover, this allowed adequate time for teams to brief families about malaria and any concerns they had regarding the insecticides. Spraying commenced at 09:00 and lasted until noon. In total, 220 rooms...
were treated over two days; teamwork played an enormous part in the successful execution of the program; see Figure 4. Both sprayers performed flawlessly. However, it was noted that the JQSX-12 compressed gas sprayer provided exceptional spray coverage and was well received by students for its speed and ease of use.

At the conclusion of the course, a graduation ceremony was held at the base clinic; see Figure 5. At the ceremony, Col Prince C Johnson III, Camp EBK Commander, and Dr Josiah George, AFL’s Chief Medical Officer, promoted a sense of partnership and appreciation. The AFL Preventive Medicine team is joining the collaboration and serving as member of the US Africa Command West Africa Malaria Task Force (WAMTF) to assist NECE and NAMRU-3 in the upcoming WAMTF training that will be held in Liberia. The course will be an effort to provide mosquito training among eight countries militaries public health programs that will have a regional impact in malaria control initiatives.

Building public health capacity remains a cornerstone for many developing countries in order to facilitate peace and prosperity. Since NAMRU-3 and NECE involvement with Liberia over four years ago, there have been enormous strides by the Liberians to turn the tide against malaria after long and brutal civil wars. Future vector control training courses with NECE seeking status as a WHO Collaborating Center on Vector Control are anticipated with other West African countries.

REFERENCES CITED


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Cooperative Extension is a 100 year old partnership of the National Institute of Food and Agriculture (NIFA) of the US Department of Agriculture (USDA), the 109 land-grant universities, and more than 3,000 county offices across the nation. Cooperative Extension combines the expertise and resources of federal, state, and local governments and is designed to meet local needs for operational research and educational programs by providing scientific knowledge and expertise to the public. The cooperative extension system includes university deans, scientists, teachers, and lots of volunteers.

The Smith-Lever Act of 1914 provided for a cooperative agricultural extension network among the agricultural colleges in the United States which were created by the First Morrill Act signed on July 2, 1862. Those colleges are now called the “1862 Land Grant Colleges and Universities.” In 1890, the Second Morrill Act added 18 historically black colleges and universities (HBCU) to the Land Grant system. HBCUs also receive funds provided by the Smith-Lever Act. Originally, the mission of these Land Grant Universities was to teach agriculture, military tactics, and mechanical arts along with classical studies. The passage of the 1862 Morrill Act was in response to a demand for acquiring knowledge in agricultural and technical disciplines to provide a practical education. There is at least one Land Grant University in every state. Some states have more than one, as a result of the passage of the 1890 Morrill Act.

This brief article will focus on opportunities for mosquito control made possible by cooperative extension programs offering suggestions on how to get your message out to the public.

The Agricultural Experiment Station at Rutgers University, New Brunswick, NJ, mandates mosquito research through its outreach/extension programs. Although mosquito research is not funded directly by the Smith-Lever Act, its funds are used at Rutgers primarily to pay salaries of agricultural experiment station extension employees. Rutgers faculty is expected to compete for state and federal funding to support their research. Rutgers’ role in mosquito control is directed through the Center for Vector Biology (CVB). The Center conducts research and provides information to the residents of New Jersey about insects, including mosquitoes and the diseases they transmit.

Rutgers researchers have helped to develop a number of tools and integrated mosquito management methodologies. Rutgers faculty work closely with county mosquito control programs which perform the vast majority of the applied suppression services for state residents; see http://njaes.rutgers.edu/mosquito. An excellent example of extension based research at Rutgers is the recently completed Area-Wide Asian Tiger Mosquito program, which can be found online at http://asiantigermosquito.rutgers.edu.


The Center for Vector Biology at Rutgers University:

- Reviews New Jersey mosquito control program budgets and recommends funding levels;
- Promotes science-based IPM programs;
- Certifies mosquito identification specialists;
- Provides online tutorials for state supported surveillance programs;
- Coordinates field trials that test new products and equipment;
- Conducts calibration workshops for both aerial and ground based equipment;
- Develops and distributes public health fact sheets;
- Hosts quarterly mosquito biologist meetings to discuss community needs and encourage NJ mosquito control programs to participate in CVB research efforts;
- Provides insecticide resistance workshops designed to transfer technology to local programs;
- Provides a vital link between the researcher and stakeholder, sharing the latest peer reviewed data.

The Florida Medical Entomology Laboratory (FMEL), Vero Beach, FL is part of the University of Florida Agricultural Experiment Station. The
Florida State Legislature, recognizing the need for greatly expanded research on the biology and control of mosquitoes, especially about the effects of insect-carried diseases on Florida citizens and on the tourist industry, mandated that the FMEL:

- Conduct research on the biology and control of biting insects and other arthropods which are important transmitters of disease or pest annoyances, giving special attention to the needs of Florida’s mosquito control organizations;

- Be a center to train students and personnel in the entomological aspects of public health, veterinary science, sanitation, mosquito control, drainage and irrigation design, wetlands management, and other areas requiring knowledge of medical entomology;

- Extend research and training to international programs.

Cooperative Extension programs provide many of the training materials we use for recertification of our Public Health Pesticide Applicator license.

Particularly helpful are:

- “Featured Creatures” series developed by the University of Florida, which includes articles on many mosquito species, http://entomology.ifas.ufl.edu/creatures/;


- The EDIS fact sheet system of the University of Florida, with fact sheets on many mosquito borne diseases and mosquito species, http://edis.ifas.ufl.edu/;


Cooperative Extension in most states is involved with providing continuing education units (CEUs) for licensed public health pesticide applicators. If they don’t directly provide the training, many are involved in getting CEUs approved for state mosquito control meetings. In several states, cooperative extension prepares or assists with the distribution of state mosquito identification guides. One example is “Mosquito Biology, Surveillance and Control” from the University of Georgia Cooperative Extension Service (Gray 2008).

Master Gardeners receive training from local county extension offices, as well as from university researchers. Master Gardeners are an excellent resource for informing the public about mosquito source reduction. They welcome presentations on “mosquito updates” and once provided, they can spread the word through the community to help in your mosquito education campaigns. How do you find them? Go to the Master Gardener website, http://www.ahs.org/gardening-resources/master-gardeners. Click on your state and you will be directed to the Master Gardener State Coordinator who can link you to volunteers in your area. Tell ‘em what you’re doing and why it is important!

Last word: Take a close look at your training guides. Chances are the cooperative extension service in your state helps develop those materials. Ya’ don’t believe me? Go to http://entnemdept.ufl.edu/fasulo/vector/chap01.pdf and look at the list of contributors!

Please thank a Cooperative Extension Agent — and Happy 100th Birthday!

ACKNOWLEDGMENTS

The authors would like to thank Dr Larry Katz, Director, Rutgers University Cooperative Extension, for providing information for this article.

REFERENCES CITED


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Climate change often carries a connotative association of melting polar ice caps and devastated polar bear populations. If in fact such dire effects result, while ecologically important, they will have minimal direct influence on the daily lives of many if not most people in the continental United States. Many of the results of global climate change realized by the “average” or typical American will be secondary effects through which climate change makes existing problems worse. Mitigation strategies for such effects to help people adapt to these problems are often good public policies, regardless of the source of climate change (whether anthropogenic or natural), or even if climate change is occurring (Hayhoe and Farley 2009). Similarly, and as a recent example, the ongoing drought in its fourth year in Texas and the central United States is not caused by climate change. However, climate change makes the drought worse by increasing evaporation and water loss. Mitigating the effects of the drought through changes in water use and management would be good policy irrespective of climate change.

The potential influence of climate change on mosquito ecology and vector competency can be anticipated to be similar to this drought, in that climate change will not directly cause the problems, but will make existing problems worse. Some current problems facing mosquito control that may be made worse by climate change include the arrival of invasive potential vector species, the expansion of geographic disease ranges, and changes to the duration of mosquito season. The objective of our article is to discuss some ways that climate change may affect vector control, and also to present a specific case study of how climate change may potentially influence *Aedes albopictus* population dynamics and possible dengue virus transmission and maintenance dynamics in the United States.

Globally, there has been resurgence in vector-borne diseases over the previous half-century that has been caused by a wide range of natural and anthropogenic factors. New diseases such as West Nile virus have arrived in North America, while long absent diseases such a dengue and malaria are resurging. Increased human population numbers have increased potential exposure to zoonoses as people develop and move into new areas and have greater interaction with wildlife populations. Disturbance from human encroachment and development of wild habitats can facilitate introduction and establishment of invasive species that may vector novel diseases. Increased and faster human transportation capabilities, ranging from ship traffic to jet travel, allows rapid dissemination of invasive species around the world and also the rapid spread of infectious agents (Lemon et al. 2008).

Dengue is resurging within the continental United States, and there are increasing numbers of cases annually, with endemic presence in Texas along the border with Mexico (Brunkard et al. 2004), and outbreaks occurring in Hawaii in 2001 (Effler et al. 2005), Key West, FL in 2009, and Martin County, FL in 2013. Dengue, also known as break-bone fever, may range in its pathology from asymptomatic infection to life-threatening hemorrhagic fever. Additional information about dengue
and current outbreaks may be found at the US Centers for Disease Control and Prevention (CDC) dengue webpage (www.cdc.gov/dengue), as well as at the US Geological Survey disease map webpage (http://diseasemaps.usgs.gov/del_us_human.html).

The recognition of emerging or re-surgent biological threats, such as dengue, and invasive mosquito species will affect mosquito control and public health professionals who are tasked with controlling them and mitigating their threat to public health. Two mosquito species that are likely to be problematic are the yellow fever mosquito, *Aedes aegypti*, and the Asian tiger mosquito, *Aedes albopictus*. *Aedes aegypti* originated in Africa and arrived in the New World, likely aboard slave ships during the 1700s. *Aedes albopictus* originated in Southeast Asia and Japan and has been transported around the world, notably in the egg stage by the used tire trade during the 1980s. *Aedes albopictus* originated in Southeast Asia and Japan and has been transported around the world, notably in the egg stage by the used tire trade during the 1980s. Both of these species are important vectors for dengue and other diseases such as yellow fever, chikungunya, and various viral encephalitides (Gratz 2004). Europe and South America have also seen recent invasions of *Ae albopictus* (Knudsen *et al* 1996, Gratz 2004).

Ecologically, it is also worth noting that the arrival of invasive mosquito species can disrupt indigenous mosquito communities. The arrival of *Ae albopictus* allowed Juliano and Lounibos (2005) to test ecological theory and the ecological effects of this species on native species and *Ae aegypti*. In North America, *Ae albopictus* generally, but not always, outcompetes *Ae aegypti*. However, in other parts of the world the reverse sometimes occurs. From an ecological perspective, this is an interesting competitive relationship. From a medical entomology perspective, the outcome is important because of the dissimilar competency of the two vector species. *Aedes aegypti* feeds on humans for the majority (~95%) of its meals, whereas *Ae albopictus* does not feed on people as often (~50%). However, *Ae albopictus* is a more robust species and can survive in both natural and human environments, whereas *Ae aegypti* usually requires humans for both habitat and food.

Climate change does not directly cause the arrival of invasive species, but it may change the outcomes and dispersion dynamics once the species has arrived. Specifically, climate change can allow species to have greater distributions than they otherwise might accomplish. Exact predictions about the future are impossible, however, modeling can provide insight into different scenarios. For example, previous modeling efforts using *Aedes* species have been reported by Focks and colleagues (1993a, 1993b, 1995), who developed an *Ae aegypti* and dengue virus model. This model is parameter intense, but produces accurate short-term predictions. We were interested in the population dynamics of *Ae albopictus* and the potential impact of climate change on dengue virus transmission dynamics by this mosquito. We initially studied dengue not only because of its public health importance, but also because of its relatively simple transmission cycle. Dengue virus cycles only between humans and *Ae aegypti* and *Ae albopictus* outside of its native range in Africa, where primates may also be part of the cycle and other *Aedes* species may vector the virus. For this project, we developed a population model for *Ae albopictus* (Erickson *et al* 2010a) and incorporated it into a dengue disease model (Erickson *et al* 2010b). We used the models with climate projections to examine the potential effects of climate change on both *Ae albopictus* and dengue virus (Erickson *et al* 2012), available as an Open Access article on the journal homepage, http://iopscience.iop.org/1748-9326/7/3/034003.

Our modeling efforts provide insight into the both the dynamics of *Ae albopictus* and dengue virus transmission under future scenarios. Broadly, we expected an increase in season duration for both the mosquito vectors and potential dengue virus exposure, and possibly mosquito abundances throughout the season.
Our simulations did predict a longer potential exposure season. However, our simulations also revealed an unexpected trend as well; future climates may be too warm for *Ae albopictus* during summer months. This prediction occurred because mosquitoes have an optimal temperature, above which they do not thrive or live as long. The simulated shortened mosquito lifespan caused a small decrease in mosquito population size and also caused mosquitoes to die before they could incubate and transmit dengue virus. The critical take home message from this modeling exercise is that potential climate change may be counterintuitive and non-linear. In other words, we should expect the unexpected. Other mosquito-borne diseases with more complicated transmission cycles, like WNv, will likely be affected by climate change and have expanded geographic ranges as well (Epstien 2001).

Vector-borne and, more specifically, mosquito-borne diseases are resurfacing in the United States irrespective of climate change. Furthermore, addressing the resurgence of mosquito-borne diseases is good policy regardless of climate change. As an example, Shaffer (2012) reported in a previous issue of Wing Beats that landscape design methods may eliminate mosquito colonization. These approaches work by reducing runoff through landscape design. Although not discussed in the article, these designs will also help with climate change adaption because projected climate change will likely increase large rain events, even if the total amount of rain decreases for many areas. This article also highlights the need for mosquito control experts to adapt operational procedures for anomalies associated with climate change. Additionally, various efforts to mitigate changes in precipitation patterns may have direct effects on mosquito populations. A non-mosquito control expert may not necessarily realize that implementing strategic plans is creating ideal mosquito habitat until the public begins complaining after construction. However, advance collaboration such as that suggested by Shaffer is essential for proactive management of mosquito vector problems before they are created.

As we are faced with a changing world, invasive mosquito species and diseases will likely continue to be transported around the globe. These impacts may stem from global problems, but the solutions are local. Mosquito control personnel will be the first to notice the arrival of invasive species, and will be tasked with controlling them. However, by continuing to develop working relationships with their colleagues in both the private sector and public sector, mosquito control experts can mitigate ongoing change. Additionally, this ongoing change highlights the importance of professional groups such as the America Mosquito Control Association and state and county vector control jurisdictions that provide continuing education to their members. Also, governmental and non-governmental resources exist to help professionals learn about new diseases. In addition to CDC, the US Geological Survey monitors and produces maps of several different mosquito-borne diseases, [http://diseasemaps.usgs.gov](http://diseasemaps.usgs.gov). The World Health Organization ([www.who.int/en](http://www.who.int/en)) disseminates information about vector-borne diseases as well. Lastly, state agencies, extension service offices, and universities all offer information, both in person and online, that can help mosquito control professionals stay current with emerging diseases and vector population threats.

**ACKNOWLEDGMENTS**

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

From where I sit... The western honeybee, *Apis mellifera*, fills almost 85% of agricultural pollination needs. Pollinators are a vital resource in today’s agricultural economy, being responsible for an estimated $18 billion in agricultural production. Keeping bee colonies healthy thus becomes a critical need in our nation’s food supply and commerce. However, the airwaves and print media these days are awash in breathless stories about the precipitous decline of honeybees and other pollinators presaging the imminent decline in agriculture output. Potential pesticide exposures, particularly the neonicotinoids, are being emphasized as possible reasons for this decline. While mosquito control does not employ this class of pesticide, make no mistake about it, this labeling of pesticides as the culprit brings mosquito control operations squarely within the sights of activist groups intent on shutting down our programs.

Interestingly, despite the dire warnings of pollinator collapse, honeybee hives and beekeepers are actually increasing in the United States and elsewhere. For instance, in Florida, Arkansas, Indiana, Michigan, Montana, North Dakota and South Dakota, hives have increased from 1,127,553 in 2006 to 1,520,662 in 2012 – a 35% increase. Other states show increases in hives and numbers of beekeepers, as well. Nonetheless, pollinator protection has become a cause célèbre for environmental activists, posing scientific, regulatory, legal, enforcement, political and public relations challenges for end-users of pesticides – including public health entities. The multidimensional nature of the issue complicates potential resolutions that may have far reaching effects on public health mosquito control efforts in the future if not successfully addressed.

The legal and regulatory aspects of pollinator protection are being discussed at length by the various agricultural stakeholders and regulatory agencies. Mosquito control is somewhat of a sideshow, but our interests are taken into full consideration through the efforts of Ed Ruckert and our partners in Responsible Industry for a Sound Environment (RISE).

Both the agricultural and regulatory communities seem intent on finding and implementing equitable label language and regulatory guidelines, but the going is slow and the stakes are high. Complicating matters further are the gaps in our knowledge of acute and chronic pesticide effects on colony health. In October 2011 the US Environmental Protection Agency (EPA) issued Interim Guidance on Honey Bee Data Requirements that would focus on studies needed to characterize "...adverse effects of chemicals to honey bees as part of the registration review and registration of new chemicals/uses."

In 2012, a number of studies were published linking colony collapse to the neonicotinoids. The following year beekeeper groups and activist groups sued EPA for allowing the continued use of neonicotinoids in the United States. During the summer of 2013 a highly publicized incident in Oregon involving the death of bumblebees associated with trees treated with dinotefuran. The media immediately focused on the role pesticides were surmised to play in bee kills and rationality began to exit stage left.

While pesticides occupied the limelight in this incident, what was not reported were the potentially lethal effects of European Linden Tree (*Tilia* species) nectar when imbibed by American bumble bees (*Bombus* species). American bumble bees lack the enzyme phosphomannose isomerase needed to digest the mannose-rich nectar of European Linden species, causing the bees to accumulate lethal levels of glycolysis-blocking mannose-6-phosphate. Interestingly, European honeybees, which had coevolved with European Lindens, had evidently evolved tolerance to the European
Linden nectar, whereas American bumble bees had not, resulting in mortality found only in bumblebees. European honeybees are unaffected by feeding on American Linden tree nectar.

This was never reported in the press, thus keeping pesticides on the radar screen as the cause of bumblebee mortality in Oregon. The lesson here is that any temporal or spatial association of your public health pesticides with bee kills will automatically be taken as de facto causation. Therefore, the greatest care should be taken to avoid even the perception of exposing pollinators to control applications lest you be blamed for pollinator problems that were probably the result of any other number of acute or chronic stressors such as varroa mites, nosema virus, hive beetles, etc. In the absence of definitive data to indicate otherwise, pesticides will continue to receive a disproportionate amount of attention. It may be obvious to us that evening ULV applications pose minimal risk to bees, but our visibility makes us an easy target – and science may not win the day.

So, how do we minimize pollinator exposure to public health pesticides without compromising our mission? First, all stakeholders must assume a proactive part in protecting this valuable resource. This presupposes a robust and ongoing dialogue between mosquito control and beekeepers regarding their respective missions and the means available to accomplish them. Clarification of roles and cooperation are key. In particular, beekeepers must recognize that mosquito control operations are affected by temperature, precipitation, wind speed, and use buffers. All affect public health pesticide choices and decisions on when, where, and how to apply them.

At a minimum, this dialogue should include: provision of lists of local beekeepers and contact information, notification procedures, hive locations, public health pesticides to be used, and areas that are routinely sprayed from survey data.

Beekeepers should be encouraged to practice proper hive management, including:

- Provision of a fresh source of water;
- Provision of supplemental feed, if required;
- Monitoring of colony health, queen status and pest/disease problems in the hive;
- Utilizing IPM practices to control hive pests;
- Placing hives at least 500 feet from roadways;
- Keeping hives ready for quick relocation, with plans for how and where to move them;
- Keeping colony health logs to provide context for bee kills.

Mosquito control personnel have their own obligations, including:

- Contacting beekeepers 48 hours prior to pesticide applications, if possible;
- Periodically reviewing and updating beekeeper lists and hive locations;
- Applying ULV pesticides as late in the day as practicable;
- Ensuring that ULV machines are properly calibrated;
- Strictly following label specifications.

Regardless, it is ultimately the beekeepers responsibility to protect his/her bees. Be mindful, though, that it is the mosquito control district’s responsibility to facilitate this to the extent their mission allows within the legal restrictions enumerated on the label.

Mosquito control needs to keep in mind the following in assessing the future of pollinators:

- The honeybee has assumed iconic status as a proxy for the health of the environment;
- Pollinator health is an important issue for mosquito control operations;
• Studies continue to be commissioned to ascertain risks of pesticides to pollinator health;

• Pollinator health will be used by activists to attack mosquito control’s use of adulticides;

• Both print and broadcast media will focus on the relationship of public health pesticides to pollinator health;

• Label modifications to protect pollinators, currently restricted to neonicotinoids, will eventually apply to other classes of insecticides.

In the short term, imprecise label restrictions for pollinator protection will be subject to misinterpretation and potential enforcement actions. Stakeholders, including the AMCA and various agricultural interests, are in the process of addressing this with the EPA.

Further complicating this issue are some of the practices of pest control operators offering mosquito control services. Although commercial pest control operators can provide useful and, at times, vital adjunct control in areas outside the jurisdiction of organized mosquito control districts, their potential effects on pollinators has yet to be studied. Misting systems, of course, are not endorsed by the AMCA for any number of reasons, but their potential effects on pollinators may eventually be their undoing if this practice comes onto the radar screen of activists. Barrier treatments could also be problematic. Both practices pose ample opportunities to expose pollinators to at least repeated sublethal exposures to pesticides.

This underscores the need for mosquito control districts to be proactive in educating their private commercial pest controllers in pollinator protection initiatives and practices. It’s important to fully comprehend that these operators are not going away – and that our profession will be tarred with any brush associated with mosquito control practices. Thus, it behooves us to get the commercial folks on board and aware of the stakes involved. They can be a valuable ally or your worst public relations nightmare – it’s your choice. It’s my preference that they be brought into the fold so they can help us protect the public. The National Pest Management Association is fully cognizant of the pollinator issue and has a policy on the subject posted on their website. Let’s take appropriate action on these mutual concerns and ensure everyone’s needs are met, be they beekeepers, pest control operators, mosquito control professionals – and, most importantly, the public.

While the pollinator protection issue remains in flux, our profession needs to maintain our focus on our core mission of protecting the public from mosquito-borne disease. Be mindful, though, that there are competing priorities that can exert a profound effect on the way we conduct our business. These are genuine interests that have perceived value to their adherents, whether beekeepers or wildlife ecologists. We would do well to continue to work constructively with these groups to gain their confidence and support.

We all have a stake in pollinator health.

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To learn more about securing peace of mind for your program give us a call at 1-800-323-5727 or email your request to clarke@clarke.com.