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The AMCA Young Professionals ................................................. 5
by Alex Chaskopoulou

IR-4: The New Partner in the Search for Public Health Pesticides ........ 13
by Karl Malamud-Roam, Stanton E Cope and Daniel Strickman

Aerial Scourge Trials at Collier Mosquito Control District ............... 17
by Jeffrey C Stizers, Kelly Huff and Marin Brouillard

International Forum for Surveillance and Control of Mosquitoes and Mosquito-borne Diseases ........................................ 24
by Rui-De Xue, Tong-Yan Zhao, Gary Clark, Gunter Müller, Jeanne Moeller and Daniel Kline

Mosquito Management and Risk .............................................. 28
by Robert K D Peterson

From Where I Sit: Notes from the AMCA Technical Advisor .......... 36
by Joe Conlon

About the Cover: Two 3D views of 5-benzyl-3-furylmethyl cis-2,2-di-
methyl-3-[2-methylprop-1-enyl]cyclopropanecarboxylate; also expressed as C_{22}H_{26}O_{3} it is more commonly known as the pyrethroid adulticide, resmethrin. The images of the cis-resmethrin molecules were rendered by Nathaniel Sickerman, University of California - Irvine.

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The AMCA Young Professionals by Alex Chaskopoulou

THE GROUP

During the 76th annual American Mosquito Control Association (AMCA) meeting in Lexington, KY, an idea was born to bring together young members of the AMCA into a special group, known as AMCA Young Professionals (YP). The idea behind this group is to provide an opportunity to enrich the experience of young professionals in the field of mosquito research and control by promoting interaction among these professionals, and enhancing communication between young and well-established, experienced professionals. The formation of such a group is one of the best ways to encourage networking, while enriching awareness of opportunities in the field of medical entomology and mosquito control. The group will specifically aim to increase participation of young professional members during the AMCA annual meetings, increase their visibility and highlight their research and accomplishments.

THE HISTORY

Looking back to 2007, I remember how excited I was to attend my first AMCA meeting in Orlando, FL. As I returned home, I reflected upon what a great conference it was, but I also realized that I was left wanting more. Even though I had thoroughly enjoyed the highly informative and diverse presentations, the exceptionally great quality of the talks given by the students during the competition session, the high attendance and representation from the industry, the abundance of breaks along with the nice food and refreshments, and above all the fancy banquet, I had not had many opportunities to meet and interact with peers as much as I would have liked. I listened to so many interesting talks that sparked many ideas and questions, but I barely had the chance to meet and interact with the presenters! I attended the entire student competition and left without knowing any of the participants. So many interesting talks to listen to and so little time, so you rush from room to room, while in the back of your mind, you are trying to deal with the stress involved with the student competition... or wondering how many e-mails you have to answer or papers to grade once back in the office... You are young and new in the field, and on top of this, if you have a shy and reserved personality, it is almost certain that you will experience an educational and informative conference but you will miss all the fun associated with it! Since 1989, students in the field of medical entomology get together once a year to compete for the best overall research presentation. As my esteemed colleague, and one of the 2010 student competition winners, Holly Tuten said “Why should we get together only to compete when we can use this opportunity to socialize with each other? At least it would make the meeting experience so much more fun!”

However, it wasn’t until Dr Stan Cope proposed the idea of forming an official group that it all fell into place for the first time during the 76th AMCA annual meeting in Lexington, KY. A group of young AMCA professionals, including a majority of the students attending the student competition, scientists, and technicians from institutions such as the US Department of Agriculture (USDA), the Centers for Disease Control and Prevention (CDC), various mosquito control districts, and private research laboratories, got together to socialize and participate in various activities. One of the most notable activities was visiting the Entomology Department at the University of Kentucky (UK). We had the honor of being welcomed by Dr John Obrycki, Department Chair and Kentucky State Entomologist, who gave a brief introduction about their program and opportunities available for entomologists. Next, we visited the Insect Systematics laboratory, where Kacie Johansen, who recently graduated with her MS in entomology, briefed us on various projects, particularly the creation of interactive keys for Brachonid wasps. We then met with Katelyn Kowles, a PhD student in the Insect Ecology laboratory. Katelyn’s interests focus on examining...
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Approximately 16 young professionals joined the group during the AMCA 76th annual meeting. Some of the young scientists present at most of the activities, their affiliations and a sample of their research interests were:

• Holly Tuten, a PhD student from Clemson University working on research to provide science with a better understanding of the potential health risks posed by mosquitoes interfacing with animals and humans in a zoo setting;
• Logan Minter, a MS student from University of Kentucky working with sand flies and investigating their biology so that information would be available for future use in IPM programs;
• Lee W Cohnstaedt, a postdoctorate scientist from the USDA ARS Center for Medical Agricultural & Veterinary Entomology working on mosquito and sand fly behavior and physiology in the presence of attractants, repellents and pesticides;
• Philip Crain, a PhD student from University of Kentucky working on quantification of the relationship between mosquitoes and Wolbachia;
• Jimmy Mains a PhD student from University of Kentucky working on impacts of endosymbionts on Aedes albopictus laboratory populations;
• Whitney Qualls, a PhD student from University of Florida working on blood-feeding behaviors and DEET repellency in Sindbis virus-infected Aedes aegypti;
• Sabrina Hayes from Florida
A&M University, working on the isolation of *Bacillus* species toxic to several mosquito species;

- Philip Otienoburu, a graduate student from Ohio State University, working on attractive synthetic floral blends for *Culex pipiens*;

- Chris Stone, a graduate student from Ohio State University, working on blood-feeding behavior of *Anopheles gambiae*;

- Bethany Swope and Martin Williams, research scientists from CDC;

- Kristine Styer, an entomologist from ICR Inc, working on insecticide efficacy testing;

- Amber Partridge and Gillian Anderson, entomologists from Colorado mosquito control.

**CALL FOR PARTICIPATION**

To be successful in our field of work, whether teaching a medical and veterinary entomology course, conducting research in the laboratory or the field, surveying and identifying mosquitoes, or promoting a new mosquitocidal product, one should have an open mind and be motivated to connect and exchange ideas with colleagues that have similar interests. We are professionals in the same field, with similar goals and ideas that could flourish unimaginably if we all join together. Participating in the various activities of AMCA YP group will provide the opportunity to become friends with other professionals who have similar interests, and it is a great way to meet and interact with well-known researchers and specialists in your field of interest from all over the world. Those of us who are still students will also realize that our education does not end when we receive our degree. We continuously learn from each other as long as we keep an open mind and are open to sharing and accepting knowledge. It is often outside our classroom or daily working environment that great opportunities arise, and ideas are born.

**SPECIAL THANKS!**

I would like to thank Dr Stan Cope and Dr Roxanne Connelly for inspiring the AMCA YP and for being strong and faithful supporters from the very beginning. Also, I would like to thank Ms Sarah Gazi, AMCA’s Executive Director, for the hard work she put into AMCA YP. Last but not least,
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- ...we need to learn the most efficient and effective methods of mosquito and vector control.
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Visit www.mosquito.org/meetings to start planning your participation now and making your case to attend. Hotel rates, estimated registration costs, and ground transportation costs will help you estimate your expenses.

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352-392-2326

Those of you who would like to become members of AMCA Young Professionals and plan to attend the meeting in Anaheim, please e-mail me at andahask@gmail.com and let me know. In the e-mail you should include your name, affiliation, title, and preferably a photo. Also, let me know if any of you would like to be actively involved to help organize our future activities. I thank you in advance for your participation and look forward to meeting you in person.

I would like to thank the Board of Directors and particularly AMCA President Dr Janet McAllister for welcoming the idea of forming a young members group with such enthusiasm and for giving us the freedom to move forward as we see fit. However, it is all of the AMCA’s young members and student’s participation, and your willingness to help that can make this group flourish and provide some continuity from year to year. Let’s not allow this group to come and go - let’s make it a reality and an everlasting, valuable part of the AMCA.

77th AMCA ANNUAL MEETING
ANAHEIM CALIFORNIA 2011

The first official meeting of the group will take place during the 77th AMCA annual meeting in Anaheim, CA. A professional session will be organized about careers in medical entomology and mosquito control. A group of well-known specialists in academia, research, industry and mosquito control will enlighten us with their insight and perspectives on current and future opportunities, and possibilities that are awaiting for us in the professional world. Additionally, there will be a social hour, with ample opportunity to mingle and meet everyone. I hope to see you all there!
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The IR-4 Project, a consortium of federal and state facilities that has long assisted the development and registration of sustainable pest control technologies for small market agriculture, has recently joined the US military and the US Department of Agriculture (USDA) in an effort to fill the toolbox of pesticides used for protecting public health. This is the latest in a series of public and private actions which recognize both the critical need for an adequate supply of public health pesticides (PHPs), and the need for public support to ensure the availability of these tools. In this article, we discuss the status of the PHP toolbox and reasons for concern, we introduce some key participants working to fill the toolbox and keep it full, and we focus on the tasks and prospects for the nascent IR-4 Public Health Pesticides Program.

PUBLIC HEALTH PESTS, PUBLIC HEALTH PESTICIDES, AND THE SHRINKING PHP TOOLBOX

There is a wide range of public health pests, which are animals (frequently arthropods) that can make you sick, either by vectoring pathogens, causing allergic reactions and secondary infections following bites, or simply through their nuisance value. Mosquitoes, ticks, sand flies, bed bugs, and their kin collectively sicken and kill millions of people annually and cause untold discomfort and lost productivity around the globe. Unfortunately, there is not a large enough set of safe, effective, and affordable tools available to combat these threats to our health, and the toolbox has been getting smaller.

Pesticides are not the only way to fight public health pests — screens and other exclusion methods, biological control, and habitat management practices that reduce pest abundance are all important — but public health pesticides are critical tools both for individuals and families and for the public entities charged with protecting their health. PHPs include all chemicals, both natural and synthetic, that help control any public health pests, but for now, at least, PHP research is focused on arthropods. PHPs are often characterized by their primary modes of action as toxicants, growth regulators, repellents and attraction inhibitors, attractants (for traps), etc., but these distinctions are not always clear. For example, both DDT and permethrin are effective insect toxicants and repellents, as are the many pyrethroids and botanical products have been formed into mosquito coils.

Some new PHPs have come onto the market in recent years, including topical repellent active ingredients for personal protection, as well as etofenprox and spinosad-based products for wide-area use, but in general the toolbox has been getting smaller for many years. In addition, resistance development, which is more likely when the range of chemical tools is limited, means that some materials that are on the market may be locally ineffective.

THE SEARCH FOR NEW PHPs

The last decade has seen a renewed interest in PHP and their availability, largely because of the continuing high morbidity and mortality associated with malaria, especially in Africa, and the slow progress in developing an effective vaccine against this disease. A renewed commitment to combating malaria and a renewed focus on the insects that transmit it, after a gap of several decades, has been reflected in the global Millennium Development Goals, the President’s Malaria Initiative, the formation of numerous aid and advocacy groups, and the funding priorities of the Gates Foundation and other philanthropists. While most of these efforts have focused on distribution of insecticide-treated nets and other interventions, important PHP research and development has also occurred as a result, much of it sponsored by the Innovative Vector Control Consortium (IVCC) in Liverpool, or the National Institutes of Health, and some of it addressing diseases beyond malaria.

An additional major motivation for PHP innovation in recent years has been the deployment of US and allied military personnel in combat areas, particularly in...
Iraq and Afghanistan, where they have been exposed to a wide range of relatively unfamiliar vector-borne diseases. A particular problem has been cutaneous leishmaniasis, transmitted primarily by the sand fly Phlebotomus papatasi, which has sickened thousands of deployed warriors. Additionally, many common mosquito adulticides have not worked adequately in some environments, especially hot deserts, where soldiers, sailors, airmen, or marines are deployed. Finally, humanitarian missions by the military, such as providing assistance after the 2009 earthquakes in Haiti, have pointed out limitations in the existing PHP toolbox.

In response to a need for safe and effective new tools to protect our troops, the military’s Armed Forces Pest Management Board (AFPMB) and the USDA’s Agricultural Research Service (ARS) rekindled the PHP development partnership that years ago brought us DEET, the aerosol pesticide can, ultra low volume (ULV) application technology, and many other innovations. Started in 2004, the Deployed War-Fighter Protection Program (DWFP) has been a highly productive research consortium, funding both ARS and outside researchers, and generating papers, patents, and incipient products for development; see http://www.afpmb.org/dwfpresearch.htm. By 2008, the DWFP research and product discovery pipeline was flowing fast, and the DWFP began moving into its next phase – product development and registration.

WHY ARE PHPs INCREASINGLY RARE?

Over the last few decades, regulatory requirements covering pesticides have increased, yet private industry has seen inadequate financial incentives to invest heavily in the PHP realm. Costs are high, increasing, and unpredictable; the market is small and unpredictable; regulatory requirements between countries are inconsistent, so the market is fragmented; and concerns about liability and litigation are ever-present. While ensuring pesticide safety and public confidence is essential, high regulatory costs can stifle innovation (the “Precautionary Principle”) or drive products from the market even when there little or no evidence that they pose significant risks (see article about Resmethrin in this volume).

Resistance is a major problem in many areas; so that even when some materials are on the market, they may not be locally effective. In addition, vector-borne disease cases have been relatively rare in the developed world (ie, the lucrative markets) for a number of years, while many members of the public in these countries are increasingly risk adverse regarding chemicals in general and pesticides in particular. This means that vocal advocates for PHPs are also increasingly rare, even among those of us that use these tools in our daily work.

FIFRA and the Food Quality Improvement Act recognized that PHPs deserve special regulatory attention, because of the key role they can play in disease prevention, but public dollars to match these statements of Congressional intent and public commitment have been scarce. In particular, the FQPA authorized federal spending of up to $12.5 million per year for regulatory support for PHP’s, but these moneys have never (yet) been appropriated.

For more information, visit the IR-4 PHP program website at http://ir4.rutgers.edu/publichealth.html or contact Program Manager Karl Malamud-Roam at kmr@aesop.rutgers.edu.
Registration support for new pest control technologies for small markets has been the mission of the IR-4 Project since it was created in 1963, so it was a clear choice when DWFP needed a new partner to help bring novel PHPs through registration to the field. A consortium of USDA facilities, land-grant universities, and state agricultural experiment stations, IR-4 has served growers of low-acreage crops and other minor users of pesticides over almost 50 years as a liaison with both EPA and the pesticide developers and registrants. In addition to advising users and potential registrants, IR-4 has analytical labs and test sites, and conducts high quality studies to support registrations when this is recognized as in the public interest.

In 2008, agreements between DWFP, ARS, and IR-4 led to the formation of the IR-4 Public Health Pesticide Program, which expands the traditional mission of IR-4 to include the facilitation of the development and registration of PHPs. As with new tools for small market agriculture, IR-4 provides advice and regulatory assistance for new PHPs, as well as direct research as budgets allow. In addition, the IR-4 PHP Program also collaborates with EPA and user groups on improved integration of chemical tools into Integrated Vector Management (IVM) strategies, support for the regulatory needs of existing PHPs, development of standardized data dossiers and other methods to streamline the PHP regulatory process, research, and outreach. The program works to identify and register PHPs for use globally, as well as within the US, through collaboration with IVCC and other global partners. Finally, The IR-4 Public Health Pesticides Program maintains the only public access database specifically dedicated to public health pesticides. Available through http://ir4.rutgers.edu/publichealth/publichealthDB.cfm, the PHP Database complements other public information on pesticide chemistry and toxicology by bringing together data on the efficacy of chemical tools against specific public health pests, PHP use patterns, and PHP regulatory status inside and outside the US.

We will probably always face the threats of disease vectors and vector-borne diseases, but rest assured that there is a significant global effort to ensure the availability of PHPs now and in the future, and that the AFPMB, USDA ARS, and IR-4 are at the forefront of this effort.
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The Collier Mosquito Control District (CMCD), in Naples, FL is uniquely situated with regard to climate and mosquito-producing habitat. Located on the Gulf of Mexico in southwest Florida, Naples has the Rookery Bay National Estuarine Research Reserve to the south, the Florida Everglades (including the 10,000 Islands) to the east and southeast, and very flat, flood-prone, reclaimed portions of the Everglades (Golden Gate Estates) to the east. [Visit www.CMCD.org or http://www.collierappraiser.com/webmap/Map.aspx for Naples area maps.]

These conditions, in conjunction with a prevailing southeast wind during the mosquito season, lead to massive, repeated invasions of Aedes taeniorhynchus, the black salt marsh mosquito, from the Everglades as well as Psorophora columbiae from fresh water habitats to plague the residents of Naples.

Because the larval habitat for these mosquitoes is outside the CMCD boundaries (salt marsh species), is classified as sensitive habitat and not treatable with larvicides (fresh and salt marsh species), or is simply too vast to treat economically (fresh water species), the CMCD relies heavily on the application of mosquito adulticides by air.

For adulticide applications, the CMCD utilizes three Shorts SC-7 Skyvan fixed wing planes and four Hughes 500D helicopters. All aircraft are currently equipped with Micronair rotary nozzles. The adulticide of choice is naled (Dibrom Concentrate®) applied undiluted at approximately 0.5 fluid ounce per acre.

While the CMCD is satisfied with the level of control achieved with naled, the potential for development of resistance in the local mosquito population or regulatory actions limiting the use of naled are concerns. Because of this, the CMCD initiated a testing program to look for viable alternatives to naled. The first product to be tested was resmethrin. A total of 10 operational trials of resmethrin (Scourge 18-54®) were completed during 2005 (3 trials), 2006 (4 trials), and 2007 (3 trials).

The trials in 2005 and 2006 were conducted at the same location, Oil Well Road, with 17 sample sites in and downwind of the treatment area in 2005 and 19 sites in 2006. The trials

![Figure 1: Foil-covered board with filter paper pads to monitor deposition of resmethrin.](image1)

![Figure 2: Mosquito cages and PVC pipe stand.](image2)
in 2007 had 19 sample sites and were conducted at two locations, two trials on Logan Boulevard and one on Golden Gate Parkway. The spacing between sample sites ranged from 800 to 3,200 feet, with most being between 1,000 and 1,500 feet apart.

Placed at each sample site was an aluminum foil-covered board, to which was pinned a filter paper disk; see Figure 1. The filter paper was used to determine the deposition level of resmethrin at each site.

Also placed at each site was an inverted, L-shaped piece of PVC pipe which held cages for mosquitoes; see Figure 2. During the first year of testing, one cage was used at each site, while in subsequent years two cages were used per site. The cages (Fig. 2 and 3) were constructed of 1.25 inch-wide rings of 4 inch PVC pipe, with the open ends of the ring covered with nylon tulle. A hole drilled in the side of each ring allowed for the introduction of mosquitoes. The hole was plugged with a cotton ball after mosquitoes were introduced into each cage.

Fresh water mosquitoes, primarily *Culex* spp, were collected using a modified John W Hock model 512\(^*\) trap (Stivers et al, 1997). The trap was baited with CO\(_2\) from a 20 pound cylinder, with a release rate of 200 ml/min, and a vial of octenol, using a method similar to Kline et al (1990). The traps were set the day before each test in areas with known freshwater mosquito populations, and were run throughout the night. The traps were collected at first light and transported to the CMCD office, where the mosquitoes were transferred to exposure cages. Once 15 to 20 mosquitoes were placed in each cage, the cages were laid flat on a tray and a cotton cosmetic pad soaked in sugar solution was placed on the nylon tulle; see Figure 3. The tray of filled cages was placed in the insectary until needed for the test that night.

For the tests completed in 2005, only one cage of mosquitoes was used per sample site. All other tests had two cages per site. Mosquitoes were transported to the field in an ice chest, with sugar pads still in place. Cages were placed at each site so that the tulle-covered opening was oriented directly into the wind to maximize potential exposure of the mosquitoes to the ULV droplets of resmethrin. The boards with the filter paper pads were placed at the base of the pole supporting the cages. Similar cages and filter paper pads were placed outside the test area to act as untreated controls.

Applications were initiated at the upwind end of the test area between 12:00 and 1:00 am with a Shorts SC-7 Skyvan equipped with the CMCD-designed air assist, or two fluid, application system. The maximum label application rate of 0.007 pounds active ingredient per acre was used for all applications. In 2005, the VMD produced by this combination of equipment and application rate was 25 µ. In 2006 and 2007, the VMD was increased to 33 µ in the hope that the larger droplet would improve efficacy. The number of passes varied from year to year; 16 in 2005, 5 in 2006 and 8 in 2007, but were the same for all tests within a year. Lane spacing of 1,000 feet was used for all applications.

Cages and filter paper pads were collected 2 hours post-application completion. The filter paper pads were folded and rolled into tubes using acetone-rinsed forceps and placed into individual glass vials with screw caps immediately upon collection. At the completion of collection, the mosquitoes were transferred into clean holding cages with a cosmetic pad soaked in sugar solution and returned to the insectary. Mosquito mortality was read at collection and again at 24 hours post-exposure. Vials with filter paper pads were filled with 30 ml of methanol to fix any
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resmethrin residue and shipped to Dr. Harry Zhong at the John A. Mulrennan Sr. Public Health Entomology Research and Education Center of Florida A&M University in Panama City, FL for chemical analysis.

The average 24 hour mosquito mortality values for the trials in 2005, corrected for control mortality where necessary, are presented in Figure 4. Also presented are the mortality values for one trial with naled for comparative purposes. For all trials the wind was from Site 1, blowing toward higher site numbers. No resmethrin deposit was found on filter paper at any of the sample sites.

As can be seen, the level of control from resmethrin was not as high as that from naled. In addition, the results from the resmethrin trials varied considerably when the trials were reviewed individually. None of this information was encouraging for the use of remethrin as a substitute for naled.

After discussions with industry representatives familiar with remethrin, it was thought that the low and variable control levels noted might be the result of overly small droplets. As a result, it was decided to continue tests in 2006 similar to the tests performed in 2005 except that the VMD was increased to 33 µ, two additional sample sites were used and two cages of mosquitoes were exposed per site.

Results in 2006 were similar to those in 2005 with considerable variation among trials; see Figure 5. The average mortality for all four trials never reached 80%. In three of these trials there were few sample sites where any deposition was recorded on the filter paper pads,
suggesting that the insecticide was not reaching the sample site in any quantity. In one trial, ten of the 19 sample sites had detectable resmethrin levels. However, only three of the sites where deposition was recorded had mosquito mortality above 80%, even though the level of deposition was very similar for all of these sites. This level of control was deemed unacceptable for the rural setting in which the trials were conducted.

It was decided to test resmethrin in a more urban setting in 2007. As a result, three trials were conducted, all in more urban areas than previously tested. Two trials were conducted on Logan Boulevard and one trial on Golden Gate Parkway. The number of sample sites, number of cages per site, and droplet VMD were the same as in 2006. The initial trial looked promising, with 12 of the 19 sample sites having mortality above 80% and 10 of those above 90%. Unfortunately, the results of the two subsequent trials were similar to those obtained in previous years. Between them, only five sites had mortality above 80%, with considerable variation among trials, as noted in previous years. When the three trials are averaged, there are only two sites with mortality above 80%; see Figure 6. As with previous results, these were considered to be unacceptable levels of control.

Deposition was recorded from a number of sites for two of the trials and at only one site in a third trial. As in previous years, the level of deposition at a particular site did not seem to be strongly related to the level of mosquito mortality at that site. Some sites with higher mortality had lower deposition than sites with less mortality.

After three years of testing, the CMCD decided that, given the application equipment used by the CMCD and the environment in which applications are routinely made, resmethrin is not a suitable substitute for naled. Districts that use different equipment, application techniques (ground or aerial), or have different mosquito species and environments might find that resmethrin is a suitable adulticide for their situation.

REFERENCES CITED

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The Entomological Society of China and Beijing Institute of Microbiology and Epidemiology hosted the 1st International Forum for Surveillance and Control of Mosquitoes and Mosquito-borne Diseases in Beijing, May 25-28, 2009. The meeting provided an opportunity to discuss current status and future challenges of mosquito and mosquito-borne disease surveillance and control programs in China and elsewhere. Other objectives included: (1) identifying possible areas of collaboration for research and development of surveillance and control of mosquitoes and mosquito-borne diseases; (2) sharing information about possible funding resources for mosquito and mosquito-borne disease control; and (3) to promote new techniques and methods for surveillance and control of mosquitoes and mosquito-borne diseases.

More than 20 leaders in the fields of mosquito surveillance and control mosquito-borne disease from nine countries were invited to give presentations in one of 10 sections to include diseases, surveillance, insecticides, physiology and ecology, behavior, invasive species and disease, programs, new technology, integrated pest management (IPM) and legislation. A total of 56 presentations were given in these 10 sections. The meeting was strongly interdisciplinary, bringing together scientists, managers, and legislators from university, institutes, government agencies, private industry, and mosquito control agencies. The meeting attracted over 166 attendees from 9 countries and 30 Chinese provinces, achieving both national and global attention. The evolving international concern about swine flu activity and quarantine measures did not affect attendance.

Oral presentations were limited to English. To facilitate communications, three projectors with three screens were used. The center screen was in English, while two side screens had slides translated into Chinese. The meeting provided many opportunities for active participation by students and enabled Chinese scientists to practice their English. The program was printed in both English and Chinese. All Power Point presentations, abstracts, and participants’ names and contact information were brought together on a single DVD that was distributed to all participants.

The host and organizers invited all international participants to visit the Beijing Institute of Microbiology and Epidemiology to attend the Chinese Duanwu Festival party and visit either the Great Wall or the Forbidden City after the meeting.
Figure 2: International Forum participants from Florida (from left to right): Daniel Kline, Paul Linser, Jeanne Moeller, Annette Cappella, Gary Clark, Rui-De Xue, Arshad Ali, and Graham White.

Tong-Yan Zhao (Professor and Director of the Department of Vector Biology & Control, Beijing Institute of Microbiology and Epidemiology, China) and Rui-De Xue (Director and Entomologist, Anastasia Mosquito Control District, St Augustine, FL) opened the meeting and moderated the first session. Zhong-Ning Zhang (Secretary of the Entomological Society of China (ESC)) and Rui-De Xue gave the welcome address and introduction.

Gary Clark (Research Leader, USDA Center for Medical, Agricultural, and Veterinary Entomology (CMAVE), Gainesville, FL) presented the keynote address, “Mosquito-borne arboviruses in the USA and dengue fever in the Americas.” Guo-Dong Liang (Deputy Director & Professor, Institute for Vial Diseases, China CDC, Beijing) spoke about “Mosquito-borne arboviruses in China” and Shang-Qing Wang (Deputy Director and Professor of Hainan CDC, Haikou) gave a presentation on “Malaria control in Hainan Island, China.” Err-Lieh Hsu (Professor, National Taiwan University, Taipei) spoke on “The role of insecticides for dengue vector control in Taiwan.” In the afternoon session of the Disease Section, Gary Clark and Chun-Xiao Li (Section Leader, Medical and Veterinary Entomology, ESC) co-moderated the Disease Section. In this section, there were presentations about mosquito-borne disease surveillance in the State of Florida, emerging mosquito-borne diseases in China, status of dengue fever in China, and surveillance of dengue vector mosquitoes in Guangdong Province, China.

In the Surveillance Section, Dan Kline (Research Entomologist, CMAVE) gave the keynote presentation “Mosquito population surveillance and techniques: past, present, and the future.” He was followed by three speakers from India and China, who gave presentations about surveillance methods practiced in India, and mosquito surveillance in China’s CDC and China’s Inspection and Quarantine System.

The Insecticide Section on the second day of the symposium was moderated by Dan Kline and Guo-Dong Liang. Graham White (Senior Entomologist, University of Florida (UF), Gainesville, FL) presented the keynote address “Insecticides for mosquito control, past, present, and the future.” He was followed by three Chinese scientists who spoke about the status of insecticide resistance in mosquitoes in China, discovery of a potential bio-insecticide, and development of insecticide resistance in mosquitoes and the role of the kdr gene.

In the Physiology and Ecology Section, Paul Linser (Professor, UF, St Augustine, FL) provided the keynote address entitled “Molecular physiology and compartmentalization of larval mosquito gut.” This was followed by a presentation on environmental change and mosquito composition in Yunnan Province, China and blocking dengue transmission in mosquitoes by the endosymbiotic bacterium Wolbachia.

The Behavior Section was co-moderated by Graham White and Shan-Qing Wang. Gunter Müller (Visiting Professor, Hebrew University of Jerusalem, Israel) provided the keynote address entitled “Sugar feeding behaviors, sugar baits, and possibility for adult mosquito control.” Then, Rui-De Xue gave a presentation entitled “Mosquito plant feeding, survival, and potential application for control.” This was followed by other 3 presentations about impacts of insecticides on mosquito behaviors, blood feeding behaviors of Anopheles minimus in Thailand, and an overview of State of Florida mosquito control programs.

Xiao-Long Zhang and Feng-Ling Song (Professors, Academy of Chinese Inspection and Quarantine, Beijing) co-moderated the session on Invasive Mosquitoes and Mosquito-borne Disease. Feng-Ling Song gave the keynote presentation about “Imported
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mosquito-borne diseases and prevention in China.” After this talk, presentations were given on Aedes aegypti as an invasive species in the border area of Yunnan, China and dengue fever in the border area of Guangdong Province.

On the third day of the symposium, Gunter Müller and Qi-Yong Liu (Professor and Director, Department of Vector Biology and Control, Institute for Communicable Disease Control & Prevention, China CDC, Beijing) co-moderated the Program Section. Gary Clark gave the keynote presentation speaking about “An overview of USDA CMAVE, Mosquitoes & Fly Unit’s research programs.” This talk was followed by Graham White’s presentation about the US Department of Defense’s Deployed War Fighter Protection research program, and three other presentations including talks about the mosquito control used during the Beijing 2008 Olympic Games, and an overview of the American Mosquito Control Association by John Holick (Regional Director, AMCA).

The New Technology Section was co-moderated by Paul Linser and Zhi-Kuan Jiang (Professor, Military Institute of Medicine, Nanning, China). Amir Gialili (Manager, Westham Innovations, Israel) provided the keynote presentation about “Attractive toxic sugar baits (ATSB), a new approach for adult mosquito control.” This was followed by presentations from Rentokil Tai Ming China, BASF, Syngenta (China) Investment Co Ltd, Bayer, and the Innovative Vector Control Consortium about mosquito control programs, techniques, and resistance management. In the second session, 6 presentations were provided by local Chinese mosquito control agencies about their surveillance and control experiences for mosquitoes and mosquito-borne diseases.

On the fourth day of the symposium, Tong-Yan Zhao moderated the Integrated Pest Management Section, Arshad Ali (Professor, UF, Apopka, FL) provided the keynote address entitled “Pestiferous chironomid midge problems and population management strategies and challenges worldwide.” Then, Tong-Yan Zhao gave a presentation about “Integrated vector management for mosquitoes in China.” An overview of the USA’s Teton County mosquito abatement program was provided by John Holick. This was followed by a presentation entitled “Biocontrol of mosquito larvae in China,” presented by Xiao-Qing Su (Professor, Guiyang Medical College, Guizhou, China).

The final section on Legislation and Associations, was co-moderated by Jeanne Moeller (Commissioner, Anastasia Mosquito Control District) and Chun-Xiao Li. Tong-Yan Zhao provided the keynote talk about “An overview of China funding resources, legislation, organizations, and associations for mosquito control research and operation.” This was followed by Jeanne Moeller’s presentation about legislation and mosquito control in Florida. Dan Kline and Rui-De Xue gave overviews of the Society for Vector Ecology and the Florida Mosquito Control Association, respectively.

At the end of the meeting, Rui-De Xue made some concluding remarks about the meeting’s program and success, expressed thanks and appreciation to the meeting hosts and organizers, financial funding organizations and companies, hotel, all moderators, speakers, and attendees.

The program committee has decided that the 2nd International Forum for Surveillance and Control of Mosquitoes and Mosquito-borne Diseases will be held in Beijing, China, May 23-27, 2011.
Mosquito Management and Risk by Robert K D Peterson

In his inauguration speech on January 21, 2009, President Obama said “We’ll restore science to its rightful place...” Although he was referring primarily to the role of science in economic and technology development, it is appropriate to extend his statement to include science’s role in societal decisions about technology and the regulation of technology. In particular, what does restoring science to its rightful place mean when it comes to the regulation of technology? Because technology is based on science, scientific evidence must be afforded its proper place in decisions about the proper use of technology. Of course, in our democratic system, science does not – nor should not – serve as the sole arbiter of societal decisions about technologies and how to use them. These decisions should use science as a foundation, but then also incorporate economic, legal, ethical, aesthetic, and cultural factors.

What does “restoring science to its rightful place” have to do with mosquito management and risk? Quite a lot, actually. Since the infectious pathogen West Nile virus invaded the United States in 1999, causing the largest encephalitis disease epidemic in US history (1), renewed public attention has been focused on mosquito management. Most of this attention and concern has involved using insecticides as an outdoor space application targeting adult mosquitoes, often called “adulticiding” (2). The concerns have revolved around two major areas: the effectiveness of adulticiding, and the risks posed by adulticiding. These concerns have led directly to opposition to adulticiding by organized activist groups and have led to misinformation and opinions that are not consistent with facts. The risks and benefits of adulticiding and other management tactics have been extensively studied. So, let’s look at each of the two major areas identified above and see what the prevailing science has to say.

We have long known that using adulticides in outdoor space applications reduces populations of adult mosquitoes, although the results can be quite variable. What has been more uncertain is the effect of adulticiding on reducing pathogen infection rates in mosquitoes and on reducing disease incidence in people and other animals. Although it is reasonable to assume that if adulticiding reduces adult mosquito populations there will also be reductions in pathogen-infected mosquitoes and disease in people and other animals, research to evaluate this has been lacking until very recently. Results from these studies suggest that adulticiding has a significant effect on reducing pathogen infections in mosquitoes and disease (3-5).

What about the ecological and human-health risks from adulticiding? Before we can examine these issues, we need to take a step back and look more broadly at the scientific discipline of risk assessment. To assess risk, one needs to understand both effect and exposure. Risk is really nothing more than an interaction of these two factors (6). And, risk assessment is simply the objective evaluation of risk in which the assumptions and uncertainties that are part of the assessment are clearly considered and presented (6,7).

In the case of adulticides, we need to know the toxicity of, and exposure to, the insecticide in question to properly estimate the risks. Like all chemical risk assessments, researchers have estimated or measured the exposure of a person or other organism to the insecticide and then compared that exposure to a threshold exposure level. The threshold level is usually determined by a regulatory agency such as the US Environmental Protection Agency (EPA). Threshold exposure levels usually incorporate safety factors that increase the protection of people and wildlife. In the case of exposure and risk to people, the threshold level is the exposure to the insecticide that has been shown in a series of studies with laboratory animals to have no toxic effects on individuals. For exposure and risk to non-target organisms, like wildlife, the threshold level varies and may be an exposure in which no toxic effects are observed, or it may be an exposure that is a small fraction of the concentration needed to kill 50% of the test-animal population. In other words, there may be a toxic effect, but it has been determined that it will not affect the populations of organisms in the short or long term.

What do the risk assessments that have been conducted for outdoor space applications have to say? Because risk assessment of insecticides is...
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dependent on the amount and frequency of exposure, the application rate tells us a lot about the resulting risk. Insecticides used for outdoor space applications are applied at a very low rate compared to agricultural and residential applications. For example, in agricultural applications permethrin is often applied at a rate thirty-five times greater than is applied for adult mosquito management. In a sense, then, the risk from outdoor space applications for adult mosquitoes is just a small fraction of the risk from agricultural applications. But is that risk acceptable or unacceptable?

The weight of scientific evidence from independent research and regulatory agency assessments strongly suggests that exposures to people from outdoor space applications of mosquito adulticides are well below threshold levels of concern (2, 5, 8-20). Epidemiology and biomonitoring studies (21-25) support the results from these risk assessments. Exposures to mammals, birds, fish, and aquatic invertebrates are also below levels of concern (19, 26-35). These assessments include short- and long-term exposures from single and multiple applications. Risks are low even for many terrestrial insects because the applications target flying mosquitoes at night (26, 27, 32, 35, 36). Risks to people, mammals, and birds are extremely low. For example, a person's exposure to permethrin as a result of an outdoor space application would be less than one ten-thousandth of the threshold exposure level (8, 19, 37); see Figure 1.

What about the risks from other mosquito management tactics such as larvicides, personal repellents, and insecticide-treated clothing and bednets? Here, too, research over many years and from many researchers indicates that exposures are below levels of concern, provided that these tactics are properly used (18, 29, 38-44). However, the use of the western mosquitofish, a biological control organism, may present unacceptable risks to fish and aquatic invertebrates where the fish is not currently endemic (45).

Mosquito management is essentially part of a broader public and environmental health enterprise. In mosquito management, we use an Integrated Pest Management (IPM) approach. This involves identification of mosquito species and surveillance of their populations. When populations of larvae, pupae, adults, or pathogen-infected adults reach pre-established threshold levels, actions may be taken to lower those populations below the thresholds. These actions may involve several tactics. When adult mosquito or disease thresholds have been breached, adulticides may be used. As we have seen above, the use of adulticides by health professionals can reduce infected mosquitoes and resultant disease. And, as we have seen, when these adulticides are used in outdoor space applications, the risks are below levels of concern.

In the US, West Nile virus and many other pathogens are alien, invasive organisms. The diseases these pathogens cause pose human health and economic problems for our society, and they pose environmental problems for ecosystem functioning and biodiversity. As part of the public and

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**Figure 1:** Estimated exposure of a person to the adulticide permethrin (0.000025 mg/kg body weight), compared to the US EPA's Acceptable Daily Exposure Level (0.25 mg/kg body weight) and the No-Effect Level (25 mg/kg body weight). The Acceptable Daily Exposure Level is the amount of chemical that an individual can be exposed to over a lifetime without experiencing any toxic effects. The No-Effect Level is the exposure at which no toxic effects have been observed in a series of laboratory animal experiments.
environmental health enterprise, mosquito management professionals are charged with the well-being of their particular local areas. If we are to put science in its rightful place, science should inform our understanding of risk and the societal decisions that need to be made about mosquito and disease management. The weight of scientific evidence shows that mosquitoes and the pathogens they carry can cause appreciable risks to public and environmental health. When mosquito populations need to be managed, IPM tactics are used that have been shown to be effective and to result in risks that are below levels of concern. Science, then, is put in its proper place by providing the facts that are used to make the best decisions to protect our health and the environment.

For more information and a complete list of citations from this article, see the West Nile Virus, Mosquito Management, and Risk website at: http://landresources.montana.edu/WNV/.

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The comment period for the Environmental Protection Agency’s draft National Pollutant Discharge Elimination System general permit has been closed since 19 July and the Agency is, I assume, revising some of its provisions to more realistically dovetail the needs of the regulated community with the requirements of the Clean Water Act. Clearly, it is premature to speculate on the final product with which we will have to live. It may mirror the draft’s provisions, or it may be a different product altogether. It will probably be unveiled at the December Pesticide Program Dialogue Committee meeting at EPA headquarters, so I’ll wait until I see it before I pontificate on its contents. Let’s discuss another pressing issue, the dwindling inventory of mosquitoicides, instead. I’ve spoken with my industry colleagues over the years and I present some of the information I’ve gleaned from their collective experience in the following article. This is particularly pertinent in light of the recent voluntary cancellation of resmethrin. Let’s take a look at this most unwelcome development and its historical antecedents.

**DEVELOPMENT OF MOSQUITOCIDES**

I would think that the process of developing a marketable mosquito control product should be of interest to all mosquito control professionals who use these products in their work. They are indispensable tools of our trade and knowledge of the intricacies involved in their development might offer an appreciation of the tenuous nature of their availability. It would also offer a unique opportunity for us to become more conscientious stewards of our limited resources.

To fully understand the scope of the research and development involved in pesticide manufacture, one must first understand how the US pesticide market is structured. The market is essentially comprised of two distinct sectors – the agricultural sector and the specialty products sector. Within this latter group are found the specialty products for turf, golf, pest control, ornamental, container and greenhouse production, retail, and mosquito control.

New chemistry development within the United States pesticide industry is driven almost exclusively by sales revenues in the crop market. Product sales in this market are measured in billions of dollars and pay for their own development costs – upwards of 200 million dollars per chemical. Companies may sometimes engage in minor product development work for smaller markets such as pest control, but for the most part, the products that are used in the specialty sector are required to demonstrate a value in the crop markets first. As the product matures, these secondary markets may be identified, enlarging the base of business that can contribute to product profitability, ultimately covering development and registration costs.

Regulatory costs have historically remained relatively constant, allowing manufacturers to accurately predict these costs along the product sales continuum. Unfortunately, in some cases, changing regulatory requirements and their attendant costs have become even more burdensome than the original registration. Faced with new tests required to secure continued registration, manufacturers are constantly reducing marginal market segments, such as mosquito control, in which they sell their chemistry. In the meantime, the cycle continues, as manufacturers vie for more of the agricultural market through development of new chemistries, each having its own set of development and regulatory costs. Manufacturers will then attempt to move their customers to their new chemistry in order to meet competition and establish their new product for sales to cover these costs. Inevitably, as these newer products mature in a market, there are fewer customers willing to buy the older chemistry. Nevertheless, each year the manufacturers must pay for the regulatory costs of these older, less profitable products. This now becomes a business decision, as reduced sales fail to cover the continued regulatory burden. To be sure, there are other considerations in the decision to keep, sell or abandon chemistry, but for the most part, it’s a pretty simple economic exercise.

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to further protect the nation’s food supply, particularly where children are concerned. The rationale was that detection and modeling methodologies had improved dramatically since the original registration, and might reveal new effects determinations heretofore unknown. These effects might then, in turn, either require removal of use patterns to reduce risk, require additional mitigation, or clear them again for their current use patterns. This ultimately resulted in an additional 10X safety factor built in to the label on top of the 100X safety factor already there. The new program, termed Registration Review (RR), streamlined re-registration by only reviewing new information not available during the initial registration. This would ostensibly save registrants money because of less paperwork. Unfortunately, each time this process occurs in the 15-year review cycle, additional tests may end up being required to support the continued registration of the product already on the market.

For example, closely after the enactment of FQPA, concerns began to be raised about certain chemicals ostensibly mimicking various hormonal functions in living systems. These substances came to be called “endocrine disruptors.” Although one of the initial studies purporting to demonstrate these effects had to retracted due to the inability of numerous outside investigators to duplicate the initial published findings, the issue of endocrine disruption had become a new source of concern and generated great scientific interest in the regulatory community. More importantly, potential endocrine disruptors became a cause célèbre in the political arena. The Agency came under intense pressure to evaluate pesticides putative hormonal effects and expended enormous sums to develop and deploy assays to determine whether pesticides would indeed exert these effects. This ultimately resulted in the tiered assay system in place today. It should be noted that the pesticides initially being evaluated for endocrine disruption were chosen by EPA solely based upon amount of usage, not suspicion of endocrine disruption.

So we now are confronted with corporate concerns regarding human exposures, crop tolerances, non-target effects, endocrine disruption, Endangered Species Act and other regulatory problems that will make the registration and use of new products in the niche mosquito control market problematic – and expensive. We must remember that the improvements in agricultural chemistry, where the lion’s share of the profits are to be found, generally work against us in mosquito control. The agricultural world seeks chemical stability for crop uses, whereas
our ULV adulticiding applications seek control through formulations that break down quickly into inert by-products.

A CURRENT CASE IN POINT: RESMETHRIN

The Scourge™ brand of mosquitoicides, including the 18% and the 4% products that have been a staple in many mosquito control programs for decades, are scheduled for cancellation as early as 2011 or 2012. Bayer Environmental Science, a division of Bayer CropScience, evidently will not continue its support of the active ingredient, resmethrin, for its upcoming registration review by EPA. It appears that the $2.5 million price tag for re-registration resulting from new data call-ins did not justify continued manufacture of the molecule. As a result, the last year of manufacture may be as early as 2011 or 2012. EPA proposed a 2-year phaseout in the Federal Register Notice, but has advised the registrant that it’s not unusual for extensions to be granted to voluntary cancellation phaseout periods, especially if there are reasoned arguments from credible sources with specified dates. Bayer had asked for 3 years, but EPA reduced it to 2 in the FR Notice. The AMCA will comment on this cancellation in the docket and will probably request the extension be extended to 5 years.

By way of background, Bayer Environmental Science is the sole registrant for resmethrin products in the US for vector control and had originally intended to re-register the product at an estimated $1.4 million price tag. As it happens, EPA now requires a series of endocrine disruption tests to be added to the existing data generation protocols for resmethrin as part of the new registration review process. According to Bayer, the estimated cost to complete the tier I endocrine disruption studies would raise the total support costs to re-register resmethrin to approximately $2.25 million. On top of that, additional ‘tiers’ (II, III, IV...) of endocrine disruption studies may be required to complete the re-registration if the initial studies demonstrate a need for more refined assessment. Each ‘tier’ of tests could potentially add $1 million to the final cost of re-registration. Bayer Environmental Science found the uncertainty surrounding the requirement for further tests and the amount of their costs to be untenable and formally notified the EPA of its decision to cancel the registration after a meeting to discuss the issue.

This is an ominous development for a mosquito control profession that has already lost fenthion in 2002 as a control option. When resmethrin is voluntarily cancelled, we will have suffered a loss of 20% of the tools available for controlling adult mosquitoes. With few materials other than etofenprox coming down the registry pipeline for professional mosquito control use, this portends badly for our future.

THE HISTORY OF RESMETHRIN

It is said that the Chinese discovered the insecticidal properties of pyrethrum around 2000 years ago when they observed that smoke from burning chrysanthemum flowers showed the ability to kill flying insects. Once this was effectively demonstrated and shown to have market potential in the late 19th Century, the production of specific species of chrysanthemums in Africa became regulated for the production of insecticides used in agriculture and pest control. By 1885, yearly pyrethrum imports to the US exceeded 622,000 pounds. However, disease, famine, labor disputes and even war regularly interrupted supplies and made the cost of this valuable chemistry wildly erratic. This drove the synthesis of the pyrethroid, allethrin, in the early 1940s. Resmethrin, permethrin and other pyrethroids would follow. This ability to synthesize pyrethrum chemistry removed much of the unpredictability in the pyrethrum market and caused sales to flourish.

The new pyrethroids demonstrated excellent activity against a variety of target insects, but the photo lability of the first generation of these products compromised their usefulness in the profitable agricultural sector. While the soil half-life of resmethrin may have exceeded 30 days, exposure to sunlight reduced the half-life to as little as 30 minutes. To meet the needs of crop protection, each succeeding generation of pyrethroids saw an increase in photo stability and half-life to provide more residual efficacy. For instance, the second-generation permethrin half-life on soil may be from 3 to 6 weeks. Bifenthrin, a fourth generation pyrethroid, has a half-life of more than 300 days in certain soils.

The early 1980s saw resmethrin beginning its role as a frontline mosquito control adulticide. Indeed, resmethrin is an ideal product for this in many ways – very active against mosquitoes, low odor profile, non-corrosive and possessing a relatively short half-life. Unlike other products used in mosquito control, where the use for the active ingredient is also prevalent in crop markets or specialty markets such as turf or pest control, virtually all the resmethrin produced in the world today comes to the US to be used in mosquito control. Other uses have been cancelled over the years as a way to decrease
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the costs of carrying the many original uses on the registration – particularly when there was alternative, newer chemistry to which users could move. Here again we see that, as resmethrin matured and lost market share, costs associated with its continued existence in the market could not be covered by the sales of the product in the agricultural markets where it was no longer sold. With this in mind, it should be also noted that the cost of producing resmethrin has been rising for years. There is actually very little resmethrin produced globally, reducing economies of scale and competition. Furthermore, the two basic chemicals required to produce resmethrin are both very expensive and are manufactured in different countries in Europe. They are then sent to Japan to produce technical grade resmethrin. The technical is then sent to the US for formulation into the branded material Scourge.™ As you can see, the costs of freight and handling associated with the final product are significant and have contributed to its current tenuous position in the mosquito control market. Further costs of new data call-ins were the last straw.

**THE FUTURE**

Fortunately, the legislators drafting the FQPA had the foresight to build a safety measure into the law that mandates consultation between the Environmental Protection Agency (EPA) and the Department of Health and Human Services (DHHS) on public health pesticide issues. The legislation also directed the DHHS to arrange for the necessary data generation support and special studies for the registration or re-registration of public health pesticides in recognition that the economics associated with these products provide little incentive for manufacturers to support these products. This entailed a set-aside of as much as $12 million annually to help defray new data collection costs for many crucial “minor use” public health pesticide products (like resmethrin) necessary to control diseases such as West Nile Virus. Without these funds, it was noted, producers might voluntarily cancel many essential public health pesticides solely for economic reasons. The cost to pesticide manufacturers of generating the necessary data to continue these pesticide registrations would simply far exceed the expected return in sales. The DHHS is responsible for requesting the necessary budgetary allocations for funds, but to date it has ignored its responsibility to request to have the funds actually appropriated.

The AMCA is asking EPA to extend the resmethrin voluntary cancellation date from 2 years to 5 years. Concurrently, the AMCA is also requesting that these aforementioned FQPA-authorized funds be appropriated and allocated to CDC for direct pass-through specifically to the USDA’s Interregional Research Project No 4, commonly known as the IR-4 program, in order to assist in performing the mandated data collection necessary to retain or develop public health pesticides. The IR-4 program is designed to assist potential registrants with data acquisition in order to lower costs for minor use pesticides and will prove to be an invaluable asset to the future development, deployment and retention of mosquito control chemicals. Whether this will result in the further registration of resmethrin is unknown at this point, but it’s worth the effort.

There are also a number of pesticide research initiatives funded through the Department of Defense Deployed War-Fighter Protection Research Program that could lead to new product registration in the United States – so the future is not totally bleak.

Unfortunately, we can expect more of these registration problems as escalating data call-ins due to expanding requirements (endocrine disruption assessments, etc) make it economically problematic for registrants to maintain their products in the pipeline. An emerging hazard-based risk assessment paradigm is being coupled with improved sensitivity in detection methodologies to exponentially widen the universe of potential harm to be mitigated through further regulation. Regardless of how vanishingly small, the possibilities for damage remotely attributable to ever more minute levels of detectable mosquitocide residues will continue to contort the regulatory process. This, in turn, will drive increasingly restrictive regulatory policy requiring additional data generation costs from registrants. Coupled with shrinking end-user budgets forming a smaller market, this vicious cycle is creating a perfect regulatory storm with which we must come to grips as both a profession and society. Indeed, the imminent demise of resmethrin as a consequence of a rational business decision is, regrettably, a sign of the times.

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