AMCA
THE AMERICAN MOSQUITO CONTROL ASSOCIATION

{ AMERICAN MOSQUITO CONTROL ASSOCIATION }

AMCA2017

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83RD ANNUAL MEETING

ABSTRACTS

SUBMITTED PAPERS, POSTERS AND SYMPOSIUM PRESENTATIONS

FEBRUARY 13-17

Town & Country Resort

AND CONVENTION CENTER

MOSQUITO.ORG

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The 2017 AMCA Memorial Lecture Honoree:
Jimmy Olson

Jim and his wife Carolyn had seven children, three sons and four daughters. Their son Robert Alexander lives in Clinton Tennessee, Jason Alexander, Snook, Texas and Christopher Olson, Cypress, Texas. Their daughters Robin Von Heeder lives in Cypress, Texas, Teresa Belyeu, Victoria, Texas, Kristine Boehm, Florence, Montana, and the youngest of the seven children, Megan Olson Collins, Houston, Texas.

Jason and Chris are the 5th and 6th in the order of the 7 Olson children. Jim was instrumental in not only raising them but also a mentor.

Much of Jason's career is credit to Jim who peeked his interest in pest management early in his life. Jason's first job was working for Mark Ivy, Cypress Creek Pest Control Company in Houston, Texas before joining the U.S. Navy in 1989 serving in Desert Storm during the early 1990's. After the Navy, Jason returned home to Snook Texas spending time with family and working for pest control companies in the Bryan College Station area. Jason is married, his wife, Donna, works for Texas A&M AgriLife Extension Service.

Jim's son Chris lives in Cypress, Texas with wife Maria. They have two children Monica and Andrew. Jim's grandkids were the sparkle in his eye. He would light up when they were around. He started trying to influence them early in their childhood with insects and bugs for both birthday and holiday gifts.

Jim in many ways also impacted Chris's career in art. He shared many of his own drawings with Chris and encouraged him along the way. Chris graduated from The Art Institute of Houston. Chris and his wife Maria are both teachers in the Cy-Fair School District where Chris teaches 3D Animation to high school students.

The 2017 AMCA Memorial Lecturer:
Bill Sames

Born in Port Lavaca, TX, Bill grew up in South Texas as his family moved west to San Antonio and eventually the Texas/Mexico border town of Eagle Pass. As a child and young man, he had many outdoor experiences related to the natural world. As a high school student, he learned to keep honey bees and was a beekeeper until 1992. After high school, he attended New Mexico Military Institute and was commissioned as a 2nd Lieutenant, Field Artillery, Texas Army National Guard. In 1984, He graduated from Texas A&M University with a degree in English and returned to Eagle Pass to teach Physical Science, keep honey bees, and raise cattle. In 1987, he returned to Texas A&M and in 1989, graduated with a Master's degree in Entomology. Dr. Jim Olson was a member of his graduate committee. In 1992, Bill entered active duty as a Medical Entomologist in the US Army. Later, he returned to Texas A&M and in 1999, he completed his Ph.D. with co-chairs, Dr. Jim Olson and Lloyd T. (Ted) Wilson. Bill's military career took him to Asia, Central America, the Middle East, and numerous locations across the United States. Throughout his career, he worked a variety of medical entomology and pest management issues and was especially noted for his mosquito work in Washington State and tick work in Korea. Bill served as the AMCA Publications Committee Chair from March 2003 to March 2006. He also provided the initiative and leadership to scan Mosquito News and the early volumes of the Journal of the American Mosquito Control Association into PDF files. At the AMCA annual meeting in 2006, Bill was awarded the AMCA Meritorious Service Award. At the AMCA annual meeting in 2011, Bill presented *William Gorgas: to Havana and Beyond!* in a symposium organized by Stan Cope, who was Bill's last military supervisor. In 2012, he worked with the Texas Mosquito Control Association to host the AMCA annual meeting in Austin. Bill retired from the military in July 2011, studied photography, and in the spring of 2014, he and his wife, Martha, moved to her family's ranch north of Leakey, TX. Besides their ranch activities, they are active in the community and state through leadership and/or working in 7 non-profit organizations. Bill, as of October 2016, is the President-Elect for the Texas Mosquito Control Association.

Oral Presentation Abstracts

Plenary Session

PL-1 **Zika Virus: Current Status and Future Predictions**
Lyle Petersen

Not Available

PL-2 **Assessing the atmospheric oxidation of pesticides used to control mosquito populations in Houston, TX**
Sascha Usenko

Urban-scale application of pesticides are increasingly an important line of defense and control for emerging infectious and vector-borne diseases, such as Zika. It is currently unknown how atmospheric oxidation of pesticides in urban areas may impact their efficacy in controlling vector populations. In the hours near or after sunset, urban ambient concentrations of nighttime oxidants, such as nitrate radicals, dramatically increase. This increase in nitrate radicals coincides with the release of adulticides, such as malathion, directly in the atmosphere by mosquito control programs. Atmospheric measurements in Houston demonstrated significant nighttime oxidation of malathion, which resulted in a reduced atmospheric half-life (~10x). Nighttime oxidants have been shown to oxidize malathion to malaoxon, a less volatile but more toxic compound. Understanding the nighttime oxidation of adulticides, relates directly to environmental and human health and is critical for effectively addressing vector-borne diseases, such as Zika.

A Blast from Our Past: Wandering the Yellow Brick Road of Medical Entomology and Mosquito Control Symposium I

1 **Dr. Samuel A. Mudd: Lincoln to Jefferson**
Thomas Wilmot, wilmote@reagan.com

Many know Dr. Samuel A. Mudd as the physician who treated John Wilkes Booth's broken leg after the assassination of President Abraham Lincoln.Less well known is the role Dr. Mudd played in fighting a yellow fever epidemic while imprisoned at Fort Jefferson in the Dry Tortugas, treating even his captors after many of the prison's staff took ill.Dr. Mudd was pardoned by President Andrew Johnson at the end of his term in office, and returned to his life in Maryland, dying in 1883.The justice of Dr. Mudd's conviction was questioned by many but, despite a century of effort by his descendants, the conviction was never overturned.

2 **We're From the Government and We're Here to Help! 100 Years of Federal Support for the Vector Control Toolbox**
Karl Malamud-Roam

Not Available

3 **Fred Soper: *Aedes aegypti* archnemesis**
Joe Conlon, conlonamcata@gmail.com

Fred Soper stands out as one of the most successful practitioners of preventive medicine and public health in the twentieth century. Soper was endowed with optimism and vision, an extraordinary ability to select and inspire capable, loyal staffs, an exceptional talent for organizing and administering difficult projects, and skill in selecting and improving effective tools.
Dr. Soper literally "wrote the book" on effective *Aedes aegypti* eradication procedures and personnel management. His draft of the Yellow Fever Service manual of operations in Brazil remains the standard handbook for this effort, and a model for subsequent eradication campaigns. This presentation will focus on documenting the elements of Soper's eradication efforts that contributed to their success.

Disease/ Vector Studies I

4 **The Zika virus in the United States**
Daniel Lindsey, dlindsey245@gmail.com

Since its discovery in Africa in 1947, the Zika virus has not garnered a great deal of notice until its reemergence in 2007. It has subsequently captured international attention causing a trail of epidemic outbreaks that spans the globe. The virus is primarily transmitted by the mosquito vector, *Aedes aegypti* but

has been found to be transmitted by a variety of other routes as well including vertically to the unborn fetus. Devastating neurological effects including microcephaly in the fetus and Guillain-Barré Syndrome in adults have led to a call for immediate action. In the wake of the first local Zika transmission in the continental United States, public health officials scramble to implement effective prevention and control strategies to combat further spread of the virus.

5 First confirmed natural transmission of Zika virus (ZIKV) by *Aedes aegypti* mosquitoes in the Americas

Ildefonso Fernández-Salas, ildefonso.fernandez@insp.mx, Mathilde Guerbois, Mauricio Casas-Martínez, Rogelio Danis-Lozano, Maricela Laguna-Aguilar, Esteban Díaz-González, Rosa Sánchez-Casas, Scott

Zika virus (ZIKV) is another emerging vector-borne disease that is impacting public health but mainly in the newborn and sexual health. Since its emergence in Uganda, no direct evidence of the vectors involved in the natural transmission has been reported. Vector competence studies suggest that *Aedes aegypti* and *Aedes albopictus* could have been the most important vectors during the ZIKV epidemics before its introduction in the Americas. Other vectors such as *Culex quinquefasciatus* has been proposed as another posible ZIKV vector. After we detected an outbreak of ZIKV infection in southern Mexico in late 2015, mosquito surveillance was carried out in order to incriminate the ZIKV vectors in Chiapas State, Southern Mexico. Mosquito collections were performed in 69 households capturing 796 mosquitoes belonging to the following species: *Ae. aegypti* being the most abundant (59.3%; 59% female), followed by *Cx. quinquefasciatus*
(40.5%; 47% female) and then *Ae. albopictus* (0.2%). A total of 15 pools of *Ae. aegypti* were qRT-PCR positive for ZIKV and none for *Cx. quinquefasciatus* nor *Ae. albopictus.* Three positive pools were successfully isolated and then full-sequences were obteined belonging to Asian lineage. The phylogenetic analysis suggests that introduction of ZIKV was probably from Guatemala. The minimum field infection rate of ZIKV in *Ae. aegypti* was estimated at 52.49–172.66 infections per 1,000 mosquitoes. Implication of *Ae. aegypti* as ZIKV vector in southern Mexico is important because no natural mosquito infections have been reported since ZIKV reached the Americas and supports the need for additional efforts to develop new strategies for *Ae. aegypti* control.

6 Entomological investigations associated with a unique case of locally acquired Zika virus in Utah

Harry Savage, hms1@cdc.gov, Marvin Godsey, Ary Faraji, Greg White, Brian Hougaard, Eric Gardner, Ryan Lusty, Gary Hatch

We present the results of mosquito surveillance efforts associated with a locally transmitted case of Zika virus in a male patient (Patient A) within the Greater Salt Lake City area of Utah. The patient was evaluated by a clinician for fever, rash, and conjuctivitis after caring for another elderly male family contact who contracted Zika virus abroad. The latter patient (Index Patient) developed septic shock with multiple organ failure and passed away in Utah. However, Patient A had no travel history to an area with ongoing Zika virus transmission; had not had sexual contact with a person who had recently traveled to an area with ongoing Zika virus activity; had not received a blood transfusion or organ transplant; and had not reported any mosquito bites. The specific method of transmission to Patient A with no known risk factors is still under investigation. However, we report on the mosquito larval and adult surveillance efforts surrounding the areas where Patient A and the Index Patient resided and visited.

7 Zika virus incidence in *Aedes aegypti* in areas with and without autocidal gravid ovitraps

Roberto Barrera, amz9@cdc.gov, Veronica Acevedo, Jorge Munoz, Manuel Amador

Zika virus was detected in Puerto Rico in December 2015, and by the end of August 2016, there were 17871 confirmed cases throughout the island. This investigation aimed at detecting and comparing incidence of Zika virus in female *Aedes aegypti* mosquitoes in two neighborhoods (Sites 1, 2) that have had three Autocidal Gravid Ovitraps (AGO traps) per home in most homes for at least one year, and in two nearby neighborhoods without control traps (Sites 3, 4). Specimens were collected weekly from January to September 2016 using sentinel AGO traps that were deployed throughout each neighborhood. Pools of up to 20 female *Ae. aegypti* were collected and stored at -80 C until the specimens were processed by trioplex RT-PCR to detect Zika (ZIKV), dengue (DENV), and chikungunya (CHIKV) RNA. Observations indicated that densities of female *Ae. aegypti* per trap per week were significantly different among sites, with the largest densities observed in the two neighborhoods without AGO control traps (Site 4= 12.5 ± 4.8, Site 3= 6.7 ± 2.1, Avg ± SD) and the lowest in intervention areas (Site 2= 1.9 ± 0.8; Site 1=1.3 ± 0.6). Zika positive pools were more numerous in mosquitoes collected from the neighborhood with the highest density (Site 4= 33 ZIKV and 3 DENV pools), followed by the neighborhood with intermediate density (Site 3= 7 ZIKV and 1 DENV), and those with the lowest densities (Site 2= 2 ZIKV, Site 4= 0 ZIKV and 2 DENV). No CHIKV positive mosquito pools were found.

8 Innovative vector control technology reduces the transmission of dengue: lessons for Zika

Steve Krause, steve.krause@valent.com, Seleena Benjamin, HL Lee

Mosquito vectors of Zika virus and related pathogens are known as container breeding mosquitoes for their ability to complete larval development in small, well-defined water habitats. Recent innovations in insecticide formulation science, delivery systems and public outreach demonstrate an economical and effective intervention is available today for container-breeder management programs worldwide.

This presentation reviews the published literature showing the human health benefit following large-scale applications of VectoBac WDG (Bti strain AM65-52) to reduce the incidence of dengue. Data from Southeast Asia and the Americas will be discussed. Local cultural practices and community health objectives will guide program implementation. A growing body of evidence suggests that the ecologically safe, epidemiologically effective, and cost-effective applications of VectoBac larvicide will become a baseline intervention in programs faced with container-breeder disease management. Implications to Zika programs and areas for further research will be discussed.

9 Combat Zika and future vector threats using global collaborative Actionable Analytics® software to track, manage, analyze patterns, interpret data, detect trends, identify specific locations at high risk for local transmission, and provide evidence based digital dashboards for decision making by local public health and mosquito control organizations

Robert James, rjames@sustainabilityanalyticscorp.com

Combating Zika and future threats using global collaborative cloud actionable analytic® software to target *Aedes aegypti* and *Aedes albopictus using University of Miami (UM) adult mosquito data base from 2012-2015.*

Idea: We developed a collaborative technological approach to track, manage, analyze patterns, and exchange findings within global communities to combat the spread of the Zika virus and other infectious disease outbreaks. We analyzed The UM data for real time insights for the development of applications to quickly interpret, analyze patterns and correlate data. We are now able to easily build applications with the Mosquito Control and Departments of Health to monitor, plan and execute project initiatives to stop the spread of Zika. Initial project evidence base outcomes can be rapidly disseminated with other Department of Health's facing the spread and establishment of Zika transmission.

We develop *Aedes aegypti* and *Aedes albopictus* habitat models and risk maps using analytical based software that identify specific urban locations at high risk for local transmission of Zika virus. Our next step is to validate the models generated in the above step by developing integrated vector management strategies on a neighborhood level to cost effectively reduce the populations of *Ae. aegypti* and *Ae. albopictus.*

This project was guided by Mr. Robert James and Mr. Ed Robin Co-Founders and Co CEO's of the Sustainability Analytics Corporation and Dr. Whitney Qualls from the U of Miami Department of Public Health Sciences.

10 *Aedes koreicus:* a new European invader and its potential for chikungunya virus

Silvia Ciocchetta, silvia.ciocchetta@qimrberghofer.edu.au, Natalie Prow, Jonathan Darbro, Leon Hugo, Francesca Frentiu, Fabrizio Montarsi, John Aaskov, Gregor Devine

Recent outbreaks of arboviral diseases such as chikungunya following the introduction of non-native mosquitoes, demonstrate the public health threat that invasions pose. The discovery of a new but poorly understood mosquito species in Europe, *Aedes koreicus*, demands an investigation of this mosquito's vectorial capacity. During four months of field and lab work conducted in Italy, I compared trapping techniques and used field collected material to establish lab-based colonies of *Ae. koreicus* first in Italy, and then at QIMR Berghofer in Australia. This colony is now used to conduct laboratory experiments on *Ae. koreicus* vector competence for Chikungunya virus. The Chikungunya (CHIKV) 'La Reunion' strain was administered via artificial oral feeds ($10^{7.5}$ TCID50/mL). Mosquitoes were maintained at two temperatures: 23°C and a fluctuating temperature simulating a Melbourne summer. Despite the low initial hatching rate of *Ae. koreicus* eggs (10.39% ± 2.41), the long gonotrophic interval (11.5 d ± 4.94) and lengthy development times (12.71 d ± 0.45) our unique colony proved suitable for viral challenges. *Ae. koreicus* were exposed to viremic bloodmeals, dissected (25 mosquitoes on days 3, 10, 14, 21 post-infection) and evaluated for CHIKV infection. Feeding rates (65.5%, N=342) and survivorship (97.3%, N= 224) were high. Body and salivary infection rates will be presented. These findings are essential for understanding the public health risks of mosquito invasions, targeting surveillance and control initiatives against invasive mosquito species and understanding the effect of daily temperature fluctuations on vector competence.

11 Transcriptional profile for defensins from *Aedes aegypti* in response to Zika virus and chikungunya virus
Liming Zhao, lmzhao@ufl.edu

Defensins are a family of antimicrobial and cytotoxic peptides thought to be involved in host defense in the most animals and plants, including mosquitoes. *AaeDefA* gene was differentially expressed in the SSH library and RNA sequencing infected with Chikungunya virus (CHIKV). To confirm whether defensin is a critical metabolic pathway in mosquitoes in response to Zika and Chikungunya viruses, we have cloned a defensin gene from *Ae. aegypti* (Key West and Orlando strains). The gene expression of *AaeDefA* through developmental stages and infected with Zika and Chikungunya viruses was analyzed using qualitative real-time polymerase chain reaction (qPCR). This information may provide a better understanding on how *AaeDefA* responds to different arboviruses with implications for development of mosquito control strategies.

12 Enhanced suppression of malaria transmission with joint medical and entomological control measures: an operational research study in highly endemic Ugandan community
Dorothy Echodu, dorothy@pilgrimafrica.org and Richard Elliott

Uganda, as a stably endemic, high-burden country with pockets of extremely high malaria transmission, possesses a large reservoir of asymptomatic infected individuals as well as high vectorial capacity. The challenge of charting a rapid, effective route from high transmission to low, and then from low transmission to pre-elimination, is strictly constrained by resource limitations. In this context, producing more health impact per dollar spent is particularly desirable. We report on the inception of a collaborative and multi-faceted project conducted in the Katakwi district in northeastern Uganda designed to rapidly decrease and sustain community-wide parasite burden. The architecture of this program has in part been guided by simulation, using model strategic approaches for intervention timing and projected impact. A first phase of the program, beginning in 2016, deploys a sequence of interventions which include both vector control through indoor residual spraying of organophosphates and universal preventive treatment with artemisinin combination therapies, timed for high potential impact and aimed to quickly and markedly reduce transmission. Modeling projects the impact of indoor residual spraying enhanced by close to 400% by synchronous deployment of universal preventive treatment, a true synergistic effect with cost implications. Field data expected by December 2016.

Mosquito SIT – Ready for Prime Time Symposium

13 Sterile insect technique (SIT)-based approaches to control *Aedes* mosquito populations
Kostas Bourtzis, K.Bourtzis@iaea.org and Jeremie Gilles

Aedes aegypti and *Ae. albopictus* are considered vectors of human pathogenic viruses including dengue (DENV), chikungunya (CHIKV) and Zika (ZIKV). In the absence of vaccines and efficient, safe and inexpensive drugs to control dengue, chikungunya and Zika, and the lack of sustainability of the conventional vector control approaches, there is an urgent need for novel, sustainable and environment-friendly approaches for controlling populations of *Aedes* mosquitoes. In response to Member States' requests, the Joint FAO/IAEA Division's Insect Pest Control Laboratory (IPCL) has been developing the SIT package for the population control of *Aedes* mosquitoes. A critical step for mosquito SIT is the separation of males from females (for male-only releases) since elimination of female mosquitoes prior to male releases is essential because females transmit the diseases. In the absence of 100% efficient sex separation methods (or genetic sexing strains), we have integrated SIT with the Incompatible Insect Technique (IIT) which is based on the symbiont *Wolbachia* that provides protection against major human pathogens, including ZIKV. This combined SIT/IIT approach can eliminate the risk of releasing fertile and pathogen-transmitting females during SIT applications, and thus represents a biosafe and biosecure approach for mosquito control. In this presentation, we will provide all the recent developments as concerns our mosquito SIT work including data on feasibility and pilot studies.

14 Suppression of *Aedes aegypti* and *Ae. albopictus* populations via the introduction of male mosquitoes
Stephen Dobson, sdobson@uky.edu, James Mains, Corey Brelsfoard, Robert Rose

New mosquito control methods are needed for reasons including the establishment of invasive vector species, the growing problems with insecticide resistance and the global spread of mosquito-borne pathogens. Autocidal approaches for suppressing mosquito populations are based on the introduction of Wolbachia-infected and/or insecticide-treated males. Both methods are similar to classical sterile insect technique in that male mosquitoes are repeatedly introduced into a population, with the intent to suppress the targeted mosquito population. This presentation will summarize open-release field trials occurring in California, Kentucky, Florida and New York. In addition to presenting entomological data, a summary of

public engagement efforts will be provided, along with a summary of communication and coordination between industry, federal and local regulators, experts in insect rearing, and abatement district managers.

15 Fast and (NOT) Furious. Making SIT a ubiquitous reality
Nitzan Paldi, Nitzan@forrestinnovations.com

Emerging diseases, insecticide resistance, climate change and an ever-globalized economy are exasperating mosquito-borne illness around the world. Although several scientific advances over the past few decades provide for some interesting options for disease-vector, the general public and in turn politicians and regulators are often concerned about the repercussions of the unknown and are reluctant to adopt the new technologies. Therefore, in implementation of a strategy such as SIT, it is essential to address the main issues regarding not only the robustness of the method, but especially the safety of the proposed approach, with special emphasis of how it is perceived. Putting the emphasis on such an approach has enabled Forrest Innovations to move quickly into a SIT deployment phase with full support of the local authorities and with minimal friction, thus enabling the technology to become an imminent reality for disease control.

16 Develop combined SIT/IIT approaches for *Aedes albopictus* suppression through field trials in China
Zhiyong Xi, xizy@msu.edu

The endosymbiotic bacterium *Wolbachia* is widely recognized for its ability to induce both a reproductive abnormality known as cytoplasmic incompatibility (CI) and a resistance to dengue virus in mosquitoes. *Wolbachia*-based population suppression strategy, referred to as Incompatible Insect Technique (IIT), entails the release of male mosquitoes infected with *Wolbachia*, resulting in sterile matings and a reduction in the mosquito population. Here, we will report an ongoing field trial to control dengue mosquito vectors through male release to induce female sterility in Guangzhou China. The released mosquito strain carry a novel *Wolbachia* from *Culex pipiens* mosquito, which induces both CI toward the wild type mosquito and resistance to dengue and Zika virus. Mass rearing capacity has been successfully developed with a production of ~5 million males per week. An X-ray irradiator, which has been developed specifically to treat mosquito pupae, is used to sterile females which may escape from sex separator to prevent from potential population replacement. Significant suppression of mosquito population has been accomplished in the release sites compared to the control. We will discuss our results in relation to implementation of SIT/IIT for the area-wide suppression of mosquito population for disease control.

17 Aerial release of millions of sterile male mosquitoes for targeted vector control
Ralph Breslauer, rsb5779@gmail.com

As mosquito SIT comes into the main stream of vector control, the need to scale becomes critically important. This talk will take you thru the technology available to safely release millions of sterile male mosquito to achieve meaningful population suppression. We will discuss the high level aeronautics involved as well as managing the full process from loading, transporting, storing and releasing these quantities. We will share data from recent trials of aerial release including dispersion modeling and density control.

18 Transgenic mosquitoes: community engagement 101
Derric Nimmo, derric.nimmo@oxitec.com

Mosquito-borne diseases, such as dengue fever, chikungunya and malaria, are major and increasing international public health concerns. The two main vectors of dengue are Aedes aegypti and Aedes albopictus and current control measures are proving difficult against both these mosquitoes. In an Oxitec control programme transgenic male mosquitoes (male mosquitoes do not bite or transmit disease) are released continually over a wide area to mate with the target pest population; progeny from these matings die and the target population declines. Over 100 million genetically engineered Oxitec male mosquitoes have been released over the past 5 years in trial around the world achieving great success with over 90% reduction in mosquitoes in every trial. However, one of the major challenges has been engaging the public and the press about this technology. I will discuss those challenges and the efforts we have put into community engagement worldwide.

Student Competition Symposium I

19 The 28th annual student paper competition of the American Mosquito Control Association
Brian Byrd, bdbyrd@wcu.edu

Since 1989 the American Mosquito Control Association has encouraged student participation by providing student members a forum to present their research. This venue is judged competitively and winners receive

the Hollandsworth Prize, which honors AMCA member Gerald Hollandsworth. Each participating student will have 15 minutes to present their paper.

20 Relative productivity of container habits for larval mosquitoes in the midwestern United States
Allison Parker, aparker9@illinois.edu, and Brian Allan

From June to September 2016, field surveys were conducted in nine residential neighborhoods within a Midwestern U.S. city cataloging A.) all man-made containers holding standing water, B.) presence/absence of larval mosquitoes within these containers, and C.) the diversity and abundance of mosquito species present in the containers. Larval and pupal mosquitoes were collected from a variety of habitats including clogged rain gutters. A comprehensive management program is recommended for larval mosquito control in residential environments.

21 Mosquito mayhem: Are Illinois mosquitoes ready for chikungunya?
Kennen Hutchison, k-hutchison@wiu.edu, and Catherine Miller-Hunt

Chikungunya virus (CHIKV) is a flavivirus that is transmitted by Aedes aegypti and Aedes albopictus mosquitoes. Although the virus has a low mortality rate in humans, it causes several severe symptoms. In 2005, an outbreak of CHIKV was identified on the French La Reunion Island and approximately a third of the island's population. This outbreak was later attributed to a CHIKV strain that exhibited a single amino acid change in the viral glycoprotein, and used the Ae. albopictus mosquito as a vector. The mutation, an alanine to valine change at amino acid 226 (A226V), allowed for a leap in vector, from primarily Ae. aegypti to primarily Ae. Albopictus and resulted in a high number of CHIKV cases on the Island. The fact that one amino mutation can expand vector competency throughout Aedes species is of interest to our lab. The aim of our project is to identify if other amino acid mutations in CHIKV's glycoprotein could permit or increase CHIKV competency in Aedes species currently located in west-central Illinois. At this time, invasive Aedes species albopictus, japonicus and. triserriatus are found throughout Illinois. The results of our study will help to indicate if west-central Illinois currently has a mosquito vector that is competent for CHIKV infection and could therefore put the communities of west-central Illinois at risk of facing the virus before the invasion of Ae. aegypti reaches our state. As a secondary objective, our research will look at the mechanisms of viral entry by CHIKV into mosquito cells.

22 Evaluating *Culex pipiens* complex and *Culiseta incidens* as competent vectors for *Dirofilaria immitis* in northern California
Jeffrey Kurosaka, jkurosaka@PACIFIC.EDU, Brittany Nelms, Shaoming Huang, Angie Nakano, Tara Thiemann

Dirofilaria immitis (dog heartworm) is a life-threatening filarial parasite transmitted by mosquitoes to domestic dogs. Endemic in the eastern United States, cases have become more prevalent over the last few decades. While prevalence in California is generally low, Lake County and San Joaquin County have reported rates comparable to the east coast at 2.11% and 0.68% (2015), respectively. Aedes sierrensis is thought to be responsible for transmission in California, but in some cases it exists in inadequate quantities and temporal ranges to explain the prevalence of the pathogen. Based on Huang et al. (2013) and Tran (2016), bloodfeeding patterns, and other vector criteria, Culex pipiens complex and Culiseta incidens were chosen to evaluate for vector competence. Female field-caught mosquitoes were reared from larvae to 4-7 day old adults. Adults were starved for 24 hours and fed infected blood containing microfilariae (3-5 mf/µl) via an artificial feeding system. Fully engorged females were separated and maintained at 24°C. At day 15, 18, or 21, females were decapitated and incubated 30 minutes in warm PBS. Emerging L3 larvae were counted. To further determine the extent of infection, head-thoraces were separated from abdomens following decapitation and independently tested for D. immitis DNA by PCR. Incriminating mosquito species will allow districts to better target control efforts and reduce the incidence of D. immitis. While Lake County and San Joaquin County, CA are the focus of this study, our results will likely be applicable to the western United States.

23 Ovipositional responses of Culex tarsalis to fish-associated semiochemicals in laboratory bioassays
Adena Why, awhy001@ucr.edu, and William Walton

The Western encephalitis mosquito, Culex tarsalis, has been shown to respond to the presence of fish-associated semiochemicals in oviposition sites by decreasing the number of egg rafts laid, in both laboratory and field bioassays. A decrease in oviposition rate on water that contained fish semiochemicals, has been attributed to the presence of different classes of chemical compounds which cause the mosquitoes to alter their oviposition behavior. Whether or not the compounds present act solely as attractants or deterrents has not been determined. To date we have identified three volatile compounds, and one non-volatile compound, that are associated with the Western mosquitofish, Gambusia affinis. To date, our results indicate that the volatile compounds may be acting as attractants while the non-volatile compound is acting as an oviposition deterrent.

24 **Population structure and the likely origins of Aedes aegypti in California**
Evlyn Pless, evlyn.pless@yale.edu, Andrea Gloria-Soria, Benjamin Evans, Vicki Kramer, Jeffrey Powell

Breeding populations of Aedes aegypti were first reported in California (CA) in 2013. Initial genetic analyses using 12 microsatellites on collections from Northern CA in 2013 indicated South-Central US (Houston or New Orleans) as the likely source of the introduction. We expanded genetic analyses of CA A. aegypti by: (a) examining additional Northern CA samples and including samples from Southern CA, (b) including more Southern US populations for comparison, and (c) genotyping a subset of samples at >15,000 SNPs. Major results are: (1) Northern and Southern CA populations are distinct. (2) Northern populations are more genetically diverse than Southern CA populations. (3) Northern and Southern CA groups were likely founded by two independent sources which came from South-Central and Southwest US respectively.

25 **Plant essential oils are capable of enhancing diverse synthetic insecticides against susceptible and resistant mosquito strains**
Edmund Norris, ejnorris@iastate.edu, Maria Archevald-Cansobre, Aaron Gross, Lyric Bartholomay, Joel Coats

The burden of mosquito-borne diseases to public health throughout the world cannot be underestimated. Every year, approximately 700,000 people die from complications associated with etiologic disease agents transmitted by mosquitoes. With insecticide-resistant mosquito populations becoming an ever growing concern, the need for new insecticidal formulations is more important than ever. We screened mixtures of various synthetic pyrethroids and natural pyrethrins (permethrin, deltamethrin, β-cyfluthrin, and natural pyrethrum) with various essential oils in order to enhance the efficacy of these insecticides. We have previously shown that some commercially available essential oils have the ability to enhance the mortality caused by the synthetic pyrethroid, permethrin. We have demonstrated that many plant essential oils are capable of differentially enhancing various synthetic pyrethroids. Moreover, we have also tested mixtures of plant essential oils and synthetic pyrethroids against insecticide-susceptible strains and an insecticide-resistant strain of Aedes aegypti in order to better assess the ability of these plant essential oils to enhance synthetic pyrethroids in wild mosquito populations. These plant essential oils were capable of enhancing synthetic pyrethroids in both insecticide-susceptible and insecticide-resistant mosquito strains. This work demonstrates the potential of plant essential oils in future mosquito control formulations, especially those used for the control of Ae. aegypti, the primary vector of both Dengue fever and Zika virus.

A Blast from Our Past: Wandering the Yellow Brick Road of Medical Entomology and Mosquito Control Symposium II

26 **Maurice Provost and the Rights of Spring: Mosquito Control as Applied Ecology**
Gordon Patterson, patterso@fit.edu

Maurice Provost occupies a pivotal position in the history of mosquito control in Florida in the mid twentieth century. Trained as an ornithologist, Provost came to Florida in the 1940s as part of the Malaria Control in War Areas program. In the late 1940s Provost led the Florida State Board of Health's efforts to launch an independent research program on mosquito control. In 1955, Provost became the founding director of the Florida Entomological Research Center (ERC) in Vero, Florida. During his twenty years leading the ERC, Provost and his colleagues advanced a scientifically based environmentally sensitive approach to mosquito control.

27 **The Untold Story of Ronald Ross**
Stan Cope

Not Available

28 **Zika and the towering Haddows**
Graham White, grahambwhite@hotmail.com

Alexander John "Sandy" Haddow CMG, FRS, FRSE (1912-1978) was born in Glasgow, Scotland, where his education began at Hillhead school and his professional life culminated as Administrative Dean and Professor of Medicine in the University of Glasgow. After graduation with honors and prizes in zoology and medicine, he was recruited by the British Medical Research Council for service in Kenya where his first product was an exhaustive account of the mosquito fauna and climate in "native huts." In 1942 he joined the Rockefeller 'Yellow Fever Research Institute' in Uganda for investigating the sylvan cycle of YF. While implicating the monkey hosts and jungle vectors of YF he interpreted the circadian activity cycles of mosquitoes and tabanids. Recognizing that their specific foraging and swarming activities occurred at particular times and heights up to the forest canopy, he pioneered the use of towers for sampling Diptera at elevations above and within Ugandan forests at Lunyo, Mpunga, Semliki and Zika. As Director (1953-1965) of what became the East African Virus Research Institute (EAVRI now UVRI) at Entebbe, he investigated arboviral zoonoses (Bunyamwera, Bwamba, chikungunya, Entebbe Bat, Ntaya, o'nyong-nyong, Semliki,

Uganda S, West Nile, Zika) discovered as byproducts of the YF program. Alec Haddow's artwork of monkeys and forests are displayed in Glasgow archives. From the patchiness of human Burkitt's Lymphoma distribution, he tried in vain to find a vector for the aetiological Epstein-Barr virus in Africa, and later mapped cancers while serving as Director of the Scotland Cancer Research Bureau. His son Alastair settled in Springfield MO, recently honored by the Mercy Clinic for HIV education (2012). His grandson Andrew Haddow now pursues Zika globally, with recent publications on Zika virus genome, phylogeny, sexual transmission, chemotherapy and vectors. Salute 3 generations of towering Haddows.

Adult Control I

29 Resistance profiling of *Aedes aegypti* from Florida, August and September 2016

Griffith Lizarraga, glizarraga@clarke.com, Alden Estep, James Becnel

Understanding the susceptibility of field populations of mosquitoes enables districts to choose which products to apply and when, thus optimizing time, personnel, and product during a mosquito-borne disease outbreak. During the 2016 Zika virus (ZIKV) outbreak in southern Florida, we evaluated the time-to-mortality of *Aedes aegypti*, a vector of ZIKV, against BioMist 315 (permethrin and PBO); Mosquito Mist 2 (chlorpyrifos); Mosquito Master 412 (chlorpyrifos and permethrin); and Duet (sumithrin and prallethrin). *Aedes aegypti* eggs were collected from sites in Miami/Dade, Broward County, and Manatee County. Females were exposed to formulated product in a modification of the existing CDC bottle bioassay protocol. We included a susceptible strain from Orlando as the baseline and a highly pyrethroid-resistant strain from Puerto Rico for comparison. We will discuss resistance management with recommendations based on time-to-mortality of field samples to the susceptible baseline.

30 Mosquito insecticide resistance affected by agricultural pest management

Mike Dunbar, dunbar17@gmail.com, Amanda Bachmann, Febina Mathew, Adam Varenhorst

Mosquito abatement programs frequently exist within landscapes that include agriculture. Although separately managed, both agricultural pests and mosquito species are targeted by similar classes of insecticides. We compared *Aedes vexans* mortality between locations with and without adult mosquito abatement programs within the northern U.S. Corn belt, a region dominated by agricultural production that routinely relies on insecticides for management of pests. Locations selected were either found >10 miles away from or within towns with active adult abatement programs. Bioassays were conducted using WHO adult resistance kits. Female *Ae. vexans* were exposed to insecticide-impregnated papers and respective non-impregnated control papers to test for susceptibility to organochlorine (OC), organophosphate (OP), and pyrethroid (PY) insecticides. No mosquitos survived exposure to either the OC or OP insecticides, regardless of their collection location. Bioassay results did indicate the existence of PY resistance; the lowest mortality occurring in small towns surrounded by agriculture (86.1% ± 2.5 (mean ± SEM)), the highest mortality found in larger towns (96.1% ± 2.9), and mortality of mosquitoes collected from purely agricultural locations falling in between (90.8% ± 2.3). These data suggest that agricultural pest management can select for resistance in non-target species such as mosquitos, however the extent that PY resistance levels observed here approach operational level significance remains unclear. Decoupling of the insecticide classes used by both agricultural and mosquito pest management programs may be necessary to ensure continued efficacy of these pest management tools.

31 Detecting resistance and its mechanisms in mosquito populations for optimized control

Kara Kelley, kkelley@fightthebite.net, Deborah Dritz, Sarah Wheeler, Paula Macedo

Pesticide resistance can dramatically affect our ability to reduce vector populations below threshold levels for disease transmission, economic impact and human and animal comfort. Monitoring mosquito populations for pesticide resistance is an integral part of the integrated vector management program at the Sacramento-Yolo Mosquito and Vector Control District. We use the bottle bioassay and microplate assays when examining *Culex tarsalis* populations, and an additional third assay - the knockdown resistance (*kdr*) assay- when evaluating susceptibility in *Culex pipiens* populations. Results are then used to help direct and optimize mosquito control strategies. Data from different mosquito populations will be presented to illustrate the utility of the combined assays.

32 Optimization of ultra-low volume (ULV) space sprays against caged *Aedes albopictus* in North Florida

Muhammad Farooq

A field study was conducted to evaluate combined effect of nozzle orientation and vehicle travel speed on droplet cloud dispersion and mosquito mortality of adulticide applied from a truck mounted ULV sprayer in the City of Gainesville, North Florida during the summer months of this year. Three multi-block areas were selected representing three different density levels of vegetation (dense, medium and sparse). Adulticide

Aqua-Reslin was applied in each area with horizontal nozzle at 15 mph travel speed, a conventional spray (45° upward orientation) at 10 mph speed and 22.5° upward orientation at 15 mph travel speed. Caged female *Aedes albopictus* was used for the entire study. Spray deposition was also determined at various locations inside the spray plot using Bond and Latham droplet impingers. Our preliminary results show that 24-hr post mortality was higher for nozzle with horizontal and 22.5° at speed of 15mph compared with nozzle with 45° at speed of 10 mph. Spray deposition is still being processing in the lab. The effects of combination of best nozzle orientation and truck speed and different vegetation levels on mosquito mortality will be discussed in the presentation.

33 Fyfanon® efficacy field trials against various mosquito species at a sub-label application rate.
Dina Richman, dina.richman@fmc.com, Allen Wooldridge

Sub-label rates of aerially-applied (via fixed wing and rotary wing aircraft) Fyfanon ULV Mosquito (96.5% malathion; EPA Reg. No.: 279-3539) were evaluated against caged mosquitoes in different geographical areas of the United States (US). The existing label rate range for aerial application is 2.6 – 3.0 fluid ounces per acre (0.21-0.24 lb ai/acre). In these studies, aerial treatments were applied at 1.0 fluid ounce per acre (0.08 lb ai/acre). Six trials, conducted at four different US locations over three years, are reported. Treatment mortalities exceeded 97%, suggesting successful mosquito control can be achieved at lower than current label rates.

34 Efficacy of aerially applied Fyfanon (malathion) upon adult *Ae. taeniorhynchus* and *Ae. aegypti* at rates below EPA-label prescription
Christopher Lesser, Christopher.Lesser@manateemosquito.com, Mark Latham

Fyfanon (malathion) is manufactured and registered by the FMC Corporation and has a long history of use in public-health mosquito control. Historically this product has been EPA-registered for aerial application at a rate between 2.6 and 3.0 fl oz/acre (ground rates are 0.38 to 0.75 fl oz/acre on this same label). Changes in aerial spray technology has permitted the generation of relatively small droplets (VMD of 30-40 microns) and spray clouds of far narrower droplet size spectrum than previously achievable with historic application equipment. A high-pressure ULV adulticide spraying system was used to evaluate the efficacy of Fyfanon at rates between 1.0 and 1.5 fl. oz/acre in semi-controlled field trial and operational situations. Data will be presented demonstrating greater than 90% efficacy of Fyfanon at rates below EPA-label instructions on adult *Ae. taeniorhynchus* and *Ae. aegypti.* Benefits of such applications rates include economics, increased aircraft efficiency, larger spray blocks per mission, and reduced environmental chemical load

35 Evaluation of DeltaGard for ULV Application for Adult Mosquito Control in Winnipeg, Manitoba
Ken Nawolsky, David Wade

Adulticiding is conducted in Winnipeg when there is an unacceptable presence of nuisance mosquitoes or to reduce the human health risk associated with mosquito vectors possibly carrying West Nile Virus (WNV). For over three decades, malathion has been used during certain summers in Winnipeg to carry out a nuisance or vector control adulticiding program using truck-mounted ultra-low-volume (ULV) application. As part of the City of Winnipeg's commitment to decrease the use of conventional pesticides, the City is exploring alternative products to malathion for adult mosquito control as there are very few adult mosquito control products registered in Canada. The efficacy of a new ULV adult mosquito control product containing 20 g a.i. deltamethrin against field populations of adult mosquitoes, primarily *Aedes vexans*, was evaluated in field trials under a research permit in Winnipeg, Manitoba. At the mid-rate of 1.0 g deltamethrin per hectare, two trials resulted in similar mortalities, ranging from 96.2% to 100% after 24 hours of treatment, with no significant variation between the distances up to 90 meters. Control mortality was less than 3.5% during this research trial. Thus, truck-mounted ULV application of deltamethrin provides effective control of adult mosquitoes as a part of integrated mosquito management program for both nuisance and vector control.

36 Efficacy of DeltaGard against *Culex quinquefasciatus* In Harris County (Houston) Texas
Mustapha Debboun, mdebboun@hcphes.org, James Dennett, Pamela Stark

Standard 3 X 3 field cage tests were conducted to compare efficacy of DeltaGard (deltamethrin) applied at 0.00089 lb/ac with Evoluer 31-66 ULV (permethrin/pbo) and Fyfanon (malathion) applied at 0.006 and 0.051 lb/ac, respectively, against adult laboratory susceptible (Sebring) and wild strains of *Culex quinquefasciatus* obtained from three mosquito control operational areas in Harris County. Overall, no significant differences were observed between the mean percent control of *Culex quinquefasciatus* obtained by Evoluer 31-66 ULV (97.24%), DeltaGard (98.20%), and Fyfanon (98.25%) at the 99% level of confidence. Based upon the methodology described, DeltaGard applied at the mid-label rate was as effective in the control of *Culex quinquefasciatus* as Evoluer 31-66 ULV and Fyfanon applied at 85% of their maximum labeled rates.

37 An evaluation of five ground ULV oil based formulations of 30% permethrin/ 30% PBO against local populations of adult *Ae. taeniorhynchus, Ae. aegypti,* and *Cx. quinquefasciatus* in Manatee County

Ambyr Marsicano, a.marsicano@manateemosquito.com, Eva Buckner, Katie Williams, Christopher Lesser, Mark Latham

In an effort to determine which ground ULV oil based formulation of 30% permethrin/ 30% PBO performs the best against three pestilent mosquito species in Manatee County, we compared the efficacy of 5 different permethrin/ PBO 30-30 truck ULV adulticides. Evoluer 30-30, Kontrol 30-30, Perm-X UL 30-30, Permanone 30-30, and BioMist 30+30 ULV were applied at mid and high label rates against local populations of *Ae. taeniorhynchus, Ae. aegypti*, and *Cx. quinquefasciatus* using standard caged trials. Briefly, three rows of sampling stations equipped with rotating 3mm Teflon-coated slides and one bioassay cage each of *Ae. aegypti*, *Ae. taeniorhynchus,* and *Cx. quinquefasciatus* mosquitoes were placed at 100, 200, and 300 feet downwind from truck path and were collected 10 minutes post-application. The results of spray droplet analysis as well as mosquito knockdown and mortality will be presented.

Disease/ Vector Studies II

38 Examining the unpredictable disease activity of West Nile Virus in Harris County, Texas in 2016

Cheryl Battle-Freeman, cbattle@hcphes.org, Martin Reyna-Nava, Monique Jackson, Sharon Mack, Jhoanna Cardozo, Lauren Bonilla, Mustapha Debboun

Emerging intoTexas in 2002, WNV has now become the most commonly occurring arbovirus in Harris County, Texas. Historical data has demonstrated that the onset of WNV and its subsequent development throughout the period of greatest risk for arboviral activity can noticeably vary from year to year. On May 20, 2016, Harris County confirmed its first positive WNV pool via WNV ELISA (Enzyme Linked Immunosorbent Assay) and WNV RAMP (Rapid Analyte Measurement Platform) tests. Because the onset of WNV in 2016 was earlier compared to the previous season of 2015, which ended with a total of 406 WNV positive confirmed mosquito samples, there was much speculation regarding WNV disease activity for 2016. Would an earlier onset this year lead to greater disease activity? How would the season unfold? The next confirmed WNV pool for 2016 wouldn't occur until almost a month later on June 14th. In July, WNV peaked during week 31 with 19 total positive pools confirmed, a much lower number when compared to the prior year 2015, in which 58 positive pools were confirmed during week 30, that season's peak week. In spite of the notable earlier start of WNV in 2016 as compared to 2015, the months to follow would not only present with lower periods of detection, but also with much lower positive confirmed pool numbers, once again demonstrating the incalculable seasonal activity of WNV in Harris County.

39 Population level assessment of protective immunity to West Nile Virus (WNV) in free ranging birds

Lauren Wilkerson (lwilkerson@hcphes.org), Martin Reyna, Cheryl Freeman

West Nile Virus (WNV) has continued to produce periodic localized epidemics throughout the United States often resulting in human deaths. These epidemics follow a period of rapid viral amplification in the mosquito-avian enzootic cycle in middle to late summer coinciding with the fledging period of many species of birds. It has been proposed that this flush of hatch year birds plays an important role in initial viral amplification by boosting the number of susceptible hosts, as after-hatch year birds may have acquired immunity from surviving infections during previous years. Here we investigated further through the use of Hemagglutination Inhibition (HI) and ELISA Immunoglobulin M (IgM) Antibody Capture assays to differentiate recent from previous infections among free ranging hatch year and after-hatch year birds over a 5 year period in Houston, TX. We found significant age differences in infection rates for both previous (χ^2 = 65.97, df = 1, $p < 0.0001$) and recent (χ^2 = 7.23, df = 1, p = 0.007) infections over the entire 5 year period. After-hatch year birds had a lower recent infection rate while having a higher proportion of previous infections demonstrating underlying protective immunity. However, this was only apparent after 2012, a year of extreme epizootic WNV activity in the Houston area.

40 West Nile virus transmission cycles in San Gabriel Valley, Los Angeles County, California

Sam McKeever, smckeever@sgvmosquito.org, Angela Brisco, J. Wakoli Wekesa, Kenn Fujioka

Since West Nile virus (WNv) arrived in Los Angeles County in 2003, outbreaks of human disease occurred in the San Gabriel Valley Mosquito and Vector Control District (District), as elsewhere, every four years. In the District these years were 2004, 2008, and 2012. However, after 2012, the virus transmission cycle remained active. To better understand the increase of WNv activity in the San Gabriel Valley we quantified the overall abundance of *Culex* spp. above ground and in underground storm drains. We utilized carbon dioxide-baited and gravid traps at several locations throughout the District and found that carbon dioxide traps underestimated the population of *Culex* spp. and the amount of WNv that circulates. Last, we will discuss sources of mosquitoes in the District that are critical to WNv transmission.

41 **West Nile virus activity in California in 2016**

Tina Feiszli, Tina.Feiszli@cdph.ca.gov, Jacklyn Wong, Kerry Padgett, Vicki Kramer

In 2016, for the 5th consecutive year, West Nile virus (WNV) activity was elevated throughout many counties in California. By early September, 155 human cases, including 2 fatalities, had been reported to the California Department of Public Health. This compares to a previous five-year average of 117 human cases at this same time. In 2015, there were only 123 cases reported as of early September, but by year's end 783 cases had been reported, including a record 53 fatal cases. The number of WNV positive dead birds, mosquitoes, and sentinel chickens in 2016 also exceeded the previous five-year averages. This presentation will include an update on WNV surveillance in California for 2016 and compare trends over the previous ten years.

42 **Making the most out of a West Nile virus dead bird surveillance program: enhanced sampling techniques**

Sarah Wheeler, swheeler@fightthebite.net, Kara Kelley, Paula Macedo

West Nile virus (WNV) surveillance programs are often augmented by the addition of dead bird collection and testing. These programs require the public to find and report dead birds, and public health or vector control agencies to collect, sample and test birds. Most agencies that use dead birds in their surveillance program will only accept and test birds dead less than 24 hours. At the Sacramento-Yolo Mosquito and Vector Control District (MVCD) a dead bird program is an important component of an integrated surveillance program and birds are collected regardless of their decomposition state. Because of the great amount of time and effort required to collect dead birds, it is paramount to make the most out of each bird collected. As such, several improved sampling techniques have been implemented to allow for the collection of quality samples from nearly every carcass. When dead birds were collected within 48 hours of death American crows were sampled by oral swab and all other species were sampled by brain aspiration. Collecting brain aspirates allowed for tissue collection without performing a necropsy. Several sample collection techniques were used for birds dead greater than 48 hours, contingent upon the state of decomposition. Maggots were successfully used to sample dead birds for WNV RNA. Additionally, WNV RNA could be detected on completely dry and skeletonized carcasses by wet-swabbing the inner surface of the braincase or the ventral vertebral column proximal to the kidneys; wet-swabbing location depended on condition and size of the bird. The integration of these sampling techniques by Sacramento Yolo MVCD during the 2016 season will be discussed.

43 **Analysis of West Nile Virus In-House Testing of Dead Bird Samples and Mosquitoes in Drought and Non-Drought Years in San Joaquin County, California, 2014-2016**

Sumiko De La Vega, sdelavega@sjmosquito.org, David Smith, John Fritz, Eddie Lucchesi, Shaoming Huang

Dead birds accepted through the California Dead Bird Hotline were sampled and tested in-house for West Nile Virus (WNV) using reverse-transcription quantitative polymerase chain reaction (RT-qPCR). Brain, ocular, and oral swab samples from dead birds belonging to the Corvidae family such as the American crow (*Corvus brachyrhynchus*), the common raven (*Corvus corax*), the yellow billed magpie (*Pica nuttalli*), and the Western scrub jay (*Aphelocoma californica*) as well as non-corvid species of birds were collected in lysis buffer and each sample type was compared to determine the most sensitive sampling methods. Dead bird testing results were analyzed over a three year period, comparing data between years of drought, extreme drought, or average rainfall in 2014, 2015, and 2016, respectively, and the correlation between WNV positive mosquito pools collected in Encephalitis Virus Surveillance (EVS) traps and gravid mosquito traps in the vicinity where dead birds were reported.

44 **West Nile Virus Dead Bird Surveillance in California: Tools and Trends**

Leslie Foss, leslie.foss@cdph.ca.gov

The West Nile virus (*Flaviviridae, Flavivirus*, WNV) dead bird surveillance program (DBSP) is a key component of the California Department of Public Health's (CDPH) comprehensive Arbovirus Surveillance Program. Wild birds (especially crows, ravens, and jays) are the primary reservoir for WNV and often die from infection; therefore WNV-positive carcasses provide early and ongoing data about WNV activity in local areas. Since 2002, the public has reported dead wild birds via the WNV dead bird hotline (1-877-WNV-BIRD), or by visiting the California WNV website (www.westnile.ca.gov). Reports are screened by hotline operators to determine carcass suitability for WNV testing. In collaboration with local vector control and public health agencies and the University of California Davis Arbovirus Research and Training (DART) laboratory, over 66,000 carcasses have been tested for WNV since 2002. Oral swabs from the dead birds are pressed onto nucleic acid preservation cards and sent to the laboratory at UC Davis for reverse transcription polymerase chain reaction (RT-PCR) testing. Some local agencies test carcasses using RT-PCR or a rapid antigen test (RAMP®). WNV surveillance in California has continued for more than a decade, and we have made changes to improve its efficiency and cost-value. A summary of trends in WNV outbreaks among birds in California is also discussed.

45 More Boots on the Ground: Expanding Door-to-Door Residential Mosquito Control in Orange County, CA

Laura Krueger, lkrueger@ocvcd.org, John Newton, Amber Semrow, Luan Ngo, Larry Shaw

In 2015, the Orange County Mosquito and Vector Control District (OCMVCD) detected *Aedes aegypti* for the first time within the county. Detections of *Ae. aegypti* and later, *Ae. albopictus, co*ntinued, resulting in 21 infested neighborhoods in 10 cities. Using a new control strategy, OCMVCD initiated a door-to-door residential mosquito control program. Teams were dispatched to residential neighborhoods that met certain criteria, including historical West Nile virus (WNV) hot spots, detections of day-biting mosquitoes, and human cases of WNV and travel-related chikungunya, dengue, and Zika. As of late 2016, door-to-door teams had investigated over 20,500 residential parcels with mosquito larvae collected from 1,174 parcels (5.7%). *Culex quinquefasciatus* and *Culiseta incidens* were the primary mosquito species collected, with *Ae. aegypti* and *Ae. albopictus* present in <5% of samples. Mosquito breeding was detected in < 6% of door-to-door investigations, suggesting that *Culex* abundance in 2016 was likely influenced by breeding sources other than those found in residential properties. The majority of residents (95%, n=19,398) gave permission for yard inspections with only 8% (n=970) refusing access. Nearly all detections of *Ae. aegypti* and *Ae. albopictus* occurred in response to public complaints, human WNV case investigations, and travel-related Zika case investigations. Findings from the door-to-door team activities were used to update the OCMVCD *Aedes* Response Plan and modify the program for 2017.

46 West Nile virus: Reactions to Florida Department of Health advisories and alerts in Bay County, FL.

Michael Riles, michael.riles@comcast.net

Bay County, Florida was issued an advisory in July 2016 and then an alert in September 2016 for the presence of West Nile virus by the Florida Department of Health. The virus was sensed through sentinel chicken sera-conversion data and positive mosquito pool collections of *Culex pippiens quinquefasciatus*. Beach Mosquito Control District in Panama City Beach, Florida had in place: reactions and control procedures for the primary vector, trapping schemes and education are discussed at length. Procedures include aerial applications, targeting gonotrophic stages for virus surveillance and door-to-door campaign surveillance.

Student Competition Symposium II

47 The use of a truck-mounted sprayer for the application of a residual barrier treatment using pyriproxyfen, both alone and in combination with lambda-cyhalothrin for the improved suppression of mosquitoes

Andrea Skiles, glennskiles@gmail.com, Nicola Gallagher, Grayson Brown

To increase the effective duration of residual sprays along large perimeters, pyriproxyfen was applied with a truck-mounted sprayer both alone and in combination with lambda-cyhalothrin. Adult mosquito surveillance using CDC light traps and gravid traps took place. Bioassays with *Aedes albopictus* larvae using water from the field were conducted to determine if transfer of pyriproxyfen to breeding sites was taking place. Results are forthcoming as data collection is still in progress.

48 Modeling the most abundant mosquito species (*Aedes vexans* and *Culex tarsalis*) in Lubbock, Texas, United States

Steven Peper, steve.peper@ttu.edu, Daniel Dawson, Grant Sorensen, Jordan Hunter, Francis Loko, Sadia Almas, Anna Gibson, Steven Presley

Vector control programs (VCPs) are regularly tasked with monitoring and controlling mosquito species that are considered a nuisance or a public health concern. VCPs often do not have the necessary information to aid in effective control efforts. During 2009-2015, we collected 96,196 mosquitoes from Lubbock, Texas, and developed a model based on weather factors to predict abundance of these mosquito species. These models will aid VPCs in utilizing their time and resources more effectively.

49 Surveillance of *Aedes aegypti* and *Ae. albopictus* mosquitos in western Texas counties

Alexander Wilson-Fallon, alexander.wilson-fallon@TTU.edu, Steven Peper, Katelyn Haydett, Hannah Greenberg, Nadin Suleiman, Steven Presley

Regional surveillance data of *Aedes aegypti* and *Ae. albopictus* is needed to recognize potential for transmission of dengue, chikungunya, and Zika viruses in the United States. A majority of west Texas counties have limited vector surveillance data regarding these species. Thirty-two west Texas counties are being surveyed to determine the prevalence of these species, to aid in developing vector control strategies throughout the area.

50 Eprinomectin's Role Fighting Malaria: A Beef Cattle Endectocide and Its Effect on Anopheles Mosquitoes

Annie Rich, annie.elizabeth.r@gmail.com, Nancy Hinkle, Seth Irish

Despite the fame of several other diseases in the world as of late, malaria is still a deadly disease in many countries. Even with modern technology, science has been unable to produce a vaccine or cure for this disease, and we instead have to rely on several innovative tactics for human protection and control of the malaria-vectoring *Anopheles* spp. mosquitoes. One such method is the use of animals to protect human hosts from the bite of mosquitoes by drawing away the insects or simply diluting the host pool, known as zooprophylaxis. This has been used as a passive method in the past, but could injecting animals with a long-lasting drug also cause the death of mosquitoes seeking a blood meal from these livestock? LongRange (eprionomectin) is a sustained release drug for beef cattle, developed for use in the United States that controls endoparasites for up to 140 days. This long-term use could be effective in mosquito control in rural agricultural areas if it kills mosquitoes that bite cattle surrounding human homes. This study tests the ability of LongRange eprinomectin injectable drug formulation to kill *Anopheles* spp. mosquitoes. If this drug proves effective it would encourage dispersal of this drug to communities in need of population control of these vector mosquitoes and ideally assist in the overall management of malaria transmission.

51 Monitoring insecticide resistance mechanisms in *Cx. tarsalis* from Sutter County, California

Bridgette Hughes, b_hughes7@u.pacific.edu, Debra Lemenager, Tara Thiemann

Culex mosquitos are known for carrying several harmful viruses in the United States. *Culex tarsalis* is found in rural as well as some residential areas in the Western United States, so they are under insecticide pressure from both agricultural spraying and vector control. In response to insecticide pressure, mosquitos can evolve two primary resistance mechanisms: target site insensitivity, as a result of DNA mutation, and elevated levels of detoxifying enzymes (GST, alpha and beta esterases, and oxidases). The two types of target site insensitivity studied here in *Cx. tarsalis* are *kdr*, which is a mutation in the para-type voltage gated sodium channel and *ace-1,* which is a mutation in acetylcholinesterase gene. This study focused on a population of *Cx. tarsalis* in Sutter County, where insecticide use shifted from Sumithrin to Naled over the course of the summer. The goal of this study was to determine if there was resistance to insecticides and characterize the mechanisms of resistance. Mosquitos were separated into resistance levels based on CDC bottle bioassay results using Naled, Sumithrin, and Permethrin insecticides. Mosquito legs were cut off and used in genetic qPCR testing for both *kdr* and *ace-1.* The rest of the body was homogenized and used for detoxifying enzyme levels; which were determined by microplate assays. bioassay results suggest *Cx. tarsalis* populations from Sutter County are mostly resistant to Sumithrin. Results also suggest this population has some resistance to Permethrin, but very little resistance to Naled. Genetic testing and microplate assays are ongoing. This research will give us a better understanding of resistance mechanisms in *Cx. tarsalis* and help vector control districts more effectively apply insecticides.

52 Larvicide resistance in Louisiana: Can adulticides select for larval resistance?

Kristen Healy

Effective mosquito control in Louisiana requires understanding the susceptibility of *Culex quinquefasciatus* to insecticides. To determine whether larvicide resistance had developed over time, mosquitoes were collected from across the state and subjected to toxicological bioassays. How susceptibility changed over the course of a single mosquito season was also examined. We discovered significant resistance toward temephos, despite its rare usage by mosquito control. Results may help inform inheritance of resistance in different stages of holometabolous insects.

Control Techniques and Possible Eradication of *Aedes aegypti* Symposium I

53 Distribution of *Aedes aegypti* in the USA

Roxanne Connelly

Not Available

54 Surveillance of invasive *Aedes* mosquitoes

Daniel Kline, dan.kline@ars.usda.gov

This presentation will emphasize recent surveillance techniques which have been developed to monitor populations of *Aedes aegypti*, *Ae. Albopictus*, and *Ae. Japonicas*. Information on effective trap designs, including size, shape and color will be provided. The development of attractant lures for use for various physiological ages of adult females and males will be discussed.

55 Control of *Aedes aegypti* by autocidal techniques

Stephen Dobson, sdobson@uky.edu

The ongoing problem of mosquito borne disease provides an impetus to develop additional methods for the control of invasive mosquito species and against the globalization of mosquito-vectored pathogens. In addition to the development of new active ingredients, there is need also to develop additional methods for delivering pesticides. Autocidal methods rely on the use of mosquitoes to 'self-deliver' pesticides and may provide a useful compliment to traditional application methods. Here, the results of recent field trials will be presented. The trials are based on the release of male mosquitoes that have been either 1) infected with a naturally-occurring bacterium "Wolbachia" to cause sterility in a targeted population or 2) dusted with pyriproxyfen, which is a powerful inhibitor of immature mosquito development. The Wolbachia method is non-GMO and categorized by the EPA as a microbial biopesticide. The pyriproxyfen dusting approach can be used alone, or combined with classical Sterile Insect Technique, Wolbachia and GMO approaches, to increase the overall impact of the introduced male mosquitoes. The different approaches will be discussed and contrasted, and their relevance to different mosquito control contexts, including areal delivery, will be discussed

56 Transgenic mosquitoes to control *Aedes aegypti*.

Camilla Beech, Derric Nimmo, derric.nimmo@oxitec.com, Andrew McKemey

Mosquito-borne diseases, such as Zika, dengue fever, chikungunya and malaria, are major and increasing international public health concerns. The main vectors of these disease is *Aedes aegypti* (*Aedes albopictus* is a secondary vector in most situations) and current control measures are proving difficult against this mosquito. In an Oxitec control programme transgenic male mosquitoes, male mosquitoes do not bite or transmit disease, are released continually over a wide area to mate with the target pest population; progeny from these mating's die and the target population declines. The Oxitec transgenic mosquito method has had great success around the world and is now being used in programmatic roll out in the Cayman Islands and Brazil to control *Aedes aegypti*. Results will be presented and progress towards a trial in the US will also be discussed.

57 Susceptibility profile of Aedes aegypti in Montclair, California to most commonly used pesticides

Min Lee Cheng, Jennifer Thieme, Quan Vong

The yellow fever mosquito *Aedes aegypti* was discovered in Montclair, CA on September 25, 2015 and a colony was established using the adults, larvae and eggs collected in the field for the purpose of studying the susceptibility profile to most commonly used pesticides. In total 14 larvicides and 4 adulticides were stdueid. Relative susceptibility was calculated in comparison with a laboratory colony of *Cx. quinquefasciatus*. The newly colonized *Ae. aegypti* showed significantly lower susceptibility to most of the pesticides assayed. This information is immediately applicable to control operations.

58 Aedes aegypti in California: novel control strategies in response to the recent invasion

Steve Mulligan and Jodi Holeman

The invasion of *Aedes aegypti* L. into dispersed areas of California, beginning in 2013, has created significant public health issues. A primary vector for dengue and chikungunya viruses, as well as Zika virus, this mosquito is closely associated with human habitation for oviposition sites and exhibits a preference for humans as hosts. In invaded neighborhoods, *Ae. aegypti* is a huge biting nuisance and source of resident complaints, yet it is difficult to control utilizing conventional treatment methods. Thus innovative approaches are called for in combating this important vector. During 2016, the Consolidated Mosquito Abatement District collaborated with MosquitoMate, Inc., to evaluate their novel sterile insect technique against a recently established *Ae. aegypti* population within a small neighborhood of Clovis, CA. This SIT incorporates the mass rearing and release of large numbers of *Wolbachia* infected males to mate with non-infected wild females. We will discuss the elements and issues involved in development of the study; including the selection of study sites, gaining access and acceptance from homeowners, development of procedures and protocols specific to the efficacy evaluation of this SIT method against *Ae. aegypti* in an arid habitat, as well as dealing with media and providing and disseminating public education materials.

Larval Control I

59 Surveillance and control of *Aedes albopictus* in Germany

Norbert Becker, norbertfbecker@web.de

Surveillance and control of *Aedes albopictus* in Germany

Norbert Becker

[1]Institute of Dipterology (IfD)/KABS, Georg-Peter-Süß-Str. 3, 67346 Speyer, Germany

Abstract

Since its first detection of *Aedes albopictus* in Germany in 2007, the species has undergone a dramatic expansion. In 2015 a surveillance program has been started focusing on expected infestation areas. The surveillance program confirmed a high infestation of an allotment garden area in Freiburg as well as a residential area in Heidelberg. The Container Index (CI) exceeded almost 30% in 2015. After the first detection of the mass development of *Aedes albopictus* immediate and comprehensive control measures have been initiated in order to reduce or even eliminate the *Aedes* population. Beside environmental management tablets based on *Bacillus thuringiensis israelensis (Bti)* have been used. Since the traditional tools were not enough to eradicate the populations the sterile insect technique (SIT) has been employed. On a weekly basis about 1000 sterile males/ha have been released from July until end of September 2016. The very defined island-like occurrence of *Ae. albopictus* in Germany in combination to the limited migration behaviour favours the use of SIT in an integrated control programme. Furthermore, metallic copper spray has been used to impregnate grave vases as frequent breeding sites of *Ae. albopictus.* Metallic copper sprayed on the interior surface of the vases provides a long-term effect and kills newly hatching larvae up to 3 months.

60 Culex quinquefasciatus resistant to spinosad and cross resistant to Lysinibacillus sphaericus is susceptible to Bacillus thuringiensis recombinants

Tianyun Su, tsu@wvmvcd.org, Min Lee Cheng, Margaret Wirth, Hyun-Woo Park, Denis Bideshi, Brian Federici

Spinosad is a biopesticide which acts at the nicotinic acetylcholine (nAChR) and γ-aminobutyric acid receptors, causing rapid excitation of the insect nervous system in many insect pests. High resistance to spinosad occurred in response to laboratory selection in Culex quiquefasciatus (Su and Cheng 2014a). Cross resistance to Lysinibacillus sphaericus evolved simultaneously during development of resistance to spinosad (Su and Cheng 2014b). At generation F68, this spinosad-resistant population showed 9.5-34.3 fold cross resistance to L. sphaericus 2362 spore/crystal mixtures, but only 0.9-1.2 fold cross resistance to a recombinant strain of B. thuringiensis (Bt) Cyt1A-BinA. At generation F80, the spinosad-resistant population showed 69.8-39,521 fold cross resistance to L. sphaericus 2362 (VectoLex WDG), but only 3.4-3.7 fold cross resistance to a recombinant strain of B. thuringiensis (Bt) Cyt1A-Cry11B-Bin. The potential of the recombinant strains Cyt1A-BinA and Cyt1A-Cry11B-Bin serves a management tool to mitigate resistance to spinosad and cross-resistance to L. sphaericus will be discussed.

61 Elevation of resistance to *Lysinibacillus sphaericus* in field collected *Culex pipiens* in response to laboratory selection

Tianyun Su, tsu@wvmvcd.org, Min Lee Cheng, Jennifer Thieme

Lysinibacillus sphaericus Meyer and Neide is a spore-forming bacterium that possesses various levels of larvicidal activity against some mosquito species. Products based on most active strains such as 2362, 2297, 1593, C3-41 that bear binary toxins have been developed to control mosquito larvae worldwide. Resistance in field Culex mosquito populations has been reported since 1995 from France, Brazil, India, China and Tunisia. Laboratory studies to evaluate resistance development risk have been conducted by many groups of scientists. Management tactics to prevent resistance development and restoration of susceptibility to L. sphaericus have also been developed and implemented. Product based on L. sphaericus strain 2362 was registered in California in 1996, and its use for mosquito control has increased considerably since invasion of West Nile virus. This report documents the first occurrence of high levels resistance to L. sphaericus in a field collected sample of Cx. pipiens in northern California, USA, where resistance ratio was 537.0-9,048.5 fold at F_4. The resistance level declined to 6.5-320 fold at F_9 in the absence of further exposure to L. sphaericus, but elevated to 769-9,157 fold at F_{15} in response to laboratory selection using product based on L. sphaericus. Susceptibility profile to other groups of pesticide in this field collection was also evaluated. Resistance management and susceptibility monitoring strategies are discussed.

62 Factors affecting effectiveness of spinosad against mosquitoes

Morgan Su, morgansu304@rusdlearns.net,

The investigation was conducted to derive the efficacy of spinosad under different conditions. In accordance with both logical analysis and background research, high fluctuations in larval mortality can be attributed to some environmental and biological conditions.

The experiment was separated into four tests, each analyzing individual responses to mortality rates and their correspondence to the tested variable. A general procedure was required for each variable tested. Water was fermented following the ratio of 250 g of commercial rabbit pellets per 5 gallons of water, which was left for two weeks in temperate weather. Mosquito eggs were collected from an urban section of Riverside, CA, utilizing polluted water as an egg laying medium. The eggs were hatched between the temperatures of 75°-85°F and the larvae (southern house mosquito) were reared to the required instar stage. The pesticide solution was produced by adding 0.2 g of Natular G30 (2.5% spinosad) to 20 ml of tap water, which was shaken vigorously until the pesticide coat was completely dislodged from the carrier

(granules of sand). The solution was then diluted by a factor of ten by adding two ml of pesticide to 18 ml of tap water. This 0.1% concentration solution was diluted to 0.01% concentration pesticide.

Larval mortality decreased as either water pollution or larval density increased, while increased when in warm emperatures or with younger instar groups. Therefore, the fluctuations in efficacy of spinosad can be effectively attributed to the variables provided. These standards for successful spinosad usage prevent inefficient application of this biological pesticide.

63 Ultra-low volume applications of Natular 2EC larvicide in a tropical environment against *Aedes aegypti* and *Aedes albopictus*

Seth Britch, seth.britch@ars.usda.gov, Kenneth Linthicum, Alongkot Ponlawat, Arissara Pongsiri, Patcharee Khongtak, Robert Aldridge, Frances Golden

Aedes aegypti and *Aedes albopictus* are key mosquito vectors of Zika, dengue, and chikungunya viruses. Larval control in general can be more effective than attempts at adult control for many mosquito species; however, larvae of *Ae. aegypti* and *Ae. albopictus* exploit abundant cryptic pockets of water that are often very small and ephemeral. One solution is to spray liquid larvicides as a ULV mist that may disperse throughout an area and reach this reticulate larval habitat more reliably than dispersal of larvicide in dust or granule formats, and that may form a persistent residual in dry locations that will become wet in the future. We conducted several trials with the biologically-based liquid larvicide Natular 2EC in a tropical environment, applied with a ULV backpack sprayer as a residual. With the spray we targeted plastic bioassay cups placed in a variety of open and vegetated areas, and among simulated residential structures, at a rubber tree plantation field site in southeastern Thailand. Water and *Ae. aegypti* and *Ae. albopictus* larvae were later introduced into the cups in a laboratory environment, and we measured treatment efficacy by counting emergence of adult mosquitoes. We discuss the relative efficacy of the larvicide treatment on these two species in the tropical environment, and comparisons with similar trials in hot-arid and temperate locations.

64 Truck mounted Natular™ 2EC ULV residual treatment of artificial containers to control *Aedes aegypti* and *Aedes albopictus* in North Florida

Robert Aldridge, robert.aldridge@ars.usda.gov, Frances Golden, Seth Britch, Kenneth Linthicum, Jessika Blersch

Populations of adult *Aedes aegypti* and *Ae. albopictus* mosquitoes are notoriously difficult to target and control, and are key vectors of Zika, dengue, and chikungunya viruses. Larval populations of these species on the other hand are easier to target due to their aquatic nature, and confined development. However, the numbers of artificial and natural containers that can be exploited by these species, coupled with the tendency to skip oviposit can render control methods such as source reduction ineffective. Alternatively, treatment of an area with a residual larvicide may prove to be an effective measure of control in light of the number of potential sources of development in an area. We treated artificial containers placed in a variety of open and protected locations via truck-mounted ULV sprayer to dispense biologically-based Natular 2EC (spinosad) larvicide in a simulated urban setting in North Florida. The containers were then returned to the laboratory for the addition of water and *Ae. aegypti* or *Ae. albopictus* larvae. Efficacy was measured by the number of adult mosquitoes that emerged from treated cups. We discuss our results in the context of control of these two species in key urban regions of the US.

65 Ultra-low volume application of Natular 2EC in a hot-arid environment against *Aedes aegypti*

Frances Golden, frances.golden@ars.usda.gov, Seth Britch, Kenneth Linthicum, Robert Aldridge, Jeremy Wittie, Arturo Gutierrez, Melissa Snelling, Jennifer Henke

The *Aedes aegypti* mosquito is an invasive species to the US that is a major vector of the Zika, dengue and chikungunya viruses. It is difficult to suppress populations of this mosquito because it is a container breeder, exploiting microhabitats (such as plant containers, gutters, and bottle caps) which are found around a typical home and are nearly impossible to completely eliminate. Even in extreme hot-arid environments, irrigated residential yards provide abundant microhabitats to this species, allowing it to thrive and pose a public-health risk. We investigated the ability of a biologically-based larvicide, Natular 2EC, to reach these microhabitats and kill larval mosquitoes in a hot-arid environment when applied with a backpack ULV sprayer. The active ingredient of Natular 2EC is spinosad, and it is specifically marketed to combat container-breeding mosquitoes such as *Ae. aegypti*. A number of spray trials were also conducted with a combination of Natular 2EC and a permethrin-based adulticide, Aqualuer 20+20. We deployed empty plastic sentinel cups in a variety of locations with greater or lesser vegetation cover in a hot-arid field environment. After spray applications, the sentinel cups were collected and capped. Upon returning to the laboratory, water and 50 colony-reared *Ae. aegypti* larvae were added to each cup. Larval mortality was determined by counting the number of adults that successfully emerged from each cup. We compare relative efficacy of Natular 2EC in this hot-arid environment to applications in temperate/sub-tropical environments, and discuss the efficacy of the larvicide when combined with an adulticide.

66 Spinosyn quantification method and its field uses

Derek Drews, ddrews@clarke.com

Innovative mosquito control techniques are a key part of an effective mosquito management plan. The application and use pattern of larvicides are essential to achieve effective control. Currently there is a need for a rapid, cost effective way to analyze product applications, particularly with residual larvicides to ensure effective concentrations are maintained throughout the product's expected duration of use. Using a Spinosyn tube kit allows post application quantitative analysis of Spinosyn, including Spinosad, in the water column. The kit uses an enzyme-linked immunosorbent assay (Elisa) to determine Spinosyn levels in the environmental sample. These results can give applicators concentration levels of their applications and allow preemptive decisions about how to proceed with recurring breeding habitats. Product concentrations in the water can indicate the expected effectiveness of a product and allow for reapplication of a product if needed. This method of quantification will also help ensure proper doses are being applied to mosquito habitats. Assuring proper larvicide applications by quantifying the active ingredient found in treatment areas will help increase the efficacy of mosquito management programs.

67 Heterodissemination: precision targeting the larval habitat of container mosquitoes with a cohabiting species carrying insect growth regulator

Randy Gaugler, gaugler@rci.rutgers.edu, Yi Wang, Devi Suman, Kshitij Chandel

The larval habitat of the peridomestic mosquitoes *Aedes aegypti* and *Aedes albopictus* is artificial containers. Management as immatures is challenging due to the often cryptic nature of their habitats which impedes penetration of spray droplets. We explored a novel approach to target cryptic habitats by exploiting the oviposition behavior of a cohabiting heterospecific non-biting midge, the chironomid *Chironomus decorus*. We tested the hypothesis that chironomid adults (1) reared in the lab, (2) treated with pyriproxyfen, and (3) released to seek water-holding containers for oviposition would serve as a vehicle to (4) transfer lethal concentrations to shared container habitats. Releasing 20 *C. decorus*, each carrying 36 µg of pyriproxyfen into a 33.4 m^3 room resulted in 90.3 and 75.7% mortality of *Ae. aegypti* larvae in open compared with cryptic containers. Residue analysis showed transference up to 190 times the LC_{50} for *Ae. aegypti*. In a large field cage (300 m^3), we obtained 53% mortality when 100 *C. decorus* females treated with a pyriproxyfen-impregnated oil, 76% when 50 treated with the oil followed by pyriproxyfen powder, and 90% when 100 were treated (oil & powder) and released. Our study supports the hypothesis that chironomids can effectively deliver insecticides to mosquito cryptic habitats. Our method may offer an economical, sustainable approach for managing these species.

Latin American Student Competition

68 Detoxifying enzymes and kdr mutations related with deltamethrin selection in *Aedes aegypti* from Mexico

Yamili Contreras-Perera, yamjaz_85@hotmail.com, Gustavo Ponce, Beatriz Lopez-Monroy, Juan Arredondo-Jimenez, Cristina Bobadilla, Pablo Manrique-Saide, Adriana Flores

The insecticide resistance is a serious problem worldwide in vector control programs. The resistance to insecticides can be caused by increased of detoxification enzymes activity and/or alteration of insecticide target sites. *Aedes aegypti* (L.) is the main vector of dengue, Chikungunya, and Zika in Mexico. In this study, we evaluate the effect of selection with deltamethrin on six populations of *Ae. aegypti* from the southeast part of Mexico, using CDC bottle bioassay. The presence and frequency of kdr V1016I and F1534C mutations was determined by PCR endpoint. The activity of enzymes involved in the detoxification of the pyrethroid was also determined. All populations showed an increase in the resistance ratio (RR) $RRLC_{50}$ between 20 to 196 fold after two generations of selection with the insecticide, by comparison with the susceptible New Orleans strain. The frequencies of kdr F1534C and V1016I mutations varied between 0.27 to 0.88 and 0.78 to 1.0, respectively. F1534C mutation showed higher frequencies and was fixed in four populations after the selection with deltamethrin. Enzymes activity varied significantly after two generations of selection. Our results reinforce the fact that the selection pressure plays a key role in insecticide resistance.

69 Pyrethroid resistance and *Kdr* mutations in the voltage gated sodium channel gene in *Aedes aegypti* from Mexico.

Franco Morales-Forcada, francomfrs@gmail.com, Beatriz Lopez-Monroy, Jade Cervantes, Selene Gutierrez, Maria Bobadilla, Olga Villanueva, Gustavo Ponce, Adriana Flores

Vector borne diseases associated with *Aedes aegypti* are considered a public health problem in Mexico, and insecticides are the most important component in vector control. However, constant use of insecticides has driven mosquito populations to develop resistance. One of the most common toxicological groups used for adult mosquito control, especially during dengue outbreaks, are pyrethroids. The cumulative evidence from molecular and toxicological studies has provided strong support for the involvement of point mutations (kdr

mutations) in the voltage gated sodium channel gene in pyrethroid resistance in vector populations. In this context, the aims of the present study were to establish the frequency and intensity of resistance to 3 pyrethroids in *Ae. aegypti* from Nuevo Leon, Veracruz, Yucatan and Tamaulipas, Mexico according to CDC protocols. And, to investigate kdr mutations through nucleotide sequencing of exons 21, 22 and 31, which encode domain II subunit 5 and 6, and domain III subunit 6 of the voltage-gated sodium channel, amplified from the same populations used in bioassays. According to results, populations studied were resistant to pyrethroids and multiple kdr mutations coexisting in *Ae. aegypti* from Mexico, which suggest their participation in pyrethroid resistance.

70 Multiple *kdr* mutations in the voltage-gated sodium channel of pyrethroids resistant mosquitoes *Aedes aegypti* from Mexico

Cecilia Nava-Salinas, cecilianava84@gmail.com, Beatriz Lopez-Monroy, Leslie Alvarez, Gustavo Ponce, Olga Villanueva-Segura, Adriana Flores

Aedes aegypti is the main zika, dengue and chikungunya virus vector in Latin America where pyrethroids are commonly used and widely accepted in agricultural and vector control programs. In order for these control programs to succeed it is imperative to understand and recognize the status of insecticide resistance in vector populations and the underlying mechanisms of it, such as knockdown resistance. The target site for pyrethroids is the voltage-gated sodium channel (*vgsc*) in which, when nonsynonymous mutations are presented, usually a knockdown resistance is conferred by interfering with the disruption of the action potential through the axon caused by the insecticide in *wild type* individuals. The *vgsc* is a transmembrane protein present in the neuronal axons and contains four homologous and repeated domains (I-IV) connected by intracellular linkers, each domain has six hydrophobic segments (SI-S6) arranged in a circle that forms a central ion channel. Most of the mutations associated with *kdr* in *Ae. aegypti* have been reported in domains II and III. Genomic DNA was previously isolated from mosquitoes from several Mexican states that presented the *kdr* phenotype (V1016I and F1534C), we amplified and sequenced regions including exon 20 and 21 of the sodium channel, which encode for domain II subunits 4 and 5, from the above mentioned individuals and from the susceptible New Orleans strain to search for any additional mutations that may be associated with resistance to pyrethroids.

71 Diversity and abundance of sand flies (Diptera: Psychodidae) vectors of the chiclero´s ulcer in three spatial scales from an endemic area

Wilfredo Arque Chunga, wilfredo.arquecng@uanl.edu.mx, Jorge Rodriguez Rojas, Ildefonso Fernández Salas, Eduardo Rebollar Téllez

Sand flies are small hematophagous dipteros (2-4 mm) of medically important, vectors of pathogens such as the parasite Leishmania Ross (Kinetoplastida: Trypanosomatidae), the etiologic agent of leishmaniasis or "chiclero´s ulcer". In Mexico there have been 50 species of sand flies (48 are current and two fossil species) of crepuscular activity and only females feed on blood. The san fly are of rural habitats or tropical environments.

CDC light trap and Shannon traps were installed at three spatial scales (15, 62 and 125 m) in a median-subperennial tropical forest of ejido Limones (Municipality of Bacalar, Quintana Roo-Mexico) from july 2013 to august 2014. A total of 10996 Sand flies were collected (540 night- traps) of two generas: *Lutzomyia* and *Brumptomyia* (França and Parrot) and 15 species: *L. cruciata* (Coquillett 1907) (38.32%), *L. ovallesi* (Ortiz 1952) (25.21%), *L. shannoni* (Dyar 1929) (15.91%), *Br. mesai* (Sherlock 1962) (5.48%), *L. cayennensis maciasi* (Fairchild & Hertig, 1948) (5.48%), *L. deleoni* (Fairchild & Hertig 1947) (4.62%), *L. carpenteri* (Fairchild and Hertig, 1953) (2.69%), *L. disneyi* (Williams, 1987) (0.96%), *L. olmeca olmeca* (Vargas and Diaz-Nájera 1959) (0.74%), *L. cratifer* (Fairchild & Hertig 1961) (0.35), *L. trinidadensis* (Newstead 1922) (0.09%), *L. permira* (Fairchild & Hertig 1956) (0.08%), *L. manciola* (Ibañez-Bernal, 2001) (0.04%), *L. longipalpis* (Lutz and Neiva 1912) (0.02%) and *L. panamensis* (Shannon 1926) (0.01%).

The most dominant species were: *L. cruciata*, *L. ovallesi* and *L. shannoni*, this species are involved in the transmission of the "chiclero´s ulcer"; the spatial scale 62 had the highest collection of sand flies, while the spatial scale 15 had higher species diversity.

72 *Aedes aegypti* microbiome modified by antibiotic impact on insecticide resistance

Mayra Gomez-Govea, mayralej34@hotmail.com, Yamili J. Contreras Perera, Luisa María Reyes-Cortez, Licet Villarreal-Treviño, Gustavo Ponce-García, Belén Olimpia Avila-Montañes, Gerardo Claudio Garza-Villarreal, Gabriel Ruiz-Ayma

Aedes aegypti plays an important role in the transmission of viral diseases like Dengue, Chikungunya and Zika. Mosquitoes have a variety of microorganisms that probably exceed the number of cells in them. Some studies have suggested the importance of microbiome for nutrient digestion, metabolism, egg production, development, and immune responses. Nevertheless, the physiological significance of these bacteria on insecticide resistance has not been established to date. Here, we present the role of microbiome (modified

by antibiotics) in insecticide resistance in *Aedes aegypti.* Adult mosquitoes were feeding with sucrose solution mixed with antibiotic (penicillin, streptomycin and gentamycin), then mosquitoes were exposed to permethrin (CL50%), followed extracted total DNA from whole mosquito body and sequencing by NGS the bacterial 16S rRNA region. With our results now we know the proportions and diversity of bacteria. Changes in microbiome are an important factor in insecticide resistance.

73 ***Homo sapiens* microRNAs present in blood transfer to eggs and first generation**
Iram Rodriguez-Sanchez, iramrodriguez@gmail.com, Yamili J. Contreras Perera, Gustavo Ponce-García, Chen-Yu Zhang, Hongwei Liang, Luisa María Reyes-Cortez, Laura E. Martínez-de-Villarreal, Belén Olimpia Avila-Montañes

BACKGROUND: In January 2012, Zhang et al, showed that plant miRNAs taken orally are present in the serum of various animal tissues. The MIR168a is a miRNA abundant in rice plants and it is one of the most abundant exogenous miRNAs in the serum of Chinese subjects. Functional studies showed that MIR168a can bind itself with the gene that encodes the low-density lipoprotein receptor adaptor protein 1 (LDLRAP1) in humans and in mice (specifically exon 4), inhibiting expression in the liver and thereby decreasing the presence of LDL (low density lipoprotein) plasma. These findings suggest that there is an external regulation of gene expression mediated by organisms in other kingdoms. OBJECTIVE: To determine whether microRNAs present in human peripheral blood ingested by blood-sucking mosquitoes transfer eggs and male and female (first generation). MATERIALS AND METHODS: We fed bloodsucking mosquitoes (*Aedes aegypti*). From the eggs, males and females and we extracted the total RNA and sequenced by NGS the microRNA portion. RESULTS: The human microRNA ingested by *Aedes aegypti* is transfer to eggs and first generation. CONCLUSION: This is the first report that evidenced the vertical transfer of exogenous miRNAs (from human). These molecules (microRNAs) can be used a power full tool for modifying the genotype and phenotype in futures *Aedes aegypti* generations.

The Collection and Public Dissemination of Mosquito Abundance Data: Perspective and Options Symposium

74 **Scope and insights from already publicly-available mosquito abundance data**
Samuel Rund, Samuel.Rund@ed.ac.uk

There are current calls for the aggregation and dissemination of mosquito population abundance data generated by mosquito abatement districts. There are many benefits of this data sharing, but also legitimate concerns. However, many districts already provide publically available data on their websites, or submit their data to state-level aggregators. I will present an overview of this already publicly available data, such as the scope, differences in reporting, hurdles, and some insights gained from aggregation of the data.

75 **Reconstructing Spatiotemporal Patterns of Vector Abundance via Online Data Sources**
Micaela Elvira Martinez

Vector-borne infectious diseases continue to pose a public health threat. Epidemiological studies of the transmission of emerging vector-borne diseases (e.g., Zika and Chikungunya) are limited, due to the lack of data as epidemics unfold. In the face of data limitations, we propose that vector abundance can be used as a proxy for pathogen transmission potential. We have identified and curated vector abundance data from online public health and environment websites. We used these integrated data to study broad spatiotemporal patterns of vector abundance. Specifically, we characterized (1) the seasonality of mosquitoes—at the genus level—using trap data, and (2) geographic variation in seasonal cycles of vector abundance. Due to the seasonal transmission of vector-borne diseases, such data can be used to form testable predictions regarding the seasonal structure of disease risk (for emerging pathogens) and to identify data-gaps to be supplemented, specifically with the collection of more trap data or epidemiological case reports of disease.

76 **Thoughts on the difficulties of interpreting shared mosquito abundance data**
Douglas Carlson

Surveillance is an integral component of any IPM-based mosquito control program yet the proper interpretation of such data must take into account a variety of environmental factors. Based on previous research, this presentation will attempt to provide some insights as to the importance of considering several variables when reviewing abundance data. However when considering shared data, it is common that such environmental factors are not adequately considered. This can lead to the strong possibility of incorrect conclusions being drawn from this shared information.

77 **Mosquitoes in Hawaii: engaging the public using the iNaturalist citizen science platform**
Durrell Kapan, dkapan@calacademy.org

The Yellow Fever Mosquito (*Aedes aegypti*) and the Asian Tiger Mosquito (*Aedes albopictus*) are major vectors of arboviruses. They were introduced to the Hawaiian Islands in the 1890s. After a concerted effort to eradicate the human associated *Aedes aegypti* from the islands ending in the early 1960s, most of the main Hawaiian Islands remained free of this highly efficient vector. The exception to this pattern was the Island of Hawaii where along the leeward coasts this species still persists. Our previous work synthesized existing vector-control surveys from 2002 and our own subsequent observations to predict areas that are likely to harbor one or both of these *Aedes* species. Here I will introduce the "Mosquitoes of Hawaii" project, started in the spring of 2015 with a modest budget, that was adopted by the citizens of the Island of Hawaii as a result of the 2015-16 Dengue epidemic and continues to be relevant today with the threat of Zika. Although we accept observations of any mosquito species found in Hawaii we focus on the comparative distribution of both the Yellow Fever Mosquito (*Aedes aegypti*) and the Asian Tiger Mosquito (*Aedes albopictus*) species on the island of Hawaii. In my talk I describe the iNaturalist platform and how this social network for natural history helps improve community involvement and self-sufficiency in the face of vector borne disease. I assess the growth and adoption of the project, the types of citizen scientists involved, how we handle data quality, privacy, storage and how we use the data to improve understanding and modeling of the distribution of the Yellow-fever Mosquito and the Asian Tiger Mosquito, two invasive vectors of Dengue and Zika that have inhabited Hawaii for over 120 years.

78 Statewide Mosquito Surveillance System for Florida
Adriane Rogers, Adriane.Rogers@FreshFromFlorida.com

The Florida Department of Agriculture and Consumer Services (FDACS) has received an increasing number of requests for statewide mosquito surveillance data since January 2016 due to the current public health emergency of global concern that we are faced with as a result of the Zika virus. A repository for statewide mosquito distribution and abundance data does not currently exist in Florida. FDACS has been pursuing the creation of a statewide database to monitore species abundance/distribution, track invasive mosquito species, identify trends in population dynamics over time, and to enhance/predict response to emergency storm events or public health situations rapidly and early. Ideally, this would be an online data sharing platform that would make access to the data immediate. This would be useful to counties to determine what species may be occurring in neighboring counties that could potentially impact their respective control operations and could be correlated with weather, flight range of species, etc.. This information would also be useful for researchers in Florida interested in various aspects of mosquito biology or ecology, arboviruses, or mosquito control. FDACS is in the very early stages of identifying resources and information technology companies to create a database that would suit the needs of Florida. This would not only be useful for Florida, but would have potential to fill a void in other states' mosquito surveillance capabilities as well.

79 Perspectives from a Mosquito Control District that shares extensive data online
Barbara Bayer

This presentation will discuss Manatee County Mosquito Control District's objective in posting surveillance data on our website and the pros and cons associated with general access to that data.

80 Mosquito Surveillance in Iowa (1969-present): Perspectives, Achievements, and Challenges
Ryan Smith

Mosquito surveillance has been performed in the state of Iowa for nearly fifty years. This has enabled accurate assessments of mosquito diversity, abundance, the establishment of invasive mosquito species, and arbovirus transmission. We will discuss the strengths of long-running mosquito surveillance, data dissemination, arbovirus transmission dynamics, as well as future challenges.

81 Connecting vector abundance with vector ecology: VectorBITE
Samraat Pawar

The Vector Behavior in Transmission Ecology (VectorBiTE) research network brings together theoreticians and empiricists interested in better understanding the role of vector behavior and variation in individual vector traits in determining disease dynamics. As part of this effort, the network is creating two publicly available data bases. One of these, VectorDyn, will contain information on vector abundance through time and space. We will present our current progress in this effort and discuss how the VectorBiTE community envisions applying this resource to better understand transmission dynamics.

82 Benefits and pitfalls of using mosquito abundance data- closing remarks and synthesis
Cynthia Lord

Closing remakrs and synthesis of the symposium

Control Techniques and Possible Eradication of *Aedes aegypti* Symposium II

83 Attractive Toxic Sugar Baits for urban *Aedes* control
Whitney Qualls, Whitney.Qualls@DSHS.Texas.gov

Urban *Aedes* control is often problematic due to their ecology and behavior. Since 2014, various laboratory and field evaluations of Attractive Toxic Sugar Baits (ATSB) for *Aedes albopictus* and *Aedes aegypti* control have been conducted. The results of ATSB vegetation and bait station applications will be presented highlighting the role of this method for incorporation into *Aedes* control programs.

84 Eradication Campaign of *Aedes aegypti* in Downtown St. Augustine, Florida
Rui-De Xue, xueamcd@gmail.com

The 1st imported zika case was reported in St. Johns County Florida in the early Feb. 2016 and *Aedes aegypti* larvae were collected from downtown St. Augustine, Florida in middle of Feb 2016. This is the 1st time official confirmed *Aedes aegypti* collection from St. Johns County, Florida after the species disappeared from 1992. Since March 2016, Anastasia Mosquito Control District (AMCD) launched an eradication program for *Aedes aegypti*. AMCD collaborated with city government and County's Department of Health conducting campaigning activity, public education, and inspection/ source reduction and control efforts by using street by street and door by door. After the past 3-4 month efforts, the positive areas of *Aedes aegypti* have been reduced from 9 spots to 1 spot. The eradication campaign and control efforts significantly reduced the population of *Aedes aegypti* in downtown St. Augustine, but the eradication of this species will take times to achieve.

85 *Aedes albopictus* and *Aedes aegypti* Surveillance and Control in Lee County, Florida
T. Wayne Gale

The abundance of both *Aedes albopictus* and *Aedes aegypti* mosquitoes in Lee County, Florida and the continued arrival of travelers potentially infected with Dengue, Chikungunya or Zika viruses has necessitated the development of improved surveillance and control methods of these potential vector species. The Lee County Mosquito Control District has instituted response plans for reacting to Florida Health Department notifications of these diseases whether suspected, confirmed, travel related or locally acquired. Additionally, routine surveillance for these mosquito species is conducted and mosquito pools are tested for the presence of viruses in our lab using PCR. Control strategies using all available methods including both aerial larviciding and adulticiding are employed to control these mosquitoes.

86 Control of *Aedes aegypti* by aerial application of larvicides and adulticides
Christopher Lesser, Christopher.Lesser@manateemosquito.com

Aedes aegypti mosquito populations have proven difficult to control due to a number of species-specific ecological factors. The Manatee County Mosquito Control District (FL) evaluated and compared the population control efficacy of multiple night-time aerial-applications of Fyfanon (ai 97% malathion, FMC) vs. efficacy of multiple aerial adulticide + larvicide application (Fyfanon + Altosid 5%). Studies were conducted within relatively isolated residential communities of Manatee County FL. Mosquito population dynamics were measured via landing rate counts over 3 month period. Spray cloud dynamics were measured at each study site. Mosquito populations subjected to aerial adulticide (only) drop significantly (97.2 to 100%) immediately after individual treatments but rebounded to pre-treatment levels within approximately 1 week; net population reduction over the study period was 65.5% as compared to pre-treatment and control population trends. Comparatively, mosquito populations subjected to both larvicide and adulticide treatments applied in a surveillance-based IPM approach observed an 89.3% reduction over the course of a 3-month period. Results of this study indicate that multiple aerial adulticide missions can be very effective in quickly reducing large domestic mosquito populations. Alternatively, if long-term and wide-area population reduction is desired, surveillance-based larvicide applications are a necessary addition to aerial adulticiding. Adult Ae. aegypti populations were significantly reduced for a 2.2 year period in the treatment area receiving the IPM-approach taking place from June-August 2014.

87 Integrative taxonomy for *Aedes aegypti* in two endemic populations of dengue in Colombia
Jesús Escobar, jeescobar@unisalle.edu.co, Lizeth Martínez, Oscar Ramos

In the absence of an effective vaccine against dengue, Chikungunya and Zika, currently the main measure of control of these diseases is directed towards the control of the insect vector, the mosquito *Aedes aegypti*. In Colombia, the genetic-population structure of *Ae. aegypti*, is little known, assuming that this mosquito is distributed as a single species. However, evidence from other countries shows that there are genetic and morphological differences among populations that could represent variations in their ability to transmit pathogens. This project, by Integrative taxonomy, morphological and genetic analysis, will provide new knowledge of the genetic and population structure of Ae. aegypti in two endemic areas of dengue in Colombia. These zones correspond to the cities of Yopal (350 m.a.s.l.) and Sasaima (1,194 m.a.s.l.) located in lowland and mountain ecosystems respectively. The collection of biological material was conducted between December / 2015 to March / 2016. For the morphological structure, a geometric-morphometric

analysis of the wings of 90 individuals were made. For each wing, through photographs, 16 Landmarks were digitized. Subsequently, by applying a principal component analysis on the set of Landmarks superimposed by the method of Procrustes, the variation in the form was obtained represented by 5 RWs. Using these RWs, an analysis of variance was performed, which concluded that there are significant differences in the morphometric wing structure between the two populations. Molecular tests with molecular marker COI (cytochrome oxidase subunit 1) were carried out in order to integrate phenotypic and genotypic results. This information will be relevant to propose and optimize vectorial control measures.

88 Comparing costs of mosquito control methods – planning for the future
Pat Dale, p.dale@griffith.edu.au, Jon Knight

Resources for mosquito management are stretched as areas needing mosquito control expand when urban settlement encroaches on mosquito habitats or when the habitats respond to other environmental changes. It is increasingly important to ensure that the most cost effective management method(s) are used. We show how costs can be calculated over various time frames, using several discount rates, to allow managers to assess the potentially best options for their programs. The scenario is applied to an example in southeast Queensland, Australia and includes larvicide treatments and habitat modification. It is a useful tool for decision makers as it can also be applied to assess the additional long-term cost of increased mosquito control related to development and to assess options for meeting those costs.

Larval Control II

89 Effectiveness of acoustic larvacide on developmental stages of mosquitoes
Chip Hancock, chancock@scgov.net, Joshua Favorite

The Larvasonic is a device developed by New Mountain Technologies that employs acoustic waves to kill mosquito larvae. These sound waves resonate in the trachea of larvae, causing them to rupture. Because pupae have a different respiratory morphology, this study investigated the effectiveness of the device against both larvae and pupae. Larvae and pupae were all *Culex quinquefasciatus*, collected and tested in Sarasota County, Florida. Individual egg rafts for each trial were collected from a single site and reared in an insectary to eliminate age and varying environmental effects on susceptibility to acoustic larvaciding. Two versions of the device (the SD2001 storm drain unit and the field arm unit) were tested in open and closed environments. Initial mortality rates and long term effect of treatment on development and survivorship were determined for both larvae and pupae. Effective range for the field arm was tested using fish breeding enclosures along transects of treatment. Water quality measurements were taken at the time of treatment and pond water was used in the closed system, open system, and controls. Two tailed ANOVAs and Mann Whitney U-tests were used to analyze results. The SD2001 unit had a decreased effect on pupae, when compared to larvae, at the manufacturer's advertised range of 36". As expected, this version of the device was far more effective in a closed system, indicating that some sound waves are reflected from the drain walls. The field arm unit demonstrated that its effective range is around 20" for pupae and around 30" for larvae. We plan to expand on this research using both units in different aquatic environments and to expand testing to include effects on non-target organisms.

90 Exploitation of ecological traps for larval control of *Culex pipiens*
Allison Gardner, allison.gardner@maine.edu, Ephantus Muturi, Brian Allan

Habitat attractiveness and quality for container-breeding mosquitoes are mediated in large part by terrestrial plant-based detritus, an important energy source for the aquatic larval stage. If there is a mismatch between the attractiveness of a habitat and its quality, an "ecological trap" may occur wherein the oviposition rate is high while the emergence rate is low. Despite the common occurrence of such traps in nature and a history of successful attract-and-kill control of forest and agricultural insect pests, ecological traps are seldom exploited for the control of medically important insects. Our study identified and investigated the application of a naturally-occurring ecological trap (blackberry leaves, *Rubus allegheniensis*, Rosales: Rosaceae) and an artificial trap (Amur honeysuckle leaves, *Lonicera maackii*, Dipsacales: Caprifoliaceae mixed with *Bacillus thuringiensis* var. *israelensis* larvicide) for the control of *Culex pipiens* (Diptera: Culicidae), the primary vector of West Nile virus in the northeastern and midwestern United Sates. Laboratory bioassays demonstrated that the composition of the bacterial communities associated with leaves of both plant species may contribute to their attractiveness and quality for mosquitoes. A field implementation of these results indicated that natural and artificial traps alter mosquito production in roadside storm water catch basins. Our findings may contribute to the discovery of a novel, cheap, and effective vector control method with minimal non-target effects and reduced potential to select for insecticide resistance.

91 Integrated strategies for the larval control of dengue mosquito (*Aedes aegypti*)
Shabab Nasir, flourenceshabab@yahoo.com, Iqra Yousaf

Mosquitoes act as life threatening diseased vectors. The synthetic insecticides cause development of resistance (in vector species), biological magnification, and adverse effects on non target organisms. So, under the Integrated Mosquito Management (IMM), emphasis is given on the application of alternative strategies in mosquito control such as use of selective chemicals, potent plant extracts and *Bti*. During the current study, fifteen plant samples were collected for oil (using ether and methanol) and aqueous extraction. Mosquito larvae were collected from different habitats, identified and reared under lab conditions. *Aedes aegypti* larvae were treated with different plant extracts and growth regulators. Six concentrations of each treatment were applied against 2nd and 3rd instar larvae with control for screening of significant plant extracts. The data was collected to check knock down effect after 6, 12, 24, 48, 72 and 168 h respectively. After screening trials, the potent plant extracts by using ether were Khor tuma (*Citrullus colocynthis*), Datura leaf (*Datura wrightii*), Charita (*Swertia Chirayaita*) and Neem leaf (*Azadirachta indica*) while the methanol extracts of Khor tuma (*C. colocynthis*), Charita (*S. Chirayaita*), Akk leaf (Calotropis procera) and Chebr fruit (*Melothria scabra*) were found significant. The significant aqueous extracts were Datura leaf (*D. wrightii*), Datura fruit (*Datura stramonium*), Khor tuma (*C. colocynthis*), Chebr fruit (*M. scabra*) while Deltamethrine and Mortein liquid were found significant among the 6 used chemicals. These plant extracts were analysed through GC-MS to know what type of chemicals were found in them. The mechanism of their action was also determined by enzyme analysis of dead larvae.

92 Liquid larviciding becomes reality: Zika control pushing protocols.

Frank Clarke, fclarke@clarke.com

Controlling container breeding mosquitoes that carry Zika has challenged all traditional control approaches. This presentation will discuss learnings from both fixed wing aerial and ground ULV applications used in the Miami Dade County.

93 Truck mounted larviciding as a control method for *Aedes aegypti* in Miami-Dade

Grifith Lizarraga, glizarraga@clarke.com, Dan Fachet

The outbreak of Zika in the city of Miami allowed the use of non-conventional tools with the purpose of reducing its main vector, *Aedes aegypti*. This emergency accelerated and created novel ideas to control this species of mosquito. One such method was the use of Buffalo turbines for larviciding similar to those described by Williams et al. (2014). This presentation demonstrates results of efficacy, methodology used and larviciding control for the city of Miami.

94 Use of optimized larviciding technologies for proven control of dengue vectors in Zika programs

Peter DeChant, peter.dechant@valent.com, Seleena Benjamin, Banugopan Kesavaraju

Response to the recent outbreak of Zika virus in the Americas has demanded innovative approaches for control of container mosquitoes, specifically *Aedes aegypti and Ae albopictus*. Historical insecticide application techniques generally failed to break disease transmission. This paper focuses on field methods development to rapidly and economically treat larval habitats with VectoBac WDG – an OMRI approved biological insecticide based on *Bti* strain AM65-52 – and break disease transmission. First developed in Asia using backpack sprayers that reduced dengue incidence (Tan et al 2012), the methodology is now applicable to truck mounted and aerial spray platforms, and was widely used by mosquito abatement districts in 2016. This paper covers the history of these development efforts and the current state of the art for wide area spraying of VectoBac WDG in operational programs throughout the Western Hemisphere. Application platform spray systems, drop spectra, and mission strategies including monitoring and evaluation methods will be discussed.

95 SPLAT BAC: Finally, a long lasting green larvicide that harnesses the power of semiochemicals.

Agenor Mafra-Neto, president@iscatech.com, Teun Dekker, Dirk Schorkopf, Leonard Mboera, Rickard Ignell, Rafael Borges, Leandro Mafra, Rodrigo Silva

SPLAT BAC is a 'green' long lasting semiochemical-based larvicidal product that employs the Attract and Kill mechanism of pest control. SPLAT BAC is fluid and can be applied using conventional spray equipment. SPLAT BAC attracts gravid female mosquitoes and induces them to preferentially oviposit on treated bodies of water. When the larvae emerge, they are attracted to, and induced to feed on, SPLAT BAC by its potent blend of larval attractants and phagostimulants. Consumption of a high dose of the formulation containing either or both microbial larvicides and insect growth regulators ensues exacting reliable larval control. We investigated the potential of the biodegradable SPLAT BAC formulation for use in attracting gravid females and control of aquatic stages of mosquitoes vectors of disease. The SPLAT BAC formulation was applied directly to water surfaces. Breeding sites containing the SPLAT BAC with oviposition attractants were strongly preferred as oviposition substrate over controls. We will discuss laboratory, semi field and field trials using SPLAT BAC formulated with either *Bacillus thuringiensis* and *B. sphericus* (*Bti* and *Bs*) or methoprene. For example, dose-mortality analysis of mosquito larvae demonstrated that a single SPLAT BAC pellet containing *Bti* and *Bs* caused high mortality of neonate larvae and 3rd instar larvae for over 40 days.

Semi field trials with SPLAT BAC formulated with methoprene indicate that the formulation has a highly suppressive larvicidal effect for over 145 days. SPLAT BAC's ease of application together with its long lasting suppressive effect provides users with a novel green larvicide concept.

96 Evaluating the vector control potential of In2Care Mosquito Traps against *Aedes aegypti* and *Aedes albopictus* under semi-field conditions in Manatee County, Florida

Katie Williams, k.williams@manateemosquito.com, Eva Buckner, Ambyr Marsicano, Chris Lesser, Mark Latham

Because no vaccines are available to prevent or cure dengue, chikungunya, and Zika viruses, controlling *Aedes* vectors has become more important than ever. Conventional larviciding and adulticiding strategies generally prove difficult for targeting *Ae. aegypti* and *Ae. albopictus* mosquitoes that breed in small, cryptic sites. The In2Care® Mosquito Trap was developed to target and kill larval and adult stages of *Aedes* by utilizing auto-dissemination. Gravid females that visit the trap not only pick up pyriproxyfen (PPF) that they later transfer to nearby larval breeding containers but also *Beauveria bassiana* spores that slowly kill them. We assessed the efficacy of the trap in a semi-field setting against *Ae. aegypti* and *Ae. albopictus.* Gravid mosquitoes were released into screen rooms containing five In2Care® traps, or one trap with four alternative breeding sites. Control experiments utilized 5 breeding sites in the same set-up. After 48 hours, mosquitoes were retrieved and experimental effects on oviposition and larval and adult survivorship were assessed. We found that the In2Care® trap is attractive to gravid *Ae. aegypti* and *Ae. albopictus* females, and that the trap serves as an egg dump. Adult females successfully auto-disseminated PPF to surrounding breeding sites, leading to a significant reduction in mosquitoes emerging from those breeding sites. Additionally, we found effective contamination with *Beauvaria bassiana* spores, which significantly reduced the survivorship of exposed *Ae. aegypti* and *Ae. albopictus*. In conclusion, the In2Care® traps successfully killed multiple life-stages of the two main *Aedes* vectors found in Florida, USA.

97 Field evaluation of the In2Care® Mosquito Trap against *Aedes aegypti* mosquitoes in Manatee County, Florida

Eva Buckner, e.buckner@manateemosquito.com, Katie Williams, Ambyr Marsicano, Mark Latham, Christopher Lesser

Because conventional larviciding and adulticiding strategies generally prove difficult for targeting *Aedes aegypti* and *Aedes albopictus* mosquitoes that breed in small, cryptic sites, the In2Care ® Mosquito Trap was recently developed to target and kill the larval and adult stages of skip-ovipositing *Aedes* by utilizing auto-dissemination of pyriproxyfen (PPF) and *Beauveria bassiana* fungus spores. After evaluating In2Care® Mosquito Traps in a semi-field setting against laboratory-reared *Ae. aegypti* and *Ae. albopictus* and finding that adult females who visited the traps successfully transferred PPF to surrounding breeding sites and suffered reduced survivorship as a result of contamination by *Beauvaria bassiana* spores, we undertook a field evaluation of In2Care® Mosquito Traps in Manatee County, Florida on Anna Maria Island, against wild *Aedes aegypti* mosquitoes. Our trial consisted of a 5-acre control area and 5-acre treatment area that possessed similar vegetation, houses per acre, and domestic mosquito service calls. In the control area, no intervention took place, and in the treatment area, 60 In2Care® traps were deployed. Trap efficacy was assessed by the ability of the trap to serve as an egg dump, larvicidal impact achieved in surrounding mosquito breeding sites, and the impact on the *Ae. aegypti* population/biting adults. We will report on the results from this field trial and discuss the suitability of integrating the In2Care® Mosquito Trap into mosquito control programs.

Latin American Symposium I

98 Structure of aquatic communities associated with larval habitats for *Culex* (Diptera: Culicidae) in the Pesqueria River in Santa Rosa, Apodaca, N.L., Mexico

Mara Garza-Rodríguez, biol.maragarza@gmail.com, Adriana Flores-Suárez, María Maldonado-Blanco, Carlos Solís-Rojas, Humberto Quiroz-Martínez, Violeta Rodríguez-Castro

Insects are very important componente in aquatic systems, streams and creeks in Nuevo Leon State have been affected by pollutants and make hábitats suitable to *Culex*. The objective of this study was to analyze structural commnunities of aquatic insects associated to *Culex* larval habitats. Samples were taken with white plastic dipper in Pequeria River in the locality of Santa Rosa, Apodaca, Nuevo Leon; samples were preserved in whirl pack bags with ethilic alcohol, later samples were separated and the insects were identify in laboratory, data analysis was according ecological index. A total of 25,573 insects were collected; *Culex quinquefasciatus*, *Cx. coronator, Cx. tarsalis, Cx. thriambus and Cx. interrogator*, were the species identified. Seven orders, 25 families, and 57 genus/species were the structural component in larval habitats of *Culex*.

99 Species and geographical distribution of mosquitoes in the Yucatan Peninsula, Mexico.

Mauricio Casas-Martínez, mcasas@insp.mx, Armando Elizondo-Quiroga, David Moo-Llanes, Rogelio Danis-Lozano, Armando Ulloa, Carlos Marina-Fernández, Guillermo Bond

In global context of vector-borne diseases, it highlights the rapid spread of invasive mosquitoes and the introduction of new arboviruses in the different biogeographic areas of the world. Therefore, between April and May 2016, entomological collections were performed in Campeche, Yucatan, Quintana Roo and Chiapas, Mexico states, in order to investigate the current status of biological invasion by *Aedes albopictus* in the Yucatan Peninsula. During the period sampling were visited 52 sites near to five protected natural areas of the Neotropical region of Mexico. Taxonomic information corresponded to nine genera and 18 species of Culicidae. *Culex quinquefasciatus, Aedes aegypti* and *Ochlerotatus taeniorhynchus* were the most common species, while *Anopheles albimanus, Cx. nigripalpus, Cx. coronator, Deinocerites cancer* were the species with moderate presence compared with *Cx. erraticus, Mansonia dyari, Wyeomyia celaenocephala, An. crucians, An. pseudopunctipennis , An. punctipennis, Coquillettidia venezuelensis, Oc. quadrivittatus, Oc. scapularis, Oc. sollicitans and Psorophora confinnis* that were the least frequent species. With respect to the presence of *Ae. albopictus* in the study area, there was no record this species. This can be attributed to *Ae. albopictus* shows higher sensitivity to egg desiccation and may result in a greater specific mortality in warmer and drier areas. Moreover, the effect of climate variability which has caused intense and prolonged periods of drought and, at the same time, the disappearance of mosquito breeding sites, that has influenced a dramatic decline in populations of mosquito vectors in the region the Yucatan Peninsula.

100 Monthly and hourly activity of four sandfly vector species (Diptera: Psychodidae) in Quintana Roo, Mexico.

Jorge Rodriguez-Rojas, jorge.rdz3288@hotmail.com, Wilfredo Arque-Chunga, Ildefonso Fernández-Salas, Eduardo Rebollar-Téllez

The objective was to document monthly and hourly activity of sandfly species of medical importance in Mexico. We conducted monthly collections in a tropical forest of southern Mexico during an annual cycle. Sandfly catches were conducted over three consecutive nights using Shannon traps from 1800 to 2400 h. In a total of 144 night-traps, we collected 12,764 female individuals of four species. Relative abundances were *Lutzomyia cruciata* (52.51%), *Lutzomyia shannoni* (35.81%), *Lutzomyia ovallesi* (11.17%), and *Lutzomyia olmeca olmeca* (0.49%). The activity of these species varied every month, such as *L. cruciata* presented from January to March (61%) a marked peaks. While *L. olmeca olmeca* and *L. ovallesi* showed a great abundance in June (41%) and August (45%), respectively. For *L. shannoni* that exhibited a high peak from December to March (38%), and also in August (16%) and June (21%) presented a great activity. Hourly activity of these species varied in their peaks of collection; for instance *L. cruciata* exhibited a peak from 18:00 to 19:59 h. In contrast, *L. shannoni* and *L. ovallesi* had peaks from 21:00 to 22:59 hours. While *L. olmeca olmeca* was more active during the first three hours (18:00-20:59 h) of collection. These data of monthly activity of *L. cruciata* and *L. shannoni* are in accordance with the literature, in which the months of December to March were reported with sandfly abundances peak. And also corroborate previous reports that female sandfly activity was mainly observed during the first hours of the night. Catches in Shannon traps can be used as a proxy for determining the biting rhythms of female sandfly species. Therefore; Shannon trap catches can be used to assess the relative role of these medical importance sandfly species.

101 *Lutzomyia evansi* and *Lu. panamensis* (Diptera: Psychodidae) as potential urban vectors of *Leishmania* spp. in Colombia

Eduar Bejarano, eduarelias@yahoo.com, Alveiro Pérez-Doria, Natalia Lastre, Luis Paternina, Lily Martínez, Daniel Verbel-Vergara, Margaret Paternina

The leishmaniases constitutes a public health problem in the Caribbean region of Colombia, where it was formerly limited to rural areas but is now also present in urban zones. The phlebotomine sand fly species responsible for transmitting *Leishmania* spp. in the urban areas are unknown however. The objective of this study was to establish which species of the genus *Lutzomyia* transmit the parasites causing leishmaniasis in the urban focus of Ovejas, Colombian Caribbean. Phlebotomines were collected monthly with a single Shannon trap and CDC traps installed in and around human dwellings. The females collected by Shannon trap were dissected and the guts examined under the microscope for flagellates, while those from the CDC traps were pooled by species and directly processed using molecular biological techniques to detect natural infection. Nucleotide sequences of the Cytochrome b gene and the subtelomeric region were used to identify the parasites found. In total 10,932 phlebotomines were captured, belonging to 11 species of the genus *Lutzomyia* and one of *Brumptomyia*. The most abundant species was *Lu. evansi* (92%), followed by *Lu. panamensis* (4%). Females of *Lu. evansi* dissected were found to be infected with flagellates, which were subsequently identified as *Le. braziliensis* and an unidentified species of Trypanosomatidae. Additionally, females of *Lu. panamensis* directly analyzed by PCR-sequencing were found infected with *Le. guyanensis*, *Le. braziliensis* and *Le. infantum.* It was concluded that both *Lu. evansi* and *Lu. panamensis* are the potential vector of these parasites in the urban leishmaniasis focus of the Caribbean region of Colombia.

102 Midgut bacterial communities of the Colombian malaria vector *Anopheles nuneztovari* according to locality and feeding status

Margarita Correa, margaritcorrea@gmail.com, Priscila Bascunan, Stefani Piedrahita, Paula Urrea, Yadira Galeano-Castañeda, David Serre

The interaction among vector, pathogen and microbiota has acquired particular interest in the search for vector control alternatives. The use of the mosquito microbiota as biological agents against malaria is based on the anti-*Plasmodium* activity of some midgut bacteria after a blood meal. Little is known about the microbiota of the Latin-American anopheline vectors and its potential use as biological agents. The aim of this study was to characterize the midgut microbiota of the main Colombian malaria vector *Anopheles nuneztovari*. Blood-fed and non-blood fed female adult mosquitoes were collected in two localities of two malaria endemic regions of Colombia: the Pacific Cost (PAC) and the Urabá-Bajo Cauca Alto-Sinú (UCS) region. Species assignment was performed by PCR-RFLP-ITS2. A characterization of the midgut microbiota was carried out by culture-based techniques and a bacterial collection was preserved. Gram-positive and gram-negative bacteria were found in the mosquito midguts of the two localities, however differences in richness and diversity were observed. Moreover, non-blood fed females showed a greater bacterial diversity and richness compared to blood fed females, similar to what other studies have shown. Sequencing of the 16S rRNA allowed to identify bacteria at the genus level, such as *Chryseobacterium* and *Acinetobacter* that were the predominant genus in the locality of PAC, and *Aeromonas* in the locality of the UCS. An ongoing Illumina sequencing will allow a more complete identification of the midgut microbiota as well as differences between localities and feeding status. Such results are a first step towards the identification of potential bacteria to be used in vector biocontrol strategies.

103 Song of choice: Characterization of acoustic signals produced by the malaria vector *Anopheles albimanus*

Hoover Pantoja, hoover.pantoja@gmail.com, Viviana Velez, Freddy Ruiz, Francisco Vargas, Catalina Alfonso-Parra

Malaria is one of the most important mosquito-borne diseases worldwide. In 2015, malaria affected an estimated 214 million people and caused ~438,000 deaths. Control of *Anopheles albimanus*, a primary vector of malaria in Colombia, is currently focused on the use of insecticides and bed nets, two common disease prevention strategies. However, an approach that exploits *An. albimanus* biological traits would allow for more specific targeting of this vector. We aim to better understand mating biology and behavior of *An. albimanus* in order to develop and/or improve tools implemented in vector control and surveillance. To gain insight into *An. albimanus* mating behavior, we are dissecting the acoustics of mating in this species to determine how they find and attract a mate. In this study, under laboratory conditions, we are characterizing acoustic signals produced by individuals during flight and recording their responses when exposed to individuals of the opposite sex. We found that the fundamental frequency of *An. albimanus* females is 376 (±30.4) Hz and 547 (±61.2) Hz in males. As has been observed in other species, *An. albimanus* individuals modulate their frequency when brought into close proximity to an individual of the opposite sex, resulting in frequencies converging. We find that this modulation happens in some couples at the female's third harmonic (around 1,128Hz) and male's second (around 1,094Hz) and in the female's fourth harmonic (around 1,504Hz) and male's third (around 1,641). The time of convergence is between 1.09 to 1.29s, which is almost half the time reported for *An. gambiae*. Taken together, these results contribute to our knowledge of *An. albimanus* mating behavior and will potentially aid in future vector control efforts.

104 Current situation of *Aedes albopictus* in Medellin: five years after its first report

Juliana Pérez-Pérez, jperezp1017@gmail.com, William Sanabria, Carolina Restrepo, Raúl Rojo, Enrique Henao, Guillermo Rúa-Uribe

Medellin is considered a hyper-endemic city for the transmission of dengue, and *Aedes aegypti* has traditionally been the vector involved. However, in 2011, the city reported the presence of *Ae. albopictus*, a species that according to previous studies could displace *Ae. aegypti* in urban and suburban areas where they coexist. In 2011, the Secretary of Health of Medellin implemented a monitoring system, due to the potential risk of *Ae. albopictus* in the transmission of dengue and other arboviruses. The system used larvitraps spatially distributed by Thiessen polygons across the city. This methodology has allowed exercising control actions for both vectors in areas of high density, as well as knowing the spatial distribution in the city of *Ae. albopictus*, which has colonized new habitats since its first record. Over the last year, it was observed that the mosquito was able to adapt to the urban environment, being inside homes and traps located in highly urbanized areas, even though it has been documented that *Ae. albopictus* has a preference for habitats with abundant vegetation. In addition, this species has been found to be naturally infected with dengue virus. Although its vector role is unknown in the country, its anthropophilic capacity and its high dispersal capabilities make it a potential vector which needs to be monitored. Thus, it is necessary to clarify its role as a vector of dengue and other arboviruses in the country, in order to design the most appropriate control and surveillance strategies

105 Dengue risk stratification of transmission in three municipalities in Colombia, using data collected routinely by the local ETV control programs

Neila Mina, neilaju@gmail.com, Veerle Vanlerberghe, Maria Echavarria, Neal Alexander, Clara Ocampo

The diversity of ecological, social and epidemiological characteristics of dengue in Colombia, and the availability of limited financial resources to control the disease, raises the need to identify areas of greatest risk to enable focused actions and implementation of effective strategies at the local level. This work proposes the development of an integrated model of analysis of epidemiological, demographic, entomological and environmental data with geospatial features, to stratify levels of risk as well as to determine key variables associated with transmission at the neighborhood level. Thus, using data collected routinely by local ETV programs. 3 municipalities with dengue transmission history were selected. Entomological, epidemiological and demographic data was obtained from the local administrations. The selected municipalities were: Buga, Girón and Yopal. Variables for stratification analysis were determined in four neighborhood-level components as follows: epidemiological (2008-2015 cumulative Incidence, percentage of severity, number of months > 5 cases and Incidence rate in epidemic years), entomology (Breteau Index and pupae/person), environmental (containers/population*1000) and demographic (population density and sites of high concentration of people). After the analysis of each component individually and the results of the integrated analysis of the 4 components in each municipality, 4 among 35 neighborhoods in Buga, 15 among 168 in Girón and 8 from 110 neighborhoods in Yopal, were determined as the highest risk for dengue transmission. This analysis will help to design evidence based strategies for vector control.

106 Surveillance of dengue virus in mosquitoes as EWS for decision making in Medellín

Rául Rojo, raul.rojo5@yahoo.es, Juliana Pérez-Pérez, William Sanabria, Carolina Restrepo, Enrique Henao, Omar Triana, Mejía Ana Maria, Guillermo Rúa-Uribe

In Colombia, dengue represents a serious public health problem. The implementation of activities to mitigate the impact of transmission is a priority, as there is no vaccine recommended by the authorities. In Colombia, surveillance of dengue is mainly based on reported cases and entomological indices, which sometimes are notified lately to the system. Therefore, intervention decisions may not be timely. The use of molecular techniques for detection of dengue virus in mosquitoes collected in field is a strategy that makes available more accurate entomological information, and contributes to an Early Warning System (EWS) for decision making. In this regard, the Secretary of Health of Medellin has implemented a system of virological surveillance in mosquitoes collected in the field, using the RT-PCR technique. Thus, 4500 homes, 70 educational institutions and 30 health institutions were visited between February and March, 2016. 536 *Aedes aegypti* and two *Ae. albopictus* specimens were captured. 171 pools were formed, 38.1% of which were positive. It is noteworthy that one of the positives corresponded to *Ae. albopictus*, being the first record of natural infection of this species in Medellín. The presence of naturally infected *Ae. albopictus* complicates the dengue problem for the city. And although, its role as a vector in the country is uncertain, it is important to continue its vigilance, given its distribution has been gradually expanded. The implementation of the virological surveillance system in mosquitoes in Medellin helped generate early warnings for decision making and impact the dengue transmission dynamics in the city

Managing Invasive *Aedes* Mosquitoes in California Symposium I

107 Discovery and establishment of *Aedes aegypti* and *Ae. albopictus* mosquitoes in California, 2011- Present

Melissa Yoshimizu, Kerry Padgett, Renjie Hu, Vicki Kramer

In 2011, a thriving population of *Aedes albopictus*, the Asian tiger mosquito, was discovered within 3 cities in Los Angeles County over an estimated 52 km^2 urban area. Two years later in 2013, *Ae. aegypti*, the yellow fever mosquito, was detected within several urban areas of Madera, Fresno, and San Mateo counties. Despite an aggressive effort to eradicate or slow the spread of these two invasive mosquitoes, the known infestation areas continued to expand outward and new sites were reported at an accelerated pace in many areas of the state. By mid - 2016, one or both species had been detected within the jurisdictional boundaries of over 100 cities and census-designated places in 12 counties, with evidence of well-established populations in many of these locations. This presentation will provide information on the discovery and widespread establishment of *Ae. aegypti* and *Ae. albopictus* in many urban areas of coastal, central, and southern California between 2011 and 2016 and discuss the subsequent rapid changes to the activities and priorities of vector control agencies in response to this unprecedented invasion.

268 Aedes control in the urban environment

Mark Daniels and Susanne Kluh

Not available

109 Effects of urban landscape structure on the establishment and spread of *Aedes albopictus*
Matteo Marcantonio, matteo.marcantonio@fmach.it, Diego Montecino, Markus Neteler, Annapaola Rizzoli, Christopher Barker

The Asian tiger mosquito, *Aedes albopictus*, is among the world's most invasive species. Invasion dynamics following introduction into a new urban area are determined in part by the structure of the landscape itself. This presentation considers the impacts of configuration and composition of the urban landscape on *Ae. albopictus* spread immediately following introduction, and explores subsequent implications for the establishment of *Ae. albopictus* in urban habitats. We have used field data and hierarchical modeling to characterize mosquito suitability in a recently invaded urban landscape in Los Angeles County, then we used the model to generate realistic household-level suitability estimates in several synthetic urban areas. We then modeled the stochastic spread of *Ae. albopictus* on each synthetic landscape using a temperature-dependent, dynamical model for mosquito reproduction and movement. Results of the model will be used to show the effects of urban structure on invasion dynamics and to consider whether some urban landscapes could limit *Ae. albopictus* spread and support its control.

110 *Aedes aegypti* surveillance in San Mateo County from 2013 – 2016
Nayer Zahiri, nzahiri@smcmvcd.org, Brian Weber

Aedes aegypti was first detected in 1979 from a site adjacent to the San Francisco International Airport, but infestations were very small in terms of numbers of mosquitoes and distribution. However, on April 2013 San Mateo County Mosquito and Vector Control District were decided to monitoring eight cemeteries and four nurseries by using Ovi-traps for early detection of invasive species. On August 2013 first eggs was detected in Holy Cross Cemetery at Menlo Park, then eggs reared and confirmed as adult *Ae. aegypti* on August 23rd by Dr. Bill Reisin at UC Davis. This finding that led to establish an intensive surveillance and inspection program to eliminate the infestation. Therefore San Mateo County Mosquito and Vector Control District utilized different monitoring techniques, immediate larvicide control measures and an intensive source reduction program to successfully eradicate *Ae. aegypti* from Menlo Park cemetery. Monitoring in 2016 failed to show any signs of continuing infestation.

111 *Aedes aegypti* Control: Complete ongoing source elimination in a small urban residential community in Clovis, CA and its impact on the *Ae. aegypti* population in that community
Jodi Holeman, jholeman@mosquitobuzz.net, Katherine Ramirez, Mark Amorino, Steve Mulligan

The invasion of *Aedes aegypti* L. into dispersed areas of California, beginning in 2013, has created significant public health issues. Conventional control methods have fallen short of District and resident expectations. Since the invasion of *Aedes aegypti* the District has encouraged residents to practice clean yard sanitation and source reduction in and around their home, as well as the need for their neighbors to do the same. Resident compliance across an entire neighborhood is significant challenge. In 2016 the District decided to demonstrate what a neighborhood can look like from a mosquito population standpoint when 100% compliance with source elimination is achieved. The District targeted 119 homes covering approximately 7 hectares. Each resident in this neighborhood was targeted for complete and ongoing source elimination. Residents were asked to signed an agreement permitting the district to cover all yard drains, modify all down spouts and provide monthly access for yard inspections. In additional to the residential source elimination the District ensured routine monitoring and inspecting of PGE vaults, storm drains, landscaping sprinkler boxes and any park area drains. Public outreach on the program started in March followed by field implementation in May. Weekly surveillance of the *Aedes aegypti* population was monitored with 5 BG sentinel traps and 14 ovitraps. We will discuss the elements and issues involved in development of this evaluation; including the selection of study sites, gaining access and acceptance from homeowners, development of procedures and protocols.

112 Infestation of *Aedes aegypti* and *Ae. albopictus* in Orange County
Robert Cummings, rcummings@ocvcd.org, kiet Nguyen, Tim Morgan, Laura Krueger

Two species of invasive *Aedes* mosquitoes, *Aedes aegypti* and *Ae. albopictus*, were discovered in Orange County, California, in April and October, 2015, respectively, in two small areas of the County. Since these initial discoveries, both species have expanded their ranges and now infest a total of 10 cities in 19 different neighborhoods. Three cities are infested with both species of invasive *Aedes,* but their ranges have yet to overlap. Preliminary genetic analysis of the introduced *Ae. aegypti* in Orange County suggests that they are similar to populations in the southwestern U.S. and are not related to the northern California populations. In contrast, the *Aedes albopictus* infestations are likely an extension of the Los Angeles County populations related to the "Lucky Bamboo" introductions of the early 2000s. The Orange County Mosquito and Vector Control District (District) has dispatched teams of technicians to survey and control infestations of these species when found in close proximity to introduced human cases of dengue, chikungunya, and Zika viruses. District control strategies involve public education, adulticiding, larviciding, and the use of traps as a means of population reduction. No local transmission of these viruses has been documented in the County.

113 Managing three invasive species of *Aedes* under the threat of Zika virus in the San Gabriel Valley, Los Angeles County, California

Gimena Ruedas, gruedas@sgvmosquito.org, Angela Brisco, Javier Romo, Martha Gonzales, Kenn Fujioka, J. Wakoli Wekesa

Aedes albopictus has spread with alarming speed since it was discovered on Sept 2, 2011 discovery in the cities of El Monte and South El Monte. It now infests 20 of 23 cities within the San Gabriel Valley Mosquito and Vector Control District (District) and beyond. In June of 2014 *Aedes notoscriptus* was discovered in the city of Monterey Park and has since been detected in three of 23 cities within the District. In June of 2016 *Aedes aegypti* was found in the city of Alhambra and as of September 2016 it has been found in three of 23 cities within our District. Managing these species of invasive *Aedes* under the threat of an outbreak of Zika has been challenging. Here we report the surveillance and control activities associated with potential and confirmed infections of Zika and other exotic arboviruses in the San Gabriel Valley, California.

114 Invasive *Aedes* species in San Diego County, California

Chris Conlan, chris.conlan@sdcounty.ca.gov

In the fall of 2014 invasive *Aedes* species were discovered in San Diego County for the first time. Their numbers multiplied rapidly and it was not long before they could be found in many areas of the County. This resulted in a number of modifications to program strategy and management techniques. Included among these new strategies was the deployment of new traps like BG Sentinel, AGO and ovitraps. The presence of new vector species also resulted in having to perform many backyard inspections as part of vector-borne illness investigations. A much stronger emphasis now had to be placed on small sources of breeding in urban and suburban areas. The shift in strategy has created greater public awareness and a better understanding of these new invaders but there is still much to be done in terms of designing management strategies that can be successful in the long term.

Adult Control/Aviation

115 Use of unmanned aerial vehicles for adult mosquito control

Gregory Williams, gwilliams@hudsonregionalhealth.org, Isik Unlu, Randy Gaugler

Ground-based adulticide operations are restricted to roadways and rely on wind drift to deliver the pesticide to the target. Aerial adulticide missions are costly and require precise measurement of meteorological data and carefully calculated offsets to ensure success. Unmanned aerial vehicles (UAV) make it possible to deliver mosquito adulticides directly to the target area increasing precision, reducing cost, and minimizing the effects of environmental factors. We present a series of experiments using UAVs to apply mosquito adulticides. We conducted replicated 3 x 3 caged bioassays with *Aedes albopictus* (Skuse). A custom-built electric multirotor UAV was fitted with a small electric rotary atomizer to deliver the product. The atomizer was tied into the flight control system of the UAV for automatic triggering. The UAV was programmed to autonomously fly over the cages and deliver the product at maximum label rate. Mortality was recorded at one and 24 hours post treatment. Rotating impingers were used to measure droplet diameter, volume and density using the DropVision FL system. Results of those trials will be presented along with future design considerations and a general update on the Rutgers Center for Vector Biology UAS program.

116 Worlds first, safe mass aerial release, of sterile males for vector control

Ralph Breslauer, Rsb5779@icloud.com

As the technology advances from general chemical spraying for vector control, to more advanced methods using sterile male mosquitos to target females directly, the need to cover large areas quickly and efficiently has emerged. This talk will cover the leading edge aeronautical solution for the safe release of millions of mosquitos from an aircraft. Insights into the first in the world capability will be provided as well as data on release patterns, swath width, drift, coverage modeling etc. We will discuss the full process from loading, storing to releasing. There will also be a discussion of real world usage which has already occurred as well as projects currently underway. Addressing some of the worlds most pressing problems from Zika and Dengue in the Americas and China to Malaria and Yellow fever in Africa, are now possible to tackle at scale.

117 Development and Optimization of Unmanned Aerial Spray Systems to Control Mosquitoes and the Development of Community Based Sustainable Vector Control.

Jane Bonds, jasbonds@gmail.com

Vector control currently offers the greatest potential for immediate large scale reduction in disease transmission. However, if vector control works so well, why has it been so neglected in developing countries? Contributing factors are costs, technical complexity and environmental concerns about pesticides.

New tools to more effectively target the vector are constantly being investigated. A low cost, robust spraying system for Unmanned Aerial Systems (UAS's) for mosquito control, primarily for Zika larviciding with a biological compound is under development. This addresses all three of the above concerns. UAV's are

cheap, simple to operate and larviciding offers the ability to spray 'safer' compounds compared to space spray adulticides namely the biological compound Bacillus Thuringiensis Israelensis (Bti).

Developing a sustainable vector control program is a challenge; positive developments however have been achieved by decentralizing the operation and promoting community involvement. Essentially this changes it from a top down process to a bottom up, by mobilizing the community and creating community ownership the program is more likely to be sustainable. Although financial backing would be required at the beginning to provide a package of equipment and training, beyond that the venture would become a self-sustaining small business. WHO research has shown that applying the principles of private sector marketing promote behaviors that contribute to sustained vector control

118 UAS(Drone) Licensing and Safety Programs for Vector Control

Marty Scholl, mscholl@fightthebite.net

Many exciting drone technologies have recently emerged and are available to mosquito and vector control operations ranging from precision mapping to conducting aerial treatments in rural areas. There are currently two licensing options (Public Certificate of Authorization(COA), or fly under FAA Part 107) to operate a small Unmanned Aerial Service (Drone) in the course of conducting mosquito control operations. As a licensed Remote Pilot Airman Certificate holder I will briefly cover some topics included in the newly created and adopted UAS General Knowledge Exam as well as FAA Part 107 and potential waivers that will pertain to Vector Control flight operations. This talk will also cover the FAA required safety checklists and crew requirements under the Part 107 or Public COA, as well as some components of a comprehensive safety program. While many components are required by the FAA, there are additional safety measures that can be implemented to help ensure the safety of all crew members involved in the surveillance or control operations utilizing a UAS.

119 Aerial perimeter treatments

Aubrey Soukup, asoukup@mmcd.org

The Metropolitan Mosquito Control District (MMCD) provides a variety of services to 2.7 million people living in an area covering 2,900 square miles in the seven county Minneapolis and St. Paul, Minnesota metropolitan area. MMCD is constantly looking at ways to improve our strategies and make our control methods more efficient. District larval surveillance indicates that larval abundance is not always distributed uniformly through wetlands. Many times mosquito larvae are more abundant around the periphery of the wetland. Thorough inspections of these large wetlands determine if the entire wetland should be treated, or if a perimeter treatment would suffice. This process of determining when only part of the wetland requires treatment has conserved employee time, control materials, and helicopter funding.

120 Aerial ULV trials in a high desert environment with Dibrom and Pyrocide 7396

Ary Faraji, ary@slcmad.org, Greg White

Aerial ULV applications are performed in Salt Lake City Mosquito Control District (SLCMAD) to control populations of adult mosquitoes. Several challenges face SLCMAD when conducting these aerial adulticide applications. Some of the challenges include erratic winds, extreme temperature inversions, and aircraft flight limitations due to a nearby international airport. Trials were conducted to determine the droplet penetration, droplet characterization, and the efficacy of these applications. Two different products, Dibrom and Pyrocide 7396, were tested in the spray trials. Dibrom is the product currently used by SLCMAD for aerial ULV applications, and Pyrocide 7396 is a "Heay Py" adulticiding concentrate that is formulated to be more dense than typical pyrethrin/pyrethroid based products.

121 North Texas imported Zika infection field response methods and lessons learned

Patrick Prather, patrick@municipalmosquito.com, Mike Swan, Erin Plaisance

North Texas counties and cities present unusual mosquito control challenges in part because no organized district or dedicated governmental agency exists with authority over home-rule municipalities. The area is comprised of communities with differing levels of appetite and resources for vector management and thus the field responses can vary significantly between jurisdictions. As a result of holding all major Zika vector response contracts in the North Texas area, Municipal Mosquito is able to work with County health authorities to try and standardize response protocols across the area. As a service provider, consultant, training and equipment resource, Municipal Mosquito has developed a unique perspective on Zika infection field responses.

This discussion will outline these response protocols and lessons learned to increase efficacy and efficiency while limiting costs associated with travel related Zika infection field responses. Field responses are always cooperative efforts between the municipality, residents, and the service provider and this cooperation is always emphasized and encouraged.

122 Adulticide application trials for *Aedes aegypti* control in Key West, Florida
Catherine Pruszynski, cpruz@keysmosquito.org, Andrea Leal

Aedes aegypti is an important vector of multiple mosquito-borne viruses including yellow fever, dengue, chikungunya, and Zika. *Aedes aegypti* is established in the Florida Keys, and as evidenced by the dengue outbreak in 2009 and 2010, conditions could be suitable for virus transmission. In order to be as prepared and as proactive as possible, within budgetary constraints, should any of the *Ae. aegypti*-vectored diseases be introduced into the Florida Keys, the Florida Keys Mosquito Control District has devised a Disease Vector Response Plan for *Ae. aegypti*. This plan includes the year-round operational domestic inspector and surveillance program, public education plan, and seasonal aerial larvicide applications. In some circumstances, aerial and ground adulticiding may be required. In this experiment, we evaluate the efficacy of aerial application of two adulticides, Dibrom (Naled) and Duet (sumethrin and prallethrin) on caged *Ae. aegypti* to model the impacts of a spray mission on adult mosquitoes.

123 Batteries not included: a simple, collapsible passive trap for collection of live mosquitoes
Scott Ritchie, scott.ritchie@jcu.edu.au, Brian Johnson, Mick Townsend, Ken Fall

Light traps are commonly used to collect adult mosquitoes for a variety of uses. However, most light traps are relatively expensive and require a battery to power the light and fan. We have developed a collapsible passive trap (CPT) that does not require batteries and is portable for ease of use in the field. Latin square field trials were conducted to compare CPT models to CDC light traps in Cairns Australia. Field trials of the CO_2-baited CPT indicate it captures ca. 50% as many mosquitoes as a CDC light trap, with a mean species richness of 11.3 and 12.3 for the CPT and CDC trap, respectively. As the mosquitoes do not go through a fan, most specimens are alive and in relatively pristine condition. The CPT could be a valuable tool for collection of mosquitoes, especially where pristine and live specimens are required.

Latin American Symposium II

124 Use of the Sterile Insect Technique (SIT) to supress *Aedes aegypti* in southern Chiapas, Mexico: a population study in two communities to assess SIT feasibility.
Guillermo Bond, gbond@insp.mx, Carlos Marina, Ariane Dor, Ildefonso Fernández-Salas, Pablo Liedo, Adriana Ramírez, Reyna Bustamante, Trevor Williams

The aim in this project is to assess the dynamics of *Aedes aegypti* populations to evaluate the effectiveness of the Sterile Insect Technique (SIT) for the suppression of vector populations in Chiapas, Mexico. Two sites of about 30 hectares each with similar environmental conditions have been selected near the city of Tapachula. Populations of *Aedes* mosquitoes have been monitored since October 2015 using ovitraps inside and outside of 15 houses in each locality. BG sentinel traps and GAP traps will also be used for monitoring of adult populations. Mark-release-recapture method will be used to evaluate population size and dispersal of *Ae. aegypti* adults. Five transects around each community have been set in the surrounding vegetation zones. Traps are located at 0, 50 and 100 m from the village perimeter. These are to evaluate the spatial distribution of *Ae. albopictus* and *Ae. aegypti*. After 18-24 months monitoring, one site will be selected for sterile male mosquito releases, and the other site will be used as control. After one year, the sites will be switched, with the purpose of have one year releases in each site. A genetically diverse colony has been established by collecting wild mosquitos from 12 sites along the coast of Chiapas to establish a mass production colony for SIT application.

125 Evaluation of two larval diets for mass rearing *Aedes aegypti* (Diptera: Culicidae).
Adriana Ramírez, adriana.osorio@espm.insp.mx, Guillermo Bond, Reyna Bustamante, Carlos Marina, Ildefonso Fernández-Salas, Pablo Liedo, Trevor Williams

The quality of a larval diet is a fundamental step in establishing a mass production system that promotes adult reproductive performance at a reasonable cost. The goal of this study was to compare two larval diets for *Ae. egypti*, to determine the best for mass rearing purposes. A genetically diverse colony was established from 12 sites along the coast of Chiapas. Two diets were evaluated: 1) a diet developed at the IAEA and 2) Laboratory Rodent Diet 500. Both diets were provided at a rate of 4% wt:vol, equivalent to a dose of 0.53 mg/ larva. To measure the effects of the diets on *Ae. aegypti* development, 750 first instars were placed in a plastic tray filled with 500 ml of deionized water, to obtain a larval density of 1.5 larvae/ ml. The effect of light on larval development was tested using covered and uncovered trays. Four treatments each with three replications were performed. Time to pupation and time to emergence were calculated as were survival to pupation and survival to adult emergence. Male pupae production at 24 h after pupation was also determined. In the adult stage, 50 males from each treatment were placed in plastic cages with sugar solution or water only.The longevity of adult males and the body size was also evaluated. 100 males and 100 females of each treatment were placed together in cages to evaluate adult longevity and egg production. The Kaplan-Meier analysis was used to estimate the mean adult longevity. General linear

models were used to analyze survival to pupation and adult emergence. Preliminary results indicate that the time of pupation and adult emergency were faster with the diet of the IAEA, and male longevity was reduced compared to males reared on the rodent diet. The final results of the evaluation of both diets will be presented.

126 Use of autocidal gravid ovitraps as barrier treatment to protect targeted houses against *Aedes aegypti*

Manuel Amador, maa4@cdc.gov, Veronica Acevedo, Roberto Barrera

The recent spread of Zika virus to urban tropical areas has caused much concern among public health agencies because this virus can cause microcephaly and Guilain-Ballé syndrome. Protecting pregnant women against Zika virus infections is a priority. CDC has recommended installing screens in windows and doors, use of insect repellent, and vector control at the home of the pregnant woman and in neighboring houses in a 150m buffer area around it. This investigation evaluated if the presence of three AGO traps in most houses (>80%) around, and at a targeted residence plus source reduction / larviciding (S-methoprene) could significantly reduce *Aedes aegypti* density in areas with a 150 m radius. Two similar areas within a same neighborhood were visually selected in southern Puerto Rico using a satellite image, and one was randomly assigned as the treatment area and the other as the control area. After two months, the control area was similarly treated (partial cross-over design). Sentinel AGO traps (21) were placed in both areas to monitor weekly changes in female *Ae. aegypti* density. In the intervention area, the number of females/trap/week significantly decreased from 20.3 ± 1.7 (Avg ± SE) in the pre-intervention period to 4.5 ± 0.2 after treatment, and the average number of *Ae. aegypti* in the core 50 m area changed from 19.5 ± 4.1 to 2.5 ± 0.2, respectively. In the control area, the number of females/trap/week significantly decreased after cross-over treatment from 22.5 ± 2.0 (Avg ± SE) in the pre-intervention period to 4.0 ± 0.5 after treatment, and in the core 50 m area it changed from 22.7 ± 3.9 to 3.9 ± 0.6, respectively.

127 Field evaluation of biorational insecticides for the control of dengue, chikungunya and zika vectors in Southern Mexico.

Carlos Marina, fmarina@insp.mx, Guillermo Bond, José Muñoz, Javier Valle, Humberto Quiroz-Martínez, Jorge Torrez-Monzón, Trevor Williams

Mexico is currently undergoing rapid invasion by chikungunya and zika viruses which appear to have been introduced through the southern border with Guatemala. The aim of this study was to evaluate the efficacy of four larvicides in an urban cemetery during an outbreak of chikungunya in Tapachula, Chiapas. For this, commercial formulations of pyriproxyfen (Knack®), λ-cyhalothrin (Karate Zeon®), spinosad (Natular ™ G30®) and mineral based granules of temephos (1% AI) were applied in ovitraps. The experiments were conducted from Nov 2014 to Feb 2015 during the dry season, and from Apr to Jul 2015, at the start of the rain season. Natular G30 and λ-cyhalothrin treatments provided 7 weeks of complete control of *Aedes* spp. immature stages in the dry season and the start of the rains. The pyriproxyfen treatment resulted in 3 and 5 weeks of total inhibition of immature stages in the dry season and start of the rainy season, respectively. Also, temephos granules resulted in 5 and 4 weeks of absolute control of *Aedes* spp. immature stages in the dry season and start of the rains. Larvae and pupae collected from ovitraps samples were reared in the laboratory and adults were identified to species. *Aedes aegypti* was the most abundant species in both sampling periods. However, the *Ae. albopictus* population increased its abundance at the start of the rainy season compared with the records from the dry season. Natular G30 and λ-cyhalothrin were the most efficient larvicides in the present study. Pyriproxyfen was the least efficient larvicide, but reduced adult emergence in samples of larvae and pupae reared in the laboratory compared to the control treatment. Temephos showed a significant reduction in its larvicidal activity compared to the results of previous studies.

128 A new larvicide ovitrap made of plastic with pyriproxyfen incorporated for *Aedes aegypti* control

Laura Harburguer, lharburguer@gmail.com, Cecilia Lorenzo, Susana Licastro, Patricia Eisenberg, Héctor Masuh, Eduardo Zerba

Aedes aegypti (L.) is a species of international concern because of its ability to transmit serious human arboviral diseases including yellow fever, dengue, zika and chikungunya, which have spread to all continents. Ovitraps are containers constructed to imitate *Aedes´* natural breeding sites and have been used for many decades as a sensitive and inexpensive surveillance tool for detecting the presence of container-inhabiting mosquitoes. Its improvement for population control purposes could introduce a new tool with low environmental impact that will allow an integrated vector control.

In this study we performed a biological and chemical characterization of a new ovitrap prototype manufactured by injection molding of low density polyethylene (LDPE) with the larvicide pyriproxyfen.

Our research shows that pyriproxyfen was immediately released from the LDPE into the water of the ovitrap and led to an emergence inhibition (EI) of 100% for over 30 weeks. In addition, ovitraps continued to show a high larvicidal activity after over 20 washes. Pyriproxyfen was detectable in the water after a contact of 20

seconds with the ovitrap and reached a peak after 24 hours. Also the *horizontal transfer* of pyriproxyfen from the ovitrap to breeding sites was observed.

Results of this work indicate the feasibility of using a long lasting material containing pyriproxyfen as larvicidal ovitrap. This tool together with the use of curtains or jar covers treated with insecticides could improve *Ae. aegypti* population control and potentially reduce dengue and zika transmission.

129 Novaluron 2GR effect on *Aedes aegypti* (Diptera: Culicidae) under controlled laboratory conditions

Juliana Perez, jperezp1017@gmail.com, Marcela Quimbayo, Jorge Velasquez, Paola Rodriguez, Juan Amaya, Guillermo Rua

Aedes aegypti, the principal vector of important diseases such as dengue, chikungunya and Zika in Colombia, has proven to be resistant to different insecticides used in public health. Taking into account that the adult stage vector is the one transmitting these diseases, and immature stages (larvae and pupae) live in water containers, using products that prevent the emergence of mosquitoes would be an excellent strategy for controlling such diseases. In this sense, Novaluron 2GR is a growth regulator insecticide that controls the formation of adult mosquitoes. With the aim of determining the lethal concentrations (LC) 50 and 99 of Novaluron 2GR on *Ae. aegypti* larvae (L1 and L4), and the percentage of emergence inhibition, bioassays under controlled laboratory conditions were conducted. 14 concentrations ranging between 50 and 0.00625 mg/L were evaluated. 4 repetitions were performed per concentration, each with four replications and their respective controls, and 25 larvae were used in each replication. A total of almost 7000 L4 and 2000 L1 larvae was assessed. The bioassays indicated that the LC50 and LC99 for L4 corresponded to 0.019 mg/L and 0.084 mg/L, respectively. Furthermore, the inhibition of emergence for the LC99 was close to 100%. These results indicate the potential of Novaluron 2GR as regulator of *Ae. aegypti* populations at very low concentrations. However, the product should be evaluated in the field to corroborate its effect for controlling *Ae. aegypti* mosquito, which transmits dengue, chikungunya and Zika, and to demonstrate its usefulness in prevention and control programs for these diseases.

130 Vectos, an integrated analysis system for decision-making in vector control

Clara Ocampo, claraocampo@cideim.org.co, Neila Mina, Maria Echavarria, Ana Estrada, Neal Alexander, Jorge Ramirez, Alexi Caballero

In Colombia and in many Latin American countries, decision-making and the development of strategies for prevention and control of urban diseases such as dengue, chikungunya and Zika represents a challenge for municipal health authorities. One of the biggest limitations is that the information product of epidemiological and entomological surveillance in many cases is analyzed fragmented and does not stratify the risk of transmission in different sectors of the city. Therefore control actions are generally reactive, generalized and intermittent. This situation has led to unsatisfactory and unsustainable control strategies of the most important vector, *Aedes aegypti*. This project aims to develop a comprehensive management system for spatial analysis of epidemiological, entomological and social variables associated with urban arbovirus transmission to help in the development and monitoring of targeted and prioritized strategies. Using information and communication technologies, two mobile applications (for entomological capture and social information) and a web system that allows the collection, geocoding, and integrated information using free geospatial analysis software were developed.

The web system VECTOS display human reported cases in a local map, as well as epidemiological, entomological and social indicators in real time to facilitate decision-making based on evidence. Additionally, allows running stratification analysis at the neighborhood level. We hope this tool offers opportunities to design targeted and differential prevention and control strategies based on evidence.

131 Map-based exploration of insecticide resistance data in VectorBase

Gloria I. Giraldo-Calderón, ggiraldo@nd.edu, Ioannis Kirmitzoglou, Sarah Kelly, Melina de Lima, Daniel Lawson, Robert MacCallum, George Christophides, VectorBase consortium

Insecticide resistance studies are usually made available in isolation and typically in the form of static maps. VectorBase has a freely available dynamic map-based interface for the interrogation and visualization of worldwide insecticide data for any vector species of medical importance. Current data includes >6000 insecticide resistance assays dating from 1965. We operate a continuous process of literature curation to add new data and are building collaborations with other teams such as IR Mapper and the Worldwide Insecticide Resistance Network (WIN) to share data. Because the map contains insecticide resistance data from different assay protocols and reported in a variety of measures and units, such as percent mortality, lethal concentration (*e.g.* LC50) and lethal time (*e.g.* LT95) a global/universal resistance color scale has been developed. This allows the side-by-side visualisation of data that otherwise would be incompatible. Custom plots compare data recorded with the same measurement type and units among any studies. Information panels and popups show detailed metadata for individual data points. In addition to directly zooming on the map there is an auto-complete aided text search facility to limit displayed data on the basis

of vector species, country (or other geographic region), insecticide, protocols used for collection, species determination and resistance assays. The filtered data points can be colored by species, insecticide and several other categories. Spreadsheet-ready data can be downloaded for any user query. This map is accessible at https://www.vectorbase.org/popbio and all its features are under constant development, please send us your requests or feedback to info@vectorbase.org.

132 Mutations in *ace-1* and in an esterase genes associated with chlorpyrifos resistance in *Aedes aegypti* from Mexico

Selene Gutierrez, selenegutierrez328@hotmail.com, Olga Karina Villanueva-Segura, Beatriz Lopez-Monroy, Karla Saavedra-Rodriguez, Franco Morales-Forcada, Ma. Cristina Bobadilla, Gustavo Ponce, Adriana Flores

Aedes aegypti (L.) represents a serious problem in Mexico as the main vector of dengue, Chikungunya and Zika viruses. The continued use of insecticides to control this vector has caused the selection of genetically populations able to resist the effects of the chemicals used recently in Mexico. The resistance has appeared to the four main toxicological groups including, organophosphates such as chlorpyrifos. One of the mechanisms of resistance to these insecticides is due aminoacid substitutions in the enzyme acetylcholinesterase and other esterases. In this study the presence of Gly12Ser mutation in the acetyl cholinesterase-encoding gene (*ace-1*) and Gly6421Arg mutation in the esterase E gene were determined and related with resistance to chlorpyrifos in seven populations of *Ae. aegypti* from different geographic regions from Mexico. The level of resistance of the populations was determined using "bottle bioassay" with the insecticide chlorpyrifos and calculating resistance ratio (RR) based on LC_{50} of the field populations and the susceptible New Orleans strain. Both mutations were detected by real-time PCR. The three populations from Nuevo Leon located in the northeast part of Mexico had RR values from 3 to 5 fold. The population from Veracruz located on the east coast resulted with a RR ~7, similar to the population of Nayarit located on the west coast with a RR ~8. Higher resistance was found in two populations from the south Mexico from the Yucatan state, with RR ~9 and 11 fold. The levels of chlorpirifos resistance correlated significantly with both mutations analyzed with the highest allele frequencies of the mutation in the *ace-1* gene of 0.75 and 0.77 for the E6421 gene, both frequencies corresponding to the populations of Yucatan.

133 Truck mounted larviciding as a control method for *Aedes aegypti* in Miami-Dade

Grifith Lizarraga, glizarraga@clarke.com, Dan Fachet

The outbreak of Zika in the city of Miami allowed the use of non-conventional tools with the purpose of reducing its main vector, *Aedes aegypti*. This emergency accelerated and created novel ideas to control this species of mosquito. One such method was the use of Buffalo turbines for larviciding similar to those described by Williams et al. (2014). This presentation demonstrates results of efficacy, methodology used and larviciding control for the city of Miami.

Managing Invasive *Aedes* Mosquitoes in California Symposiun II

134 Discovery, surveillance and control of *Aedes aegypti* in Coachella Valley, California

Jennifer Henke, JHenke@cvmvcd.org, Jeremy Wittie

Aedes aegypti were detected in the city of Coachella on May 9, 2016. Since the introduction, the District used Integrated Vector Management principles to inform residents, conduct surveillance, and lead control efforts against the invasive mosquito. While the District used methods that other mosquito control districts pioneered, the District also was the first to conduct aerial larvicide applications over a city of California. This presentation outlines the notification process used, the applications made, and the evaluation of those applications. The speakers will also discuss some troubleshooting that occurred as the applications were being made.

135 Managing Invasive *Aedes* in Imperial County, California

Paul Johnson, PaulJohnson@co.imperial.ca.us

Aedes aegypti was first detected in Imperial County in January of 2015. The southeast corner of the County is adjacent to the Mexican city of Algodones where our first positive occurred. A BG Sentinel trap was used near the border checkpoint. We next detected activity in Calexico, a city on the border with Mexico in the center of the valley. Our strategy was to track the progress of the mosquito northward. The mosquito spread rapidly throughout the valley and may have had separate and possibly simultaneous introduction(s) in several neighborhoods. *Ae. aegypti* have been detected almost everywhere in Imperial County with the exception of the extremely arid and windy northern end of the valley. The Imperial County Public Health Department and Environmental Health Division have had to adjust to this invasive species. We are enhancing our capabilities in response to the new species. However, *Aedes aegypti* is very different from our nuisance mosquitoes associated with agriculture and flood irrigation. This invasive species requires more intensive surveillance and public outreach; sources are difficult to detect. The public's awareness of and willingness to reduce sources must be encouraged. Our mosquito control efforts are also moving toward a more individualized complaint response as opposed to multiple complaints from neighborhoods near large

obvious agricultural sources. We have modified our treatment capabilities and have adjusted our pesticide choices to more closely fit the requirements needed to control this invasive species.

136 *Aedes aegypti*: What We Know, What We Think We Know & What We Need to Know
Chris Sumner, chrisumner@gmail.com, Cesar Barajas, Amy Picone

Aedes aegypti in the low desert does not appear to follow the conventional behavior of being a strictly diurnal, human feeder. Yuma County Pest Abatement District (YCPAD) has observed that *Ae. aegypti* mosquitoes have adapted to the low desert climate by changing their flight activity times, and will feed on non-human hosts. It has been collected in locations distant from human activity where birds are the sole source of blood meals. Bird-feeding *Ae. aegypti* may have the potential to bridge vector other Flaviviruses such as West Nile and St Louis Encephalitis viruses. YCPAD evaluated lethalized ovitraps and measured no significant reductions in *Ae. aegypti* collected by BG Sentinel traps after deployment compared to numbers prior to deployment. Knowledge gaps include: Confirmation of night-time flight activity, blood meal analysis, evaluation of the use of Ultra-Low and Low Volume applications of Insect Growth Regulators, monitor the pesticide resistance profile, and evaluation of the use of BG Sentinel traps to locally remove adult mosquitoes as an alternative to adulticide applications.

Collaborative Surveillance and Response Efforts to Combat Invasive Aedes-Transmitted Diseases in the San Diego-Baja California/Mexico Border Region Sympoisum I

137 Epidemiology and Risk of Local Transmission of Zika, Dengue, and Chikungunya in California
Vicki Kramer, vicki.kramer@cdph.gov

Current and historic epidemiological information on Zika, dengue, and chikungunya in California will be provided. Data will include total case numbers, case outcomes, mode of virus transmission, seasonal trends, geographic origin, and counties of residence. Proximity of potentially viremic cases relative to known infestations of *Aedes aegypti* and *Aedes albopictus* will be discussed as a measure of local transmission risk. Zika preparedness and response activities will be summarized.

138 Surveillance and outreach for IATD in the San Deigo/Mexico border region
Eric McDonald

Not Available

139 Response and outreach for invasive *Aedes* transmitted diseases in San Diego County
Nikos Gurfield, Nikos.gurfield@sdcounty.ca.gov

The detection of the invasive *Aedes* mosquitoes (IAM), *Aedes aegypti* and *Aedes albopictus*, in San Diego County in 2014 and 2015, respectively, necessitated enhanced response and outreach strategies to protect residents from invasive Aedes transmitted diseases (IATD). Although no IATD acquired from local mosquitoes have been reported in San Diego County, from 2011-2015, multiple travel-associated cases of dengue (54), chikungunya (20), and Zika virus (3) were reported to Public Health. The establishment of IAM in the County required tightly coordinated communication and responses between County Public Health and Vector Control in order to prevent mosquito transmission. Responses included assessment of case residences and nearby properties for IAM larvae or adults, and, if found, rapid communication to affected neighbors and the general public that balanced transparency of operations and patient confidentiality. Outreach strategies 72 hrs. prior to treatment included notification of affected residences by door hangers, sandwich board placement on street corners, phone bank activation, web page updates, and media releases. Day-of-treatment outreach and response consisted of placing subject matter experts onsite for media inquiries, using multiple 4-person treatment teams consisting of a scout, scribe, applicator and spotter and delivering area warrants. Support staff from pesticide regulation, animal services, and law enforcement were available as needed. These preparations helped result in a favorable response from most communities.

Spatial Repellents I

140 An historical overview of spatial repellents.
Daniel Kline, dan.kline@ars.usda.gov

This presentation will provide an historical overview of spatial repellents and their use in vector control programs. Various definitions of spatial repellents are in use. These will be discussed with particular emphasis on how mosquito behavior impacts these definitions. The presentation will provide an historical perspective of various active ingredients and delivery systems that have been used or are currently being used. Particular emphasis will be placed on why the compounds/devices/practices are still a work in progress.

141 Spatial repellents: the final frontier?|
Dan Strickman, dan.strickman@gatesfoundation.org

Other than swatting, the use of spatial repellents (as smoke produced by burning certain plants) was probably the first anti-mosquito measure used by humans. Despite the long history, the great variety, and the sheer volume of their use, spatial repellents remain one of the least consistent methods for stopping mosquito bites and the pathogens they transmit. We continue to work on improving spatial repellents because the logic of putting a chemical into the air that kills, knocks down, or otherwise incapacitates female mosquitoes has great appeal to the public and professional. Recent work using high-quality coils showed that it was possible to significantly reduce malaria transmission. Mysteriously, the reduction in transmission was higher than the reduction in biting. That result suggested that the active ingredient was having an effect on mosquitoes beyond simply killing or repelling them. New products and chemistries may be able to take advantage of non-lethal physiological effects so that spatial repellents become an important part of preventing pathogen transmission where other measures are impractical. Better spatial repellents can also contribute to area-wide mosquito control by contributing to push-pull systems, helping solve the problem of residual transmission.

142 A critical path of development for spatial repellents: *what data will be enough?*
Nicole Achee, nachee@nd.edu

Global charges of malaria elimination and eradication, along with increased country and case reporting of arboviruses, have reinforced the need for prompt vector control optimization and innovation. Spatial repellents are included among a range of products currently being evaluated for efficacy in reducing pathogen transmission. However, challenges exist with integrating a rigorous scientific approach with new policy development in order to meet timely public health demands. This presentation is intended to provide an overview of a critical path of development for spatial repellents for the control of arthropod-borne disease with special attention highlighting data requirements and gaps for supporting implementation of these products as public health tools. Examples will be drawn from an ongoing spatial repellent trial.

143 Non-pyrethroid spatial repellents
Joel Coats, jcoats@iastate.edu, Edmund Norris, James Klimavicz

Spatial repellents represent a promising class of tools that can provide important protection from mosquitoes. In malaria programs, they could be used in addition to treated bed nets and indoor residual spraying. In yards, parks, livestock facilities, etc., they can deter mosquitoes from entering a treated area. Currently most personal or local uses of spatial repellents involve burning of a pyrethroid coil or otherwise emitting a pyrethroid insecticide. Burning or otherwise emitting oil of citronella is the primary alternative to the pyrethroids. We have synthesized a series of 150 biorational derivatives of natural terpenes to create repellents that provide physicochemical and biological properties that represent improvements over citronella and other terpene repellents. Pyrethroid spatial repellents work well in some instances, but are less effective against pyrethroid-resistant strains of mosquitoes. Further, some pyrethroid spatial repellents cause mosquito knockdown and mortality, thus potentially contributing to enhancement of pyrethroid-resistance in a mosquito population. The mechanism of repellent action for terpenes is probably different from that of pyrethroids, so an optimized integrated mosquito management (IMM) program could include a rotation of spatial repellent classes, between advanced terpenes and volatile pyrethroids, along with other traditional tactics.

4th Annual AMCA Arthropod Highlights Symposium

144 Introduction
Lee Cohnstaedt

145 Highlights of vector biology
Michael Reiskind

Over the past year there have been hundreds of scientific articles about the biology of arthropod vectors of disease, many of which focused on mosquitoes. In this talk the highlights of this science are discussed, organized by their ecological scale: global to landscapes, communities to individuals, physiology to molecules. Important papers are recognized and fit into the context of mosquito control. The future outlooks on scientific research in vector biology will also be addressed.

146 Highlights of vector control
Gregory White, greg.white@slcmad.org

Recent outbreaks of Zika virus caused a global interest in vectors and vector control. This presentation will highlight some of the latest advancements in vector control based on papers published in 2016. Papers were

selected based on likely having a big impact in the field of vector control. Advances in control methods for multiple vectors will be highlighted. New equipment, application methods, active ingredients, physical control biological control methods and new technologies will be discussed. A few manuscripts will be discussed in depth and others will be given a more broad overview to help highlight some of the many findings published in the past year in vector control. Both academic and applied impacts of the presented research will be discussed.

147 Highlights of biting fly research
Will Reeves

Black flies, Simuliidae, are some of the most significant biting pests across the world. These flies cuase significant economic damage to both the recreation industry and to agriculture. While black flies are pests they are also vectors of several diseases of both humans and animals. The larvae of these flies live in fresh running water, which is unlike most mosquitoes. I will focus on a review of literature highlights from 2015-2017 on developments in vector borne disease in North America, species diversity and monitoring, and in how black flies are responding to changes in water quality in the USA. I will also briefly discuss new issues involving vector-borne disease and sand flies, Psychodidae, in the SW USA

Behavior/ Biology I

149 History of the Asian tiger mosquito, *Aedes albopictus* in southeastern Massachusetts
Priscilla Matton, brismosqpc@comcast.net, Todd Duval, Matthew Osborne

The Asian tiger mosquito (*Aedes albopictus,* Skuse) has been collected from one site in southeastern Massachusetts yearly since 2009. BG-Sentinel™ mosquito traps were used to determine the regional distribution in the area during the 2013 and 2014 mosquito season. In 2014 and 2015, ovitraps were added to the program to determine presence or absence of the species at multiple sites. The 2016 data from these traps have shown a range increase of the species into new areas within southeastern Massachusetts. In some locations, ovitraps collected *Ae. albopictus* eggs but the BG-Sentinel™ mosquito traps did not collect any corresponding adults. Additionally two overwintering studies were performed to determine ability of *Ae. albopictus* eggs to survive the local climate.

150 Oviposition site defense by *Aedes aegypti* against ovipositing *Toxorhynchites rutilus rutilus* in a laboratory setting
Rachel Morreale, morreale@lcmcd.org, Jonathan Hornby, T. Wayne Gale

When provided a single oviposition site in a laboratory setting, *Aedes aegypti* (L.) have been observed to actively defend the site from ovipositing *Toxorhynchites rutilus rutilus* (Coquillett). During oviposition attempts of the predacious mosquito, *Tx. r. rutilus*, female *Ae. aegypti* will deliberately fly at the *Tx. r. rutilus*, sometimes even making contact with them. While this behavior rarely deters female *Tx. r. rutilus*, it is a persistent effort made by the *Ae. aegypti* in an apparent effort to interfere with the successful oviposition of these predacious mosquitos. This behavior has not been observed with male *Ae. aegypti* or with *Ae. albopictus*.

151 Determining peak activity times of *Aedes albopictus* using new BG-Counter and modified Rotator Trap
Jay Kiser, jkiser@suffolkva.us, Karen Akaratovic, Charles Abadam

Due to the observed diurnal behavior of *Aedes albopictus*, adulticiding after sunset is thought to be less successful than with other species. Understanding peak activity times for male and female *Ae. albopictus* may allow for more effective control efforts. Using Biogents' new BG-Counter (BGC) trap (BG-Sentinel 2® trap equipped with a remote monitoring device that counts unspeciated mosquitoes), we were able to monitor *Ae. albopictus* activity throughout a 24 h cycle in 15 min intervals. Over 24 nights, June-September 2016, the BGC had an average accuracy of 96% in its ability to identify and count mosquitoes compared to human calculations. The BGC caught 9,161 mosquitoes with *Ae. albopictus* comprising 90% (4,228 females and 3,994 males); 5-7pm showed the highest level of activity (1,949 mosquitoes and 24% of the trap total) with a peak between 5:45-6pm (total of 290 mosquitoes). Because the BGC is unable to speciate or sex, we incorporated a modified CDC bottle rotator (CBR) trap. The CBR, set from 1-7pm (peak activity times found by the BGC) rotating hourly, was set 20 m away from the BGC, August-September. The preliminary CBR data shows that male and female *Ae. albopictus'* activity differ from one another; male activity peaks between 5-6pm while female activity dips from 5-6pm and peaks from 6-7pm. While more data is needed to fully understand the specific activity times of males and females, *Ae. albopictus* as a species has predictable time periods of activity.

152 *Aedes albopictus* surveillance in the Florida Keys

Heidi Murray, hmurray@keysmosquito.org

Aedes albopictus , commonly referred to as the Asian Tiger Mosquito, was first documented in the United Sates in Texas in 1985 (Sprenger and Wuithiranyagool 1986). A year later, *Ae. albopictus* was discovered at a tire dump in Jacksonville, Florida (O'Meara 1997). By 1994, *Ae. albopictus* had spread to all 67 counties in Florida (O'Meara et al. 1995). Currently, it is the dominant *Aedes* mosquito found in domestic containers throughout Florida. An exception to this is the Florida Keys, where *Aedes aegypti* remains the dominant container mosquito. In 1993, the Florida Keys had their first *Ae. albopictus* sighting at Ocean Reef on Key Largo in the Upper Keys. In December of 2001, the Florida Keys Mosquito Control District (FKMCD) collected its first *Ae. albopictus* sample in the Lower Keys on Big Pine Key. In 2002, the FKMCD decided to attempt to eradicate *Ae. albopictus* from the Lower Keys. The following methods were used: regular domestic inspections, routine sweeps, public education, aerial larviciding, barrier treatments, adulticiding by truck, aerial adulticiding, larval sampling, adult trapping, sentinel tires and ovicup sampling. Through these efforts, the FKMCD discovered that, even though *Ae. albopictus* can establish itself in the Florida Keys, with extensive effort, populations can be knocked down (Vlach and Fussell 2003). For years, the number of *Ae. albopictus* collections remained low, despite extensive surveillance. However, in 2016, the number of positive *Ae. albopictus* samples rapidly increased throughout the Florida Keys. While *Ae. albopictus* numbers are still relatively low compared to the local *Ae. aegypti* population, they are progressively on the rise. This invasive species, previously spotted occasionally on a few islands, can now be found throughout the Keys. The FKMCD continues to make extensive efforts to reduce the population of *Ae. albopictus*.

153 Entomological investigations during early stages of a chikungunya outbreak in the United States Virgin Islands, 2014

Joan Kenney, Kristen Burkhalter, Mariah Scott, Janet McAllister

During the 2014 chikungunya (CHIK) outbreak in the Caribbean we conducted an entomological investigation in the United States Virgin Islands (USVI). We conducted adult mosquito collections for species composition studies, blood-meal identifications and virus screening. In addition we used ovitraps to collect mosquito eggs for insecticide resistance testing. Also we conducted ecological risk evaluation studies in selected neighborhoods by quantifying breeding habitats within these urban habitats. The dry conditions prevented collection of large numbers of adult mosquitoes and we did not detect virus in any of the mosquito samples we tested. However we identified *Aedes* (*Stegomyia*) *aegypti* (L) and *Aedes* (*Gymnometopa*) *mediovittatus* (Coquillett) in the samples we collected and these two species are known vectors of chikungunya virus (CHIKV). Ecological evaluation surveys established widespread availability of larval sites and potential larval habitats of *Ae. aegypti* throughout the USVI which suggested a high probability of autochthonous transmission of CHIKV in the USVI. Lastly, we detected resistance to malathion and permethrin in several local populations of *Ae. aegypti* on St Thomas Island, which suggested that these two insecticides may not be used during CHIK outbreaks.

154 Neuromodulation of Mosquito Feeding Behavior for In Vivo Colorimetric Detection of Arboviral Envelope Proteins with Aptamer-Gold Nanoparticle Conjugates

Alexander Bosak, alexander.bosak@ucf.edu, Alicia Brown, Soumen Das, Edward Ross, Daniel Kline, Barry Alto, Sudipta Seal, Bradley Willenberg

Colorimetric determination of the arboviral infection status of mosquitoes via imbibed aptamer-gold nanoparticle conjugates (Apt-AuNPs) is a nascent surveillance technology platform currently under development in our laboratory. Optimization of this innovative approach includes increasing the volume of our Apt-AuNPs containing solution consumed by mosquitoes. We posit that a fully engorged mosquito will enable an easier and more accurate assessment by eye of the color change from red to blue occurring when our Apt-AuNPs bind to arbovirus envelope proteins inside the mosquito midgut. Thus, we are investigating several drugs targeting alpha-aminergic, 5HT-inergic and TRPA1 signaling as it is known in other insects that modulating biogenic amine sensory pathways can increase the level of engorgement, and that sensing heat from a host is one of the last stimuli needed for a mosquito to feed. Currently, we have been able to nearly quadruple the number of female mosquitoes (*Aedes aegypti*) with higher engorgement levels of our Apt-AuNP diagnostic solution via the addition of these drugs compared to controls feeding on solutions lacking the compounds.

155 Development of mosquito larvae in randomly discarded materials at the Smithsonian National Zoo, Washington, DC.

Jerome Hogsette, jerry.hogsette@ars.usda.gov, Gregory Ose, Anthony Hiza

There has been much discussion and speculation about the ability of mosquitoes to develop in small amounts of water in natural containers, e.g., tree holes, and those provided inadvertently by humans, e.g., buckets. There are little or no data indicating the ability of mosquito larvae to develop in extremely small amounts of water in extremely small containers, e.g., discarded plastic candy wrappers. To provide data for

this topic, a survey was done at the Smithsonian National Zoo, Washington, DC, of natural and discarded materials in the natural areas. Anything that might hold water was investigated, the presence or absence of water notes and mosquito larvae, if present, were counted and identified. Data indicate the ability of mosquitoes to utilize scraps of paper, discarded snack bags and other objects capable of holding water to maintain local adult populations. This behavior makes larval development sites difficult to locate and essentially impossible to manage.

156 The effect of ultraviolet radiation on tire deterioration and the impact of the release pollutants on disease-vector mosquito ecology

Oswaldo Villena, oswaldo.villena@gmail.com, Paul Leisnham, Edward Landa, Joseph Sullivan, Bahram Momen

Used vehicle tires degrade when exposed to ultraviolet (UV) radiation and leach numerous soluble contaminants. Studies have shown toxicological effects of tire leachate on a few focal taxa. Although numerous vector mosquito species utilize used tires as developmental sites, there is a lack of knowledge on the effects of tire leachate on mosquito communities. This study investigated the effects of tire contamination on the ecologies of two common tire-utilizing mosquito species, *Aedes albopictus* and *Culex pipiens.* The main objectives of this study were to: (1) Examine tire degradation and leachate, using zinc concentrations as a marker contaminant, under different UV radiation treatments; and (2) Test the effects of tire leachate on competition between *Ae. albopictus* and *Cx. pipiens.* We exposed tires to either full sun, shade, or no UV conditions, and then conducted a competition trial between *Ae. albopictus* and *Cx. pipiens*. We sampled zinc concentrations from water, biofilm and mosquitoes from each treatment. Zinc concentrations were higher from water and biofilm in tires exposed to full sun conditions. *Ae.albopictus* had higher zinc concentrations than *Cx. pipiens*. Survival for both species were consistently lower under full sun conditions, and *Ae. albopictus* regularly had higher survival. These results show that greater UV radiation from full sun conditions advances tire degradation and contaminant leaching, and decreases mosquito survival. Although *Ae. albopictus* may to be exposed to greater concentrations of contaminants, presumably by browsing leachate-rich biofilm, it was able to maintain competitive dominance over *Cx. pipiens* indicating the importance of used tires to the spread of this pestiferous invasive species.

Collaborative Surveillance and Response Efforts to Combat Invasive Aedes-Transmitted Diseases in the San Diego-Baja California/Mexico Border Region Symposium II

158 Surveillance and outreach for IATD in Baja California

Nestor Hernandez

Not Available

159 Update on current mosquito control activities in Baja California

Luis Ibarra

Not Available

160 US-Mexico binational collaborations

Esmeralda Iniguez-Stevens and Nestor Hernandez

A description of binational public health collaborations efforts will be provided. Particular emphasis will be placed on how state, local, and federal public health officials have worked together to enhance situational awareness, facilitate cross-border exchange of information, and develop joint communication protocols for investigating binational infectious disease cases and outbreaks. Presentation will also include a summary of a recent U.S.-Mexico borderwide vector-borne disease tabletop exercise.

162 Use of big data and novel visualization tools in the US-Mexico border region to combat emerging threats

Eric Frost

"Imaging and mapping small bodies of water of concern as habitats for mosquitoes can be done by directly flying over a site and imaging standing water as water. Many times this is both difficult in terms of the enormous size of a jurisdiction like San Diego County and Baja California. One means of detecting small bodies of water is using sun glint---simply flying over a region and photographing the ground with the reflection of the sun that wonderfully reflects off standing water. Using a quadcopter with a camera oriented at an angle toward the sun provides unusual imagery that is rarely done except for sun glint imaging. Similar imaging to see spin patterns of flow/no flow in the water is also effective. Transferring this imagery into smartphone mapping tools much like those used for wildland firefighting can powerfully enable the detailed on-ground discovery of the standing water and GIS mapping. Change detection by flying over the same route then shows differences as before and after rains or times of prolonged dryness.

Another means of "visualizing" mosquitoes is acoustically because of their distinctive high-frequency flight noise. Detecting this with the microphone of a smartphone and then doing mapping and time of day can help define where mosquitoes are, particularly flying aggressively in the mid-day. Several Homeland Security graduate students are working on a Smartphone App to do this, where the microphone is on and simply listening for the sound of mosquitoes. The phone using GPS can provide location and time and thus help with the mapping such as from field workers, Border Patrol agents, CBP officers, and a host of other people who are along the border including on both sides of the border. This Internet of Things App can be a wonderful aid to cross-border collaboration, including with refugees."

Spatial Repellents II

163 Heterocyclic Amines that Produce Anosmia In Insects

Ulrich Bernier, uli.bernier@ars.usda.gov

Volatile chemicals that emanate from a host can be used by mosquitoes and other arthropods for host location or avoidance. In general, naturally produced host chemicals that attract arthropods (kairomones) outnumber those that repel or lead to host avoidance (allomones). The kairomones are almost exclusively a subset of naturally produced compounds which often must be combined properly to produce an artificial blend which ideally will attract as well as the preferred host. Allomones are often used as single compounds and can be natural compounds or blends or they can natural product derivatives and synthetics. Examples of the latter are the spatial repellent, methofluthrin, which is a volatile pyrethroid insecticide which is a synthetic based on the structure of pyrethrum, and the common topically applied synthetic skin repellent N,N-diethyl-3-methylbenzamide (DEET). A newer allomone class is comprised of chemicals that are not toxic to the mosquitoes, nor do they repel in the traditional sense of producing oriented movement away from the chemical source (such as DEET). Instead, these chemicals create a temporary state of insensitivity to kairomones. Some of these heterocyclic nitrogen compounds are present on human skin at trace levels; however, when larger quantities of these compounds are presented concurrently with human odors to mosquitoes, they produce anosmia (inability to detect odors) and hyposmia (decreased ability to detect odors) in the test mosquitoes. This presentation will cover the research that led to this discovery of a novel means to deter mosquitoes from finding hosts.

164 Field Evaluation of Spatial Repellents in Thailand

Alongkot Ponlawat, alongkotp@afrims.org, Thanyalak Fansiri, Udom Kijchalao, Silas Davidson

A "push-pull" approach has been developed utilizing spatial repellent technology to "push" mosquitoes away from a target area followed by attractive bait that would "pull" them into traps to be killed. The objective of this study was to evaluate the efficacy of new commercially spatial repellents against important malaria vectors in Thailand. Evaluation was conducted using a semi-field 50-m tunnel setup. We hypothesized that repellent vapors would influence mosquito behavior, resulting in fewer mosquitoes being trapped near the repellent source, compared to an identical experimental setup minus the repellent source. Spatial Activity Index (SAI) was calculated for each repellent product to reveal spatial repellency of each product. Our results revealed that OFF!® Clip On™ provided significantly better protection against *An. minimus* and *An. cracens* compared to other repellent devices, and is worth evaluation for further field experiments against malaria vectors.

269 Next Generation of Controlled Release Devices against Vector Borne Diseases

Noel M. Elman, noel.elman@gmail.com, Ulrich R. Bernier, Daniel L Kline, Melynda Perry, Craig A. Scoops, Gissella Vasquez, Carmen Flores, Jennifer C. Stevenson, Limonty Simubali, Twig Mudenda, Pablo Gurman

Controlled Release Devices (CRDs) were developed as novel personal and field use protection systems with optimized performance of spatial repellents, maximizing protection and limiting environmental toxicity. CRDs were designed for deployment in various settings (indoors, semi-outdoors and outdoors), obtaining a protective area of approx. 25 m^2 in semi-outdoor areas. Numerical simulations based on Computational Fluid Dynamics (CFD) were performed to simulate release kinetic profiles in conjunction with physical characterization of active ingredients (AIs) obtained using analytical chemistry (HPLC, GCMS). CRDs rely on the use of heat transfer and micromembranes to perform sustainable of AIs over periods of days to weeks, depending on volume of reservoirs and formulation. CRDs were manufactured using cost-effective micro-injection molding technology, including the implementation of biodegradable polymers to minimize impact of environmental waste. CRDs containing metofluthrin as the AI were tested against *A. Quadrimaculatus, A. Darlingi and A. Gambiae*. Entomological studies included human landing catches (NAMRU-6, Iquitos, Peru), spatial repellency tests in huts (Macha, Zambia), and mortality and bite inhibition in indoor, semi-outdoor and outdoor studies (USDA, FL). CRDs represent the next generation of devices that leverage the use of advanced engineering to optimize vector control in regions affected by Malaria, Dengue, Zika, and other vector-borne diseases. CRDs represent the next generation of controlled release devices that leverage the use of advanced engineering tools to optimize vector control

165 The impacts of metofluthrin and transfluthrin on pyrethroid-susceptible and resistant *Aedes aegypti*

Gregor Devine, greg.devine@qimrberghofer.edu.au, Tamara Buhagiar, Kanchana Nakhapakorn, Richard Paul, Maggy Sikulu, Craig Stoops, Gisella Vasquez, Scott Ritchie

Mosquito management remains a mainstay of control for many vector-borne diseases for which there are no vaccines or chemotherapeutants. Existing vector control tools are compromised by coverage, cost, insecticide resistance and human compliance. Faster, more efficient methods of insecticide delivery are needed and an under-exploited group of volatile pyrethroids look promising. Passive formulations of these odourless pyrethroids with high vapour pressures were deployed as "hangable" or "sprayable" formulations in real urban houses and free-flight rooms. Impacts on adult *Ae. aegypti* abundance and biting behaviour were determined in lab-reared and wild type pyrethroid-susceptible and resistant populations in Australia and Thailand. Deployment of volatile pyrethroids in urban houses caused 25-50% of *Ae aegypti* mosquitoes to be knocked down and 80-100% of bites to be prevented 3-8 m from the device. These devices remained effective for >20 days. In the field, and in free flight rooms, some formulations retained their ability to prevent biting by resistant mosquitoes despite the demonstration of conventional knock-down resistance in CDC bottle bioassays. Lab and field studies show that formulations of metofluthrin in particular did not act as repellents. This is a potentially attractive trait as the burden of biting is not, therefore, simply shifted to unprotected neighbours. We conclude that some, insecticides, used inventively and thoughtfully, can still form part of an innovative defence against mosquito-borne disease.

166 Effective indoor use of metofluthrin to reduce biting from *Aedes aegypti*, the primary vector of dengue and Zika virus

Tamara Buhagiar, tamara.buhagiar@jcu.edu.au, Scott Ritchie, Gregor Devine

Metofluthrin, a vapor-active, synthetic pyrethroid, is a spatial repellent that has been shown to significantly reduce biting in *Aedes aegypti*, the primary vector of dengue and Zika virus. Unlike "traditional" repellents, metofluthrin's effect on biting is achieved through a different mechanism: the exposed mosquito initially becomes confused, inhibiting host-seeking behaviours, however, once exposed for a longer period of time, the mosquito is knocked down and eventually dies. Previously published studies in smaller rooms, up to 25m^3, have shown excellent results in biting reduction in the presence of a metofluthrin emanator. In our evaluation, we examine metofluthrin's (10% AI w/w) efficacy in a much larger room (111m^3), highlighting its strengths, and exposing its limitations. Using human landing counts, we evaluated the emanator's efficacy up to distances of 8m, in the presence of common household harborage areas, and in a room with and without fans. We go on to answer, what happens when a new mosquito enters a treated room and what is the likelihood of being bitten? What happens to mosquitoes that are in protected air spaces within a treated room, such as under a bed or in a cupboard with its door slightly ajar? Are they protected from its effects, and if so, for how long? Here, we reveal how to use metofluthrin most effectively indoors in order to reduce biting, and ultimately transmission risk.

Catch Basin Mosquito Control- Operational Effectiveness Evaluations Symposium I

167 Catch basin mosquito control perspectives

Justin Harbison, jharbison@luc.edu

For over a century, catch basins and associated structures have been common targets for mosquito pesticide applications. Although catch basins are routinely treated by many mosquito control programs there is a relatively small amount of published research regarding the effectiveness of catch basin pesticides. This presentation will provide a brief overview of the challenges with applying and evaluating catch basin pesticides, with particular emphasis on extended-release formulations that have grown in popularity over the past few decades.

168 Evaluations of treatments to catch basins in the Sacramento-Yolo Mosquito and Vector Control District

Paula Macedo, pmacedo@fightthebite.net, Randy Burkhalter

Catch basins can be a significant source of mosquitoes in urban and suburban areas. The Sacramento-Yolo Mosquito and Vector Control District has a Catch Basin Control Program, which consists of a crew of ten technicians who inspect and treat over 200,000 catch basins multiple times every year. Due to the significant resources required to inspect and treat such a large number of basins, effectiveness and longevity of the treatments need to be considered. Over the years, The District has performed and/or collaborated on various studies evaluating different products and their uses under different conditions, such as water depth, organic content, and catch basin design. This presentation will summarize some important findings from these studies.

169 WNV vector control in catch basins in Minnesota
Stephen Manweiler, mmcd_sam@mmcd.org, Kirk Johnson

Controlling WNV vectors developing in catch basins is an integral part of reducing WNV risk. We implemented a catch basin treatment program in Minnesota in 2003 and have evaluated the effectiveness of several commercially available products containing methoprene, Bti/Bs or spinosad. Our results suggest that all three actives effectively control WNV vectors (primarily *Culex restuans* and *Culex pipiens*). Long release formulations work best during dry seasons. Treatments involving multiple granules or tablets per catch basin more effectively resist flushing by heavy rain and resultant loss of control.

170 Have *Culex* spp. larvae in catch basins developed resistance to *Bacillus sphaericus* over a 15 year period in the Boston metropolitan area?
Brian Farless, brian.farless@state.ma.us, Doug Bidlack, Dave Henley

The duration of activity of *Bacillus sphaericus* for control of *Culex* species was evaluated in 80 catch basins in Newton, MA in 2001 and 80 catch basins in Boston, MA in 2016. Both studies were conducted from early July to early December. In both studies 40 catch basins were used as controls and 40 catch basins were used as treatments. All catch basins were sampled once a week using a Lander's Ladle. Average treatment control over the first 6 weeks was 91.4% in 2016 and 97.9% in 2001.

Management/ Public Relations/ Education

171 Withdrawn

172 Standing Ground on Public Health: PR lessons learned from Miami Dade's fight against Zika.
Laura McGowan, lmcgowan@clarke.com

History may have re-written this abstract from the time it was submitted until presented. This will review the stances and key messaging City, County and State officials used in addressing Zika control in Miami Dade. Hear the benefits of the textbook approaches taken to manage public communication through this public health emergency.

173 Zapping Zika: It takes a village
Beth Ranson, branson@keysmosquito.org

Zapping Zika takes a village. In Monroe County, various organizations and municipalities have come together to educate the public in an effort to prevent the Zika virus from taking hold there. The collaboration includes a joint website, bi-weekly meetings and a unified group of Public Information Officers. Community volunteer events, social media and shared presentations have assisted in spreading the word on why it is important to zap Zika. The presentation will share examples of challenges and successes of working together during a time of concern for public health.

174 Zika 101…Separating Fact from Fear - *A Community Engagement Toolkit*
Rebecca Riley, rriley@hcphes.org, Mustapha Debboun, Hallie Frazee, Sandy Kachur

This presentation will provide an overview of the comprehensive community outreach toolkit developed by Harris County Public Health (HCPH) Mosquito & Vector Control in response to Zika virus in Harris County, Texas. The toolkit was designed to be used as part of the HCPH Zika Communication Plan for education and communication purposes that can be tailored for schools, businesses, and a variety of community organizations. The outreach tools are translated in multiple languages and can be co-branded for use in the community.

175 Extension response to Zika in Florida
Roxanne Connelly, crr@ufl.edu

In a state-wide response to Zika in Florida, the University of Florida, Institute of Food and Agricultural Sciences, Florida Medical Entomology Laboratory (FMEL) worked with mosquito control, public health, state, and local agencies to provide educational programs about Zika virus, container mosquitoes, source reduction, and personal protection. The cooperative extension network throughout the state was utilized to assist in the response to Zika by creating videos, offering workshops, writing news articles, identifying mosquitoes, and responding to questions from the public. The county agents and Master Gardeners in many Florida counties participated in a state-wide container mosquito survey by providing egg collections to FMEL. Results of the egg survey and discussion of the educational efforts will be discussed.

176 Australia was amazing! The Florida Mosquito Control Association and the Mosquito Control Association of Australia Personnel Program.
Michael Riles, michael.riles@comcast.net

My experiences as the recipient of the Florida Mosquito Control Association and the Mosquito Control Association of Australia Personnel Exchange Program. Concerning the operational outlook of Australian

mosquito control methodologies from three Australian states including Queensland, Western Australia and New South Wales; five major cities visited Gold Coast, Brisbane, Townsville, Perth and Sydney. My tenure in Australia as depicted by daily events, work schedules, meetings, identification, media events and social interactions.

177 Insecticide resistance evaluation of *Culex pipens* in treated versus untreated areas of Larimer County, Colorado

Milena Guajardo, mcbguajardo@gmail.com, Mariah Scott, Broox Boze, Skyler Griffin, Ashley Gramza, Janet McAllister

Vector management appropriately utilizing insecticides is vital to the prevention of vector-borne diseases. Misuse or overuse of insecticides can result in insecticide resistance, which is a threat to public health. In a collaboration between Colorado Mosquito Control, Vector Disease Control International, and Centers for Disease Control and Prevention, bottle bioassays were performed on *Culex pipiens* mosquitoes collected as egg rafts from known larval production sites in Larimer County, CO. The reared adult mosquitoes were evaluated to determine differences in permethrin resistance in regularly treated areas compared to untreated areas. No significant difference was found between the two areas. Insecticide resistance surveillance is essential to guide future management strategies in Larimer County, the county with the fourth highest number of human disease cases of West Nile virus in 2016.

178 Preventing the risk of Chikungunya outbreaks through vector control programs in temperate climate countries: a cost-utility analysis in the epidemic scenario of Emilia Romagna

Filippo Trentini, trentini.filippo@unibocconi.it, Alessia Melegaro, Piero Poletti

In 2007, Italy has experienced the first large epidemic outbreak documented in a temperate climate country caused by Chikungunya virus, with approximately 161 laboratory confirmed cases concentrated in two bordering villages in the Emilia Romagna region. Although Chikungunya is not yet an endemic disease in Europe, as a consequence of globalization, the risk of observing future outbreaks of tropical vector–borne diseases is increasing in temperate climate countries. It becomes therefore critical to assess, both from an epidemiological and an economic point of view, which are the most effective and cost-effective control measures for controlling potential vector-borne epidemics. A previously published mathematical model is here used to describe the temporal dynamics of the competent vector, known as *Aedes albopictus*, taking into account climatic factors and the infection transmission mechanism driving the spread of the epidemic in both mosquitoes and humans. The model is calibrated on the observed epidemiological data of the Emilia Romagna 2007 epidemic and further extended to simulate a variety of different epidemiological scenarios and intervention strategies based on breeding sites removal, larvicidal and adulticidal programs. A cost-utility analysis with a stochastic approach to account for uncertainty on incidence of cases provided by model predictions, on costs and on DALYs loss was performed. The effects of the arrival of the primary case on the effectiveness and cost-effectiveness of different control measures is also explored. Model results show the most cost-effective and cost-saving interventions in reducing the burden of Chikungunya disease in different plausible epidemiological situations.

179 Mosquito Control after the 2015 Summer of Fire

Jamesina Scott, Sandi Courcier

In less than 7 weeks , wildland fires burned over 265 mi^2 in Lake County, CA. The fires claimed 4 lives and destroyed more than 1,300 homes, dozens of businesses, and hundreds of barns, garages, and other outbuildings.

The fires displaced over a quarter of the county's population during the mandatory evacuations and brought in more than 14,000 firefighters and thousands of utility workers, support staff, volunteers, and emergency personnel who lived outside or in tents or trailers during the height of the WNV and mosquito season.

Our immediate concern was to protect the evacuees and emergency personnel who were camped all over the county from mosquitoes and WNV.

As the fires were extinguished, we were amazed by how quickly mosquitoes repopulated the burned areas, and where we found them.

We expected mosquitoes in the pools, animal watering troughs, ornamental ponds, and debris left behind by the fire. We also suspected that mosquitoes would colonize the concrete foundations and holes left behind by burned buildings and trees.

None of us predicted that the biggest mosquito sources would be underground. Most of the destroyed homes were on septic systems rather than municipal sewers, and each was now a potential mosquito source. In the end, about 15% of the destroyed homes had damaged and exposed underground septic tanks and each one was producing extraordinary numbers of mosquitoes.

This presentation will discuss our agency's response during and after the fires, and its continuing effects.

267 Making a proboscis point of view
Cindy Mulla

Whether it's your first solo flight or if you are circling back into the local public arena, conveying a sharp point of view or two that will successfully stick with the audience can be onerous. At any level of public relations, researching the best venue, media method, phrase or word, while staying on target with your important public health message, is a challenging piece of groundwork. Creating and delivering a public relations campaign message having a light air of humor can lift and heighten your message. Multiple new methods and thought-provoking phrases will be suggested and shared to help encourage the individual whether novice or seasoned to add some new spice to their public relations and outreach program campaign for their local areas.

Innovative Solutions for Increased Program, Operational, and Research Effectiveness Symposium

180 Innovative Managing Methods to Promote Safety and Develop Employee Relationships
Gary Hatch, hatchgaryl@gmail.com, Paul Gines

Innovative ways the Mosquito Abatement District-Davis and our insurance carrier the Utah Local Government Trust use to promote safety. We bring on 34 seasonal employees each summer and training, safety and maintaining good job performance has always been a challenge. We have developed a few ways to help promote a culture of safety and "ownership" in the district.

181 Sampling Techniques for Small Spray Droplets
Brad Fritz

When spraying public health protection products for controlling mosquitoes, applicators for mosquito abatement districts are always challenged to selectthe appropriate application equipment for each job. To assess the functionality and performance of this equipment, personnel and researchers use a variety of sampling methodology to determine the effective spraying area and droplet size generated from a multitude of sprayers. The most common method for collecting and measuring spray droplets is rotating slides of varying widths and rotational speeds. Other methods include volumetric air samplers and thin strings. All of these samplers have advantages and disadvantages so it is important to understand the collection efficiency and sampling bias of each sampler in order to make proper assessment of the spray cloud.

182 Determining the nesting phenology of *West Nile virus* avian hosts using infrared thermography
Kevin Caillouet, caillouet@stpmad.org

Annual enzootic amplification of *West Nile virus* (WNV) has been linked to the seasonal end of avian nesting. The ecological triggers of WNV transmission have remained poorly understood in part due to the lack of directly observed data on the seasonal host traits and behaviors that may facilitate amplification. To address this we conducted weekly surveys of the understory vegetation using an infrared thermal imager to determine the seasonal abundance of shrub nesting and roosting birds in St. Tammany Parish, Louisiana during 2015 and 2016 and in Henrico, Virginia in 2015. Avian nesting data has proven useful in parameterizing WNV transmission models and may further inform the mechanisms promoting WNV outbreaks.

183 Strategies for surveillance and control of *Culiseta melanura* and secondary vectors of eastern equine encephalitis by the Metropolitan Mosquito Control District
Kirk Johnson, kjohnson@mmcd.org, Stephen Manweiler

Prior to 2001, eastern equine encephalitis had not been detected in Minnesota. In many years since, EEE antibody detections have occurred in Minnesota wildlife and the virus has caused at least four equine illnesses in the state. Following the first veterinary EEE case inside our District in 2001, MMCD began exploring options for surveillance and control of *Culiseta melanura*. We will discuss our strategies for monitoring this important vector, our limited options for controlling the species and our longstanding control programs targeting *Aedes* species and *Coquillettidia perturbans*.

184 Efficacy of control techniques of *Aedes aegypti* in Key West, Florida
Andrea Leal, aleal@keysmosquito.org, Catherine Pruszynski

Since dengue was discovered in Key West, Florida in 2009, the Florida Keys Mosquito Control District has prioritized the control of *Aedes aegypti* in the Key West area. The District has employed multiple control methods, including ground and aerial adulticide, use of wide-spread aerial larvicide, lethal ovicups, and increased door-to-door treatments and education. Overall efficacy of each method was evaluated. Results show that an integrated approach including multiple control methods can reduce overall *Ae. aegypti* populations in Key West, FL.

185 Equipment modifications for more successful *Aedes aegypti* trapping
James Will, Jr, jameswill@mail.maricopa.gov, John Townsend

Maricopa County Environmental Services Vector Control Division sets 780 EVS traps weekly. Of these approximately 20% capture *Aedes aegypti*. With the abundant numbers of adult *Ae aegypti* being collected, CDC and several Universities have requested field caught eggs for clinical studies. We have used standard ovitraps for this purpose but have since modified several traps to increase egg deposition. Also as part of our ongoing studies regarding adult control, we are also evaluating the best timing for adulticide applications to determine when our local *Ae aegypti* populations are most active. Programmable collection traps for adults have demonstrated that our local females seeking blood meals are not always occurring during typical daylight hours as sited in literature. Trap modification and adult feeding activity will be discussed.

186 Launching a new, scalable, adaptive vector-focused community engagement and mobilization framework and operating system
Grey Frandsen, greyfrandsen@gmail.com

There is ample justification for the need to develop a new, comprehensive community engagement and mobilization framework and strategy to organize and then activate the public into an effective, integrated force in the fight against vector-borne diseases. Developed first as a model to establish vector control operations where governments could not, the *"Sequenced Activation, Vertical Engagement" ("SAVE") model is being developed as an adaptive, scalable community engagement model* that empowers communities to stand up effective and sustainable community-based vector control initiatives. SAVE is being designed to serve as the first "operating system" for vector-focused community engagement globally, including a standardized organizational model, standard methodology and language, a range of operational modules (i.e. "Volunteer Precincts"), and a dashboard system for measurement and evaluation. SAVE seeks to make community engagement initiatives an efficient and organized process with clear instructions, templates, training, and plug-and-play structures that enlist and empower the full range of stakeholders needed for citizen-driven vector control efforts, including citizens, businesses, civil society, faith institutions, students, elected officials, governments, and others. This model attempts to overcome the "top-down" approach used by most vector control agencies and instead create a system that is more predictable, responsive, and interoperable with formal vector control efforts, thereby creating synergy. This talk will provide an overview of the SAVE model and how synchronizing and aligning community engagement efforts with formal vector control operations can generate significant gains.

187 Effectiveness of autodissemination stations containing pyriproxyfen in reducing immature *Aedes albopictus* populations
Isik Unlu, iunlu@mercercounty.org, Devi Suman, Yi Wang, Ary Faraji, Randy Gaugler

Aedes albopictus, the Asian tiger mosquito, is an aggressive, highly anthropophilic, day-biting mosquito with an expanding geographic range. Management of *Ae. albopictus* is difficult because of the abundance and prevalence of larval habitats within peridomestic environments, particularly cryptic habitats such as corrugated extension spouts, fence post openings, discarded food containers, etc. Because of the challenges of eliminating larval habitats of this species, we tested an autodissemination concept to contaminate these habitats with the insect growth regulator pyriproxyfen.

188 Evaluating the effects of pesticides on honey bees
Kristen Healy, khealy@agcenter.lsu.edu

The effects of pesticides on bees has been a topic that has received much attention in recent years. Our laboratory at the Louisiana State University has been working closely with East Baton Rouge Mosquito Control, the USDA Honey Bee Breeding, Genetics, and Physiology laboratory, and local beekeepers in the state to better understand the effects of mosquito control on honey bees. In 2013, we established a research collaboration to evaluate products in the laboratory, in semi-field environments, and in real-world field studies. In order to determine effects on bees, we studied numerous end points (mortality, colony health, and detoxifying and stress enzymes). Techniques to determine toxicity and exposure include laboratory bioassays, wind tunnel assays, semi-field cage trials, sentinel hives fitted with collecting devices, hive sampling, and colorimetric assays. These studies have allowed us to conclude that when mosquito control is done correctly, there should be minimal impacts to bees. To help reduce exposures to bees, we advocate for increased communication between mosquito control and beekeepers.

Legislative and Regulatory Symposium

189 Update on status of U.S. Fish and Wildlife Service developing their technical handbook for mosquito control on national wildlife refuges
William Meredith, william.meredith@state.de.us

The U.S. Fish and Wildlife Service is in the final stages of creating a handbook intended to guide national refuge managers through current Service policies, and how those policies may be applied to mosquito and vector control. If the handbook is distributed prior to the annual meeting, this presentation will provide an in-depth look into its contents.

190 Pollinators and Pesticide Policy: Regulatory and Legislative Challenges for Mosquito Control
Frank Wong, frank.wong@bayer.com, Jan Brill, Joe Barile, Gordon Morrison

Pesticides are under increasing regulatory and legislative scrutiny for their potential impacts on pollinator health, yet simultaneously, fear of Zika, Chikungunya and Dengue fever have increased efforts to control mosquitos globally. This seminar will discuss the impact of U.S. pollinator policies on mosquito control tools and practices. The current state of pollinator health, recent pesticide regulations that affect mosquito abatement, and best management practices that minimize pesticide applications on pollinators will be discussed. Future regulatory and legislative trends for pesticide use in the U.S. will also be highlighted.

191 Environmental Protection Agency's Response to the Zika Public Health Emergency
Susan Jennings, Jennings.Susan@epa.gov, Jennifer Urbanski Saunders, Ph.D.

Zika is a public health emergency that requires a concerted and coordinated response from federal, state and local governments. EPA, as the federal governments lead on pesticides, has been actively working with CDC and others to promoted safe and effective use of mosquito adulticides and larvicides to control the Aedes mosquitos that may be transmitting Zika. During this session, EPA will discuss its response to promote safe and effective pesticide use, knowledge and understanding during this emergency.

192 Endangered Species subcommittee comments and responses to risk assessments concerning public health pesticide applications.
Michael Riles, michael.riles@comcast.net

This past year the AMCA Endangered Species Sub-committee has assessed and responded to several regulatory documents, media reports, and studies that have the potential to impact public health pesticide applications.

193 Mosquito control resource mapping
Ben Prather, pratherb@casscountynd.gov

North America is home to over a thousand government agencies who practice mosquito control on an annual basis. The size and scope of these organizations is as varied as the species we seek to control. History has taught us that the number and scope of these organizations swell to meet the demands and dangers that our world presents. During the past year Zika Virus in particular has taught us many things and raised many questions. Perhaps most frustrating is the inability to answer the question, "How many mosquito control organizations are there?"

On the surface this question seems like it should be an easy one. Request census information from any national chain business (fast food, retail, mega-marts) and their response is likely one or two clicks away. However, for the government mosquito control industry this answer is much more nuanced and obscure. For every seven or eight figure mosquito control district there are most likely countless more cities, counties, HOA's and other jurisdictions that participate in the application of pesticide to control mosquitoes.

As the threat of mosquito borne illness again is elevated to the public eye, it is prudent in any risk assessment to determine what and how many resources available to repel and mitigate these dangers. To date, few if any concerted efforts to ask "who are we and how many of us are there" has been undertaken. The project to identify the actors both big and small in "mosquito control" has begun. Your assistance and input is paramount to not only the success of this project but potentially will aide in the steering of resources, collaboration, and funding in the future.

194 History and Current Status of the NPDES Fix
Gary Goodman, gwgoodman@fightthebite.net

This presentation will cover the history and current status of legislation seeking to reduce the regulatory burden of the National Pollutant Discharge Elimination System (NPDES) permitting system as it relates to mosquito control pesticide applications. Legislation intent on clarifying the Clean Water Act and the Federal Insecticide Fungicide and Rodenticide Act has taken on many forms over several sessions of Congress. In 2016 the bill took on a new form and was included in the controversial Zika Vector Control Act.

195 Federal Funding Available to Mosquito Control Districts
Micah Ali, mali@comptoncreekmad.org

Both the Zika emergency package and the full-year federal appropriations bill provide substantial deference by Congress to the Centers for Disease Control and Prevention to determine how funds are to be spent for various activities below the master line items.

196 AMCA Washington DC Conference 2017
Mark Newberg, mnewberg@central.com

Dates, location and goals for the 19th Annual AMCA Washington Conference.

Adult Control II

197 Barrier Spraying for Mosquito Control in Panama City Beach, Florida
James Clauson, jamesclauson@comcast.net

Beach Mosquito Control District, located in Panama City Beach, Fl. has been utilizing barrier spraying for mosquitoes for the past 15 plus years. Many studies have been conducted, both in the lab and in the field, utilizing a low volume adulticide spray that is applied on vegetation to act as a "barrier" against mosquitoes moving from one location to another.

Beach Mosquito Control District uses a trapping/surveillance system to monitor adult mosquito populations within the district. To determine the efficacy of the barrier spray, BMCD sets out mosquito light traps baited with CO2 and octenol. Traps are placed inside the "barrier" and outside the barrier and are monitored weekly.

The district targets mosquitoes around our schools and public ball parks. We have 15 years of trap data that shows conclusively that barrier spraying does work controlling host seeking mosquitoes.

266 Effects of Mosquito Control Adulticides On Sterile Male Adult New World Screwworms Flies
Lawrence J. Hribar

The reintroduction of New World screwworm flies, Cochliomyia hominivorax (Diptera: Calliphoridae), into the Florida Keys caused mobilization of significant County, State, and Federal resources to eradicate the flies. Effects of mosquito control adulticides on screwworm flies were questioned. Permethrin, naled, and malathion were assayed. Bottle bioassays were conducted and indicted that permethrin was very toxic to adult sterile male flies, whereas naled and malathion were less toxic. Toxicity varied by time after bottle application and by chemical applied. Anecdotal observations on the death process of flies were noted.

200 The passive Gravid Aedes Trap (BG-GAT): An environmentally-friendly, low-cost and effective tool for *Aedes* (*Stegomyia*) surveillance
Jennifer McCaw, jennifer.mccaw@biogents.com, Brian Johnson, Alvaro Eiras, Scott Ritchie

The current circulation of Zika has once again shown the importance of sensitive and effective surveillance tools for these invasive species. An early detection of such species and/or their viruses can help prompt adequate mosquito control programs to reduce the spread and transmission of these diseases.

The recently developed passive *Gravid Aedes Trap* (BG-*GAT*) is an effective, practical, low cost, and easily transportable tool to collect gravid *Aedes* (*Stegomyia*) species which does not need electricity. The BG-GAT is essentially a lethal oviposition trap where trapped mosquitoes are killed, usually by contact insecticides, and can be easily collected and identified during trap inspections. Such features are essential in large-scale monitoring programs.

In semifield observations, the BG-GAT captured a significantly higher proportion of gravid *Ae. aegypti* than the double sticky ovitrap. Further field trials in Cairns and the USA compared the BG-GAT to existing sticky ovitraps and the BG-Sentinel trap. While field trials in Brazil demonstrated low capture rates due to a high resistance to pyrethroids, a new publication investigated several alternative insecticide and insecticide-free killing agents for use in the BG-GAT. These included long-lasting insecticide-impregnated nets (LLINs), vapor-active synthetic pyrethroids (metofluthrin), canola oil, and two types of dry adhesive sticky cards. These results demonstrated that the use of inexpensive and widely available insecticide-free agents could be an effective alternative to pyrethroids in regions with insecticide-resistant populations.

201 Development of ATSB® Bait Stations for prolonged vector control
Onie Tsabari, onie@westhamco.com, Amir Galili

The constant struggle to contain and eliminate arthropod borne diseases entails novel methodologies for vector control. One promising paradigm involves exploiting the sugar feeding behavior of certain vectors, including most mosquito species, and targeting such vectors with plant-based attractants combined with sugar and an insecticidal active ingredient. Such methods, termed attractive targeted sugar bait (ATSB®), have been previously shown to significantly reduce mosquito population densities of *Anopheles*, *Culex*, and

Aedes species in a wide variety of ecosystems. The ATSB® technique has been successfully used for nuisance control in the U.S., however, it has yet to be implemented as a vector control tool mainly due to the difficulties of providing a long-acting bait which can efficiently attract and kill the target vector over prolonged periods of time without periodic re-applications.

Here we describe the development of a novel bait station that contains ATSB® in a two-dimensional configuration rendering it both attractive and efficient for prolonged periods of time. The ATSB® formulation is protected by a patented membrane that is penetrable only by mosquito probing, making it inaccessible to non-target insects and aiding in retention and slow release of the attractant volatiles. Data from ongoing experiments indicate these ATSB® Bait Stations retain their efficacy for 3-6 months, making them a valuable tool for integrated vector control strategies.

202 Outdoor vector control needed for malaria elimination in Africa ---- an individual-based modeling study

Lin Zhu, l.zhu3@med.miami.edu, Günter Müller, John Marshall, Whitney Qualls, WayWay Hlaing, Yosef Schlein, John Beier

Residual malaria transmission has been reported in many areas even with good coverage of indoor vector control tools. There are considerations of incorporating outdoor interventions into integrated vector management (IVM), however, more information on the combinational effectiveness are needed.We modified a spatial individual-based model to simulate the environment and malaria transmission activities in an typical African village setting. We used long-lasting insecticidal nets (LLINs) and outdoor attractive toxic sugar bait (ATSB) stations as examples of indoor and outdoor interventions, respectively. We tested different combinations of interventions and lenghths of efficacy periods. We compared mosquito populations and entomologic inoculation rates (EIRs) between different interventions and efficacy periods. With continuous efficacy until the end, 50% LLIN coverage, 100% LLIN coverage, outdoor ATSB, and 50% LLIN coverage plus outdoor ATSB reduced female *An. gambiae* population from 400 to 78, 77, 3, and 2, respectively; and reduced annual EIR from 237.89 to 2.00, 1.96, 0.08, and 0.01, respectively. The minimum intervention period needed to have significant long-term vector population and EIR reduction was four months for LLIN treatment, and one month for outdoor ATSB alone or outdoor ATSB in combination with LLIN. Our results highlight the value of incorporating outdoor adult mosquito control into IVM as a supplement to traditional indoor practices for malaria elimination in Africa. We suggest further field trials for outdoor control evaluation.

203 The use of Biogents Snap traps to reduce adult *Aedes albopictus* populations in Mercer County, New Jersey.

Nicholas Indelicato, nindelicato@mercercounty.org, Isik Unlu, Scott Gordon

Aedes albopictus poses a serious concern both as a potential disease vector, and as a nuisance biting mosquito due to its anthropophilic nature. In areas where *Aedes albopictus* are established, the large numbers of containers which create larval habitat make door to door source reduction operations near impossible. For this reason, we evaluated the use of the Biogents Snap trap (Biogents AG, Regensburg, Germany) as a method of adult *Aedes albopictus* control in residential neighborhoods in Mercer County, NJ, USA. The deployment of these traps reduced the number of adult *Aedes albopictus* and the details will be discussed in the presentation.

204 Withdrawn

205 Personal Protection with a Non-DEET Mosquito Repellent Ethyl Butylacetylaminopropionate

Howard Epstein, howard.epstein@emdgroup.com

In less than a year, the *Aedes aegypti* mosquito has spread the ZIKA virus to more than 25 countries. Previously this species of mosquito inhabited the forest. During the past few decades it has adapted to rural, suburban environments inhabited by humans. The female mosquito spreads the virus while feeding on a person who is already infected. The virus may then be transmitted between eight and twelve days later when the mosquito bites other people. Local transmission of the Zika virus by *Ae. aegypt*i is reported on the continents of Africa, the Americas, Asia and Pacific. *Ae. albopictus is* a species of mosquito that survives cooler environments and is also found to transmit Zika. *Ae.* bites during the day and thrives in breeding sites that are anticipated to increase as a result of global warming. Visitors and service workers in areas where the *Ae. aegypt*i and *albopictus* flourish are concerned about the possibility of contracting Zika and other mosquito borne diseases. Pregnant women are particularly concerned about contracting Zika, because it is associated with birth defects. For these reasons many people seek alternatives to DEET that can safely be applied to very young children and pregnant women. IR3535 is approved by the EPA to be effective against mosquitoes that carry the Zika virus. IR3535 can be safely reapplied during the day and is shown to be safe for use by pregnant women, lactating mothers and nursing babies. IR3535 is classified by the EPA as a biopesticide repellent indicating it has a high degree of safety. It is derived from a source functionally identical to a naturally occurring amino acid ß-alanine. Supporting data to be presented.

Behavior/Biology II

206 Vector competence of some species of mosquitoes from Canada to transmit Zika virus
Mahmood Iranpour, mahmood.iranpour@phac-aspc.gc.ca, Antonia Dibernardo, Robbin Lindsay

Zika virus (ZIKV) is transmitted primarily by *Aedes aegypti* and *Ae. albopictus*. The role of other mosquito species may play as vectors is unknown. The objective of this study is to determine the ability of mosquito species from Manitoba, Canada to amplify and transmit ZIKV. Adult mosquitoes were collected from southern Manitoba during the summer of 2016. Mosquitoes were infected with the Thailand or Puerto Rico strains of ZIKV either orally through infected blood or directly by needle inoculation. After incubation at 25C for 10 to 14 days, RNA was extracted from the bodies, legs, and saliva of experimentally infected mosquitoes and tested for ZIKV by real-time PCR. More than 15 mosquito species were collected and tested. ZIKV was detected in bodies of most needle inoculated species but not all. Likewise, ZIKV was recovered in the saliva of needle inoculated *Aedes vexans* (16.7%) and *Culex restuans* (3.8%); however, 1.6% (n=129) of *Ae. vexans* saliva samples from orally infected mosquitoes were positive. This preliminary data suggests that growth of ZIKV occurs in some species but in most individuals midgut or salivary gland barrier likely prevents transmission when mosquitoes are orally infected. To date, most mosquitoes species collected from southern Manitoba do not appear to be competent vectors for ZIKV in the laboratory. Further studies are planned to determine the capacity of broader range of mosquito species to acquire and transmit ZIKV.

207 Dark rice field mosquito *Psorophora columbiae* in Iberia Parish Louisiana
David Martin, dmartin@iberiagov.net

Psorophora columbiae is by far the most abundant floodwater mosquito in Iberia Parish, outnumbering all other floodwaters combined. However, in this virtually rice-free landscape, *columbiae* plagues are highly episodic. Over the last 6 years, 16 outbreaks (defined as >100 mosquitoes/trap/trap night) have been observed in the parish. Rainfall events have never produced outbreaks when the mean weekly temperature fell below 74 F, and only one occurred when the mean weekly temperature exceeded 83 F. 88% of rainfall events (22 out of 25) occurring in weeks during which the mean weekly temperature exceeded 82 F produced no outbreaks. No outbreaks occurred between CDC weeks 24 and 32 (notwithstanding 15 rain events during this period of as much as 6 inches). It is known that larval survival in this species drops off sharply at rearing temperatures below 78 F. When rain events associated with mean weekly temperatures below 74 degrees are excluded, both temperature and rainfall have statistically significant effects on *columbiae* plague intensities. It appears that in this landscape, outbreaks are most likely, and tend to be most severe, when water temperatures are sufficiently high to preclude high larval mortality, but evapotranspiration rates are sufficiently low to allow a substantial fraction of the hatch to reach metamorphosis before breeding sites completely desiccate. However, even when conditions seem appropriate, plague intensities are extremely variable among sites.

208 Which historical malaria vector lives in Colorado? *Anopheles freeborni* or *An. hermsi* or both?
Tariq Bouaichi, tbouaichi@msudenver.edu, Alissa Bonetti, Angel Robinson, Robert Hancock

In North America, the historical malaria vector mosquitoes *Anopheles (Anopheles) freeborni* and *An. (An.) hermsi* are cryptic species that exhibit indistinguishable morphology. Past research has suggested that *An. freeborni* was not present in Colorado (CO), but *An. hermsi* was. *Anopheles* spp. were collected during 2014, 2015 and 2016 in CO_2-baited CDC mini light traps from 8 collection centers within 5 (of the 7) state-wide river drainages. Species identification was performed using PCR-based species-diagnostic assays and confirmatory DNA sequencing. Preliminary findings indicate that, contrary to previous studies, *An. freeborni* is present, but only in the South Platte River Basin (SPRB) in the northeastern part of the state. Conversely, *An. hermsi* has not been sampled in the SPRB, but has been found in the other 4 river basins tested: Arkansas River Basin (SE CO), San Juan Dolores River Basin (SW CO), Gunnison River Basin (Southwest Central CO) and the Colorado River Basin (Northwest Central CO).

209 Teasing apart the behavioral responses of *Culex tarsalis* to fish-associated semiochemicals
Adena Why, awhy001@ucr.edu, William Walton

The Western encephalitis mosquito, *Culex tarsalis*, has been shown to respond to the presence of fish-associated semiochemicals in oviposition sites by decreasing the number of egg rafts laid, in both laboratory and field bioassays. A decrease in oviposition rate on water that contained fish semiochemicals, has been attributed to the presence of different classes of chemical compounds which cause the mosquitoes to alter their oviposition behavior. Whether or not the compounds present act solely as attractants, repellents or deterrents has not been determined. Using chemical ecology techniques we have identified three compounds of interest to date. Using various bioassays, we evaluated the resulting behavioral sequences of female *C. tarsalis* to chemicals associated with the Western mosquitofish, *Gambusia affinis*, and evaluated their potential role in mosquito oviposition behavior.

210 Using Nitrogen-15 to determine metabolic rates of *Cx. quinquefasciatus* larvae and the impact this could have on operational use of larvicides

Emily Boothe, emilyb@lsu.edu, Kristen Healy

Louisiana Mosquito Control Abatement districts currently incorporate larvicides along with adulticides in order to effectively manage mosquito populations. Despite larvicides being used widely, there is a lack of data looking at resistance and susceptibility of these compounds and their effects on two of the most prominent vectors in the South, *Culex quinquefasciatus* and *Aedes albopictus*. With the impending threat of Zika and recurring threat of West Nile virus, it is vital that we have a better understanding of how these mosquitoes metabolize larvicides in order to effectively control them. Currently, we are using stable isotopes as a means to measure the metabolic rate of our susceptible lab strain colonies at different temperatures and further using that data to predict larval mortality to two commonly used larvicides, *Bascillus sphaericus* (BS) and spinosad. Outcomes of this study will allow us to better comprehend how temperature impacts metabolism and larvicide susceptibility. This project will also act as a foundation for future studies looking at other environmental impacts that could have an affect on the way we use larvicides in Louisiana.

211 Biodiversity of aquatic insects in a rice-field ecosystem and the impact of vector control treatments

Alexandra Chaskopoulou, achaskopoulou@ars-ebcl.org, Javier Castells, Ioannis Giantsis, Javid Kashefi

A great variety of insect species is present in rice fields including both beneficial and harmful insects. Mosquitoes of major public health importance are known to proliferate in rice-field ecosystems and for this reason these environments are repeatedly targeted with vector control applications. Compatibility of vector control with beneficial and natural enemy populations is a critical aspect of IVM practices. Vector control should supplement rather than replace natural mortality factors of mosquitoes such as natural mosquito predators. Furthermore, rice-fields are known to act as biodiversity conservation areas with an important role as alternative habitats for insect species originating from natural wetlands. Little information is available on vector control impacts on insects embedded in their natural ecological contexts such as rice-paddies. To determine whether vector control affects insect diversity we initiated a survey for aquatic insects in the rice-field region of North Greece, where no records of aquatic insects are available in the literature. Surveys were conducted simultaneously in rice-paddies exposed regularly to mosquito control treatments versus unsprayed fields. Insects were identified using both morphological and molecular techniques and categorized as follows: a) harmful b) invasive, c) mosquito predators, and d) other non-target insects. More than 25 aquatic insect species were detected in the region including invasive species (first record for the country), rice pests, and promising mosquito predators, whereas DNA barcodes were characterized for the first time for a number of species. No significant differences were detected in insect diversity between treated and untreated fields.

212 Species diversity and a report of a novel third biting black fly in the San Gabriel Valley, Los Angeles County, California

Kimberly Nelson, KNelson@sgvmosquito.org, Angela Brisco, Kenn Fujioka, J. Wakoli Wekesa

Black flies are infamous worldwide for their biting nuisance and ability to transmit disease. Recently, canids infected locally with *Onchocerca lupi* (Spirurida: Onchocercidae) were found in Los Angeles County. This parasite is transmitted by black flies (Diptera: Simuliidae). Although there are 24 known species of black flies in California, with the exception of a few larval studies reports are rare about the abundance and diversity of black flies in southern California. We evaluated the larval and adult population of black flies in the San Gabriel Valley to determine their diversity and abundance in the backdrop of the recent association with *O. lupi* transmission.

We collected black fly larvae and pupae by placing one-meter strips of "caution tape" in running water at various locations in the District; adult black flies were collected with carbon dioxide-baited traps. In addition to the two well-known biting species; *Simulium vittatum sensu lato* and *Simulium tescorum,* we identified and report a third less familiar biting species *Simulium hippovorum*.

213 Primary Pest Black Fly Species (Diptera: Simuliidae) Occurring in Mississippi

Jerome Goddard

Black flies are second only to mosquitoes as being notorious blood-feeding insects. In many parts of the world, black flies are a serious problem and transmit various diseases such as onchocerciasis (human) and leucocytozoonosis (animal). Black fly outbreaks were common in Mississippi during the first half of the 20th century, but ended for unknown reasons. There has been a resurgence of black fly problems in Mississippi 2009. This study was initiated as part of a broader project on black flies in Mississippi. To survey the species occurring in Mississippi we searched for any *bona fide* records or specimens in the Mississippi Entomological Museum (MEM), Mississippi State University. In addition, we sampled for black flies in 10 sites around the state near rivers and creeks known to have black fly breeding. Specimens were collected twice a month from February – July 2015 and again in 2016. And then, once a month the remainder of the two years. A

total of 79 specimens were found in the MEM, comprising 14 species. Collections at the 10 sites during 2015 yielded 104 specimens and 2016 yielded 168 specimens, all being either *Simulium meridionale* or *Simulium jenningsi* (our two main pests). Seasonality of the two main pest species was March through July, with a peak in May. There was another, smaller emergence of *S.jenningsi* in October/ November.

The Efficacy of Multiple Mosquito Control Agents in Attractive Bait Stations
David Popko, Bradley Mullens, Eric Huynh, Jennifer Henke, and William E. Walton

Attractive toxic sugar bait (ATSB) stations were tested in laboratory and field trials for control of adult and larval *Culex quinquefasciatus* from ingestion and/or contact with multiple agents transferrable among adults and their breeding sites. Lethal and sub-lethal reproductive effects of boric acid (ingested) and entomopathogenic fungi (contact) were examined. Visiting adults were also exposed to the insect growth regulator pyriproxyfen (PPF) and autodissemination to larval habitats was indicated by larval development and eclosion rates. ATSB performance was tested on females 3-7 days old, at different reproductive stages (host-seeking, bloodfed, and gravid) and with males in laboratory assays. In the field, a single ATSB was hung at the center of a 2 meter tall pyramidal mesh enclosure with fifty gravid female and fifty male *C. quinquefasciatus* for 10 days in two separate trials during spring and fall 2016. For laboratory and field exposures, water bowls (300-750 mL) with fourth instar larvae (n = 30) were included in cages and enclosures to collect egg rafts and assess PPF transfer rates by adults. For laboratory and field exposures, live and dead adults, larvae, and egg rafts were enumerated and mortality, infection, and emergence rates assessed in observation chambers/pans up to a month post-exposure. Laboratory ATSB-boric acid (1% in bait) averaged adult mortality rates of 50-80% (2-21d) compared to 5-30% (2d-21d) for controls. ATSB-boric acid (1%) doubled the average number of dead adults collected from enclosures compared to controls in a spring 2016 field study. Entomopathogenic fungi in ATSB designs produced inconsistent mortality and infection rates that depended on experimental conditions. Fungal efficacy was greatest for *Beauveria bassiana* applied as a dry powder in the laboratory and when assayed with host-seeking females; however, dry *B. bassiana* exhibited reduced efficacy in laboratory assays with gravid females. Field deployment of dry *B. bassiana* in fall 2016 resulted in a 5% average infection rate among recaptured gravid females. PPF treated ATSBs significantly reduced emergence rates (26 ± 15%) compared to controls (71 ± 29%) in laboratory exposures of both host-seeking and gravid females. Exposures of females to PPF-ATSB during blood-feeding resulted in reduced egg hatch rates (70 ± 18%) compared to controls (94 ± 1%); although PPF-ATSB exposure during egg-laying did not appear to alter egg hatch rates (78 ± 6%) compared to controls (84 ± 11%). Overall, a multiple control agent ATSB can target a diversity of mosquito stages and promote adult-based autodissemination but requires additional testing to optimize its design for effective mosquito abatement.

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Catch Basin Mosquito Control- Operational Effectiveness Evaluations Symposium II

215 Evaluation of the IGRs and Attractive Toxic Sugar Bait stations against *Culex quinquefasciatus* in storm drains, St. Augustine, Florida
Rui-De Xue, xueamcd@gmail.com

Since 2010, Anastasia Mosquito Control District (AMCD), St. Augustine, Florida has more focused on the control of *Culex quinquefasciatus* mosquitoes in storm drains, St. Augustine, Florida due to WNV present. The IGRs, methoprene (altosid), a new IGRs novaluron (mosquiron), and Attractive Toxic Sugar Bait stations (ATSB) have been evaluated in storm drains in St. Augustine, Florida. The two IGRs formulations were evaluated for natural population of mosquito larvae. The laboratory-reared pupae of *Culex quinquefasciatus* were placed in the storm drains for ATSB efficacy evaluation. Also, ANVAL 10+10 formulation has been applied by the thermal fogging for the caged adult mosquito control in the storm drain. The results showed effective control of larvae by the IGRs for a few weeks, but the rain fall effected the testing results. The ATSB application and thermal fogging application with ANVAL 10 +10 provided effective control of the species of released and caged mosquitoes.

216 Catch basin field evaluation – No heavy lifting required
William Stanuszek, stanuszek@scmac.org

Catch basin sampling often requires the removal of heavy iron grates to sample the mosquito habitat within. Saginaw County Mosquito Abatement utilizes a time-saving sampling method that requires no removal of catch basin covers. This method along with catch basin history; routine sampling; and use of controls allows for efficient, safe, and meaningful larval sampling. The system is utilized for product and application efficacy testing, as well as, directing catch basin treatment.

217 What lies below: Is that product working in the storm drain?
Jennifer Henke, Jhenke@cvmvcd.org

Using products involves the inherent variability within the landscape. Storm water structures, particularly when moving from one city to another, vary in size, depth, and the amount of irrigation runoff (also known as urban drool) that is allowed to collect within them. Thus mosquito control agencies know that the application of a product can vary from one site to another. In this presentation, the author examines how the Coachella Valley Mosquito and Vector Control District began evaluating product applications. The talk highlights work completed with Sustain MBG, Natular 2EC, and Nuvan Prostrips.

218 Catch basin control in northern Cook County, Illinois
Amy Runde, arunde@nsmad.com, Roger Nasci

The North Shore Mosquito Abatement District is a recurring WNV hotspot in northern Cook County, Illinois. Approximately 40,000 catch basins associated with the regional stormwater management system and an additional 3,500 residential catch basins are sources of *Cx. pipiens* across the District. Since WNV was first detected in Illinois in 2002, control of mosquito larvae in catch basins has been a priority. A variety of extended-release formulations has been used in the district's catch basins, however they did not provide the suggested 150-180 days of control and retreatment was required to get effective control for the duration of the WNV season. During 2016 a systematic evaluation of two extended release formulations (Natular™ XRT and Fourstar®) and three 30-day formulations (Natular™ T30, Natular™ G30, VectoLex® FG) was conducted. The extended release formulations were re-treated after 16 weeks and the 30 day formulations were retreated every 28 days. Basins were sampled weekly for the presence of early stage or late stage larvae or pupae, and the pupae were counted. These were compared to untreated basins. Control was considered to have failed for a treatment when >25% of basins contained late stage larvae or pupae. Results indicated that the extended release formulations first applied in early April did not provide effective control past 9-10 weeks and required re-treatment. The 30 day granular formulations generally provided acceptable levels of control for the 4 week duration between treatments. Performance of Natular™ XRT and VectoLex® FG were also evaluated in an extensive quality-control inspection system. Results will be discussed with reference to the implications of effectiveness and cost on operational control decisions.

GIS/GPS/Equipment

219 Spatially-explicit simulation modeling of mosquito populations: a potential mosquito control tool
Daniel Dawson, dedawson@ncsu.edu, Christopher Salice

Mosquitoes have a complex ecology characterized by an aquatic larval phase and a highly mobile terrestrial adult phase. Because the population dynamics of each phase are influenced by different factors, the control of mosquitoes and the management of risk posed by them can be challenging, particularly at a landscape scale. Spatially explicit population models can help by providing predictions of mosquito populations and their associated risks to humans, given environmental and mosquito control conditions. In this research, we describe a potential application of a spatially explicit simulation model developed for the western encephalitis mosquito, *Culex tarsalis,* in Lubbock County, TX, a representative landscape in the Southern US High Plains. This model simultaneously models the aquatic and adult phases of the mosquito life cycle, allowing for stage-specific stressors like larvicides to be incorporated into model predictions. To demonstrate the model's potential as a mosquito control tool, we simulated a potential scenario where predicted mosquito populations were translated to a metric of relative contact risk, which was then used to identify and simulate mosquito control applications at high risk locations in the landscape. The simulation showed that a risk-based control approach can disproportionately reduce mosquito contact risk compared to reductions in the overall mosquito population. This research demonstrates that this type of model has the potential to be a useful tool to control mosquito populations.

220 Visualizing Surveillance and Control Data with Fusion Tables
Dan Fisher, dfisher@fightthebite.net

Many of us are familiar with or use tools such as spreadsheets, Google Maps, Google Earth and ArcGIS Online software for analyzing and mapping mosquito control data. However, as we deploy more technology within our organizations and collect more and more data, our data sets begin to outgrow these tools. The next step up to professional mapping products such as ESRI ArcGIS is a leap in both cost and complexity.

Fusion Tables is free web based software from Google that bridges the middle ground and grows with your data. It provides a way to easily upload large data sets, join them together to generate maps and charts, and share them for collaboration with others or publish live on the web. This brief introduction will go over these features using data sets from mosquito control operations and surveillance. Examples will show how Fusion Tables provides the means to visualize data in an accessible manner that is amenable for internal analysis or shared externally on a website.

221 Map-based exploration of vector surveillance data in VectorBase

Ioannis Kirmitzoglou, i.kirmitzoglou@imperial.ac.uk, Sarah Kelly, Melina de Lima, Daniel Lawson, Robert MacCallum, George Christophides, VectorBase consortium

Laboratories and institutions (*e.g.*, the President's Malaria Initiative, the Centers for Disease Control and Prevention, the European Centre for Disease Prevention and Control and the International Centers of Excellence for Malaria Research) produce various types of data relevant to vector population biology research. Such data are often visualized with maps that are typically zoomable but static, with precomputed prevalence shown only at the state or county level. The limitations of static maps are that geographic, population or epidemiological features at finer-resolution are not available for visualization or download and often lack the ability to filter the data based on metadata, such as collection method or date. VectorBase (VB) has been collecting surveillance data for more than a decade but lacked, until recently, a tool that offers access to flexible queries and visualizations at a fine resolution level. VB PopBio is a freely available map-based interface for the interrogation and visualization of this type of data for invertebrate vector species of medical importance. Built on top of a leading search engine, it offers autocomplete-aided search that instantly updates the data shown on the map. Users can search for a variety of metadata, such as species, country, protocols used for collection, species determination, genotyping and phenotyping. Traditional and seasonal date searches are also supported. Users can visualize the data with custom plots, view details about data points and download a spreadsheet file with data containing all of the search results. The map is under active development with more data types and visualization options coming soon and is accessible at https://www.vectorbase.org/popbio.

222 Fighting Vector-borne Disease – Putting the Pieces Together with Geospatial Solutions

Chad Minteer, chad@frontierprecision.com

Join us for a discussion of how geospatial business solution "puzzle pieces" can help you with your operations, including Zika response. We at Frontier Precision, Inc. (formally Electronic Data Solutions (Elecdata) have been actively involved in developing, implementing, and supporting GIS-based mosquito control software solutions for more than a decade. Our experience has been that using GIS in a targeted manner can improve operational efficiency and provide solid information for intelligent decisions.

In this presentation, we will discuss and demonstrate new developments in our geospatial operations solutions, FieldSeeker GIS & Sentinel GIS, including our new ULV for Windows, the new Juniper Mesa 2 Windows 10 tablet, our GeoSpatial Value Plan, and the positive changes from merging with Frontier Precision. We'll also share specific examples from the Esri Vector-Borne Disease Surveillance & Control business solution and demonstrate how they can work with any solution you currently have or are planning on using, including FieldSeeker GIS, Sentinel GIS, home-grown systems, or other vendor products.

223 Mapping larval saltwater mosquito habitats by integrating hydrology, GIS and remote sensing

Jon Knight, j.knight@griffith.edu.au, Mark Call, Pat Dale

Isolated and difficult to access estuarine islands that are habitat for saltwater mosquitoes are becoming increasingly important to mosquito control agencies because of large-scale urban development within range of the mosquitoes. Previously remote larval habitat areas now need to be managed. In this presentation, we demonstrate an approach for identifying and mapping larval habitat areas across saltmarsh and mangroves. We show how to integrate information from hydrologic surveys, tidal data and high-resolution digital elevation models to create hydro-topographic contours and delineate larval habitats. The research has 56icrosoft aerial treatment by significantly improving knowledge and understanding of the larval habitats and their extent. The approach may be modified for use in other wetlands that produce mosquitoes.

224 Aerial Survey for Neglected Pools

Ruben Rosas, rrosas@fightthebite.net

The Sacramento-Yolo Mosquito and Vector Control District implemented an aerial survey in search of neglected pools. The District was able to delineate the area based on the densities of West Nile virus (WNV) positive mosquito pools, dead birds and residential parcels that currently hold an in-ground pool permit. Based on the data provided by the survey, the District was able to mobilize technicians to inspect and treat these newly identified swimming pools. These swimming pools were added to the District's database and have been integrated in the District's pool surveillance program. This talk will discuss the process and the

enhancements of the District's direction in handling the issue of unmaintained swimming pools in residential areas with high WNV activity.

225 The BG-Counter, the first operative automatic mosquito counting device for online mosquito monitoring: field tests and technical outlook

Michael Weber, 57icroso.weber@biogents.com, Martin Geier, Ilyas Potamitis, Catherine Pruszynski, Michael Doyle, Andreas Rose, Matthias Geismar, João Encarnação

An autonomous mosquito trapping station automatically differentiates captured mosquitoes from other insects and wirelessly transmits counts to a cloud server. Build-in sensors log temperature, relative humidity, ambient light intensity and GPS location. Precipitation and wind can also be recorded. Time windows for attractant release (CO_2) can be set up remotely.

The user can analyze mosquito counts from multiple stations in real-time on a cloud-based dashboard accessible from PCs, tablet, and smart phones. The data can also be exported to Excel.

Vector control professionals can now follow the mosquito situation with unprecedented data density, overcoming constraints associated with the laborious manual setting and retrieval of traps and counting of contents. Since mosquito abundance can be measured continuously, adulticiding can be performed when mosquitoes are the most active. The effectiveness of control measures can be validated immediately. The collected data can give insights into variables that influence mosquito activity, supporting research into the development of more efficient and environmentally friendly mosquito control techniques.

In many mosquito control challenges, the target species are known, and a differentiation of mosquito species is unnecessary. However, for surveillance of invasive mosquitoes or the monitoring of disease vectors during epidemics, the identification of target species would be valuable.

We describe the technical background of the BG-Counter and show field data. We also present initial results from our research into advanced hardware and software to identify and differentiate species. This work is supported by the EU's Horizon 2020 programme (grant 691131, acronym REMOSIS).

226 ISCA's SMART Trap™ Autonomously Identifies and Counts Mosquitoes

Agenor Mafra-Neto, president@iscatech.com, Shailendra Singh, Eamonn Keogh, Gustavo Batista, Jesse Saroli, Marcelo Lorenzo, Paul Howell, Mehdi Shahbazi

Mosquito populations are notoriously difficult to monitor and to control. Here ISCA Technologies, in collaboration with UCR, USP and Farmsense Inc., introduces a novel mosquito monitoring and management tool, the ISCA Smart Trap™. The ISCA Smart Trap is very affordable, easy to use and install. It consists of two parts: one is the trap body, baited with a proprietary long lasting mosquito attractant, and second is the Laser Bug Sensor (LBS) positioned at the entry port. The LBS is a monitoring tool that not only detects the mosquito species but also instantaneously identifies the flying mosquito to the species level (and sex) with very high (>95%) levels of accuracy. The sensor automates the daunting task of counting, separating and identifying the captured mosquitoes to the species level, and can wirelessly provide users with a 24/7 stream of accurate population field data on which to base their vector management decisions. Using field data streaming from a network of ISCA Smart Traps, decision makers will be able to determine exactly where and when mosquito population suppression actions are needed, and then establish how well the control measure worked. As an inexpensive, efficacious, and easy-to-use mosquito monitoring system which not only traps mosquitoes but also provides instantaneous field data on which species are present in that area, the ISCA Smart Trap will be very helpful in improving the health and quality of life of people living in endemic regions around the globe.

227 Achieving consistent collections of gravid Culex quinquefasciatus through novel trap modifications

Chip Hancock, chancock@scgov.net

Sarasota County Mosquito Management Services conducts gravid trapping for seasonal surveillance of West Nile Virus in *Culex quinquefasciatus* populations throughout the county. Typical, host seeking traps do not accurately reflect populations of this vector in the area and gravid traps are used to avoid the testing of naïve mosquito populations for virus presence. Population surveillance of this mosquito species is integral in determining potential areas of concern for seasonal amplification and transmission events, in regards to West Nile Virus activity. In conjunction with improving the quality of mosquito collections for disease surveillance, novel trap modifications were made to allow for consistent population surveillance of *Cx. quinquefasciatus* between trapping locations. Modifications were made to the Reiter/Cummings gravid trap to allow for temporal and spatial surveillance of *Cx. quinquefasciatus* populations in Sarasota County, Florida. The changes were made to include consistent timing of collections, ensure mosquitoes could not escape, and to keep ants from entering the traps. These traps were operated for a late spring, summer, and early fall season. Specimens collected with this newly modified trap were of collection quality and still living

upon retrieval, which is desirable for disease testing, as well as positive identification. Collection data will be used for establishing baseline indices of *Cx. quinquefasciatus* populations in Sarasota County, Florida.

Unmanned Aerial Systems in Mosquito Control Symposium

228 Multispectral imagery in mosquito control operations
Bill Reynolds

Multispectral imagery and aerial surveillance using technologies and capabilities offered by UAS were successfully used to identify the presence of mosquito larvae in daily control operations.

In 2016, UAS were used in mosquito control operations to identify mosquito breeding sites and positively confirming the presence of mosquito larvae. Custom configured multispectral cameras with modified and filtered camera lenses are increasing the efficiency in covering large areas to collect larval surveillance data sets. This is resulting in tremendous time savings while maximizing the safety of field technicians.

229 FAA Part 107 & Part 137: How do these regulations impact mosquito control?
Bill Reynolds

The FAA has paved the legal path for public agencies, such as mosquito control districts, to safely, legally and successfully integrate UAS technologies into operational use. Public agencies can operate UAS under "public use aircraft" for surveillance and aerial applications of larvacides and adulticides. The process of applying for the required documents and license will be presented in detail. Following the presentation participants will be provided with documents to assist in successfully applying for the require COA and UAS pilot license. You don't have to be a pilot to fly UAS in the United States anymore!

230 UAV technologies
Greg Williams

Not Available

231 Yamaha RMAX and FAZER in mosquito control applications
Ken Giles

The Yamaha RMAX has been used for more than 20-years in Japan and Australia for treating agricultural crops. In cooperation with the University of California, Davis and Dr. Ken Giles, operating under an FAA issued Certificate of Operation (COA's), Dr. Giles provided critical operational and efficacy evaluations of the RMAX for use in aerial applications in California vineyards. This early research paved the way for the commercial use of the RMAX in 2016 and now Yamaha operates commercially under FAA Part 137 regulations. In 2017, Leading Edge Associates will be operating the Yamaha RMAX in mosquito control operations as a service. Yamaha will be introducing the Fazer in 2018, doubling the payload capacity and offering greater efficiencies.

Disease/ Vector Studies III

232 Evaluation of commercially available assays to detect West Nile and Zika viruses from honey cards
Kristen Burkhalter, ktb3@cdc.gov, Barry Alto, Nathan Burkett-Cadena

Traditional means for detecting arboviruses in mosquito pools require specialized laboratory equipment and expertly-trained personnel to perform, preventing some agencies from being able to conduct this necessary testing. Easy-to-use commercially-available assays utilizing antigen- and nucleic acid-detection chemistries have provided options for mosquito control disctricts to screen their mosquito populations and make timely operational decisions regarding vector control. These commercially-available assays have the potential to be utilized even more advantageously when combined with honey-soaked nucleic acid preservation substrate ("honey card") testing by reducing or replacing the time- and labor-intensive efforts of collecting and processing mosquito pools or bleeding sentinel chickens. Laboratory-reared female *Culex quinquefasciatus* and *Aedes aegypti* mosquitoes were infected with WNV and ZIKAV, respectively, and allowed to individually feed (and deposit saliva) on honey cards which were removed for testing at various time points. We tested each honey card and its associated mosquito with three assays to compare detection rates, determine the limit of detection for each platform with respect to honey card virus detection of a single infected mosquito, and quantify the time-interval of virus preservation on the cards. Assays evaluated included CDC protocols for real-time RT-PCR for WNV and ZIKAV, Pro-Lab Diagnostics WNV Loop-mediated amplification (LAMP) and ZIKAV LAMP assays, and the Rapid Analyte Measurement Platform (RAMP) WNV assay.

233 Lee County Mosquito Control District's arbovirus testing capabilities: A retrospective approach
Milton Sterling, sterling@lcmcd.org

The Lee County Mosquito Control District's mosquito-borne disease surveillance program was established in 1977 to monitor and detect arbovirus activities in an effort to minimize the risk of human infections throughout Lee County. Our early laboratory testing capabilities include the Hemagglutination Inhibition Test (HAI) analysis of sentinel chicken sera samples for WNV, SLEV, and EEEV viral antibody response; and the manualized PCR and gel electrophoresis analysis of vector mosquito pools for WNV, SLEV, and EEEV. We modernized our capabilities by implementing ELISA testing of chicken sera, and 48 well StepOne RT-PCR machine which expanded testing to include WNV, SLEV, EEEV, and DENGUE. Our recent upgrades include the latest RNA purification system and a 96 well PCR system allowing the testing capabilities for WNV, SLEV, EEEV, Dengue, Chikungunya (CHIKV), Zika (ZIKV), and Yellow Fever for the presence of viral RNA. The cost associated with equipment acquisitions and testing per pool may vary based on budgetary constraints.

234 The re-emergence of St. Louis encephalitis virus activity in California

Tina Feiszli, Tina.Feiszli@cdph.ca.gov, Jacklyn Wong, Kerry Padgett, Vicki Kramer

In 2015, St. Louis encephalitis virus (SLEV) re-emerged in California after 11 consecutive years of no documented activity throughout the state. No human cases were reported, but enzootic activity was detected in one southern California county via mosquito and sentinel chicken surveillance. The disappearance of SLEV was notable, because prior to the introduction of West Nile virus (WNV) in California in 2003, SLEV activity had been detected in California every single year since 1969. In 2016, SLEV virus activity was detected in 6 additional counties. Enhanced outreach to county public health departments was initiated following environmental detections to encourage human testing for SLEV in addition to WNV. A historic overview of SLEV activity in California will be provided, along with summary of 2015-2016 activity.

235 Integrating Area Profile and Environmental Surveillance in monitoring the risk of Arbovirus Disease Transmission in Harris County and the City of Houston, Texas

Maximea Vigilant, mvigilant@hcphes.org, Chris Fredregill, Christine Roberts, Mustapha Debboun

The ecological and climatic conditions in Harris County (HC) and the City of Houston (COH), Texas, are conducive to the propagation of mosquito species implicated in the transmission of arbovirus diseases. In HC and COH, mosquito surveillance is conducted in 268 operational areas. Mosquito collections were conducted utilizing modified Centers for Disease Control and Prevention (CDC) miniature light traps in storm sewers (SS), modified CDC Reiter Gravid Traps (GV) and Biogent Sentinel (BG) traps on private and public properties. Traps were strategically positioned based on geographic proximity and ease of access within the County. Traps were retrieved and mosquito species collected were sorted, identified, and pooled based on the order of importance for disease transmission, then submitted for virus testing. Each year, from 2011 to 2015, approximately 10,000 mosquito collections were conducted, yielding on average more than 1,700,000 female mosquitoes. More than 68,000 pools were submitted for virus testing during that period, resulting in 2,945 West Nile virus (WNV) positive isolates and five St. Louis Encephalitis (SLE) positive isolates.

236 Identifying the risk of Chagas disease in Harris County, Texas

Kyndall Dye, kdye@hcphes.org, Rodion Gorchakov, Melissa Garcia, Martin Reyna, Mustapha Debboun

Multiple studies suggest there is a definite risk for Chagas disease for humans, domestic, and sylvatic animals alike in the border state of Texas. Eight species of triatomines have been identified in the state, and all are considered potential vectors of the parasitic disease. Although there have been many comprehensive studies assessing Chagas disease risk in many rural areas of Texas, it would be critical to understand the potential risk in a highly populated area, like Harris County and the city of Houston. A comprehensive study was conducted in the summer of 2016 in order to assess this risk through multiple means. Educational materials on Chagas disease and kissing bugs were provided to the public; local public parks, abandoned homes, and the Houston Zoo were surveyed for triatomines weekly through trapping, all animal shelters in the county were surveyed for kissing bugs, black light trapping was conducted at a select number of animal shelters, citizens were encouraged to submit any kissing bugs from residential areas, and stray dogs from one animal shelter were tested for presence of *Trypanosoma cruzi* using both Chagas disease STAT-PAK and qRT-PCR throughout the end of summer and fall. All kissing bugs were identified to species and tested for presence of *T. cruzi* through qRT-PCR. A map of risk is being developed for the county, and public awareness is being raised about this parasitic disease. The results of this survey and the future goals of this project will be discussed.

237 Public Health Investigations and Public Records Act

Sherry Burroughs, s.burroughs@irmosquito2.org, Doug Carlson, Donald Shroyer

Given the recent increase of transmission of dengue, chikungunya and Zika in the U.S., Mosquito Control Districts may be faced with difficult issues related to disclosure of disease surveillance data. There are potentially conflicting mandates with regards to public records and personal health information. Violators of the public records act may be liable for attorney's fees in ensuing litigation, while improper disclosure of confidential information can result in fines or criminal penalties. The presentation will outline the public records act and confidentiality issue and provide suggestions on how programs can handle public records

requests for documents that may contain personal health information that could be protected from disclosure under state or federal law.

238 Regulatory Climate and Challenges for Public Health Pesticides – Fyfanon as a Case Study
Paul Whatling, paul.whatling@fmc.com

Under the *Federal Insecticide, Fungicide and Rodenticide Act* (FIFRA), all pesticides sold or distributed in the United States must be registered by the US Environmental Protection Agency (EPA). In 1996, FIFRA was amended by the *Food Quality Protection Act* (FQPA), and as required by FQPA, registered pesticides must undergo registration review to account for changes in science, policy and pesticide use practices that have taken place since the original registration or last re-registration. As a result, EPA is required to re-evaluate registered pesticides every 15 years. Malathion, an organophosphate that has been used for mosquito control in the US since 1956, was deemed eligible for re-registration in 2009 after a lengthy review by EPA that began in 1998. That same year, EPA began another review of malathion as part of its Registration Review program. EPA's Registration Review program for malathion is expected to conclude in 2017. Some of the science and regulatory challenges facing products undergoing registration review will be explored.

239 North American Mosquito Project and Invasive Mosquito Project: 2016 updates
Lee Cohnstaedt, Lee.Cohnstaedt@ars.usda.gov

The North American Mosquito Project (NAMP) started in 2011 and the Invasive Mosquito Project (IMP) started in 2014 are national mosquito collection and surveillance networks that use professionals and citizen scientists respectively. This 2016 update will cover the genetics work being done with the NAMP samples. The *Culex tarsalis* and *Aedes vexans* samples have been sequenced and analyzed resulting in identification of discrete populations. These populations are now being examined for clues about their genetic make-up. The 2016 update of the partnered citizen science IMP will discuss how the project expanded in its first year of national collections using teachers partnered with local professionals to collect invasive mosquito species using oviposition cups. Detailed in this talk is how the project expanded and problems we encountered with rapid program expansion.

240 Florida's 2016 Zika case response from a state perspective
Adriane Rogers

On February 3rd, 2016, FL Governor, Rick Scott signed Executive Order 16-29 which directed the State Surgeon General to declare a public health emergency for the four counties (at the time) that had confirmed, travel associated Zika virus cases. As new counties identified cases, they've been added to the emergency declaration. The Florida Department of Health (FdoH) is the lead agency and has been working very closely with local mosquito control programs (MCPs) and the Florida Department of Agriculture and Consumer Services (FDACS). FDACS plays a supportive role by providing technical assistance to MCPs and FdoH, by actively engaging them in discussions, monitoring their response to cases, supplementing them as necessary, performing RT-PCR testing on mosquito pools, and providing a Zika Task Force to respond to areas within the state that don't have MCPs or very limited capacity to perform mosquito control. Since the Monday following the declaration, FDACS has held a recurring conference call with the affected counties in order to open and maintain active lines of communication, identify resource needs and limitations, and to facilitate sharing of equipment or regional expertise. FDACS has held educational workshops and webinars for MCPs, FdoH, national emergency responders, pest control operators, bee keepers, and various other stakeholders within Florida.

Larvicide and Adulticide Resistance in Mosquitoes of Public Health Importance Symposium I

241 Mosquito Susceptibility Screening against Six Active Ingredients for *Culex* and *Aedes* Populations in the United States
Stephanie Richards, richardss@ecu.edu, Jo Anne Balanay, Kurt Vandock, Joe Hope

Mosquitoes may develop resistance to specific active ingredients in insecticides after periods of repeated exposure. Thus, it is crucial that target mosquito populations in abatement districts be tested for resistance to confirm efficacy of control and inform management decisions. Eggs from different mosquito species (*Aedes albopictus, Aedes aegypti, Culex pipiens, Culex quinquefasciatus, Culex pipiens* complex) were collected by mosquito abatement districts in different geographic regions of the United States. This represents the second time some of the populations have been tested in as many years. Centers for Disease Control and Prevention bottle bioassays were used to determine susceptibility/resistance status for six active ingredients used in mosquito control programs. Preliminary results show variation in insecticide susceptibility between species, regions, active ingredients, and years. This study builds on a baseline study we conducted in 2015 and represents one of the first studies evaluating insecticide susceptibility for several active ingredients across several regions for successive seasons. Results of this study will provide insight into possible resistance occurring in mosquito populations in the United States.

242 Strategies and Measures for Resistance Management
Janet McAllister, jvm6@cdc.gov

There are many assays available for measuring insecticide resistance that have been used over the years. Each has benefits and deficits. Often it is hard to interpret how their results should be used to make changes in products used. Strategies to detect resistance are availalabe but successful management has been more difficult to codify given the paucity of tools available for control and the lack of long term surveillance done in the United States.

243 Resistance status of *Aedes aegypti* and *Aedes albopictus* in Florida and Texas
Alden Estep, Alden.Estep@ars.usda.gov, Neil Sanscrainte, James Becnel

Although pyrethroid resistance is widespread and well characterized outside the US, very little information about the resistance status of domestic *Aedes aegypti* and *Aedes albopictus* is available. The threat and recent spread of Zika infection has added new importance to the development of this information for at risk states.

In cooperation with numerous mosquito control programs, we have been conducting a survey of resistance in *Ae. aegypti* and *Ae. albopictus* from locations in Florida and Texas to determine resistance levels and mechanistic contributions. Toxicological testing indicates widespread resistance (6-65-fold) to pyrethroids in *Ae. aegypti* from Florida and Texas. Several strains had resistance levels comparable to the resistant Puerto Rico CDC standard reference strain. Testing indicated a contribution from overexpression of detoxification enzymes; however, genetic modification of the sodium channel was present in all strains. Analysis for common resistance-linked mutations indicated near fixation of the 1534 phenylalanine to cysteine substitution. In the Florida strains, we identified a strong correlation between the frequency of the homozygous 1016I mutation and permethrin LD_{50}. This correlation was also found in four strains from Houston, Texas. In contrast to the resistance detected in *Ae. aegypti*, no *Ae. albopictus* strains showed significant levels of resistance, even when collected from the same locations.

Although resistance of *Ae. aegypti* to pyrethroids appears common, additional testing showed effective adulticide and larvicide options are available. Resistance monitoring is thus critical for effective vector control programs and should drive informed selection of active ingredients.

244 Is resistance behind the dengue epidemics in Taiwan?
Err-Lieh Hsu, elhsu@ntu.edu.tw, Hsiu-Hua Pai

Taiwan is situated in the tropical and subtropical geographical region, hot and humid which is endemic for malaria, JE, filariasis in the past but recent epidemic of DF/DHF. Dengue virus is spread by the *Aedes aegypti* and *Aedes albopictus* species of mosquitoes. In northern parts of Taiwan, there is less risk of dengue fever because of lack of the *Aedes aegypti. Aedes aegypti* is currently limited to parts of southern Taiwan. The *Aedes albopictus* mosquito as the minor vector of dengue occurs in the whole Islands where below an altitude of 1000 meters. During more recent years, dengue outbreaks have been confined to southern Taiwan. There were high level and high frequency of applications of adulticides and larvicides for emergency control of vectors. The insecticide resistant development is inevitable. Over the past 10 years, large outbreaks have occurred in the southern Taiwan. There is currently no vaccine or preventative medicine for dengue in Taiwan. Vectors control and avoiding mosquito bites are the best prevention. We had very successful vector control experience by emergency spray stopping dengue spread previously but failed in 2002, 2014 and 2015. It was highly related to the insecticides resistance in *Aedes aegypti.*

245 Resistance detection: from conventional bioassay to molecular approach
Tara Thiemann, tthiemann@pacific.edu, Eva Choi, Bridgette Hughes

Conventional bioassays are crucial for evaluating functional resistance in a mosquito population. However, standard bioassays do not give great insight into the mechanisms behind the resistance. Target-site mutations are a category of resistance mechanism in which DNA mutations lead to changes in protein structure. These changes confer resistance, typically by altering or preventing the binding of an insecticide. The two most common target-site mutations are (1) *kdr*, a mutation in the voltage-gated sodium channel that leads to pyrethroid resistance and (2) *ace-1*, a mutation in the gene encoding acetylcholinesterase that confers resistance to organophosphates. Unlike conventional bioassay methodology, which can typically be used across multiple species, molecular testing requires the development of new primers or primer/probe sets to detect target-site mutations for each mosquito species. Here, we develop qPCR diagnostics to detect *kdr* and *ace-1* in *Culex tarsalis*, an abundant mosquito in the Western United States that can transmit West Nile and other arboviruses. Preliminary results show that *kdr* may be prevalent in some populations, but thus far, no *ace-1* mutations have been detected.

Larvicide and Adulticide Resistance in Mosquitoes of Public Health Importance Symposium II

246 Monitoring susceptibility of *Culex pipines* to larvicide products currently in use in San Mateo County

Nayer Zahiri, nzahiri@smcmvcd.org, Theresa Shelton

The aim of the current study was to investigate the susceptibility of laboratory and field populations of *Culex pipiens* (Diptera: Culicidae) larvae to different formulations of Biological Larvicides and Insect Growth Regulators in laboratory conditions. Larval bioassay followed according to the recommendations of WHO Bulletin. The baseline susceptibility was determined by using a laboratory mosquito population that has not been exposed to larvicides. Fifty and ninety percent lethal concentrations (LC50 and LC90) of each product were determined by exposing early 4th-stage larvae to serial dilutions of each material, and data were subjected to log probit analysis. The recommended rates from manufactures were applied in each bioassay. In this study we evaluated the susceptibility of larvicide products against a susceptible *Culex pipiens* laboratory colony and filed mosquito population.

247 Variation of Pyrethroid Resistance and Knockdown Resistance (Kdr) Gene Distribution in *Culex pipiens* Complex Mosquito Populations in North San Joaquin Valley, California

Shaoming Huang, shuang@sjmosquito.org, David Smith, Sumiko De La Vega, John Fritz, Eddie Lucchesi

The San Joaquin Valley makes up the south two thirds portion of the Central Valley, which is one of the most productive agricultural areas in the world. In most part of the San Joaquin Valley, cities and residential areas are immediately close to agricultural areas, where migration of some mosquito species including the West Nile virus vector *Culex pipiens* and *Cx. tarsalis* to cities and residential areas is a serious concern. Therefore, mosquito control in agricultural area is an essential component of most agencies' mosquito control program in San Joaquin Valley. Data shows that pesticide use by agriculture far more exceeds that from public health sources, and may have shaped the unique resistance levels and related molecular mechanisms. In this study, we conducted a county wide monitoring of pyrethroid resistance and knockdown resistance (Kdr) gene distribution in *Culex pipiens* complex mosquitoes. Results showed that there was considerable variation in resistance levels and kdr frequency, even within range in a few kilometers. The most resistant populations were invariably collected in agricultural zones. This study further emphasized the importance of pesticide resistance monitoring for mosquito control agencies.

248 Universal issues of resistance management – from low desert to high desert

Gregory White, greg.white@slcmad.org, Melissa Snelling, Ary Faraji

Resistance management issues are highlighted from examples in two mosquito control districts found in the western US. In Coachella Valley Mosquito and Vector Control District resistance to adulticides in *Culex quinquefasciatus* populations have been observed. Bottle bioassays were performed on adulticide products including newly available pyrethroids as well as organphosphate formulations that have not been examined in many years. These results showed that malathion may be a promising active ingredient to use in the future to control adult mosquitoes that are resistant to many pyrethroids. At the Salt Lake City Mosquito Abatement District a different issue was encountered when treatment failures with larvicides were noticed at a number of locations in urban habitats. A number of trials were performed to narrow down the source of the ineffective treatments. Early findings showed that larvicide resistance was the most likely cause for what was observed.

249 Resistance management: an industry perspective

Jennifer Williams, 62icrosof.williams@mgk.com

Mosquito resistance to control, risk of mosquito-borne disease and public awareness of these issues are emerging simultaneously. Urgency is mounting for effective mosquito resistance solutions. Attributes specific to industry R&D challenges will be presented. Recent advances in understanding the biochemical basis of pyrethroid resistance in mosquitoes will be discussed. Challenges specific to adulticiding efforts will be covered. Further research specific to novel active ingredients, including synergists, for mosquito control will be discussed. Efforts relating to the development of biologically based adulticides for integration into environmentally sustainable mosquito control will be presented. Spatial repellents, personal repellents, confusants their use and potential in mitigating resistance risk will be reviewed.

New Product Trials/Operations

250 How to make adult mosquitoes do what we want using inexpensive, long lasting, semiochemical blends: the case of Vectrax™

Agenor Mafra-Neto

Mosquito populations are notoriously difficult to monitor, often necessitating the application of measures such as traps that require electrical power and a source of CO^2; and notoriously difficult to control, frequently requiring well timed broadcast sprays of conventional contact insecticides. Here, ISCA Technologies introduces Vectrax™, a novel semiochemical attractive and phagostimulant blend that

facilitates both the monitoring and the management and control of adult mosquitoes. The semiochemical blend acts as a lure that attracts male and female mosquitoes by mimicking the scent and taste of attractive plants. As a lure, ISCA's blend can provide long-term attraction for passive traps, free of the power demands and CO_2 canisters or dry ice required of current monitoring traps, making it an ideal, low cost solution for monitoring programs. Further, the semiochemical blend also induces mosquitoes to feed on the formulation, which, when mixed with small amounts of insecticide, results in an attract and kill formulation that will effectively target adult mosquito vector species while leaving non-target beneficial organisms unharmed. Vectrax prepared in this manner and used to treat vegetation or structures outside residential areas and public spaces will attract and kill outdoor mosquitoes before they can bite a host, and indoor biters before they can enter households in search of blood meals. As an inexpensive and easy-to- apply mosquito monitoring and control formulation specifically designed for outdoor use, this product will help to address critical weaknesses in current efforts to control mosquitoes, namely the expense and difficulty in monitoring adults and emphasis on controlling of indoor biting mosquitoes.

251 The delivery of lethal doses of insecticide by male mosquitoes

James Mains, Stephen Dobson

Mosquito control most commonly involves chemical insecticides, with formulations that include larvicides and adulticides, sprayed by hand or by vehicles, e.g., truck or aircraft mounted sprayers. While larvicides have been proven effective at reducing mosquito-borne disease transmission, its implementation at the programmatic level can be difficult. The aquatic habitats of many mosquito species, including the Asian tiger mosquito (*Aedes albopictus*) and the yellow fever mosquito (*Aedes aegypti*), can be small and difficult to locate and treat, sometimes referred to as 'cryptic breeding sites'. Here we discuss an auto-dissemination approach where mosquitoes 'self-deliver' a larvicide to cryptic breeding sites. Pyriproxyfen (PPF) was directly applied to adult male *Ae. albopictus* and *Ae. aegypti* and the males released at field sites to examine for transfer of PPF to breeding sites, and to examine for an effect on adult population size. Field trials with *Ae. albopictus* and *Ae. aegypti* demonstrate an ability of PPF-treated males to transfer lethal doses to introduced oviposition containers either directly to breeding sites or indirectly by cross-contaminating females. A decline in the *Ae. albopictus* and *Ae. aegypti* population was also observed following the introduction of PPF-treated males.

252 ADAM – Male mosquito release pilot program to control *Aedes aegypti* in Los Angeles County

Tanya Posey, tposey@glacvcd.org, Paul O'Connor, Harold Morales, Steven Vetrone, Rande Gallant, Jimmy Mains, Corey Brelsfoard, Stephen Dobson

Prior to 2013, *Aedes aegypti* was reported sporadically in California. Recently however, breeding populations of *Ae. aegypti* have established and detections have increased in frequency in central and southern California. *Ae. aegypti* is difficult to control due to inaccessibility of cryptic breeding sites, highlighting the need for new tools to supplement existing vector control techniques. The Auto Dissemination Augmented by Males (ADAM) approach relies on males dusted with a larvacide to: 1) directly deliver lethal doses of the larvacide to oviposition sites or 2) do so indirectly via transfer to females during mating. The pilot program in collaboration with researchers from the University of Kentucky and MosquitoMate is designed to examine: 1) ADAM male survival and fitness following cross-country shipment, 2) for the transfer of larvalcide to artificial oviposition sites, and 3) for an effect of ADAM male release on the immature and adult population. To make this project possible, regulatory issues had to be addressed and the local community had to be informed to ensure their support. Release as well as control sites were chosen based on previous surveillance records and releases were conducted between June and August 2016253 Is resistance behind the dengue epidemics in Taiwan?

253 A *Wolbachia*-based autocidal approach to control *Aedes* mosquitoes.

James Mains, jmains@mosquitomate.com, Corey Brelsfoard, Robert Rose, Stephen Dobson

The *Aedes aegypti* and *Aedes albopictus* are invasive species and public health concerns due to their ability to transmit medically important pathogens (*e.g.*, Zika, dengue, chikungunya) and aggressive day-biting behavior. Despite intensive use of pesticides to manage these species, they have colonized much of the U.S.A., and in recent years have expanded to states including into California and New York. A proposed autocidal approach for its control is based on *Wolbachia*, which are endosymbiotic bacteria common to many insect species. Similar to sterile insect technique, the *Wolbachia* approach is based on repeated, inundative releases of *Wolbachia* infected males, which cause a form of conditional sterility in the targeted population. This presentation will include regulatory updates related to the *Wolbachia* bio-pesticide and results from recent open field trials used to examine for *Wolbachia* infected male efficacy under field conditions.

254 Incorporating bulk larvicide containers to improve the efficiency of mosquito control operations.

Mark Smith, mmcd_mes@mmcd.org

The Metropolitan Mosquito Control District is utilizing bulk reusable containers of granular larvicide materials to improve the overall efficiency of our operations. Using bulk materials allows staff to decrease helicopter loading times, reduces the handling time of empty packaging, and eliminates large volumes of waste from our operations.

255 Maintaining a biosafety level 3 laboratory
Stormy Freese, stormy.freese@co.cape-may.nj.us, Peter Bosak

Following the introduction of West Nile virus in New York City in 1999 and its subsequent spread into New Jersey, Cape May County decided to upgrade its biosafety level-2 (BSL-2) laboratory into a biosafety level-3 (BSL-3) laboratory. Testing on site for arboviruses such as; West Nile, eastern equine, La Crosse and Saint Louis would enable the county to perform control operations rapidly as compared to sending mosquito pools to the New Jersey State Laboratory and waiting for results thereby delaying control efforts. When the Cape May County Department of Mosquito Control stopped using select agents in 2012, it was decided to maintain the status of a BSL-3 laboratory which would eliminate the time consuming CDC inspections and FBI clearance but still include; safety equipment, biosecurity and biosafety manuals, standard operating procedures, permits, HEPA filter decontamination, equipment preventative maintenance, negative pressure and HVAC systems.

256 The Implementation of Mosquito Forecast System and the New Development of the Smart Mosquito Identification and Counter Device
Hoonbok Yi, Jae-seung Yu, Hyunjung Kim, Sun-young Kim, Soo hyun Lee, In ok Han, Gyu Dae Kim, Hea Sook Hong, Chang Bo Kim, Rui-de Xue, JaeGun Kim, Sangwoo Seok, Minjeong Baek, YeonJae Bae

We developed the smart mosquito counter device (height 1080mm × width 560mm × diameter 320mm, 220V 60Hz 30W), which could attract the blood sucking female mosquitoes by emitting CO2 gas (300ml/min), could count the number of the captured mosquitoes by an infra-red beam area sensor, and could send the captured mosquitoes' number through the CDMA module at real time. We operated the 50 smart mosquito counter devices at Seoul city areas (605 km2) of South Korea for one year (2015) and, based on the mosquito occurrence data, we predicted the mosquito population size according to the weather condition. By using the 2015 data, we calculated mosquito model formulas and we performed the mosquito forecast on the website in 2016. Seoul government implemented the mosquito forecast. Continuously our research group are developing the new smart mosquito identification and counter device. The newer device installed with digital camera can take a picture and can identify the main mosquito identification by using RGB image analysis. The smart device would be very useful for the future mosquito surveillance study.

257 Lessons learned from dengue and chikungunya: applications for future exotic arboviruses
Charsey Porse

Not Available

Operations/Management

258 Emergency response efforts to control Zika virus and *Aedes aegypti* in the Marshall Islands
Broox Boze, bboze@comosquitocontrol.com

The first large outbreak of disease caused by Zika infection was reported on the South Pacific Island of Yap in 2007. In February of 2016, The Marshall Islands first human case of Zika virus was reported in a young woman from Majuro. She had no history of travel outside the island state indicating localized mosquito-borne transmission. Given the historical impact of Zika in the Pacific, The Marshall Islands quickly began human surveillance efforts and declared a state of emergency requesting aid from both the Centers for Disease Control (CDC) and Vector Disease Control International (VDCI). The Marshall Islands face myriad challenges including their extremely remote and isolated location near the equator, a population spread over a chain of 29 coral atolls (islands), a per capita GDP of only $3,600, and little in the way of traditional infrastructure or healthcare. However, because the government (Department of Health, Department of Sanitation, Environmental Protection Agency) and the Marshallese people took mosquito control so seriously, we were able to overcome significant obstacles and put an end to the outbreak in that area. I will discuss the challenges of a partnership between two vastly different national governments and private industry working together to control *Aedes aegypti* populations. Topics include the cultural, environmental and logistical aspects of ULV larviciding and Indoor Residual Spray (IRS) applications in addition to public outreach and communication efforts.

259 Challenges Faced in Preparation for Zika in Tarrant County, Texas
Nina Dacko, ndacko@hotmail.com

Tarrant County, Texas is located in North Central Texas where the City of Fort Worth serves as the county seat. Vector species of mosquitoes including *Aedes aegypti* and *Aedes albopictus* are numerous throughout

the county. This lead to planned responses to the potential of the local transmission of Zika virus that is likely to take place from traveler to mosquito, ultimately leading to acquisition of Zika virus within the local mosquito population. This presentation discusses the planned vector control responses to imported human cases of Zika and the challenges that have been faced due to a variety of issues within, among, and between government entities and perceptions about Zika response within the media and the public.

260 Dengue, Chikungunya, and Zika virus Surveillance through the Implementation of BioGent Sentinel traps in Harris County, Texas

Martin Reyna Nava, mreyna@hcphes.org, Mustapha Debboun

Harris County Public Health (HCPH) Mosquito & Vector Control Division (MVCD) implemented the use of the BioGent (BG) Sentinel collection device on its Vector Surveillance Program in 2009 to increase the likelihood of collecting the main vectors of Dengue (DENv), Chikungunya (CHIKv) and Zika virus (ZIKv): *Aedes aegypti* and *Ae. albopictus*. *Aedes* populations occur from mid-May to late November in Harris County, TX. In 2009, BG collections resulted in 57 % *Ae. albopictus*, 21 % *Culex quinquefasciatus* (the main vector for Saint Louis Encephalitis (SLE) / West Nile virus (WNv)) and 11 % *Ae. aegypti*. BG collections continued, and increased in numbers and length of use from 2012 – 2016, to mirror our SLE / WNv Surveillance program in covering all Harris County. Average BG collections over this period show the following composition: 1) *Cx. quinquefasciatus* (39 %); 2) *Ae. albopictus* (25%); 3) *Ae. taeniorhynchus* (13%); and 4) *Ae. aegypti* (8%). Since 2002, there has been over 100 *Aedes* mosquito isolates positive for WNv (11 *Ae. aegypti* and 97 *Ae. albopictus*) in Harris County, but only one pool of each species have been collected via a BG Sentinel Trap (2013). All other positive pools have come from CDC light (SS) traps placed in the storm sewer system of the County (11 *Ae. albopictus* and 2 *Ae. aegypti*), and from CDC gravid (GV) traps (85 *Ae. albopictus*, and 8 *Ae. aegypti*). Thus, while the BG Sentinel trap is useful at collecting more diversity and DENv/CHIKv/ZIKv vectors than the other collecting devices (SS and GV), *Cx quinquefasciatus* remains the main species collected with all three types of traps in Harris County.

261 Zika in Miami: Control measures learned in tackling the unknown.

Frank Clarke, fclarke@clarke.com

This presentation will discuss the control measures assessed and the final protocols employed in Miami Dade County in responding to travel related Zika cases. This will be contrasted to the shift made once local transmission was determined.

262 12 to 173 in 42 days: A behind the scenes look at implementing "boots on the ground" in Miami.

Michelle Selander, mselander@clarke.com

What does it take to mobilize from 12 to 173 people in 42 days from a make-shift operations center? This presentation will discuss the operational details behind Clarke's SITE Guard support to Miami Dade County. From securing space, vehicles and equipment to hiring and IT needs, this presentation will outline what it took to respond quickly and efficiently.

263 Search and Scale: Recruiting for Zika ground support

Kim Schulke, kschulke@clarke.com

Learn from this presentation the hiring strategy and techniques used to attract, screen, interview, train and on-board 173 individuals over 42 days. Hear about a key difference in this effort vs. other seasonal mosquito control work.

264 Effect of Aerial Larvicide and Adulticide Applications on *Aedes aegypti* During a Zika Virus Outbreak in Miami-Dade County, FL

Chalmers Vasquez, Mario Porcelli, Roxanne Connelly, John-Paul Mutebi, Janet McAllister

Local mosquito-borne transmission of Zika virus occurred in Miami-Dade County Florida in 2016. During the outbreak the county performed intensive mosquito control using ground application of insecticides and source reduction where active transmission was occurring. High levels of insecticide resistance to pyrethroids were detected, diminishing the effect ground based adulticiding. Aerial application of an organophosphate was added to control efforts. In addition, aerial and truck application of BTI was done concurrently. Both larvicide and adulticide together were needed to reduce *Aedes aegypti* population and maintain them at low levels. This strategy was effective at reducing transmission of Zika virus.

265 Field Assessment of Low Volume Truck-mountd Larvicide Applications in Broward County, Florida for the Area-wide Control of Aedes aegypti and Aedes albopictus

Daniel Markowski, Broox Boze

The emergence of Zika virus in the Americas has brought to light many of the challenges facing mosquito control programs when attempting to rapidly control container-breeding Aedes during a disease outbreak.

Traditional door-to-door interventions for controlling Aedes aegypti and Ae. albopictus have put stress on the financial budget of many programs and proven ineffective as it requires unrealistic manpower, there is often limited access to private property and inspectors often cannot identify or access all the small, cryptic breeding grounds utilized by these mosquitoes. In this study we assess the efficacy of area-wide larvicide applications utilizing Vectobac WDG and truck-mounted Buffalo Turbine Mist Sprayer units within several areas of Broward County, Florida. Bti deposition in bioassay cups resulted in an average mortality of 90% amongst tested larvae indicating that this is a cost-effective and valuable tool for suppressing Ae aegypti and Ae. albopictus populations in a large urban environment.

266 EFFECTS OF MOSQUITO CONTROL ADULTICIDES ON STERILE MALE ADULT NEW WORLD SCREWWORM FLIES

Lawrence J. Hribar

The reintroduction of New World screwworm flies, Cochliomyia hominivorax (Diptera: Calliphoridae), into the Florida Keys caused mobilization of significant County, State, and Federal resources to eradicate the flies. Effects of mosquito control adulticides on screwworm flies were questioned. Permethrin, naled, and malathion were assayed. Bottle bioassays were conducted and indicted that permethrin was very toxic to adult sterile male flies, whereas naled and malathion were less toxic. Toxicity varied by time after bottle application and by chemical applied. Anecdotal observations on the death process of flies were noted.

Poster Session Abstracts

Adult Control

P-01 Effect of Pyriproxyfen on Sperm Production and Survivorship of *Aedes albopictus*

Chanyapat Nitatsukprasert, chanyapatn@afrims.org, Patcharee Khongtak, Silas Davidson, Alongkot Ponlawat

The insecticide pyriproxyfen (PPF), an insect growth regulator, is considered an alternative method for mosquito control in areas with insecticide resistance problems. This study investigated the impact of PPF on sperm production in males and the survivorship of both male and female *Ae. albopictus* under laboratory conditions. *Aedes albopictus* adults (1-day old) were exposed to a fabric treated with 0.05 g ai/m^2 of PPF (Sumilarv™, 2.0% powder) for 24 hrs. Testes of PPF exposed males were dissected 4 days after exposure to determine the sperm production compared with untreated males. For the survivorship experiment, *Ae. albopictus* were provided 10% sugar and kept in a room at 28±2 °C. Observations on mortality were conducted daily from 0900 to 1000. Statistical analysis showed that PPF exposed males had a significant reduction in sperm production compared to controls ($p<0.05$). Moreover, results revealed that PPF decreased daily survivorship of adult *Ae. albopictus* ($p<0.05$). Our findings demonstrate that PPF can have the dual effect of decreasing sperm production and survival rate and the use of PPF treated materials under field conditions should be further evaluated as a means to control *Ae. albopictus* populations.

P-02 Baseline diagnostic times and doses for permethrin in a population of *Aedes vexans* and *Culex tarsalis* from eastern South Dakota

Geoffrey Vincent, 66icrosof.vincent@sdstate.edu, Justin Davis, Ryan Alley, Alex Macki, Lucas Zilverberg, Chris Carlson, Michael Wimberly, Michael Hildreth

Pyrethroid use has been historically low in the Northern Great Plains, but the high incidence of West Nile virus in this region has prompted most communities to increase its usage for vector mosquito control. To begin monitoring insecticide resistance, a base-line diagnostic dose and diagnostic time must be established for the region. Mosquito collections were collected outside of the adulticiding zone of Brookings South Dakota, at a site with very high mosquito abundance. From June 16th to August 1st, 2016 adult female mosquitoes were collected with a CDC miniature light traps baited with CO_2, and used immediately in a CDC bottle bioassay protocol involving reagent-grade permethrin at concentrations of 1 ug/ml, 10 ug/ml, 20 ug/ml, and 40 ug/ml. *Aedes vexans* (n = 1084) and *Culex tarsalis* (n = 421) were the predominant species collected and the focus of the study. To determine the diagnostic dose, a probit model was used to calculate the lethal concentration 50% (LC_{50}) and 100% (LC_{100}) at 30, 45, and 60 minutes post-exposure. At these time points, the LC_{50}s for *Ae. vexans* (*Cx. tarsalis*) were 26.2 (26.0) µg/ml, 20.4 (20.7) µg/ml, and 16.1 (16.7) µg/ml respectively; the LC_{100}s were 38.4 (38.3) µg/ml, 31.8 (32.1) µg/ml and 27.0 (27.5) µg/ml. The LC_{50} and LC_{100} values did not differ significantly between the two species (p = 0.78). Few studies have published diagnostic dose and times for *Cx. tarsalis*; however, these values appear to be similar to data for a bioassay study for *Cx. tarsalis* from eastern Colorado. With multiple diagnostic times and doses in place, future studies on the permethrin resistance in nuisance and WNV vector mosquitoes can be monitored and accounted for in mosquito control programs in South Dakota.

P-03 Autodissemination strategies for *Aedes* control

Cynthia Lord, clord@ufl.edu, Barry Alto, Sara Ortiz, Keenan Wiggins, Joseph Pohedra, Nathan Burkett-Cadena

Domestic mosquito control for container-inhabiting *Aedes* is challenging, and novel methods are needed. Autodissemination strategies of insect growth regulators (IGR) are one such method. In this control method, females are attracted to stations treated with an IGR, become treated, and subsequently deposit the IGR in natural oviposition sites, preventing adult emergence. We modified and tested autodissemination treatment stations (ADS) in semi-field conditions. These modified stations were then used in a field experiment testing the impact of the stations on inhibition of adult emergence in sentinel cups. Three treatments (control, low density, high density of ADS) were compared. Adult emergence was significantly different between treatments, with emergence under both high and low density ADS lower than the control treatment (no ADS). A stochastic, individual based simulation model was constructed to explore treatment strategies. Treatment stations at both high and low density reduced adult emergence and the total population of females; number of stations had relatively little impact. Increasing toxicity of the treatment chemical also decreased emergence and population size, but this effect was small relative to the presence of control overall. This method potentially can have strong impacts on the mosquito population and warrants further development as a deployable control strategy for domestic mosquitoes.

P-04 Residual Effectiveness of Barrier Sprays on *Aedes albopictus* in Virginia

Benjamin McMillan, benm93@vt.edu

Aedes albopictus (Skuse) is the most widespread mosquito in the world and has been demonstrated to be a competent vector for many viruses. Because of its diurnal activity, standard mosquito control efforts utilizing spray trucks to administer insecticides offer little control, as this control method is generally directed towards crepuscular species. Thus, homeowners have sought more effective control methods. Residual pesticides applied to mosquito resting sites in vegetation have been shown to reduce pest mosquito populations. We tested four chemicals on *Rhododendron spp.* Lambda-cyhalothrin, indoxacarb, deltamethrin, and bifenthrin were applied to individual plants according to the highest recommended label concentration. Indoxacarb was applied to an individual plant at double the high label rate. This application was done using a Stihl sr200 mist blower just to the point of runoff. Tested plants were kept outside on a 10 ft. sq. plot and exposed to natural conditions and were watered as necessary. Two to three day old female mosquitoes were placed into glass vials with leaves from the treated plants and were evaluated for their condition after one hour and 24 hours of exposure. Additional female mosquitoes were tested for short term effectiveness of the treatments by exposing the mosquitoes to the treated foliage for five minutes. These mosquitoes were then transferred to individual containers and monitored. Testing was done once a week for 12 weeks. Knockdown percentages were collected at one hour after exposure, and mortality percentages were collected after 24 hours of exposure. Both knockdown and mortality were highest for day zero and week one across all treatment groups, but the individual rates varied with the chemical used.

P-05 Comparison of three products for adult mosquito control

Gerald Chuzel, Gchuzel@cvmvcd.org, Jennifer Henke

Applications of adulticide were made to a rural area of the Coachella Valley to combat a high number of St. Louis Encephalitis virus mosquito samples. Three different products were applied. The applications were evaluated using lab-reared, caged *Culex quinquefasciatus* adults that were 3-5 days old. Cages were places in the open ground, in 50% vegetation cover, and in 100% vegetation cover. Although the *Cx.quinquefasciatus* adults are known to not hide in vegetation, the authors wanted to examine the ability of the product to move into vegetated areas in preparation for potential applications for *Aedes aegypti*. Applications of Duet, Anvil 10 + 10, and Scourge 18 + 54 were most effective in the open (0% cover), though Scourge had variability in the vegetation coverages. Overall, Scourge and Anvil were thought to be the best products for controlling *Culex* mosquitoes in the rural area, while more work should be done prior to applying adulticides from helicopter for *Aedes* control.

P-06 Assessment of spray efficacy and resistance status during a West Nile virus and Saint Louis encephalitis virus outbreak in Maricopa County, AZ 2015

Cassie Scott (gni6@cdc.gov), Janet McAllister, Kirk Smith, James Will, Steven Young, John Townsend

Caged field trials using *Culex quinquefasciatus* and *Aedes aegypti* were conducted to evaluate the efficacy of sumethrin, permethrin, and etofenprox based products on mosquitoes collected during an outbreak of West Nile virus and Saint Louis encephalitis virus in Maricopa Co., AZ. For the sumethrin based product, overall mortality in the field trials was 79% for *Cx. quinquefasciatus* at 0.0022 lb/acre and 89% at 0.0036 lb/acre. Mortality at the mid label rate was less for *Ae. aegypti,* overall 66%. For the permethrin based product, the overall mortality was 89% for *Cx. quinquefasciatus* at 0.0035 lb/acre. Overall mortality for the etofenprox based product at 0.0035 lb/acre was 79% for *Cx. quinquefasciatus*. Subsequent testing of *Cx. tarsalis* and *Cx. quinquefasciatus* in the lab demonstrated resistance in the population to permethrin, malathion, sumethrin, and etofenprox.

Behavior/Biology

P-08 Shannon diversity and noise in mosquito collection data
Todd Duval, todd.duval@massmail.state.ma.us, Priscilla Matton

2016 marks the centenary of the birth of Claude Shannon, one of the first big thinkers in Information Theory. The Shannon Diversity formula, often called the Shannon-Wiener (or Weaver) Index, was developed in 1949 to make predictive statements about the probability of the next character in any coded message in telecommunications. Shannon's formula was later adopted by ecologists in the 1960s to help assign a value to the seeming randomness of individuals in any ecological assemblage. Simply put, the Shannon index helps to determine species richness in a given area and the probability of finding the dominant species in any sample. If the Shannon index formula is applied to mosquito trap night data, it gives us a single numerical output. The output number alone doesn't tell much about what species are present, however it does give us a proportion that might be comparable to other trap night data with similar parameters. This poster will attempt to show how the Shannon index might be useful in mosquito collection data and whether there may be any correlation between mosquito diversity and human health concerns.

P-09 Mosquitoes and the June 23, 2016 flood of West Virginia
Eric Dotseth, Eric.J.Dotseth@wv.gov

On June 23 2016, thunderstorms brought torrential rain to much of West Virginia, resulting in accumulations of 10 inches within 12-24 hours. Governor Tomblin of West Virginia declared a state of emergency for 44 of the state's 55 counties. On June 25 2016, West Virginia was declared a major disaster area and President Obama ordered aid provided to flood victims in Kanawha, Nicholas, and Greenbrier counties. Adult mosquito data from flooded areas in Kanawha and Nicholas counties was compared with adult mosquito activity results from the same surveillance sites in 2015. In comparison with 2015, *Culex pipiens*/*restuans* showed the same or reduced activity in 2016. Although adult *Culex erraticus* emerged earlier in Kanawha County in 2016 than 2015, the adult emergence patterns for *Cx. erraticus* in Nicholas County remained the same between 2015 and 2016. Some La Crosse virus vectors (*Aedes triseriatus*, *Aedes albopictus*) showed a slight increase in activity in 2016 while other La Crosse virus competent vectors (*Aedes 68icrosoft*) were less common in 2016. Floodwater mosquitoes (*Aedes trivittatus*, *Aedes vexans*, *Psorophora ferox*) were less abundant in 2016 than 2015.

Disease Vector Studies

P-10 Black Fly Species (Diptera: Simuliidae) Occurring in Mississippi
Dr. Jerome Goddard, Dr. Audrey Harrison-Lewis, Dr. Wendy Varnado

Black flies are one of the few arthropod groups that have actually killed animals during massive and severe attacks by exsanguination. Black flies are second only to mosquitoes as being notorious blood-feeding pests. In many parts of the world, black flies are a serious problem and transmit various diseases such as onchocerciasis (human) and leucocytozoanosis (animal). Black fly outbreaks were common in Mississippi during the first half of the 20th century, but ended for unknown reasons. Since 2009, there has been a resurgence of black fly problems in Mississippi. During the early to mid 1930's, Dr. George Bradley, a medical entomologist for the U.S. Centers for Disease Control and U.S. Department of Agriculture, conducted detailed experiments and reports on black flies in various small rivers in the Mississippi Delta (Table 1). His research showed the ecology and biology of the black fly pest species, Cnephia pecuarum, in Mississippi. Early outbreak years interested Dr. Bradley with complaints from county extension agents and local veterinarians. In 1927, Yazoo City, MS had 100 farm animals killed and in 1928, Charleston, MS had an undocumented number of mules killed. During his study in 1931, over 1,000 mules were killed in Coahoma county, Mississippi. Since the reemergence of black flies, there have been several documented outbreaks. In 2009, black flies attacked backyard poultry near Vicksburg, MS and then, in 2011, there was a black fly outbreak in Natchez, MS. A human patient was treated at a hospital for black fly bites in 2013.These studies conducted by Dr. Bradley and the recent outbreaks were the basis for this study.

P-13 Vector competence of *Aedes* mosquitoes for Cache Valley virus
Kevin Chan, kchan90@vt.edu, Sally Paulson

Cache Valley virus (CVV) is a neuroinvasive Bunyavirus that is spread by mammal-biting mosquitoes. The virus typically causes mild symptoms in humans with a few potentially life threatening cases. Illness associated with CVV infection may include fever, meningitis, and encephalitis (Campbell et al. 2006). In the field, CVV has been isolated from *Ae. albopictus* and *Ae. 68icrosoft* (Armstrong et al. 2013; Yang and Chan 2016). *Ae. albopictus*, along *with Ae. triseriatus* and *Ae. 68icrosoft*, can be found throughout the United States with varying, but overlapping, distribution. Although many arboviruses can be isolated from wild mosquitoes, not all mosquitoes are capable of transmitting the virus. The objective of this study was to determine if *Ae. albopictus, Ae. triseriatus*, and *Ae. 68icrosoft* are competent vectors for CVV. The mosquitoes were provided with an infected blood meal and then tested for vector competency 14 days post

exposure (DPE). CVV-infected saliva was detected in *Ae. albopictus* (48%), *Ae. triseriatus* (23%), and *Ae. 69icrosoft* (28%). The results show that these three mosquitoes may potentially play a role for the succession and transmission of CVV in the United States.

P-14 Mosquitoes collected in Datem del Marañon and Alto Amazonas Provinces in Loreto, Peru as part of vector-borne disease studies in the Amazon Basin

Victor Zorilla, victor.zorilla@med.navy.mil, Gissella Vasquez

Mosquito-borne pathogens such as malaria, dengue and other arboviruses are a significant health risk to the people of Peru. The objective of this study was to refine mosquito species distribution at four sites in the Peruvian Amazon to determine risk of mosquito-borne pathogen transmission. Mosquito collections were conducted from January to March 2009 in four villages in the provinces of Datem del Marañon and Alto Amazonas, Loreto 635 km southwest of Iquitos. The four villages included: Saramiriza and Puerto America located along the Marañon River in the province of Datem del Marañon; Lagunas and Santa Cruz located along the Iquitos–Yurimaguas road near the Huallaga River, Alto Amazonas province. Mosquitoes were collected using CDC Light Traps run from 1800hrs to 0600hrs, protected Human Landing Collections from 1800hrs to 2100hrs, and back pack aspirators from 0800hrs to 1245hrs. A total of 22,357 female mosquitoes were collected in the four study sites with the three different methods and 12 genera and 38 species were identified. The genera *Culex* and *Mansonia* accounted for 75% of all mosquitoes collected across the four sites (56.8% and 17.9% respectively). *Aedes* spp. Only comprised 7% and *Anopheles* spp. 3% of the total collections. This study supports the idea that mosquito diversity is very high in the Amazon Basin and will serve as a baseline for any future study involving mosquito-borne pathogens or mosquito faunal diversity in this region of the Amazon.

P-15 Mosquito mayhem: Are Illinois mosquitoes ready for Chikungunya?

Kennen Hutchison, k-hutchison@wiu.edu, Dr. Catherine Miller-Hunt

Chikungunya virus (CHIKV) is a flavivirus that is transmitted by *Aedes aegypti* and *Aedes albopictus* mosquitoes. Although the virus has a low mortality rate in humans, it causes several severe symptoms. In 2005, an outbreak of CHIKV was identified on the French La Reunion Island and approximately a third of the island's population. This outbreak was later attributed to a CHIKV strain that exhibited a single amino acid change in the viral glycoprotein, and used the *Ae. albopictus* mosquito as a vector. The mutation, an alanine to valine change at amino acid 226 (A226V), allowed for a leap in vector, from primarily *Ae. aegypti* to primarily *Ae. Albopictus* and resulted in a high number of CHIKV cases on the Island. The fact that one amino mutation can expand vector competency throughout *Aedes* species is of interest to our lab. The aim of our project is to identify if other amino acid mutations in CHIKV's glycoprotein could permit or increase CHIKV competency in *Aedes* species currently located in west-central Illinois. At this time, invasive *Aedes* species *albopictus*, *69icrosoft* and*. Triserriatus* are found throughout Illinois. The results of our study will help to indicate if west-central Illinois currently has a mosquito vector that is competent for CHIKV infection and could therefore put the communities of west-central Illinois at risk of facing the virus before the invasion of *Ae. aegypti* reaches our state. As a secondary objective, our research will look at the mechanisms of viral entry by CHIKV into mosquito cells.

P-16 Geographic and environmental overlap of malaria mosquito vectors in an endemic area of Colombia

Margarita Correa, margaritcorrea@gmail.com, Mariano Altamiranda, Juan Parra, Sair Orieta, Townsend Peterson

The transformation of natural ecosystems changes the ecological conditions important for human disease vectors; therefore, it is essential to identify the variables that determine species distribution in order to design programs for preventive control. Ecological niche modeling and background similarity tests were used to evaluate the potential distribution and assess the hypothesis of niche similarity among three main Colombian malaria vectors. As predictor variables, the Normalized Difference Vegetation Index (NDVI) was chosen; this indicates the spatial and temporal dynamics of different vegetation types. This index is obtained based on high resolution (250 m every 16 days) images from the MODIS satellite. The models were constructed based on data from 40 localities using the maximum entropy algorithm that were evaluated using partial ROC plots. Niche similarity for these species was quantified. The Bajo Cauca zone presented the highest suitability for the presence of *Anopheles 69icroso*. *Anopheles nuneztovari* presented the widest potential distribution being the most suitable area the Urabá and Bajo Cauca zones. While for *Anopheles albimanus* the most suitable zone corresponded to coastal areas of the Alto Sinú and Urabá- Bajo Cauca. An extensive geographic overlap was found between *An. Nuneztovari* and *An. Albimanus*. *An. Nuneztovari* had a broader niche and the widest potential distribution. Possibly, the dispersal ability of these species and the ability to occupy different types of ecosystems facilitate sympatry in a broad environmental

and geographical space. Finally, these models may be used for the design and implementation of species-specific vector control programs in this important malaria region.

P-17 Multilocus analysis of Colombian species of the Arribalzagia Series in the *Anopheles* Subgenus
Natalí Álvarez, Giovan Gómez, Margarita Correa (margaritcorrea@gmail.com)

The Arribalzagia Series of the *Anopheles* Subgenus is composed of at least 24 species with only 12 reported in Colombia. Some of these species are morphologically similar in the female adult stage and in the male genitalia, difficulting species identification such as those from the informal Group Punctimacula: *Anopheles calderoni, Anopheles punctimacula* s.l., *Anopheles guarao* and *Anopheles malefactor*. In addition, some species are part of complex, the Punctimacula and Apicimacula complex. In order to discriminate the morphospecies of the Arribalzagia Series present in Colombia, this work used a multilocus approach based on ITS2, *COI* and *CAD* sequences. *Anopheles* specimens were collected in nine localities of malaria endemic regions of Colombia. Intra and interspecific variation and 70icrosof analysis were conducted. ITS2 and COI allowed confirming species assignation. Variability results showed that *COI* sequences were more polymorphic than those of *CAD*. At the intraspecific level, *COI* presented higher variability in *An. Apicimacula* and *CAD* in *An. Malefactor*. Individual and concatenated 70icrosof analysis showed a 0.95 support for each of the seven species detected and reinforced the previous report of a complex for specimens *An. Apicimacula* from the Pacific Coast and northwest Colombia. In addition, *COI* allowed identifying a molecular operational taxonomic unit-MOTU, near *An. Peryassui*, endorsing the primary hypothesis of the new Peryassui species complex. CAS

P-18 Plague surveillance in the northern Sierra Nevada, California, 2016
Elizabeth Andrews, elizabethsandrews@gmail.com, Bryan Jackson, Greg Hacker, Kelly Liebman, Michael Niemela, Mark Novak

Plague was first recorded in California and the continental United States in San Francisco in 1900. Through flea exchange, plague transferred to sylvatic rodents and has since become endemic in California. The California Department of Public Health (CDPH) conducts statewide surveillance, prevention, and control for plague. Plague surveillance was enhanced in the northern Sierra Nevada in 2016 following detection of epizootic plague activity in the Tahoe Basin and two human plague cases associated with Yosemite National Park in 2015. CDPH – Vector-Borne Disease Section (VBDS) staff conducted live rodent trapping for plague surveillance at multiple locations in the Lake Tahoe Basin Management Unit and Tahoe National Forest, primarily at campgrounds, day use areas, and other popular recreation sites. The goal was to evaluate rodent and flea abundance, estimate exposure to *Yersinia pestis* (the causative agent of plague), and determine if human plague risk was elevated in these recreational areas. Fleas and blood samples were collected from captured rodents and tested for the presence of *Y. pestis* at the CDPH – VBDS laboratory. Seropositive rodents were detected at all surveyed recreational sites in the Tahoe Basin Management Unit and in two of three recreational sites surveyed in Tahoe National Forest. Here, we describe the details of the plague surveillance process, our risk assessments, and public health recommendations to help mitigate plague risks.

P-19 A survey for container-inhabiting *Aedes* of public health importance: North Carolina (2016)
Brian Byrd, bdbyrd@wcu.edu, Michael Reiskind, Stephanie Richards, Diane Styers, Jennifer Stewart, Larry Michael, Julie Casani, Carl Williams

An intensive multi-agency ovitrapping survey was conducted May-October 2016 in order to update distribution records of container-inhabiting *Aedes* species in North Carolina. Efforts were primarily designed to determine the presence, relative abundance, and seasonal occurrence of *Aedes aegypti*, *Ae. albopictus*, *Ae. triseriatus*, and *Ae. 70icrosoft* in counties within metropolitan statistical areas, or other areas likely to be at higher risk for the transmission of arboviruses by *Aedes* mosquitoes. To date (9/16), we have received 171,207 *Aedes* eggs from participating counties, municipalities, and partners; 36,787 specimens have been identified microscopically to species. The majority (99.8%) of the ovitrap collections are represented by 3 species: 77% (n=28,526) of the identified *Aedes* are *Aedes albopictus*, 11% (n=4,203) are *Aedes triseriatus*, and 11% (n=4,058) are *Aedes 70icrosoft*. At present we have not identified any *Ae. aegypti* in NC this year. The percentages of *Ae. 70icrosoft* and *Ae. triseriatus* vary regionally, but *Ae. albopictus* is the primary container inhabiting *Aedes* in the participating counties according to the ovitrap data. These results are discussed in the context of risk assessment for traveler introduced arboviruses (e.g., chikungunya, dengue, and Zika) and endemic arboviruses (e.g., Jamestown Canyon and La Crosse).

Equipment

P-20 Biogents Sweetscent Lure increases the collection rate of *Aedes aegypti* and *Aedes albopictus* in commercially available homeowner mosquito traps
Martin Geier, martin.geier@biogents.com, Daniel Kline, Scott Willis, Joyce Urban, Scott Gordon

We tested 7 commercially available mosquito traps ranging in price from $49 to $140. Traps were designed for homeowner use and were available from local home improvement stores or from online merchants. Tests were conducted in Florida and Louisana using a modified Latin square design to assess the collection efficacy of the traps with and without Biogents Sweetscent Lure. Sweetscent Lure contains a chemical blend designed to simulate human skin emissions and is effective for 2 months after opening. In Florida, the MosClean UV LED, Dynatrap XL DT2000XL, Bite Shield Protector, Flowtron Galaxie PV 75 and Skeetervac Bite-Guard SVE6211 were tested. All traps with Sweetscent Lure showed an increase in the number of *Ae. albopictus* collected (between 2.1 and 4.5 times) compared to the traps without the lure. *Aedes aegypti* was collected in higher rates (between 1.5 to 9.7 times) in all traps with Sweetscent except the Flowtron, which was also the poorest performing trap overall. In Louisiana, the Black Flag BZ-40-DX, Skeetervac Bite-Guard SVE6211 and the Dynatrap DT1000-12V were tested. In Louisiana, between 1.9 and 3.8 times more *Ae. albopictus* were collected in traps baited with Sweetscent Lure. These results demonstrate that using Biogents Sweetscent Lure can greatly increase the catching success for *Ae. aegypti* and *Ae. albopictus* when using off the shelf mosquito traps.

Larval Control

P-21 Integrating chemigation into a larval control program at a lumber mill

Haley Bastien, hbastien@shastamosquito.org

Located in Anderson, CA within the Shasta Mosquito and Vector Control District is a large lumber mill which produces thousands of *Culex tarsalis* and *Culex pipiens* every year from April until September. Additionally, the area within a one and a half mile radius of the mill produced 14 West Nile virus (WNV) positive mosquito samples in 2015. The log decks at the mill are hard to access from the ground as a gantry crane moving along two parallel tracks is employed to transport logs. A granular spreader specially designed to mount under the crane was used to apply spinosad (Natular™ G30, 2.5% spinosad), *Bacillus thuringiensis israelensis* (*Bti*) + *Bacillus sphaericus* (Vectomax® FG, 2.7% *B. sphaericus* + 4.5% *Bti*), methoprene (Altosid Pellets®, 4.25% methoprene), and temephos (Skeeter Abate®, 5% temephos) to the log decks in an effort to reduce mosquito numbers. However, in 2015 updates were made to the crane which prevented future applications using the granular spreader. With difficult to reach crevices and bodies of water, using an injection system in order to chemigate the log decks became a possible solution to the problem. The New Jersey light trap (NJLT) at the mill saw a significant reduction in the number of *Culex* mosquitoes over the course of the season. The Encephalitis Virus Surveillance (EVS) traps located within a mile and a half of the mill produced fewer WNV positive mosquito samples. Injecting a methoprene (Altosid® Liquid Larvicide, 20% methoprene) water mixture into the sprinkler system over the log decks greatly reduced the number of mosquitoes produced by the mill, the amount of time needed to treat the mill, as well as increased overall safety.

P-22 Can *Aedes aegypti* females act as lufenuron carriers to larval habitats?

Laura Harburguer, lharburguer@gmail.com, Paula Gonzalez, Héctor Masuh

Insect growth regulators (IGRs) are considered a new generation of insecticides having great prospects for insect control. The activity of IGRs generally results in the reduction of adult emergence of the target insect. However, they seem to have side effects, particularly on female reproduction following larval IGR treatments, for example, effects on fecundity (increase or diminution of the number of eggs laid) and on fertility (reduction of hatchability or viability of eggs).

Several studies have demonstrated that blood fed females of *Ae. aegypti* (L.) that had been forced into contact with surfaces treated with the IGR pyriproxyfen belonging to the juvenile hormone analogs group, transported sufficient amounts of the IGR to disrupt larval development in untreated oviposition sites. However there are no studies that show the existence of this phenomenon with IGR belonging to the chitin synthesis inhibitors group.

In this work *Ae. aegypti* females were exposed to a concentration between 0.2 and 0.8 mg i.a./cm^2 of lufenuron, were blood fed and then transferred into cages with 250 ml beaker containing an oviposition paper and 15 late 3^{rd}/early 4^{th} stadium larvae in 100 ml of declorinated water. After 3 days beakers containing larvae were collected and mortalilty and emergence were recorded daily. We found that adult females can deliver biologically active amounts of lufenuron to larval habitats depending on the doses and the number of females used.

Results of this work show that the innate behaviors of adult mosquitoes can be exploited to transfer IGRs to larval habitats as an integrated vector control strategy to improve *Ae. aegypti* population control and potentially reduce dengue and zika transmission.

New Product Trials

P-23 Knockdown and mortality effects of LLINs against malaria vectors in Thailand
Thanyalak Fansiri, ThanyalakF.fsn@afrims.org, Arissara Pongsiri, Udom Kijchalao, Silas Davidson, Alongkot Ponlawat

Long-lasting insecticide-treated nets (LLINs) are a key component of most malaria control programs. Three commercially available LLINs were evaluated against *Anopheles dirus*, *An. Minimus* and *An. Sawadwongporni* in large mosquito enclosures under semi-field conditions in Thailand. The three nets evaluated were the Olyset Net® (2% permethrin), Olyset Plus® (2% permethrin plus 1% piperonyl butoxide), and Olyset Duo® (2% permethrin and 1% pyriproxyfen). A double-layer bed net consisting of the LLIN as the inner-layer net and the untreated net as the outer-layer net were designed to measure knockdown effect and mortality. Thirty to forty mated females were released into the space between the inner and outer-layer nets for 13 h. Dry ice and human skin lure were placed inside the inner-layer net to attract mosquitoes. Percent knockdown of all *Anopheles* species was between 95-100% after 1 h of exposure. The pairwise comparison revealed percent knockdown of *An. Sawadwongporni* and *An. Dirus* was significantly lower when exposed to Olyset Net® compared to Olyset Plus® and Olyset Duo®. High mortality rates after exposure were observed (89-100%) in all tested species. Chi-square tests revealed a strong association between mortality and mosquito species when exposed to Olyset Duo®. Findings from this study demonstrate that the co-application of two active ingredients with different modes of action, or the combination of an insecticide and synergist, is a potential technique to improve control of malaria vectors in Thailand.

P-24 Integrating the Project Premonition Smart Mosquito Trap into a large U.S. mosquito surveillance program
Ethan Jackson, ejackson@microsoft.com, Douglas Norris, Yan Zhu, Eamonn Keogh, Anadasankar Ray, Max Vigilant, Martin Reyna, Mustapha Debboun

Project Premonition is joint-effort between Microsoft Research, academic teams, and government organizations to detect unexpected pathogens before they become threats – by high-throughput robotic capture of mosquitoes and big data analytics to elucidate mosquito and pathogen dynamics. Microsoft Research designed and manufactured the first generation of smart traps from Spring 2015 to Spring 2016, for deployment in Spring 2016.

We report on the integration of the Project Premonition Smart Mosquito Trap and data analytics pipeline into the Harris County Public Health Mosquito Surveillance Program during the Spring / Summer 2016. During this period, we collected and analyzed over 20 GB of mosquito-trap interactions paired with detailed abiotic data. The majority of this data was collected within Houston, TX during the emergence of Zika Virus in North America, concurrently with imported cases of Zika Virus in Houston, TX. We observed that the Project Premonition Smart Mosquito Trap could, in real-time, differentiate between disease vectors in the *Aedes* and *Culex* genera with over 90% precision and reconstruct activity patterns with unprecedented detail. We describe the trapping protocols and data analytics required to make the collection and processing of such large data sets practical and actionable by public health organizations. We conclude with implications on faster trap sorting and better predictions of disease spread.

P-25 Novel control tools for *Aedes* mosquito vectors
Emilie Bess, Rebecca Heinig (rheinig@springstar.net)

Zika made headlines in 2016, but this arbovirus is merely the most recent addition to the diverse arsenal of human diseases spread by *Aedes aegypti* mosquitoes. For a number of reasons, *Ae. aegypti* does not respond to traditional mosquito control approaches, so SpringStar has been actively developing a variety of new technologies designed to target this prolific vector. The Trap-N-Kill Mosquito Trap was developed in conjunction with the US military and effectively controls container-breeding mosquitoes like *Ae. aegypti* and *Culex* species. SpringStar has also recently begun distributing a commercial version of the CDC's autocidal gravid ovitrap (AGO), which reduced *Ae. aegypti* population density by more than 80% and cut chikungunya infection incidence by half in Puerto Rico. Finally, we are introducing NovaGel, a water-absorbing polymer which traps mosquito larvae and prevents adult emergence.

Operations

P-26 Tick and tick borne disease surveillance at a local mosquito and vector control district
Tommy Moore (tommym@placermosquito.org), Mary Sorensen

At Placer Mosquito & Vector Control District the tick surveillance program runs during the fall through winter and into early spring (November to March). In 2015, the tick surveillance program was overhauled to standardize multiple aspects, including establishing nine permanent sites at different elevations. Collections are performed with a one square meter section of fabric dragged at the trail margin. Collecting distance at each site was standardized to 0.8 km, measured with a measuring wheel (rather than standardizing by collecting time), the amount of collections was standardized to once per month, and measuring methods

were established for temperature and humidity (measurements taken at the start of collecting at ground level and at four feet). Among the goals of the new program are to look at tick abundance and Lyme infection rates at different elevations and to identify the effect of temperature and humidity on collection success.

Other

P-27 Detection and Characterization of Insecticide Resistance Mechanisms in *Culex tarsalis*

Eva Choi (echoi@pacific.edu), Tara Thiemann, Debra Lemenager, Paula Macedo, Kara Kelley

Insecticide resistance in disease-transmitting arthropods is an obstacle for successful vector control. Mosquitoes are known vectors of pathogens that cause diseases like malaria and West Nile virus. Several mosquito species, including *An. Gambiae* and *Cx. quinquefasciatus,* possess mutations (denoted *kdr* and *ace-1*) or enhanced detoxifying enzymes (oxidases, esterases, GSTs) that confer resistance. *Cx. tarsalis*, a primary vector for WNV in Northern California, is a target for insecticide application, making it likely to adapt these resistance mechanisms. In this study, adult females were collected from Yolo and Sutter counties, CA. A bottle bioassay was completed to determine prevalence of resistance to Sumithrin (a pyrethroid; N=186) and Naled (an organophosphate; N=193). Microplate assays were completed to investigate levels of detoxification enzymes present as well as acetylcholinesterase. PCR was used to amplify the voltage-gated sodium channel and acetylcholinesterase genes. Amplicons were sequenced to determine if *kdr* and *ace-1* were present. No evidence of *ace-1* was found in any samples; but, *kdr* was seen in all individuals resistant to Sumithrin. Microplate data revealed differences in certain detoxifying enzymes within mosquitoes from each group. A-esterases were higher in resistant mosquitoes collected from Sutter County exposed to Sumithrin compared to susceptible colony mosquitoes. Oxidases in the susceptible group from Yolo County exposed to Naled were lower than the somewhat resistant group. The data obtained from this study suggests that resistance to Sumithrin in both populations is carried out by metabolic and target site insensitivity, while resistance to Naled is caused by metabolic resistance only.

P-28 Colonizing *Culex erythrothorax*

Nathan McConnell (nmcco001@ucr.edu), William Walton

The tule mosquito, *Culex erythrothorax*, is a locally abundant, pestiferous species inhabiting wetland environs of the western United States (Darsie and Ward 2005), especially those with *Typha spp.* And *Schoenoplectus spp.* (Carpenter and LaCasse 1955, Walton 1997). Adult emergence can exceed 420/m^2/day, resulting in standard CO_2 baited trap-night counts in the thousands (>33,000) (Walton 1997, Walton, Popko, Van Dam 2013). Although not a primary vector of disease it is a competent vector of WNV (Goddard et al. 2002), can transmit SLE (RP Meyer, JL Hardy, SB Presser 1988), and has been found to transmit Rift Valley Fever virus (Turell et al. 2010) and Bancroftian filariasis in the laboratory (Scott, Richards, Seaman 1945). As mitigated wetlands continue to be developed near housing tracts, concern for this species continues to grow for mosquito control personnel and those living within flying distance (<0.5 km) of larval maturation sites (Walton and Workman 1999, Cummings et al. 2005, Marcus, Lauren, and Rory 2007). As such, the need to be able to perform research with this species is growing. However, since this species is notoriously difficult to collect as larvae due to its ease of being startled and prolonged diving habits (Workman 1998), colonization is needed. Although Blakeslee et al. (1962) colonized *Cx. erythrothorax* in the 1950's for several months, it took some special requirements to do so, namely cage size aided by near constant access to blood meals. Recolonization attempts using today's IACUC Animal Use Protocols hampered the ease of colonization, however, a colony was established. The successes and pitfalls of colonizing *Cx. erythrothorax* are highlighted for anyone interested in developing a colony.

P-29 Human-disease causing arbovirus prevalence in Kenyan mosquitoes

Claire Heath PhD, Malaya Sahoo PhD, Bryson Ndenga PhD, Francis Mutuku PhD, Njenga Ngugi, Joel Mbakaya, Peter Siema, Peter Aswani, Warren Macdonald MS, Jesse Waggoner MD, Benjamin Pinsky MD, A. Desiree LaBeaud MD MS

Arthropod (mosquito)–borne viruses (arboviruses) comprise some of the most important emerging pathogens due to their geographic spread and increasing impact on vulnerable human populations. Over 100 arboviruses are known to be pathological in humans and present a significant global health burden, yet the transmission, epidemiology, and incidence of arbovirus-related human disease burden remains poorly defined, particularly in sub-Saharan Africa. In Kenya, the continued population growth and associated urbanization is conducive to mosquito vector spread; thus the characterization of arboviral circulation in this region is imperative to better inform human risk assessments and vector control practices. We used a variety of trap types and capture methods to collect *Aedes* and *Anopheles* species mosquitoes, at varying stages of the life cycle and during different seasons, at four sites in Kenya: Msambweni and Ukunda on the coast, and Chulaimbo and Kisumu in the west. Mosquitoes were then sorted by species, sex, trap type and date of capture, and grouped into 458 pools of ~25 individuals. Tissue was mechanically lysed and total RNA was extracted. Using a multiplex real-time reverse transcriptase PCR assay, mosquitoes were tested for

dengue (DENV) and chikungunya (CHIKV) viruses, as well as the five *Plasmodium* species known to cause human disease. CHIKV was detected in 14 of 290 (1.9%) of *Aedes spp.*pools. Of these three were from the western site, caught between March and May 2014. Interestingly, these were found in male mosquitoes bred in the laboratory from ovi- and larval traps, suggesting trans-ovarial transmission of these viruses. One pool from the coastal site was positive for CHIKV in an ovitrap female mosquito pool in November 2014. DENV was not detected in any sample. Of the 83 *Anopheles* pools tested for the five Plasmodium spp., one pool tested positive for *P. falciparum*. These data suggest a considerable prevalence of CHIKV in Kenyan mosquitoes, and that viral distribution varies both geographically and temporally. These data contribute to arboviral surveillance in Kenya, and suggest that the prevalence of CHIKV is underestimated

P-30 Characterization of larval habitats of Aedes aegypti in Kenya

Desiree LaBeaud, Njenga Ngugi, Francis Mutuku, Bryson Ndenga, Peter Siema, Henry Maleka, Lucy W. Irungu, Dunstan Mukoko, John Vulule, Uriel Kitron

Aedes aegypti, the principal vector for dengue and other emerging arboviruses, breeds preferentially in various man-made and natural container habitats. In the absence of vaccine, vector control is the primary means to reduce the incidence of dengue. Effective vector control depends on a good understanding of larval and adult vector ecology of which little is known in Kenya. Twenty sentinel houses in each of four study sites (in western and coastal Kenya) were assessed for immature mosquito incidence once a month for a period of 20 months (May 2014 to December 2015). All water-holding containers in and around the households were inspected monthly for immature *Ae. aegypti* mosquitoes. A total of 19,249 containers were inspected from Chulaimbo (6929) and Kisumu (6927) in the west, and from Msambweni (2689), and Ukunda (2704) on the coast. Of these, only 5.8%, 5.3%, 5%, and 6.6%, respectively, were positive for *Ae. aegypti* immatures. In all four sites, significantly more positive containers were located outdoors than indoors (χ^2= 712.4, DF=1, P<0.001). A total of 12,547 *Ae. aegypti* immatures were collected from these containers, which comprised 13 container types. More than 40% were from buckets, tires, and water-tanks, which produced 49% (1,245/2,530) of the pupae in the western and coastal study sites combined. Tanks, buckets, drums, and flowerpots were the key indoor containers, producing > 80% (92/108) of the pupae. Key outdoor containers in the coast were tires, tanks, buckets, and basins which accounted for 57% (1,316/1,965) of pupae, while pots and tires were the only key containers in the western region producing 71% (329/457) of pupae. Coast region produced significantly more *Ae. aegypti* immatures than the western region (Kruskal-Wallis, χ^2 = 179.8, DF=1, P< 0.0001). These results indicate that *Ae. aegypti* breeding habitats are abundant outdoors and are diverse both in the coast and western regions of Kenya. However, only a few containers are responsible for majority of the production. Targeting source reduction efforts towards these productive containers may be a cost-effective way to reduce dengue transmission in these regions.

P-31 Withdrawn

Public Relations

P-32 Preparing residents in Clovis, CA for the release of 640,000 male *Aedes aegypti* into their neighborhood.

Jodi Holeman, jholeman@mosquitobuzz.net, Steve Mulligan

The transition from the laboratory to the field requires more than just packing up the lab and setting up outside. A field site set in an urban residential neighborhood can present unique challenges. The Consolidated Mosquito Abatement District, in collaboration with MosquitoMate, the University of Kentucky and the University of California, Davis, developed a public outreach program on the evaluation of their novel sterile insect technique against a recently established *Ae. aegypti* population within a small neighborhood of Clovis, CA. In March 2016, the public outreach program was launched, targeting approximately 400 homes in Clovis, California. This program was designed to prepare residents for the release of 640,000 male *Ae. aegypti* mosquitoes over the span of 16 weeks. We will discuss the elements of the outreach program as well as survey results from the outreach effort.

Latin American Posters

P-33 Prevalence of head lice in San Nicolas de los Garza children of the town of Nuevo León, Mexico.

Rosa Sanchez Casas, sanchezcasasrossy@yahoo.com), Maricela Laguna Aguilar, Jesus Hernandez Escareño, Esteban Diaz Gonzalez, Wilfredo Arque Chunga, Ildefonso Fernandez Salas

Head lice are common in all social strata of Mexico, although its prevalence is difficult to establish by the lack of epidemiological records. Despite the few studies on the subject it is known that at least 13-60% of the population in Mexico is infested. Urban and peri urban groups are considered vulnerable populations for this reason a study was conducted to determine the prevalence of lice in children in the municipality of San Nicolas de los Garza during the months of november and december in the search of nits, nymphs or adult lice was performed in children under 15 years using a mechanical (lice comb) technique. The results showed

a higher prevalence of pediculosis with 8.2 times (95% CI 4.8-3.7) in girls (22.4%) than boys (4.7%). The scant attention and awareness of this problem has allowed lice infestations remain out of control. So vulnerable populations require renewed attention to the prevention and treatment of head lice.

P-34 Pyrethroids insecticide resistance *in Aedes aegypti*, *vector* of dengue, chikungunya and zika viruses from Colombia.

Angelica Aponte, aaponte@cideim.org.co, Clara Ocampo, claraocampo@cideim.org.co, Rosa Penilla, Alma López, Francisco Solís, Américo Rodriguez

In Colombia *Aedes aegypti* is the major vector of dengue, chikungunya and zika viruses. These arboviruses are considered a major public health threat, because in recent years they are responsible of major outbreaks producing high morbidity and mortality. This mosquito species is characterized by possessing the ability to develop insecticide resistance mechanisms and is thus a major threat to public health in the tropics. In Colombia pyrethroids are used extensively for adult mosquito control, especially during arbovirus outbreaks. We study the mechanisms involved in pyrethroid resistance in 3 laboratory selected strains and 4 field strains from Colombia. CDC assays, biochemical assays and *kdr* Real time PCR are used to assess phenotype, biochemistry and mutations Ile1016 and Cys1534, respectively. The phenotype and levels of detoxification enzymes were determined and compared to Rockefeller susceptible-strain as a control. The mosquitoes strains were tested for susceptibility to Permethrin and Type II (deltamethrin and lambdacyalothrin) pyrethroids. All strains were resistant to type II pyrethroids, and only one from Medellin was susceptible to Permethrin. Differences in the levels of α, β estersaes, CYP^{450} and GST were found between the control strain and the field strains. However we found that 4 strains did not show an increase in CYP^{450} compared with the control susceptible strain, suggesting that this is probably not the mechanism that confers resistance to pyrethroids in these populations. In the all strains evaluated, the mutations Ile1016 and Cys1534 (associated with pyrethroid resistance) were found with varying frequency, some strains had high frequency to both mutations, indicating high pyrethroids resistance.

P-35 Assessment of Novaluron 2GR in Urban Areas for Control of *Aedes aegypti*

Marcela Quimbayo, marceladelpilar64@yahoo.es, Juliana Perez, Jorge Velasquez, Pola Rodriguez, Juan Amaya, Guillermo Rua

Diseases such as dengue, chikungunya and Zika generate serious epidemics with an important economic and social impact in Colombia. These diseases are spread by the *Aedes aegypti* mosquito, which is present in more than 80% of the national territory. Given there is no vaccine to control such diseases that is recommended by national health authorities, the most cost-effective strategy is vector control. However, it has been documented for different regions of the country that *Ae. aegypti* is resistant to some insecticides used in public health. Therefore, it is necessary to evaluate new products to improve vector control. Novaluron 2GR is a growth regulating insecticide that controls the emergence of adult mosquitoes and could contribute to the mitigation of these epidemics. Considering Novaluron 2GR has proved to be efficient in controlling *Ae. aegypti* under laboratory conditions, the current study evaluated the product's effect on vector mortality and inhibition of emergence, in urban areas of Medellín. To do this, a neighborhood with high incidence of dengue was selected. 30 homes were randomly chosen, where three 40L buckets were located. One corresponded to the control, while the other two were treatments (with and without weekly water replacement). The product's effect was evaluated for 12 weeks, through the assessment of 90, 95 and 99 lethal concentrations (LC), based on previous laboratory results. The results obtained allow to consider Novaluron 2GR as a regulator of populations, useful in prevention and control programs for dengue, chikungunya and Zika in Colombia

P-36 Lethal ovitrap with entomopathogenic fungus (*Metarhizium anisopliae*) for larval control *Aedes aegypti* (Linnaeus, 1762) (Diptera: Culicidae) Acapulco, Guerrero, Mexico

Ewry Zarate-Nahon, aeznx1@hotmail.com, Abel Jimenez-Alejo, Rocio Ramírez-Jimenez, Maricela Laguna-Aguilar, Jose Rosas-Acevedo

Abstract

Dengue, Chikungunya and Zika, have become major public health problems in the state of Guerrero, Mexico, mainly in coastal areas, as have all the characteristics that favor reproduction and vector-human contact. Traditionally the vector *Aedes aegypti* is fought with insecticides, however acceptance and effectiveness has not been the best, besides the vector has developed resistance to insecticides used; therefore they have sought alternatives that are environmentally friendly and do not create resistance easily. Entomopathogenic fungi are emerging as potential candidates for mosquito control. Diseases caused by fungus entomopathogenic insects occur naturally apart from being common and widespread. It has been shown that the use of entomopathogenic fungi is high potential, and death inducing production of multiple toxins, which reduces the possibility of resistance developing. Ovitraps have proven to be an effective tool for surveillance of *Ae. aegypti*. We use ovitraps with fungus *Metarhizium anisopliae* for control of larvae and

adults of *Ae. aegypti*. Preliminary results indicate that lethal ovitraps can be a tool for vector control, besides having greater acceptance by the population and are environmentally friendly.

P-37 Spatiotemporal variation of mosquito diversity (Diptera: Culicidae) at places with different land-use types within a neotropical montane cloud forest matrix

Carlos Antonio Abella-Medrano, abella22@gmail.com, Sergio Ibanez-Bernal, Diego Santiago-Alarcon

Land-use change has led to a dramatic decrease in total forest cover, contributing to biodiversity loss and changes of ecosystems' functions. Insect communities of medical importance can be favored by anthropogenic alterations, increasing the risk of novel zoonotic diseases. We evaluated the response of mosquito (Diptera: Culicidae) abundance and richness to five land-use types and three seasons embedded in a neotropical montane cloud forest landscape. We performed standardized collections using 8 CDC miniature blacklight traps, baited with CO_2 throughout the year. We used generalized additive mixed models to describe the seasonal and spatial trends of both species richness and abundance. Rank abundance curves and ANCOVAs were used to detect changes in the spatial and temporal structure of the mosquito assemblage. We performed two cluster analyses, using 1-βsim and the Morisita-Horn index to evaluate species composition shifts based on incidences and abundances. Highest richness was recorded in the dry season, whereas higher abundance was detected during the rainy season. The urban forest had the highest species richness when compared to all other sites. However, when considering the abundance of such species, the well-preserved montane cloud forest showed significantly higher abundance. Moreover, the urban forest is only 30% similar to other sites in terms of species abundances, indicating a possible isolating role of the urban environment. Mosquito assemblage responded to land-use change and seasonality, but at the same time the assemblage is rather homogeneous across the studied landscape, suggesting a high degree of spatial connectivity.

P-38 Infection of native *Wolbachia* in *Aedes albopictus* from cemeteries in urban areas of southern Mexico

Jorge Torres Monzon, jatorres@insp.mx, Mauricio Casas Martinez, Brenda Moran-Aceves, Rebeca Carballlar-Lejarazu, Ildefonso Fernandez Salas

The invasive mosquitoes *Aedes aegypti* and *Aedes albopictus* are recognized as vectors of arbovirus. Currently, an increasing prevalence and incidence of diseases transmitted by mosquitoes is the result of numerous factors, including the lack of vaccines and physiological resistance development in mosquito populations due to chemical control. A new approach for arbovirus control in mosquitoes is the use of endosymbionts such as *Wolbachia*, which has been proved being efficient in reducing pathogen transmission. Here, we evaluated the prevalence of *Wolbachia* infections in *Aedes albopictus* field populations from cemeteries of southern Mexico. A field prevalence of 38% was found via polymerase chain reaction (PCR).This is the first study in the Soconusco region, Chiapas, that shows the infection of *Wolbachia* in *Ae. albopictus* and its absence in *Ae. aegypti* populations. This evidence may be relevant from the epidemiological point of view because *Wolbachia* infection in *Ae. albopictus* has different effects in the mosquito life cycle as well as a blocking effect on pathogens development, which strengthens the idea of using *Wolbachia* as a biological control strategy for emerging and re-emerging arboviruses in the country.

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AMCA AWARDS

HONORARY MEMBERS

1937	Leland O. Howard (USDA)	1965	Arthur W. Lindquist (KS)	1991	Kenneth L. Knight (NC)
1938	C. C. Adams (NY)	1967	Fred L. Stutz (FL)	1994	Harold C. Chapman (LA)
1944	Thomas J. Headlee (NJ)	1970	Robert L. Vannote (NJ)		Lewis T. Nielsen (UT)
	William B. Herms (CA)		Richard W. Fay (USPHS)	1998	Eugene J. Gerberg (MD)
	J. A. LePrince (USPHS)	1971	Christian T. Williamson (NY)		Glen C. Collett (UT)
	Louis L. Williams, Jr.	1972	Alan R. Stone (MD)	1999	Donald R. Johnson (GA)
1948	Robert D. Glascow (NY)		Edward S. Hathaway (LA)	2001	Fred W. Knapp (KY)
	Willard V. King (USDA)	1974	Theodore G. Raley (CA)	2003	E. John Beidler (FL)
1951	Lewis W. Hackett (CA)	1976	John A. Mulrennan, Sr. (FL)	2004	David A. Dame (FL)
	Robert Matheson (NY)	1979	Thomas D. Mulhern (CA)	2005	Donald J. Sutherland (NJ)
1955	Harold F. Gray (CA)		Austin W. Morrill, Jr. (CA)	2006	Martin S. Chomsky (NJ)
1958	Louis A. Stearns (DE)	1981	William R. Horsfall (IL)	2013	Judy Hansen (NJ)
1964	George H. Bradley (USPHS/USDA)	1983	Anthony W. A. Brown (WHO)	2013	Henry Rupp (NJ)

HAROLD FARNSWORTH GRAY MEMORIAL CITATION MERITORIOUS SERVICE TO MOSQUITO CONTROL AWARD

This now discontinued award was presented to an active member of AMCA for exceptional service to the Association and to mosquito control or related vector control.

1964 Fred C. Bishopp (DC)

DR. THOMAS J. HEADLEE MEMORIAL AWARD

This now discontinued award recognizes a living member of the Association for outstanding service to the field of mosquito control, while simultaneously commemorating the name of a deceased member.

1968 George H. Bradley (USDA/USPHS)

MEDAL OF HONOR

Next to honorary membership, the Medal of Honor is the highest award regularly given by AMCA. The only specific limitation for the Medal of Honor is AMCA membership, and nominees are selected on the basis of exceptional contributions to mosquito control or related fields. After 1982, the Board of Directors set a suggested maximum of one Medal of Honor

1972	Maurice W. Provost (FL)	1983	Harry D. Pratt (GA)	2001	Gary G. Clark (USPHS)
	William R. Horsfall (IL)		John A. Mulrennan, Sr. (FL)	2002	Lucas G. Terracina (LA)
1973	Don M. Rees (UT)	1984	George T. Carmichael (LA)	2003	Robert J. Novak (IL)
	Thomas D. Mulhern (CA)	1985	Norman G. Gratz (WHO)	2004	James D. Long (TX)
1974	Anthony W. A. Brown (WHO)	1986	James R. Caton (CA)	2005	James W. Robinson (FL)
	Donald L. Collins (NY)	1987	Jay E. Graham (UT)	2006	John L. Clark Jr. (IL)
1975	Daniel M. Jobbins (NJ)	1988	Lewis T. Nielsen (UT)	2007	E. John Beidler (FL)
	Arthur W. Lindquist (USDA)	1989	Andrew J. Spielman (MA)	2008	David A. Dame (FL)
1976	Austin W. Morrill, Jr. (CA)	1990	Glen C. Collett (UT)	2009	Dan Ariaz (NV)
	Carroll N. Smith (USDA)	1991	Harold C. Chapman (LA)		Gary Breeden (VA)
1978	James B. Kitzmiller (FL)	1992	D. Bruce Francy (CO)	2010	Mir S. Mulla (CA)
	William D. Murray (CA)	1993	Gilbert L. Challet (CA)	2011	Dave Brown (CA)
1979	Richard F. Peters (CA)	1994	Ronald A. Ward (MD)	2012	Sammie L. Dickson (UT)
1980	William E. Bickley (MD)	1995	T. Wayne Miller (FL)	2013	Wayne Crans (NJ)
	John N. Belkin (CA)	1996	Marshall Laird (New	2014	Chester G. Moore (CO)
1981	Stanley J. Carpenter (CA)	1997	Robert K. Washino (CA)	2015	Jorge Arias
	Roland E. Dorer (VA)	1998	John D. Edman (MA)	2016	Graham White (FL)
1982	Kenneth L. Knight (NC)	1999	Bruce F. Eldridge (CA)		
	William C. Reeves (CA)	2000	Judy A. Hansen (NJ)		

MERITORIOUS SERVICE AWARD

Given to individuals for outstanding service, the contributions of the nominees must be considered outstanding as judged by their peers. Only AMCA members in good standing who are not past presidents of AMCA are eligible. After 1982, the Board of Directors set a suggested maximum of no more than two awards per year.

1972	Charles F. Scheel (IL)	1980	Donald E. Weidhaas (FL)	1997	Thomas J. Zavortink (CA)
	Donald L. Collins (NY)		E. John Beidler (FL)	1998	James D. Long (TX)
	Theodore G. Raley (CA)		Eugene J. Gerberg (MD)	1999	Hilton B. Munns (CA)
1973	Francis P. Creadon (CA)	1981	A. Ralph Barr (CA)	2000	Leroy J. Bohn (VA)
	Vernon Conant (NJ)		Gilbert L. Challet (CA)		Dreda McCreary (VA)
	Austin W. Morrill, Jr. (CA)		Edgar A. Smith (VA)	2001	Charles T. Palmisano (LA)
1974	Leslie D. Beadle (USPHS)	1982	Hugo A. Jamnback (NY)	2002	Thomas G. Floore (FL)
	John H. Brawley (CA)		Donald R. Johnson (GA)		Sherry McLaughlin (TX)
	John W. Kilpatrick (GA)		Harold D. Newsome (MI)	2003	Wayne L. Kramer (NE)
	T. Oscar Fultz (GA)		James V. Smith (GA)		John L. Clarke, Jr. (IL)
	Howard R. Greenfield (CA)	1983	Richard F. Darsie (CO)	2004	Yadira N. Rangel (Venezuela)
	Paul J. Hunt (FL)		Ronald A. Ward (DC)		James W. Robinson (FL)
	William C. McDuffie (USDA)	1984	Samuel G. Breeland (FL)	2005	Major S. Dhillon (CA)
	Donald R. Johnson (GA)		Donald J. Sutherland		William H. Meredith (DE)
	Helen Sollers-Riedel (DC)	1985	John C. Kuschke (NJ)	2006	William J. Sames (WA)
1975	Lewis E. Fronk (UT)		James R. Caton (CA)	2007	Henry R. Rupp (NJ)
	Joseph G. McWilliams (USN)	1986	C. Lamar Meek (LA)	2008	Allan Inman (CA)
	Lewis J. Ogden (USPHS)	1987	John C. Combs (CA)		Manuel Lluberas (FL)
	Rajindar M. Pal (WHO)	1988	Chester G. Moore (CO)	2009	Joe Conlon (FL)
	Kenneth D. Quarterman		Margaret Parsons (OH)	2010	Norbert Becker (Germany)
	Herbert F. Schoof (USPHS)	1989	John S. Billodeaux (LA)	2011	Harry Savage (CO)
1976	Robert A. Armstrong (MA)		Edgar S. Bordes, Jr. (LA)		L.A. Williams (SC)
	Osmond P. Breland (TX)	1990	Richard D. Morton (WA)	2012	Lal S. Mian (CA)
	George B. Craig, Jr. (IN)		Lucas G. Terracina (LA)		Edsel M. Fussell (FL)
	Claude M. Gjullin (USDA)	1991	David A. Dame (FL)	2013	Kenneth J. Linthicum (FL)
	T. Wayne Miller (FL)	1992	Jerry Mix (TX)	2014	Diann Crane (MN)
1976	Donald J. Pletsch (Mexico)	1993	William E. Hazeltine (CA)		Daniel Kline (FL)
	Glenn M. Stokes (LA)	1994	Sally A. Wagner (MI)	2015	Mark Latham (FL)
	Luis M. Vargas (Mexico)	1995	Frederick W. Wagner	2016	Rui-de Xue (FL)
1978	Richard C. Axtell (NC)	1996	Donald J. Sutherland		William Reisen (CA)
1979	Marco. E. C. Giglioli (BWI)		Ronald A. Ward (MD)		
1980	James D. Gorman (FL)	1997	Roger S. Nasci (CO)		

PRESIDENTIAL CITATION

The Presidential Citation recognizes individuals not eligible to receive other awards but who are eminently deserving of special recognition by AMCA. Recipients need not be AMCA members. After 1982 the Board of Directors set a suggested maximum of no more than 2 awards per year.

1980	John M. Poché (LA)	1994	James W. Robinson (FL)	2005	Mark Newberg (IL)
	Leslie E. Fronk (UT)		Dan L. Ariaz (NV)		Susan Maggy (CA)
	Jesse B. Leslie (NJ)	1995	Sally Kuzenski (LA)	2006	Teung Chin
1981	Linda G. Raiche (CA)	1996	Carl R. Tanner (IL)	2007	Karl Malamud-Roam (CA)
	Margaret S. Slater (NY)		Sammie L. Dickson (UT)	2008	Wiliam H. Meredeth (DE)
1982	K. G. Nolan (NY)	1997	Charles T. Palmisano (LA)	2009	Rep. Dennis Cardoza (CA)
	Charles F. Scheel (IL)		George J. Wichterman (FL)	2010	Gordon Patterson (FL)
1983	Coyle E. Knowles (NY)	1998	Douglas B. Carlson (FL)		Gary Clark (FL)
1984	Ray Treichler (DC)	1999	Charles Beesley (CA)		Yasmin Rubio-Palis
1985	Lawrence T. Cowper (USAID)		Donald R. Johnson (GA)	2011	Angela Beehler (WA)
	Janice B. Wells (NY)	2000	Peter B. Ghormley (CA)		Roxanne Connelly (FL)
1986	T. Oscar Fultz (GA)		David A. Brown (CA)	2012	Truc Dever (CA)
1987	Sharon A. Colvin (IL)	2001	Donald Menard (LA)	2013	Robert Peterson (MT)
1988	Daniel D. Sprenger (TX)		Joel Margalit (Israel)	2014	Salvador Rico (TX)
1989	Fred C. Roberts (CA)	2002	Dennis Moore (FL)		
1990	Leonard E. Munsterman (IN)		Henry R. Rupp (NJ)		
1991	James D. Long (TX)	2003	James R. McNelly (NJ)		
1992	Charlie D. Morris (FL)		Robert Bonnett (MN)		
1993	Robert J. Novak (IL)	2004	James R. Brown (FL)		

JOHN N. BELKIN AWARD

The John N. Belkin Award is given for meritorious contributions to the field of mosquito systematics and/or biology and may be given to anyone judged by his peers to be worthy. Usually, a maximum of one award per year is given.

1981	Botha de Meillon (PA)
1982	Lloyd E. Rozeboom (IL)
1983	Kenneth L. Knight (NC)
1984	Thomas J. Zavortink (CA)
1985	Stanley J. Carpenter (CA)
1986	Elizabeth P. Marks & John Reid (Australia)
1987	James B. Kitzmiller (FL)
1988	Allan R Stone (MD)
1989	Pedro Galindo (Panama)
1990	Peter F. Mattingly (UK)
1991	Jose P. Duret (Argentina)
1992	Bruce A. Harrison (NC)
1993	Edward L. Peyton (DC)
1994	Theodore H. G. Aitken (CT)
1995	Oswaldo P. Forattini (Brazil)
1996	A. Ralph Barr (CA) Michael W. Service (UK)
1997	Christine J. Dahl (Sweden)
1998	Ralph E. Harbach (UK)
1999	Yiau-Min Huang (DC)
2000	Lewis T. Nielsen (UT)
2001	John F. Reinert (FL)
2002	Richard F. Darsie (FL)
2003	Richard C. Wilkerson (MD)
2004	Kazua Tanaka (Japan)
2005	Ronald A. Ward (MD)
2006	William K. Reisen (CA)
2008	Maria-Anice Sallum (Brazil)
2010	Daniel Strickman (MD)
2011	Rampa Rattanarithikul, Ph.D. (Thailand)
2012	Maureen Coetzee, Ph. D. (South Africa)
2013	John F. Anderson (CT)
2014	Graham White (FL)
2015	Elena B. Vinogradova (Russia)

MEMORIAL LECTURE HONOREE & MEMORIAL LECTURER AWARD

The Memorial Lecture Honoree must be one who has made exceptional contributions to the broad field of mosquito control during his lifetime. If there is more than one honoree in a given year, then the group must have made significant contributions as a team or equal stature in the same time frame and to the same aspect of mosquito control. The Memorial Lecturer Award is given to an outstanding speaker (one per year) to present the annual Memorial Lecture in honor of the Memorial Lecture Honoree. The Memorial Lecture Award is not limited to a member of AMCA, but the recipient should be a recognized authority in the broad field of vector control.

	HONOREE	**LECTURER**	**TOPIC**
1979	Don M. Rees	J. David Gillett	Out for blood: Flight orientation upwind & in the absence of visual clues
1980	Maurice W. Provost	Anthony W. A. Brown	What have insecticides done for us?
1981	Leland O. Howard	Leonard J. Bruce-Chwatt	Leland Ossian Howard (1857-1950) and malaria control then and now
1982	Carlos Finlay Walter Reed William Gorgas Fred Soper	William C. Reeves	A memorial to Finlay, Reed, Gorgas and Soper as major contributors to present-day concepts essential for control of mosquito-borne viruses
1983	Harry H. Stage	Michael W. Service	Biological control of mosquitoes—Has it a future?
1984	Louis L. Williams	George B. Craig, Jr.	Man-made human disease problems: Tires & La Crosse virus
1985	Thomas J. Headlee	William R. Horsfall	Mosquito abatement in a changing world
1986	Marston Bates	A. Ralph Barr	The basis of mosquito systematics
1987	William B. Herms Harold F. Gray	Robert K. Washino	
1988	John A. Mulrennan,	Susan B. McIver	Mosquitoes, medicine & memories
1989	Brian Hocking	John D. Edman	Are biting flies gourmet or gourmand?
1990	John N. Belkin	Thomas J. Zavortink	Classical taxonomy of mosquitoes—A memorial to John N.
1991	Edward S. Hathaway Anderson B. Ritter	C. Lamar Meek	Les maringouins du mech: The legacy of two men
1992	Sir Patrick Manson	Bruce F. Eldridge	The man we honor
1993	Willard V. King	Ronald A. Ward	Renaissance man of medical entomology
1994	Stanley B. Freeman	Mir S. Mulla	Now & in the future
1995	Maurice T. James	Wayne A. Rowley	Maurice T. James
1996	Telford H. Work	Charles A. Calisher	Telford H. Work—A tribute
1997	Stanley J. Carpenter	Lewis T. Nielsen	In honor of Stanley Carpenter
1998	George B. Craig, Jr.	Robert J. Novak	George Brownlee Craig
1999	A. Ralph Barr	Andrew J. Spielman	
2000	John B. Smith	Wayne J. Crans	
2001	William R. Horsfall	Jimmy K. Olson	
2002	Edward F. Knipling	Waldemar Klassen	Titan and Driving Force in Ecologically Selective Area-Wide Pest Management

MEMORIAL LECTURE HONOREE & MEMORIAL LECTURER AWARD (continued)

	HONOREE	LECTURER	TOPIC
2003	Kenneth L. Knight	Ralph E. Harbach	Mosquito systematics: From organism to molecules—A tribute to Kenneth L. Knight
2004	Donald J. Pletsch	David A. Dame	Six Decades of International Commitment
2005	William E. Hazeltine	Bruce F. Eldridge	William E. Hazeltine: Rebel with a cause
2006	William C. Reeves	Grant R. Campbell	
2007	Norman G. Gratz	Graham B. White	Remembering Norman Gratz (1925-2005) – Doyen of Vector Control
2008	Andrew Spielman	John D. Edman	
2009	Lamar Meek	Roxanne Connelly	
2010	Harold C. Chapman	Tokuo Fukuda	
2011	H.G. Dyar	Terry Klein	
2012	James D. Long	John Welch	
2013	Thomas Mulhern	Randy Gaugler	
2014	Founding Mothers of Mosquito Control	Gordon Patterson	
2015	Dr. Richard F. Darsie, Jr.	Dr. Jonathan F. Day	
2016	Oscar Fultz	Joe Conlon	

INDUSTRY AWARD

Established in 1997, the Industry Award is presented to a representative of a mosquito/vector-related industry who has through his/her efforts advanced the work of mosquito and/or vector control or research.

1997	Charles T. Galley (FL)	2007	Bob Bonnett (MN)
1998	William German (FL)	2009	Clarke Hudson (IL)
1999	Gary A. Mount (FL)		Bill Strange (ID)
	Daniel F. Boyd (GA)	2010	Peter Connelly (FL)
	David W. Waldron (GA)	2011	David Sullivan (MT)
	J. David Waldron (GA)	2012	Stephanie Whitman (WY)
2002	Robert E. Richard (TX)	2013	Larry Erickson (IL)
2003	Allen W. Wooldridge	2014	Gerry Hutney (FL)
2004	John L. Clarke, Jr. (IL)	2015	Joe Strickhouser (NC)
2005	Ernest Danka (IL)	2016	Terry Couch (FL)
2006	Willie N. Cox (IL)		

GRASSROOTS AWARD

This award is given to recognize excellent performance and dedication by mosquito control field staff.

2005	Omar S. Akbari	Reno Washoe Country, Nevada
	Christopher Trapp	Multnomah County Vector Control,
2006	John Phelps	Mercer County, New Jersey
2008	Chris Frame	Cape May County, New Jersey
2009	Jason Craig Hardman	Salt Lake City MAD, Utah
2010	Jessica Fales	Midland County MC, Michigan
	Gary Hillsdale	Metropolitan MCD, Minnesota
	Elizabeth Vice	Buttle County MVCD, California
2011	David Bruget	Kings MAD, California
	Russell Eck	Washoe County Health District, Nevada
	Phillip Henry	Butte County MVCD, California
	Levi Zahn	Williston VCD, North Dakota
2012	Mike Smith	Anastasia MCD, Florida
2013	Arturo Gutierrez	Coachella Valley MVCD, California
2013	Michael Martinez	Coachella Valley MVCD, California
2013	David Lopez	Greater Los Angeles County VCD, California
2013	Martin Serrano	Greater Los Angeles County VCD, California
2014	Dell Boyd	Butte County MVCD, California
	John McCready	Jackson County VCD, Oregon
	Gaby Perezchica-Harvey	Coachella Valley MVCD, California
	Geneva Ginn	Coachella Valley MVCD, California

GRASSROOTS AWARD (Continued)

2015	Kevin Hill
	Richard Ortiz
	Terry Sanderson
	Melissa Snelling
2016	Patrick Morgan
	Janet Nelson
	Richard Weaver

STUDENT PAPER COMPETITION AWARDS

The AMCA Student Competition was established in 1988 to recognize the outstanding student research paper presented at the annual meeting. Judging of oral presentations is based upon organization, delivery, clarity and effective use of visual aids. In 1991, a $500 cash award was presented to the winner, and in 1998 the Hollandsworth Prize was established by the family of Gerald Hollandsworth to encourage student participation in the AMCA national meeting. There is a $250 prize for honorable

1989	Scott Willis	McNeese State U.
1990	Andrea Brown	Peru State Coll.
1991	John Paul Mutebi	Notre Dame U.
1992	Rosmarie Kelly	U. Massachusetts
1993	Merry L. Holliday-	U. California, Davis
1994	John E. Gimnig	U. California, Davis
	Alice Shaeffer*	U. Mainz, Germany
1995	Glen Scoles	Notre Dame U.
	Jittawadee Rochaeroen*	U. California, Riverside
1996	Esther Chow Schaeffer	U. Maryland
1997	Lynn Cooper	U. Maryland
1998	C. Roxanne Rutledge	Louisiana State U.
	Emmalee Kennedy*	U. Illinois
	Timothy Schaub*	U. Illinois
1999	Laura Harrington	U. Massachusetts
	Adam S. Jones*	U. Massachusetts
	Hillary Reno*	U. Illinois
2000	Jason L. Rasgon	U. California, Davis
	Hope Q. Liu*	Virginia Polytechnic
2001	No competition	
2002	Laura B. Goddard	U. California, Davis
	Sharon L. Minnick*	U. California, Davis
	Margaret Sherriffs*	Yale U.
2003	Sarah Yaremych	U. Illinois
	Laura Goddard*	U. California
	Jason L. Rasgon*	U. California, Davis
2004	Gregory M. Williams	U. Delaware
	Stephen Aspen*	Colorado State U.
	Christian Kaufmann*	U. Zurich
2005	Wesley Rubio	San Diego State U.
	Whitney Qualls*	Auburn University
	Rebecca Trout*	University of Kentucky
2006	Robert D. Anderson	University of Winnipeg
	Linda O'Connor**	University of Delaware
	Joshua R. Ogawa*	Oregon State University
	Matthew Eaton*	Concordia College
	Linda M. Styer*	U. California, Davis
2007	Jennifer Armistead	University of Florida
	Robert D. Anderson*	University of Delaware
	Thomas M. Mascari*	Louisiana State U.
2008	Jerome Schleier	Montana State University
	Christopher Barker*	U. California, Davis
	Lisa Reimer*	U. California, Davis
2009	Alexandra	University of Florida
	Stephanie Larick*	University of Florida
2010	Sarah Wheeler	University of California,
	Kimmy Mains*	University of Kentucky
	Holly Tuten*	Clemson University
2011	Logan Minter	University of Kentucky
	Kristen Meckel-	San Diego County Vector
2012	Jerome Schleier	Montana State University
	Elizabeth Andrews*	University of Kentucky
	Jennifer Gordon*	University of Kentucky
	Joseph Iberg*	University of Georgia
2013	Brian Johnson	Rutgers University
	Andrea Egizi	Rutgers University
	Brittany Nelms	U. California, Davis - CVEC
2014	James Ricci**	University of California
	Eva Bickner***	University of Florida
	Allison Gardner***	U of IL Urbana - Champaign
2015		
2016		

* $500 cash award presented to winner ** Gerald Hollandsworth Prize *** Honorable mention

AMCA OFFICERS, EXECUTIVE DIRECTORS AND EDITORS

AMCA PRESIDENTS

1935-1939	Thomas J. Headlee*	1968-1969	Thomas D. Mulhern	1995-1996	John D. Edman
1939-1940	Christian T. Williams*	1969-1970	George T. Carmichael	1996-1997	Robert J. Novak
1940-1942	Louis A. Stearns*	1970-1971	Albert W. Buzicky	1997-1998	Gary G. Clark
1942-1944	Robert C. Botsford*	1971-1972	Andrew J. Rogers	1998-1999	Dan L. Ariaz
1944-1945	Robert L. Vannote	1972-1973	Glen C. Collett	1999-2000	William J. Zawicki
1945-1946	Perry W. Ruth	1973-1974	Kenneth L. Knight	2000-2001	David A. Dame
1946-1947	Harry H. Stage	1974-1975	Robert M. Altman	2001-2002	Sammie L. Dickson
1947-1949	H. Duke Peters	1975-1976	Harold C. Chapman	2002-2003	David A. Brown
1949-1950	Harold F. Gray	1976-1977	D. Bruce Francy	2003-2004	Fred W. Knapp
1950-1951	Lester W. Smith	1977-1978	Lewis T. Nielsen	2004-2005	Roger S. Nasci
1951-1952	Don M. Rees	1978-1979	Paul J. Hunt	2005-2006	William R. Opp
1952-1953	Cecil R. Twinn	1979-1980	Glen M. Stokes	2006-2007	Joseph F. Sanzone
1953-1954	Fred C. Bishopp	1980-1981	Robert K. Washino	2007-2008	Gene R. Payne
1954-1955	Roland E. Dorer	1981-1982	Claude H. Schmidt	2008-2009	Major S. Dhillon
1955-1956	Richard F. Peters	1982-1983	Richard C. Axtell	2009-2010	Doug Carlson
1956-1957	Fred L. Stutz	1983-1984	Jimmy K. Olson	2010-2011	Janet McAllister
1957-1958	Arthur W. Lindquist	1984-1985	Gilbert L. Challet	2011-2012	William H. Meredith
1958-1959	John M. Hirst	1985-1986	T. Oscar Fultz	2012-2013	Thomas R. Wilmot
1959-1960	Archie D. Hess	1986-1987	Donald J. Sutherland	2013-2014	Roxanne Connelly
1960-1961	Daniel M. Jobbins	1987-1988	George B. Craig, Jr.	2014-2015	Steve Mulligan
1961-1962	William E. Bickley	1988-1989	Bruce F. Eldridge	2015-2016	Ken Linthicum
1962-1963	Arthur W. Geib	1989-1990	Judy A. Hansen	2016-2017	Stan Cope
1963-1964	Don W. Micks	1990-1991	Robert C. Sjogren		
1964-1965	John A. Mulrennan,	1991-1992	Matthew Yates		
1965-1966	Anthony W. A. Brown	1992-1993	Cyrus R. Lesser		
1966-1967	Jay E. Graham	1993-1994	John A. Mulrennan, Jr.		
1967-1968	Harry D. Pratt	1994-1995	Chester G. Moore		

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AMCA TREASURERS

1935-1943	Thomas D. Mulhern *	1994-2000	Charles T. Palmisano
1944-1950	Thomas D. Mulhern	2000-2011	Allan D. Inman
1950-1953	Roland E. Dorer	2011-present	Gary Hatch
1954-1964	Lester W. Smith		
1965-1979	William D. Murray		
1980-1985	James R. Caton		
1985-1986	Douglas C. White		
1986-1988	C. Lamar Meek		
1989-1994	John S. Billodeaux		

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SECRETARY, EXECUTIVE SECRETARY, EXECUTIVE DIRECTOR

1935-1943	Thomas D. Mulhern*	Secretary	1986-1991	Harold C. Chapman	Executive Director
1944-1950	Thomas D. Mulhern	Secretary	1991	Lucas G. Terracina	Acting Executive Dir.
1950-1952	Thomas D. Mulhern	Executive Secretary	1992	Mark Vinsand	Executive Director
1953-1973	Theodore G. Raley	Executive Secretary	1992-1993	Harold C. Chapman	Executive Director
1973	Theodore G. Raley	Executive Director	1993-1994	Lucas G. Terracina	Acting Executive Dir.
1974-1978	Thomas D. Mulhern	Executive Director	1994-1995	Robert T. Graham	Executive Director
1979-1980	William D. Murray	Executive Director	2006-2015	Sarah B. Gazi	Executive Director
1980-1985	Thomas D. Mulhern	Executive Director	2015-2016	Lori Jensen	Executive Director
1985-1986	James R Caton	Interim Executive	2016-present	Bill Schankel	Excecutive Director

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BUSINESS MANAGER

1995-1999	Pamela D. Toups
1999-2000	Marlene Comeaux
2000-2001	Robertamarie Kiley
2001-2004	Martin. S. Chomsky
2004-2006	Sarah B. Gazi

TECHNICAL ADVISOR

2000-present	Joseph M. Conlon

EDITORS OF *JOURNAL OF AMCA***

1941	Edited by the Publications Committee, Lester W. Smith, Chair[†]
1942-1943	Edited by the Publications Committee, Ralph W. Vanderwerker, Chair[‡]
1944	Edited by the Publications Committee, J. T. Hart, Chair
1944-1948	Robert D. Glascow
1949-1973	Donald L. Collins
1973-1981	William E. Bickley
1981-1996	Ronald A. Ward
1996-1998	Robert K. Washino
1999-2003	Bruce F. Eldridge
2004-2006	Kenneth J. Linthicum
2007-	Lal S. Mian

* - *Mosquito News* became the *Journal* of AMCA in 1985

[†] - Publication of the Eastern Association of Mosquito Control Workers

[‡] - Volume 4, Number 1, was edited by the Publications Committee; subsequent volumes had a single editor

EDITORS OF *MOSQUITO SYSTEMATICS***

1969-1979	Kenneth L. Knight
1979-1992	Lewis T. Nielsen
1992-1993	Lewis T. Nielsen & Ralph E. Harbach, co-editors
1993-1995[†]	Thomas J. Zavortink, editor, & Lewis T. Nielsen, editor emeritus

* - Prior to 1973 *Mosquito Systematics* was named *Mosquito Systematics Newsletter*

[†] - In 1995 this publication was discontinued