



AMERICAN MOSQUITO CONTROL ASSOCIATION

AMCA

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**SHERATON KANSAS
CITY HOTEL
AT CROWN CENTER**

ABSTRACTS

SUBMITTED PAPERS, POSTERS
AND SYMPOSIUM PRESENTATIONS



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Oral Presentation Abstracts

Plenary Session

- PL-1 “The Species Gap” – Are we better prepared today for zoonotic threats than we were in 1999?**
Dr. Tracey McNamara, tmcnamara@westernu.edu

The goal of biosurveillance for zoonotic threats is to push the epidemiologic curve to the far left and detect impending disease outbreaks in animals before they spill over into the human population. But that assumes that all species are under surveillance and that the information is available to public health and intelligence and national security officials. That is not the case.

- Animals found in urban settings that can and have served as sentinels for biological and chemical threats currently *fall outside of the jurisdiction of any federal agency and therefore are not under federal surveillance*. The mandate of the USDA is agricultural species only.
- State wildlife agencies have little to no diagnostic capacity and their focus is on game species of economic value, not urban wildlife.
- Although dogs, cats, local wildlife handled by wildlife rehabilitators, zoo species and animals found in shelters have historically served as sentinels for known and emerging biological threats (Plague, tularemia, West Nile virus, monkeypox and most recently H3N2 in dogs and H7N2 Influenza in cats), the early warning they could have provided has been missed.
- The USG has spent a fortune on programs like Biowatch and NBIC (National Biosurveillance Integration Center) but both have failed. The private sector could help address some of the weaknesses in these systems. It is time for a Public-Private partnership for biosurveillance.
- We need a species neutral approach to biosurveillance. By focusing surveillance efforts solely on CDC and USDA mandated species, we end up using taxpayers as sentinels. This can be avoided by the incorporation of urban animals into a surveillance network that will enhance situational awareness and provide public health entities with the context they need to interpret emerging events.

- PL-2 From Chaos to Calm: Professional Mosquito Control Response to Hurricanes Harvey, Irma, and Maria. - A Panel Discussion**

Andrea Leal, district perspective; Janet McAllister, CDC perspective; Adrian Rogers, State of Florida response perspective; Whitney Qualls, State of Texas response perspective; Mark Breidenbaugh, military response perspective; Dan Markowski, contractor perspective; Jason Trumbetta, insecticide supply perspective

Exploring Innovative *Aedes aegypti* Surveillance and Control Solutions (IVCC, USAID and the Gates Foundation) Symposium I

- 1 IVCC: A global vector product development partnership**
Nick Hamon, nick.hamon@ivcc.com

IVCC is a global product development partnership investing donor funds in research and development to overcome barriers to innovation in vector control. Its purpose is to facilitate the development and delivery of novel and improved vector control tools and solutions in failed markets to combat the rapidly growing problem of insecticide resistance. The major IVCC funding partners include the Bill & Melinda Gates Foundation, USAID, Unitaid, UKaid and the Swiss Agency for Development and Cooperation. Since its formation in 2005, IVCC has worked with industry to develop a pipeline of new insecticides and other vector management solutions, primarily to support the global effort to eradicate malaria. This includes decision-making and quality assurance tools, new long lasting indoor residual sprays, new long lasting insecticidal nets, insecticides repurposed from agricultural use, novel insecticide active ingredients with new modes of action and systems for prevention of outdoor transmission. This pipeline has potential application for other arthropod-borne diseases including arboviral diseases transmitted by *Aedes* species. IVCC has a four-fold strategy for leveraging this potential: (1) direct extension of products for use against other diseases, where existing formulation and application method are appropriate; (2) extension of products to a similar but novel use, where a different application method is involved; (3) extension of products to a different use, where new formulations or delivery systems are required; and (4) extension to outdoor uses for novel insecticide active ingredients developed for indoor use. IVCC is also working with USAID on its Grand Challenge for Combating Zika and Future Threats. This involves providing structured support for the innovators carrying out proof of concept projects in order to maximize their prospects of success vs. *Aedes*, to help determine their potential for prevention of other vector-borne diseases and to identify key future technologies that merit support beyond 2018.

2 **The challenges of surveillance and control of *Aedes aegypti***

Dan Strickman, dan.strickman@gatesfoundation.org

In terms of global distribution and number of infections transmitted, *Aedes aegypti*, is without doubt the most important mosquito vector of human disease. Several aspects of its biology make it particularly well-adapted to this role, one that has evolved in a remarkably short amount of time. From our standpoint, perhaps the key feature of this species' biology is the egg. The egg is loosely attached above the water line, but, significantly, a few eggs end up on the water's surface. Like other aedines, the egg is normally in Stage II and requires a stimulation of lowering oxygen tension in order to hatch. Once embryonated, the egg is resistant to mild drying conditions and can survive for several months. It is the relative resistance of the egg that makes local elimination of this species a challenge, because excellent larval or adult control is usually overcome by the "egg bank." Recent attention to this species has come about because of dramatic increases worldwide in dengue, an appreciation for the domestic habitat caused by the global spread of *Aedes albopictus*, and most dramatically by the global pandemics of chikungunya and Zika viruses. Previous successful attempts at local elimination were successful using less advanced tools than are available now. We now have several excellent traps for monitoring based on chemical attractants that were not even recognized during earlier campaigns. Remote sensing has been used successfully to at least prioritize areas for closer examination. Genetic manipulation, a renewed interest in sterile male technique, autodissemination of pyriproxyfen, and the very recent availability of alternative active ingredients for indoor residual spraying and bed nets are all key developments. What we lack are better surveillance techniques on the ground, an ovicide to replace DDT, and standardized organizations to apply a suite of surveillance and control tools.

3 **USAID and IVCC partnering to fill *Aedes aegypti* surveillance and control gaps**

Julian Entwistle, julian.entwistle@ivcc.com

In 2016 USAID launched 'Combating Zika and Future Threats: A Grand Challenge for Development'. The \$30 million Challenge called upon the global innovator community to generate cutting-edge approaches to fight the Zika outbreak and to help strengthen the world's ability to prevent, detect, and respond to future infectious disease outbreaks. 26 projects were selected for funding from almost 900 proposals. USAID involved IVCC to provide additional support and guidance for 9 of the projects which focus on surveillance and control of *Aedes aegypti*. These are proof of concept studies in 2017 and 2018 based in the USA, Brazil, Spain, UK, Tanzania and Australia, with several of them involving further international academic and industrial partnerships. Field studies are planned or underway in Belize, Brazil, Haiti, Mexico, Puerto Rico, Tanzania and Zambia. Four projects involve spatial repellency (transfluthrin, metofluthrin and electronic-based systems), two are biorational insecticides (*Chromobacterium* and RNAi), and three are for improving surveillance through an enhanced lure or automated traps. IVCC is supporting these by a market-oriented approach, working with the projects towards defined Target Product Profiles and securing links with industrial collaborators. IVCC also provides access to expertise in research, testing, development, regulatory approval and commercialisation of surveillance and control solutions and identifies synergies with its existing portfolio of technologies and identified malaria vector control needs. This support is delivered through a structured method involving a Program Manager and Expert Scientific Advisory Committee. It involves working closely with USAID's Center for Accelerating Innovation and Impact and with the Boston Consulting Group on market studies. A set of experts on *Ae. aegypti* have been consulted over the gaps that exist in the capabilities of existing *Ae. aegypti* control programs and this has revealed the key needs for new solutions which can be matched with these projects and other relevant innovations

4 **Automatic insect recognition with optical sensors with variability of temperature and humidity**

Gustavo Batista, gbatista@icmc.usp.br, André Maletzke, Claudia Milare, Barbara Nadai, Jesse Saroli, Shailendra Singh, Juliano Corbi, Eamonn Keogh, Agenor Mafra-Neto

In recent years, we have witnessed a tremendous increase in the incidence of mosquito-borne diseases (MBD) such as the explosion of the cases of dengue fever around the world, as well as the spread of chikungunya and Zika fevers. The major commonality between these diseases is the *Aedes aegypti* mosquito as the primary vector. *Ae. aegypti* is highly adapted to urban conditions and its resilience to insecticides has made unilateral governmental mosquito control activities largely ineffective. The control of mosquito populations is only possible with the joint effort of organizations and governments and the active participation of the community in question. We propose an innovative approach for community engagement and vector control. Our idea is to produce an inexpensive, intelligent trap that will empower the population with the knowledge of *Ae. aegypti* population densities. Such a trap will make use of mobile devices to educate the community about proper mosquito control activities, as well as evaluate the effectiveness of these activities based on the number of captured mosquitoes. We have developed sensors to identify mosquitoes to the species level using artificial intelligence and machine learning techniques. We propose to use those sensors to augment traditional (mechanical) mosquito traps. These new (intelligent) traps will capture and automatically identify the species and sex of the trapped insects, providing counts of

the number of *Ae. aegypti* mosquitoes in a monitored area. In this paper, we present a comprehensive evaluation of the sensor with 16 species and four machine learning classifiers. We collected data with temperature and humidity variation for all species. We show we can recognize female *Ae. aegypti* mosquitoes with over 95% accuracy.

This work was supported in part by funding from USAID Grant No AID-OAA-F-16-00072, FAPESP Grant 2016/04986-6 and CNPq Grant 306631/2016-4.

Larval Mosquito Control I

5 **Efficacy of area-wide larvicide application targeting *Aedes aegypti* in New Orleans, LA**

Sarah Michaels, srmichaels@nola.gov, Edward Foster, Brendan Carter, Princeton King, Cynthia Harrison, Claudia Riegel

Abundant populations of the Zika virus vectors, *Aedes aegypti* and *Ae. albopictus* are found in New Orleans, Louisiana. The developmental larval stage of these mosquitoes frequently inhabit numerous man-made containers in the urban environment. Traditional ULV adulticide applications offer rapid suppression of localized mosquito populations but population resurgence remained an issue, particularly for *Aedes* species. Area-wide larvicide applications using equipment adapted from the agricultural industry, are emerging as an effective tool to rapidly cover a large geographic and suppress the mosquito population for an extended period. Field trials were conducted which evaluated the application of VectoBac® WDG (Valent Biosciences) using modified agricultural sprayers, Buffalo Turbine and Curtis Dyna-Fog Ag-Mister LV8™ Low Volume Sprayer. Field trials were conducted in March 2017 in an open field setting and in an urban, residential area. Bioassay cups were placed at 50 ft intervals from the application site, and collected following application. Once returned to the laboratory, 15 first instar larvae were added and monitored at 1 hour, 24 hours, and 48 hours post-treatment for mortality. Using the Buffalo Turbine, average larval mortality was 80-100% from 50-300 ft while LV-8 observations ranged from 0-100% over the same distance. The residential applications also demonstrated control in both open and sequestered locations (range 28.9-82.8%). Area-wide larviciding applications demonstrated sufficient efficacy to justify incorporation into operational use and part of outbreak prevention and response.

6 **Ground ULV application of Bti-based larvicide mixed with permethrin-based adulticide in a simulated urban habitat in a cool-humid environment against *Aedes aegypti* and *Aedes albopictus***

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

Application of larvicides is an important component of integrated vector management (IVM) measures against peridomestic mosquitoes such as *Aedes aegypti* and *Aedes albopictus*. However, resources available to IVM programs are typically limited, and it could be advantageous to apply larvicides and adulticides simultaneously with the objective of both knockdown and long-term suppression. We applied Vectobac 12AS (*Bti*) alone and mixed with Aqualuer 20-20 (permethrin, PBO) in a simulated urban habitat in north central Florida targeting sentinel adult *Aedes aegypti* and larvicide collection cups placed in a variety of exposed and cryptic locations using a truck mounted ULV generator. Larvicide alone had little effect on sentinel adults (as expected) or susceptible colony reared larvae of either *Aedes aegypti* or *Aedes albopictus*. Presence of adulticide marginally increased efficacy against both sentinel adults and larvae of both species, with the majority of effects only in the most exposed locations. These results underscore the difficulty of controlling these medically important peridomestic species with standard IVM measures.

7 **Heterodissemination: Targeting the larval habitat of malarial vectors with a cohabiting species carrying insect growth regulator**

Nicholas Indelicato, nindelicato@mercercounty.org, Ary Faraji, Ron Oppenheimer, Isik Unlu

Immature stages of malarial vectors can be challenging to treat with conventional larviciding methods due in part to the labor intensive nature of treating these habitats. We explored a novel approach to target larval habitats by using frogs treated with pyriproxyfen as a vehicle, transporting lethal concentrations of larvicides to shared mosquito habitats under room, large cage, and field conditions. This presentation will provide the preliminary results of this study.

8 **Insights from a first year storm drain bicycle application program**

Carter Synhorst, carter_synhorst@yahoo.com

During the spring of 2017, the Grand River Mosquito Control District (GRMCD) decided to implement the bicycle application program for treating storm drains. In the past, storm drains were treated once a year with a five month Altosid briquette. This process would take one full week of treatment for the entire valley. Each Technician would park their truck and get out to treat one or two drains and then pull forward to the next set. This year, three of our Field Technicians were trained on how to treat the storm drains from a bicycle. GRMCD purchased two bicycles for the program as well as letting the Technicians pick out individual

helmets for the job. The overall startup cost was very reasonable. By using the bicycles, the Field Technicians could treat nearly 500 drains a day, and the entire District was treated several times. Making multiple applications solved many problems that the District had faced in the past. VectoLex WSP was used for the first time with good success. The *Culex* numbers were down throughout the District, and only one mosquito pool tested positive for West Nile all summer. Using bicycles resulted in more and faster applications while providing better control of the mosquitoes.

9 Integrated management and prevention of *Aedes* and *Anopheles* mosquitoes through plant extracts along with selective chemicals and Bti

Shabab Nasir, flourenceshabab@yahoo.com

Mosquitoes act as vectors for many life threatening diseases like malaria, dengue fever, West Nile virus, Zika virus etc. Due to drug resistance in human beings in some diseases (malaria) and in some cases non availability of vaccines and proper treatment (zika virus, dengue fever, etc), the only solution is to control mosquitoes. In case of mosquito control, continuous application of synthetic insecticides develops insecticidal resistance in mosquitoes in spite of many other drasting effects on environment. So, current study was designed to manage the mosquito population under lab conditions with selective chemicals, plant extracts and Bti. For this study, mosquito larvae (*Anopheles stephensi* & *Aedes aegypti*) were collected and reared in lab. After identification, two species were reared separately in cages for bioassay. Along with selective chemicals and Bti, fifteen plants were selected for this study and their extracts were obtained through ether as solvent. Six concentrations (0.0001, 0.001, 0.01, 0.1, 1.0 and 10%) of each treatment were applied against 2nd and 3rd instar larvae separately in case of each species for screening trails. The data was collected to check knock down affect after 2, 4, 8, 16, 32, 64 and 128 hours respectively. The data was analysed through ANOVA to find out significant factors. Datura leaf, datura fruit, khor tuma, Bti and deltamethrine was screened out as significant factors. After screening experiments, different significant extracts, chemicals and Bti were tested in combination to test their efficacy. In the mixing trials, the highest (100%) mortality was observed with those solution having insecticides and Bti. The least value of LC50 (1.3-40 ppm) and LT50 (0.35-0.83hrs) was observed with solution of ether extracts, Bti and insecticides for *Anopheles* and *Aedes* larvae. *Anopheles* larvae were more susceptible than *Aedes*.

10 Development of mosquito larval emergence model using benthic macroinvertebrate communities

Dong Gun Kim, ecology@syu.ac.kr, Hwang Goo Lee, Hyun Jung Kim, Yeon Jae Bae

The mosquito is the most important taxon which affects human health and most prolific invasive species contributing to the spread of endemic or exotic diseases. To prevent infections by mosquitos, humans have been developing and using many mosquito control methods based on the physical, chemical, and biological mechanisms. Many researchers tried to anticipate mosquito populations and to estimate a model equation for the decrease of mosquito control cost and development the mosquito control efficient. Usually, they select environment factors like precipitation, moisture, and temperature as variance for explaining mosquito adult emergence. However, mosquito control methods are usually more effective when they target larva, and mosquito larva density has a close relation with biological factors, such as community index and predator population etc. Therefore, we selected community index (dominance, species diversity, richness, and evenness) and HOC-groups index (Hemiptera, Odonata, Coleoptera group diversity and richness). We found species richness and HOC-groups richness has a close relation with mosquito larva density. As the results, we assumed 19 model types using species richness and HOC-groups richness as a main factor and evaluated the suitability of those models using R-square value and Akaike Information Criterion (AIC). We choose the most suitable model and estimated the anticipating formula whose R-square value is 0.532, and AIC is 2.659.

11 Comparative efficacy of Bti, spinosad, and methoprene larvicides applied with thermal fog in a hot-humid tropical environment against *Aedes* and *Anopheles*

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

In tropical areas such as Thailand, endophilic/peridomestic mosquitoes like *Aedes aegypti* and sylvatic mosquitoes found near human communities such as *Ae. albopictus* may exploit abundant and often minute pockets of standing water for larval development. These cryptic habitats are targets for applications of larvicides in integrated vector management (IVM) programs, yet mosquito populations typically rebound quickly. We investigated the comparative efficacy of three typical larvicide active ingredients, *Bti*, spinosad, and methoprene, applied with a portable thermal fogger against colony-reared larvae of *Ae. aegypti* and *Ae. albopictus* in a small uninhabited rural settlement in a hot-humid tropical environment in eastern Thailand. We collected applied larvicide in and around several structures with varying levels of protection from the

outside environment to investigate which locations in this scenario are the most difficult to treat effectively and thus could contribute to population rebound. Results suggested that very few locations are effectively treated, and some of the highest larval mortality was observed in unexpected locations such as the rear of buildings farthest from the operator. These findings underscore the difficulty controlling these species with traditional IVM techniques.

12 Using Natular to control *Coquillettidia perturbans*, a potential bridge vector of EEE virus in the Northeast

Derek Drews, ddrews@clarke.com

Coquillettidia perturbans is a potential bridge vector of Eastern Equine Encephalitis (EEE) virus to horses and humans in the Northeastern U.S. *Cq. perturbans* larvae pierce the roots of aquatic plants, such as cattails for oxygen, making them hard to collect and control. They also spend the majority of their life cycle in the larval form and typically emerge as one or two major broods in mid to late summer. In 2016 and 2017 Natular G was applied at 10 lbs/acre by backpack applicator to Cattail Marshes in Berkshire and Norfolk County Massachusetts. Emergence traps in 2017 showed a total *Cq. perturbans* reduction of 72% the following year from a single application in each county. Applications were made in fall in Norfolk county and early spring in Berkshire County. These results indicate that Natular G applied at 10 lb/acre reduced the mid-summer brood that had not been controlled during traditional seasonal applications.

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

Agenor Mafra-Neto, president@iscatech.com, Teun Dekker, Rodrigo Silva, Jesse Saroli, Leonard Mboera, Elison Elieza

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 *Culex* 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 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. sphaericus* (*Bti* and *Bs*) or methoprene. For example, dose-mortality analysis of mosquito larvae demonstrated that a single SPLAT BAC dollop 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.

Legislative and Regulatory Symposium I

14 Introduction to the legislative and regulatory symposium

Angela Beehler, angela@mosquitocontrol.org

In 2016 there was a flurry of activity on Capital Hill as Congress reacted to the looming Zika crisis. Vector control and public health officials banded together to educate lawmakers on the current capacity of mosquito and vector control in the United States and what is needed to conduct timely surveillance and control of emerging vector-borne diseases. The legislative and regulatory sessions will explore how the Zika supplemental funding is being spent, what we've learned about vector control capacity, and what is being done to maintain and improve our road to success in protecting public health.

Mosquito control programs must be aware of and follow the laws and regulations behind their operation. The AMCA has amazing resources and people to help you navigate the regulatory world. These sessions will provide an introduction to many of the exciting topics to be discussed during the AMCA Annual Meeting such as the CDC's Regional Centers of Excellence, unmanned aircraft, genetically modified mosquitoes, pollinator protections. Come see us and let us know how we can help you.

15 A tale of 3 competencies: Mosquito surveillance and control capabilities across the United States and its legislative implications

Oscar Alleyne, oalleyne@naccho.org, Chelsea Gridley-Smith

Mosquito-borne diseases are an ongoing public health concern in the United States. In 2016 alone, mosquitoes caused over 2,000 cases of endemic West Nile Virus (WNV) and 224 cases of emerging Zika virus (ZIKV). Controlling the spread of vector-borne diseases (e.g., WNV, ZIKV) is the responsibility of a

variety of departments across the country, including local health departments, yet little data exists on these departments' level of preparedness.

The National Association of County and City Health Officials (NACCHO), in partnership with the Centers for Disease Control, developed and distributed an electronic survey to assess mosquito surveillance and control capacity among almost 2,000 local vector control programs nationwide. The responses were scored, quantitatively, by evidence-based activities essential to a competent vector control program. Using this criteria, the nearly 1,100 respondents (57% response rate) ranked 8% "Fully Capable," 4% "Competent," and 84% "Needs Improvement." Of the vector control programs ranked as "Needs Improvement," all of them lack the capability or capacity to perform pesticide resistance testing and more than half lack competency in performing routine surveillance and species identification.

This assessment gathers previously unavailable baseline data on local mosquito surveillance and control in the United States. A majority of local departments reported significant gaps in programmatic activities, indicating significant susceptibility to mosquito-borne diseases like WNV and ZIKV. By identifying these gaps, this assessment enables local, state, and federal agencies and their partners to prioritize and develop targeted approaches, regulatory and legislative solutions for improving vector control programs. Local vector control programs need quality and ongoing staff training, enhanced partner engagement, and resources to support essential mosquito surveillance and control activities.

16 Public health confronts the mosquito: Developing sustainable state and local mosquito control programs

Chester Moore, Culex.tarsalis@comcast.net

Manuals originally developed by the Association of State and Territorial Public Health Officials (ASTHO) for West Nile virus have been revised and expanded to cover mosquito control and vector-borne disease in the era of chikungunya and Zika viruses. In addition to revised sections on biology and public relations, several appendices have been added that provide information on state regulations governing vector control districts, types of trapping and sampling equipment, and several other useful types of information. These newly revised manuals provide a helpful resource for communities seeking to develop vector control programs, or to improve or expand existing programs

17 The Gateway - web-based data management for surveillance and pesticide usage

Christopher Barker, cmbarker@ucdavis.edu, Jody Simpson

The California Vectorborne Disease Surveillance Gateway is a web-based system for storage, exchange, and analysis of data on mosquito surveillance and control. Since its inception more than a decade ago to address needs related to West Nile virus, the Gateway has expanded to include modules for pesticide usage, pesticide resistance, and invasive *Aedes*. This presentation will cover the growing list of tools available in the Gateway, including maps and GIS functions, risk calculators, and new ways to link data on surveillance and control.

18 Regulation of genetically modified mosquito trial in the Florida Keys

Andrea Leal, aleal@keysmosquito.org

Since 2010, the Florida Keys Mosquito Control District (FKMCD) has worked closely with Oxitec to perform an efficacy trial of the release of genetically modified male mosquitoes in the control of *Aedes aegypti*. Because this is the first trial in the United States, the regulatory process has been long and arduous. In August of 2016, the Food and Drug Administration granted a Final Notice of No Significant Impact which allows FKMCD and Oxitec to move forward with the trial process. Despite this notice, there are multiple complicating factors that have continued the delay of this trial.

19 Unmanned Aerial Systems (UAS) in mosquito and vector control: A regulatory overview

Joel Buettner, joelb@placermosquito.org

Unmanned Aerial Systems (UAS), otherwise known as "drones", are currently experiencing a technological, cultural, and regulatory boom. With the promulgation of commercial UAS regulations from the FAA in August 2016, the commercial UAS industry has taken off, and in this new market, opportunities and pitfalls abound. While there is clear potential for UAS technology to benefit mosquito and vector control operations, the regulatory pathway to safely and effectively explore and eventually integrate UAS into a mosquito control program is still somewhat fluid. I will provide a brief history of UAS regulations as they pertain to mosquito control and discuss opportunities and challenges that mosquito and vector control agencies may confront should they decide to bring UAS into their operations.

20 Pollinator Protections and Pesticide Labels

John Paige, john.paige@bayer.com, Jan Brill, Frank Wong

Protection of pollinators during mosquito control efforts is an increasing area of public concern. A number of pesticides used to control mosquitos do have activity against beneficial insects including honey bees and other pollinators, but successful mitigation of risks can be accomplished by adhering to label directions and following industry best management practices. There is limited research to show any negative effects of larvicide and adulticide applications on managed honey bee hives, but federal regulatory activity examining the impact of pesticides on honey bees, and a recent controversial incident implicating mosquito applications for the loss of a number of hives in South Carolina, have highlighted the need to review pollinator protections in place. This session will provide a brief overview of the potential impact of products on pollinators, the current risk pollinator assessments being conducted for pesticides, review current pesticide label directions and recommendations for the protection of pollinators, and highlight the latest research that is guiding industry best management practices.

Student Competition Symposium I

21 The 29th Annual Student Paper Competition of the American Mosquito Control Association

Brian Byrd, bdbyrdd@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.

22 Plant oils as future enhancers for the control of insecticide-susceptible and insecticide-resistant strains of mosquitoes

Edmund Norris, ejnorriss@iastate.edu, Maria Archevald-Cansobre, Aaron Gross, Lyric Bartholomay, Joel Coats

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 with various essential oils in order to enhance the efficacy of these insecticidal mixtures. New evidence demonstrating these oils are capable inhibiting various detoxification enzymes suggests that these plant essential oils may act as insecticidal synergists in future insecticidal formulations used for the control of mosquitoes.

23 Death by cattle: Zooprophyllaxis and endectocide efficacy in the control of *Anopheles* mosquitoes

Annie Rich, aerich@uga.edu, Nancy Hinkle, Seth Irish

Insecticidal zooprophyllaxis holds promise in rural agricultural communities impacted by malaria. This study utilized LongRange eprinomectin, and mosquitoes were fed in the lab (preliminary) and on cattle post-injection (field). Mortality was observed post-feeding and mosquitoes fed on-host were also observed for fertility. Mosquitoes fed on lab-treated blood had an approximate LC_{50} of 0.0125 μ L LR/mL blood. Mosquitoes fed on single and double dose-treated animals did not have mortality significantly different from those fed on control.

24 Can sub-lethal exposure to spatial repellents affect mosquito fecundity or oviposition behavior?

Christopher Bibbs, cbibbsamcd@bellsouth.net, Daniel Hahn, Phillip Kaufman, Rui-de Xue

Volatile pyrethroid compounds, commercially dubbed "spatial repellents," are tools available to and frequently used by public consumers for protection against mosquitoes. Substantial exposures to volatile pyrethroids can kill mosquitoes, but even sub-lethal exposures may be beneficial for mosquito management if these it affects mosquito fitness. If damage occurs to fitness or behavior, we can expand spatial repellents to broader public health strategies. The fecundity and behavioral results of preliminary sub-lethal exposure assays are reported here.

25 Insecticide resistance survey of *Stegomyia* mosquito species throughout Texas jurisdictions

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

Insecticide resistance surveillance as part of an integrated approach to vector control is often neglected due to resource and personnel limitations of mosquito control entities. Insecticide resistance surveillance is essential for validating, or improving currently applied vector control strategies. Insecticide resistance assays were performed on *Aedes aegypti* and *Aedes albopictus* mosquitoes to determine susceptibility levels in populations throughout Texas jurisdictions. This study provides crucial information to mosquito control entities without insecticide resistance surveillance capabilities.

26 Improving the CDC light trap

Thomas Hempy, tjhempy@ksu.edu, Elin Maki, Dustin Swanson, Lee Cohnstaedt

The CDC light trap is a common mosquito monitoring tool, however only a small percentage of insects attracted to the trap are collected. This study evaluated methods to increase trap capture, while maximizing the preservation of the collected specimens. Insect damage and collection efficiency were quantified at fan blade speeds generating suction of 4 and 8 m/s. Increased suction was accomplished with minimal trap modifications and the impact of airflow obstructions on suction were discussed.

27 The effects of larval exposure to pesticides on the adult male reproductive system of *Culex quinquefasciatus*

Shiloh Judd, sjudd1@lsu.edu, Shiloh Judd, Kristen Healy

Larvae of *Culex quinquefasciatus* were exposed to sub-lethal doses of three different larvicides to determine the effects of this exposure on the adult male reproductive system. Both wild and lab reared mosquitoes were dissected at different ages (in days: 1, 4, 7, and 14) and total sperm counts were estimated. Lab reared mosquitoes had higher control sperm counts, but were more affected by the pesticide exposure than their wild counterparts, Spinosad having the greatest effect.

28 The effects of temperature extremes and fluctuations on the invasive mosquito *Aedes albopictus*

Madeleine Chura, mchura@agcenter.lsu.edu, Madeleine Chura, Kristen Healy, Rodrigo Diaz

The objective of this research was to examine how field-based environmental conditions may affect the phenology and distribution of *Ae. albopictus* in the United States. Populations from a southern and a northern location in the U.S. were examined for both cold and heat tolerance. Southern *Ae. albopictus* were exposed to fluctuating extreme temperatures both in the lab and field to determine how development may differ from constant temperatures often used in laboratory experiments.

Exploring innovative *Aedes aegypti* surveillance and control solutions (IVCC, USAID and the Gates Foundation) Symposium II

29 VectorWEB: A network of connected smart mosquito traps

Margaret Glancey, mglancey@jhu.edu, Kimberly Ashman, Teja Maruvada, Wm. Patterson, Laura Scavo, Tristan Ford, Adam Goodwin, Jewell Brey, Collyn Heier, Soumyadipta Acharya, Collyn Heier

Aedes aegypti mosquitoes are responsible for transmitting many of the world's infectious diseases associated with extremely high morbidity and mortality, including dengue, chikungunya, yellow fever and Zika. Surveillance of these vectors could improve preparation for and prevention of large disease outbreaks and inform the general public of disease risk. Unfortunately surveillance is often not done consistently due to the high cost and human labor demands. In order to address this, we have created a novel device that automatically counts and identifies mosquitoes caught in a trap. This information is then sent to a central platform where data is collected, analyzed, and mapped. The data can be accessed by health systems to monitor mosquito data in real-time, as well as individual citizens through an SMS or app based system. In addition to mosquito density, data about the device maintenance and functionality is collected and sent to reduce the human resources required to regularly check traps. Currently, this technology is being designed to work with existing manufactured mosquito traps.

30 Lure and kill yeast interfering RNA larvicides

Molly Duman Scheel, mscheel@nd.edu, Limb Hapairai, Keshava Mysore, Yingying Chen, Alexandra Lesnik, Na Wei, Nicole Achée, John Grieco, David Severson

New mosquito control strategies are vitally needed to address established arthropod-borne infectious diseases such as dengue and yellow fever and emerging diseases such as Zika and chikungunya, all of which are transmitted by *Aedes aegypti*. *Saccharomyces cerevisiae* (baker's yeast) was engineered to produce short hairpin RNAs (shRNAs) corresponding to several genetic targets identified in a recent screen for *Ae. aegypti* larval lethal genes. Feeding *Ae. aegypti* with the engineered yeasts resulted in silenced target gene expression, disrupted development, and highly significant larval mortality. Larvicidal activities were retained following heat inactivation and drying of the yeast into tabular formulations that induced >90% mortality in laboratory trials. Results from lab trials also demonstrated that dried inactivated yeast interfering RNA tablets attract adult females to oviposit. Initial results from ongoing semi-field yeast interfering RNA larvicide trials are encouraging. Ready-to-use inactivated yeast interfering RNA tablets may one day facilitate the seamless integration of this new class of biorational lure-and-kill species-specific mosquito larvicides into integrated *Ae. aegypti* control programs.

31 Spatial repellents and attractants for personal and community protection

Jason Richardson, jason.richardson@ivcc.com

The global mosquito repellent market is currently valued at more than 3 billion dollars per year and is predicted to reach 5 billion by 2022. This begs the question, can vector control programs leverage this product class to protect the public? It is well established that personal protection products can effectively protect an individual but it is harder to assess the potential community benefits of these products. There is a need to identify both priority technologies and tools that could significantly reduce mosquito biting rate as well as delivery and implementation solutions that could achieve the required coverage rates to achieve community protection from personal protection products. Products such as the volatile pyrethroids, often referred to as spatial repellents, can also be adulticidal and lure and kill products such as attractive sugar baits also offer promise as novel adulticide delivery systems. The presenter will provide an overview of various development efforts on this front and discuss key challenges associated with making the leap from individual to community protection.

32 A human scent mimic to trap Zika mosquitoes

Conor McMeniman, cmcmeni1@jhu.edu

The primary vector of Zika virus, *Aedes aegypti*, is a highly anthropophilic mosquito species that blood feeds preferentially and frequently on humans. To orient towards us, *Ae. aegypti* is largely thought to rely on its exquisitely tuned sense of smell to pick up on volatile chemicals emanating from our skin and breath. We are currently applying thermal desorption-gas chromatography/mass spectrometry coupled with two-photon imaging in olfactory centers of the mosquito brain to identify the signature components of human scent that attract *Ae. aegypti* towards humans. Guided by this information, we are developing a human scent mimic lure that we envisage will be a powerful applied tool to improve both vector surveillance and control measures to combat Zika and other vector-borne diseases.

33 An affordable, low technology hessian fabric emanator that releases transfluthrin vapour to protect against outdoor-biting *Aedes aegypti* in coastal Tanzania.

Nicodem Govella, govella@ihi.or.tz, Alphonse Assenga, Gerry Killeen

Background: Although emanator products for protecting people against outdoor mosquito bites, by releasing vapour-phase insecticides and repellents, do exist they are too short-lived, expensive and impractical for continuous use in low-income settings. A novel simple, affordable low-technology emanator for delivering transfluthrin vapour, made of treated hessian fabric strips, recently proven highly protective against night-biting *Anopheles*, *Culex*, and *Mansonia* mosquitoes for up to a year, so here this device is evaluated against day-biting *Aedes aegypti*, the most important vector of Dengue, Chikungunya and Zika globally.

Methodology: The effects of the 2ml transfluthrin-treated hessian fabric emanator upon *Aedes aegypti* biting exposure experienced by users and nearby non-users at varying distance, were evaluated outdoors in urban Dar es Salaam, coastal Tanzania, using Mosquito Electrocuting Traps (METs)

Findings: Hessian fabric treated with transfluthrin provided 84% protection against wild population of *Aedes aegypti* at temperatures $\geq 22^\circ\text{C}$, but not below this temperature. Use of treated emanators did not significantly increase or decrease the exposure rates of nearby non-users between 2 and 25m away.

Conclusion: With such high protective efficacy at permissive temperatures, this device may be useful for protecting against arboviruses transmitted by day-biting *Aedes* mosquitoes.

34 Repelling vector mosquitoes with electric fields

Farooq Tanveer, farooq.tanveer@biogents.com, Andreas Rose, Elies Molins, Krijn Paaijmans

An electric field is formed between two electrically charged conductors (electrodes). The strength of the electric field depends on the electric potential difference (voltage) and the distance between the electrodes. To observe the effects of electric fields on mosquitoes, we performed experiments in which two cube-shaped plastic insect cages (Bug Dorm-1 Insect Rearing Cage) were fixed at the two sides of a glass tunnel. Parallel plate electrodes were positioned in the middle of the glass tunnel and were connected to an adjustable high voltage source, with which a wide range of strong electric fields could be generated between the electrodes.

During the experiments, hungry female mosquitoes (*Aedes aegypti*) were released in cage1. A test person then introduced his hand into cage2, while a ventilator produced a gentle air flow through the glass tunnel in the direction of the mosquitoes in cage1.

Mosquitoes lured into the direction of the hand had to pass through the electric fields between the plates. It was observed that electric field of strength 1 kilovolt per centimeter (1kV/cm) prevented mosquitoes from

passing through. As the field strength decreased, more and more mosquitoes passed through the barrier. When the electric field was turned off, mosquitoes passed freely.

These results demonstrate that strong electric fields can be used to effectively repel mosquitoes. Additional work in this project includes the study of the potential of electric fields to protect human habitations and out-door resting places or enclosures against mosquitoes.

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Larval Mosquito Control II/Adult Control I

35 **Control of *Aedes aegypti* using portable ULV and thermal fog sprayers in a hot-arid environment**

Robert Aldridge, robert.aldridge@ars.usda.gov, Frances Golden, Seth Britch, Melissa Snelling, Arturo Gutierrez, Kim Hung, Jennifer Henke, Jeremy Wittie, Kenneth Linthicum

Aedes aegypti is the key vector of Zika, dengue, and chikungunya viruses. The recent encroachment of *Aedes aegypti* into hot-arid regions of southern California has proven difficult for operators to control. Larval populations of *Ae. aegypti* are potentially easier to target due to their aquatic nature and confined development. However, the very large number of artificial and natural containers that may be exploited in peridomestic habitat, coupled with the tendency of this species to skip oviposit can render control methods such as source reduction ineffective. We treated sentinel containers targeting larval and adult mosquitoes placed in open and protected locations with larvicides and/or adulticides using portable ULV and thermal fog sprayers in a natural hot-arid desert area in southern California. The sentinel larval containers were returned to the laboratory for the introduction of water and *Ae. aegypti* larvae. Efficacy was measured by the number of adult mosquitoes that emerged from treated cups, or that died in the sentinel cages. We discuss our results in the context of control of this species in southern California and the Southwestern US.

36 **Updates on the production process of the mosquito larval predator *Toxorhynchites rutilus* for use in releases in Harris County, TX**

Anita Schiller, aschiller@hcp4.net, Mary Allen

Since 2013, the Harris County Precinct 4 (Mosquito) Biological Control Initiative called DRAC/MAP has worked to evaluate and develop rearing methods for the Eastern U.S. native mosquito assassin, *Toxorhynchites rutilus septentrionalis* (*Tox. rutilus*) for its use in augmentative releases as part of an Integrated Mosquito Management approach against peri-domestic *Aedes aegypti* and *Aedes albopictus*. We tried utilizing rearing methods shared by colleagues and other researchers and although adhering to their protocols the team was unable to achieve the desired adult production numbers. By thinking outside of the proverbial box and using selective breeding techniques to tame the fickle *Tox. rutilus* behavior, we've managed, thus far to keep this domestic phenotype for over 100 generations and in colonies of up to 800 animals per cage. Despite three major floods between April 2016 and August 2017, of which two resulted in catastrophic losses to the DRAC/MAP lab, we produced enough *Tox. rutilus* adults to conduct release efficacy studies in down town Houston, sites selected by Harris County Mosquito and Vector Control Division for their high *Ae. aegypti* burden and three sites in Precinct 4 high in *Ae. albopictus*, *Ae. aegypti* and *Ae. triseriatus*. The 2017 release study, colony maintenance and the select breeding project required approximately 800-900 *Tox. rutilus* adults per week, plus their various prey cultures of live nematodes and mosquito larvae. In working with Purina Mills Nutrition Labs, a promising artificial diet is in development which aims to replace the need for culturing live prey to feed the larval predator and possibly serve as its sole larval diet. With this presentation, we wish to share the past and present trials, tribulations and successes of the Harris County Precinct 4 native mosquito assassin rearing program.

37 **Impact of *Tolypocladium cylindrosporum* (Hypocreales: Ophiocordycipitaceae) on eggs of *Aedes aegypti* and *Aedes albopictus* at low temperature**

Lina Flor-Weiler, lina.weiler@ars.usda.gov, Alejandro Rooney, Robert Behle, Ephantus Muturi

We examined the potential of *Tolypocladium cylindrosporum* IBT 41712 to infect eggs of *Aedes aegypti* Linnaeus and *Aedes albopictus* (Skuse) mosquitoes at low temperature (15°C). To determine the optimum temperature for the fungus, we cultured the fungus at eight temperatures (4, 12, 15, 21, 28, 33, 37 and 40 °C) and measured the diametric growth. The optimum temperature for growth was 28°C since it had the highest diametric growth rate (2.1 ± 0.05 mm/day) and the fastest sporulation period (within 8-10 days of incubation). There was no fungal growth at the three highest temperatures (33, 37 and 40°C) but plates incubated at 33°C when shifted to optimal temperature (28°C) showed visible growth indicating that incubation at 33°C, the fungus remained viable. IBT 41712 successfully infected mosquito eggs at 15°C. Fungal treatment induced egg hatch on moist seed germination paper and this effect was more pronounced in *Ae. aegypti* compared to *Ae. albopictus*. When treated eggs were immersed in dH₂O 21 days post treatment, larval hatch of both *Ae. aegypti* (control = 91%, 1×10^7 conidia/mL, fungal treatment = 0%)

and *Ae. albopictus* (control = 85%, fungal treatment = 28%) was significantly lower in fungal treatment compared to the controls. The ability of the strain to grow in a wide temperature range, and effectively infect mosquito eggs and induce egg hatch at low temperature warrants further investigation for its potential as a mosquito control agent targeting eggs that overwinter or undergo long diapause.

38 Eave Tubes: A novel malaria mosquito control tool – field results from Tanzania, Kenya & Ivory Coast

Marit Farenhorst, marit@in2care.org

House improvement shows great potential to complement contemporary chemical-based malaria vector control methods and may further reduce indoor mosquito biting and disease transmission. Open eaves serve as important mosquito house entry points and provide a suitable location for intercepting host-seeking anophelines. Eave Tubes are a new malaria control product that block mosquitoes from entering the house and effectively kill them with special insecticide-laced netting. The product comprises wall tubes removable gauze inserts that are placed in the wall under the roof of houses where they attract malaria mosquitoes at night, block them from entering the house, and contaminate them with a lethal dose of insecticide.

Eave Tubes have been scientifically tested in Tanzania and Kenya by the Ifakara Health Institute and the International Centre of Insect Physiology and Ecology. Experiments included semi-field and open field evaluations of Eave Tube attraction and mosquitocidal impacts when installed in various local style brick and plastered house constructions. The screenhouse studies comprised release-recapture tests with cohorts of *Anopheles gambiae* s.s. and *Anopheles arabiensis*.

Eave Tubes are also currently being validated in Ivory Coast via a large-scale Randomized Control Trial in 40 villages, in collaboration with Penn State University, London School of Hygiene and Tropical Medicine and Institut Pierre Richet. This study was designed based on WHO VCAG recommendations and is focused on measuring impacts on malaria incidence. It also includes entomological monitoring and social science studies to assess Eave Tube user acceptability.

Implementation results show that Eave Tubes can be successfully deployed in remote rural areas and that they are suitable for installation in the majority of African house styles, and acceptable to local communities. Research in Tanzania proved that window screening and installation of Eave Tubes reduces the number of indoor mosquitoes by up to 90%. In2Care's patented charged netting technology deployed in this product was shown to successfully kill even insecticide-resistant malaria vectors. Semi-field results from Kenya showed that open Eave Tubes were a highly attractive route of entry for anophelines. When tubes were fitted with bendiocarb- or deltamethrin-treated inserts, we observed significant reductions in recapture rates, which demonstrates high mosquitocidal efficacy in only a single night. We will also present the latest results from the ongoing RCT in Ivory Coast, including entomological and epidemiological impacts, as well as social science study outcomes

39 Evaluation of the "CreeLog" for control of larval *Culex quinquefasciatus* in organically enhanced aquatic habitats

James Cilek, james.e.cilek.civ@mail.mil

On forward operating bases sewage lagoons or urine soakage pits are often constructed to deal with human waste disposal. The water in these areas is highly organic and often referred to as black water. Local weather patterns, soil composition, or improper maintenance of human waste disposal areas can make black water sources considerably attractive for the development of many mosquito disease vectors, including *Culex quinquefasciatus*. I will report on the effectiveness of a novel commercially available silicone formulation impregnated in a bentonite clay matrix extruded in a sawdust binder ("CreeLog") against larval *Culex quinquefasciatus* in organically enhanced habitats (black water). (The views expressed in this abstract are those of the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, or the US Government.)

40 Public Distribution of *Gambusia holbrooki* for peridomestic mosquito control in Hillsborough County, FL

Ron Montgomery, Montgomeryr@HCFLGOV.Net

Mosquito Fish have long been used in Florida to provide a biological control alternative in intermittent swamp and pond habitats. With the arrival of Zika virus into Hillsborough County in 2016, a modified strategy was developed with the goal of distributing mosquito fish directly to the public for use in backyard habitats. This presentation will cover the development of a mosquito fish holding facility, delivery system, and messaging campaign to help mitigate peridomestic mosquito production in Hillsborough County, Florida.

41 Preventing mosquito-borne diseases: A multi-modal approach

Robert Wirtz, PhD, rwirtz@bellsouth.net

The world's most dangerous animals are not the Big Five from Africa, as many would suppose, but mosquitoes, other arthropods and the many diseases they transmit to human and animals worldwide. The most effective approach to limiting the morbidity and mortality of mosquito-borne diseases has been a multi-modal approach capitalizing on the concurrent use of all available tools, to include focal mosquito control and drugs. The U.S. President's Malaria Initiative will be described as a model program demonstrating the success of a multi-modal approach for a mosquito-borne disease.

The President's Malaria Initiative was launched in 2005 as a five year program to reduce malaria-related mortality by 50% across 15 high-burden sub-Saharan African countries. The program relied on the rapid scale-up of four proven and highly effective malaria prevention and treatment measures: insecticide-treated bed nets (later long lasting nets), indoor residual spraying, accurate diagnosis and prompt treatment with artemisinin-based combination therapies and intermittent preventive treatment for pregnant women. From 2005-2015, the PMI and other international programs were responsible for reducing the infection prevalence of *Plasmodium falciparum* in endemic Africa by 50% and reducing the incidence of clinical disease by 40%. An estimated 660 million clinical cases have been averted since 2000, and approximately six million deaths among children under five years of age prevented.

Dengue, chikungunya, Zika and other arthropod-borne viruses are emerging or reemerging worldwide. A brief summary of these diseases will be given, with a focus on the emergence of Zika in the Americas and the need for a multi-modal approach for control.

References:

Bhatt, S. et al. (2015) The effect of malaria control on *Plasmodium falciparum* in Africa between 2000 and 2015. Nature 526: 207-212 doi:10.1038/nature15535

President's Malaria Initiative website: <https://pmi.gov>

CDC Zika website: <https://www.cdc.gov/zika>

42 How implementing a multi-modal approach to fight the spread of heartworm disease in dogs can help mosquito abatement professionals achieve their goals for controlling mosquitoes and the diseases they may spread in their communities

I. Craig Prior, [email needed](#)

This presentation will provide background on the prevalence and on treatment of heartworm infection. New among our control strategies is the mitigation of heartworm transmission by preventing mosquito feeding on dogs. Canine Heartworm Disease is one of the most common and serious vector borne diseases of dogs in the US, with over 118,000 cases reported in 2016, up over 10,000 cases from the year before and continuing to rise when looking at the 2017 forecast, according to the Companion Animal Parasite Council. Macrocytic lactones are the class of drug used to prevent infective L3's (larval stage) from becoming adults, and are one of the most common class of drugs used in veterinary medicine. Unfortunately, the battle is being lost, and recent research provides evidence that veterinarians need to combine vector control with macrocytic lactones to try to slow down the increase. Important new research data indicate that treatment of dogs with available products containing dinotefuran, pyriproxyfen and permethrin can prevent both uptake of microfilaria by mosquitoes and subsequent transmission of infective larvae. This strategy also helps prevent infection with resistant heartworms. Mosquito forecasting appears to be a long way off, but can the success of mosquito abatement programs for humans be confirmed by CAPC heartworm prevalence maps and heartworm forecasts?

Legislative & Regulatory Symposium II

44 AMCA's 20th annual Washington Day Conference

Stanton Cope, secope29@gmail.com

Washington Day (WD) is AMCA's premier legislative/regulatory event of the year. It normally occurs in May, with about 100 attendees from about 22 states. This presentation will cover all major aspects of WD for 2018, including logistics, past successes, issue papers, how attendees are educated and prepared to meet with Capitol Hill staff, travel stipends, and much more!

45 Update on U.S. Fish and Wildlife Service's guidance for mosquito control on National Wildlife Refuges

William Meredith, William.Meredith@state.de.us

For several years the U.S. Fish and Wildlife Service has been working on producing a "Handbook for Mosquito Management on National Wildlife Refuges," which when done will serve as a guidance document for Refuge Managers. The Service unveiled in April, 2017 to a small workgroup of AMCA representatives a draft of its proposed Handbook, and from the standpoint of those mosquito control programs that have to

work on NWRs it was a greatly improved product over earlier versions of Service draft policies or guidance documents that attempted to address these matters. The AMCA workgroup met with the Service in May, 2017 to discuss the pros-and-cons of the draft Handbook, and followed up with a written set of comments and recommendations to the Service to try to make the Handbook even better. There were 3 primary issues needing further attention: 1) the need to accommodate mosquito control on-refuge to also deal with non-pathogenic public health risks/threats caused by excessive numbers of mosquito bites per se, sans any disease pathogen transmissions, which can also adversely affect human health having medical complications; 2) the need to better accommodate where warranted some limited, judicious adulticiding practices on-refuge in practicable, efficacious manner; and 3) for mosquito control programs working on-refuge not to have to undertake any studies of non-target impacts or other environmental effects of mosquitocide use (as the draft document proposed) unless a program might voluntarily want to perform or participate in such studies. Several other more minor matters were also addressed via the AMCA's input along with some editorial changes. At time of abstract submission in September 2017, the Service was considering how to address the AMCA's written input, to then hopefully satisfactorily incorporate it into a final version of the Handbook. A status update of where things now stand will be presented.

46 Status of updating Florida's White Paper on Mosquito Control

Doug Carlson, Doug.Carlson@irmosquito2.org, Aaron Lloyd, Roxanne Connelly

At the request of the Environmental Protection Agency, in 1998 the Florida mosquito control community developed a "white paper" on mosquito control. The intent of this document was to help define the state of mosquito control in Florida with the goal of developing recommendations on how chemical use and risk could be reduced. Given changes in the mosquito control profession during the 2000s, a first revision of the Florida White Paper was published in 2009 and during 2017-18, a 2nd revision has been under development. This presentation will describe the process for updating this document which has proven to be a valuable reference over the past 20 years.

47 Best management practices for integrated mosquito management – A U.S. update

Isik Unlu, iunlu@mercercounty.org, William Schankel

This presentation will provide a comprehensive update on the Best Management Practices for Integrated Mosquito Management in the United States. AMCA was selected as the sole contractor, through federal funding by the CDC, to establish training and certification programs for mosquito surveillance, control, and prevention. This presentation will delve into the strategy of updating the 2009 Best Management Practices for Integrated Mosquito Management manual as well as developing a comprehensive learning platform consisting of three separate learning tracks for all audience levels. We will explore our advisory board approach, successes and "lessons learned" in conducting Train-the-Trainer events across specific HUBs as well as introduce our professional eLearning modules that cover such topics as an overview of understanding and controlling the Zika virus. While these comprehensive educational venues set the foundation for integrated mosquito management, more work and funding is still needed to effectively train the vector control community.

48 AMCA-CDC Train the Trainer Program: An overview

Christopher Gregory, hgk4@cdc.gov, Janet McAllister

In order to strengthen and coordinate a system of successful mosquito control across the United States, a comprehensive, integrated approach that includes multiple tools aimed at reducing both larval and adult mosquitoes should be used in all programs. While decisions about which methods to apply remains with state and local authorities, the Centers for Disease Control and Prevention selected the American Mosquito Control Association for federal funding to create and provide a program to help those same authorities update and maintain the education and best practices for vector recognition, surveillance, and control. The contract is titled "Establishment of Training and Certificate Program for Mosquito Surveillance and Control." Under it, AMCA will develop and deploy a targeted mosquito surveillance and control training program for states and protectorates responsible for conducting mosquito control. Dr. Christopher Gregory, branch chief of the CDC's Arboviral Diseases Branch in the Division of Vector-Borne Diseases will review the role CDC envisions for this "Train the Trainer" program as a key component of its comprehensive strategy for supporting nation-wide vector surveillance and control in the U.S.

49 AMCA's CWA and NPDES legislation efforts

Gary Goodman, gwgoodman@fightthebite.net

The Clean Water Act (CWA) and National Pollutant Discharge Elimination System (NPDES) permits have been a major focus of the AMCA's Legislative and Regulatory Committee for nearly 20 years. The NPDES permit renewal in 2016 with no significant or substantial changes shows that the energies of AMCA members in educating our lawmakers on the impacts to public health are proving to be effective. However, the future of the permit may be impacted by the pending Waters of the U.S. definition currently being

reviewed. This discussion will focus on the history of the AMCA's efforts to date, explanation on the AMCA's progress, and provide direction for the association moving forward.

50 AMCA's federal funding initiatives

Gary Goodman, gwgoodman@fightthebite.net

The AMCA has been extremely active in trying to educate and convince the federal government to fund mosquito and vector control initiatives. Relationships with the Centers for Disease Control and Prevention, State Health Departments, and local districts is critical in presenting the case for building a comprehensive vector control network including the need for operational research, continuing education, and enhanced surveillance for vector borne disease. This discussion will focus on the AMCA's role in establishing and maintaining these relationships and working to build a sustainable funding mechanism for the future.

Student Competition II

51 Modeling the spread of Zika virus in interconnected networks

Tanvir Ferdousi, tanvirf@ksu.edu, Caterina Scoglio, Lee Cohnstaedt, D McVey

Zika virus has affected the world as a long-term threat. We propose a novel interconnected network to simulate both vectored and sexual transmission. Our plan includes extensive simulations to understand the effects of model parameters and network topology on the spreading of infection. Sexual transmission contributes to the epidemic spread and under certain conditions, can sustain it up to a month without vectors. This can potentially lead to recurrences once the mosquitoes overwinter.

52 Prevalence of canine heartworm in potential mosquito vector populations in Lubbock, TX, USA (2010-2016)

Katelyn Haydett, katelyn.haydett@ttu.edu, Steven Peper, Alexander Wilson-Fallon, Hannah Greenberg, Steven Presley

Canine heartworm is a mosquito-borne parasitic infection caused by the third-larval stage (L3) of *Dirofilaria immitis*. In conjunction with an on-going West Nile virus vector surveillance program in Lubbock, Texas, more than 41,000 mosquito specimens were collected. Mosquitoes were identified and screened for the L3 stage of *D. immitis* using reverse transcriptase polymerase chain reaction to determine the prevalence of canine heartworm in potential mosquito vector populations during a six-year period.

53 Probability of canine heartworm (*Dirofilaria immitis*) infection in mosquitoes from Lubbock, TX

Steven Peper, steve.peper@ttu.edu, Katelyn Haydett, Hannah Greenberg, Alexander Wilson-Fallon, Steven Presley

Canine heartworm (*Dirofilaria immitis*) is one of the most serious parasitic diseases for dogs in North America, and although rare, has been reported to infect humans. As part of an ongoing West Nile virus vector surveillance program we tested a subset of collected mosquitoes for *D. immitis* using a reverse transcriptase polymerase chain reaction assay. We developed a statistical model to predict the probability of mosquitoes captured in Lubbock County being infected with *D. immitis*.

54 Individual level network model for spatial temporal behavior of WNV and parameter estimation by Bayesian

Sifat Afroj Moon, sifatafroj@ksu.edu, Lee Cohnstaedt, Caterina Scoglio, D McVey

WNV (a mosquito-borne arbovirus) entered USA through New York in 1999, and then it spread over the whole USA within three years. We have developed an individual-level network model across the USA with the goal of understanding the long-range dispersal of WNV. In this research, we have calculated force of infection for *Culex* genus of mosquitoes from spatial-climate data and used Bayesian inference to fit the model with the observed human incidences.

55 Estimation of parameters and basic reproductive ratio for Japanese encephalitis transmission in the Philippines using a sequential Monte Carlo filter

Md Mahbubul Huq Riad, mahbubriad@ksu.edu, Caterina Scoglio, Lee Cohnstaedt, D McVey

We developed a sequential Monte Carlo filter to estimate the states and the parameters in a stochastic model of Japanese Encephalitis (JE) spread in the Philippines. This method can also capture the variability in the incidence through time which is dependent upon various factors relating to the host species and the weather. Parameters and basic reproductive ratio estimated from the particle filter simulations show seasonal as well as yearly variations.

56 Geospatial predictive modelling of *Aedes aegypti* and *Aedes albopictus* mosquitoes in Texas

Hannah Greenberg, hannah.greenberg@ttu.edu, Alexander Wilson-Fallon, Steven Peper, Katelyn Haydett, Steven Presley

Aedes aegypti and *Aedes albopictus* (*Stegomyia*) are competent vectors of several viral human pathogens, including Zika virus. Local mosquito-borne transmission of Zika virus was reported from Texas in November 2016 and is believed to be vectored only by *Stegomyia* spp. Using ovitraps during 2016 and 2017, we determined presence/absence of these vectors throughout Texas. Surveillance data was used to generate a geospatial predictive model of *Stegomyia* distribution, applicable to public health and vector control practices.

57 Ecological and socioeconomic perspectives on risk of juvenile mosquitoes in contain habitats

Allison Parker (aparker9@illinois.edu), Brian Allan

Knowledge of mosquito ecology, attitudes of who is responsible for mosquito control, and control practices (KAP) being implemented by residents living in neighborhoods may be influenced by social and biological factors. In a midwestern city, nine neighborhoods were both surveyed for the presence of mosquito larval habitats and administered KAP questionnaires. Results suggest differences in KAP and mosquito prevalence occur across social and biological gradients and may influence the success of mosquito control efforts.

Aerial Control/Aviation

58 Efficacy against mosquitoes following aerial applications of DeltaGard® Insecticide in Pasco County, FL

Dennis Moore, dmoore@pascomosquito.org, Ming Huang, Mike Greer, Agne Janauskaite, Tom Janousek, Neta Wicker, Jing Zhai

DeltaGard® Insecticide, containing the active ingredient (AI) deltamethrin, is the only Type II pyrethroid registered in the United States for wide area mosquito control. It is currently registered for application with hand-held, backpack, portable and truck ultra-low volume (ULV) sprayers. It has been proposed for registration and use in aerial applications. This study was conducted under the Experimental Use Permit #432-EUP-12. The purpose of this study was to determine the efficacy of DeltaGard® Insecticide when applied via an aerial ULV spray application using a Piper Aztec PA23 fixed-wing airplane and a single tail-end AU4000 Micronair spray nozzle at 0.00089 lbs AI/acre and 0.00134 lbs AI/acre against lab-reared *Aedes aegypti*. Treatment stations were placed on a 3x3 grid at three increasing distances downwind from the flight path. Three control stations were placed upwind of the flight path for each treatment. Each station was equipped with mosquito cages and rotating 1x3 inch Teflon-coated slides for capturing data on droplet spectrum. Additionally, four sampling stations only equipped with rotating 1x3 inch Teflon-coated slides were placed along a transect at four different distances outside of the treatment grid. Mosquito knockdown data was recorded approximately one hour post-treatment and mortality data was assessed approximately 12 hours post-treatment. Knockdown and mortality for controls was ≤2.3% for both applications. No noticeable differences were found between the two treatment rates: 0.00089 lbs AI/acre and 0.00134 lbs AI/acre. The knockdown and mortality for *A. aegypti* was ≥98.1% and 100%, respectively, for both applications. This indicated that the aerial application of DeltaGard® Insecticide was effective when used as an adulticide against *A. aegypti*.

59 Efficacy against mosquitoes following aerial applications of DeltaGard® Insecticide in Calcasieu Parish, LA

Scott Willis, swillis@cppj.net, Neta Wicker, Jing Zhai, Tom Janousek, Ming Huang

DeltaGard® Insecticide, containing the active ingredient (AI) deltamethrin, is the only Type II pyrethroid registered in the United States for wide area mosquito control. It is currently registered for application with hand-held, backpack, portable and truck ultra-low volume (ULV) sprayers. It has been proposed for registration and use in aerial applications. This study was conducted under the Experimental Use Permit #432-EUP-12. The purpose of this study was to determine the efficacy of DeltaGard® Insecticide when applied via an aerial ULV spray application using a King Air 90 fixed-wing airplane and two wing-tip AU4000 Micronair spray nozzles at 0.00089 lbs AI/acre and 0.00134 lbs AI/acre against lab-reared *Anopheles quadrimaculatus*. Treatment stations were placed on a 3x3 grid at three increasing distances downwind from the flight path. Knockdown and mortality for controls was ≤2.5% for both applications. No noticeable differences were found between the two treatment rates: 0.00089 lbs AI/acre and 0.00134 lbs AI/acre. The knockdown and mortality for *A. quadrimaculatus* was ≥97.1% and 100%, respectively, for both applications. This indicated that the aerial application of DeltaGard® Insecticide was effective when used as an adulticide against *A. quadrimaculatus*.

60 Effect of variable environmental conditions on aerial Ultra Low Volume mosquito adulticide applications in Placer County, CA

Jacob Hartle, jakeh@placermosquito.org, Mario Boisvert, Mary Sorensen, Joel Buettner

Ultra Low Volume (ULV) aerial applications for adult mosquito control can be an effective way of treating large areas of mosquito habitat. To improve the efficacy of our ULV aerial applications we wanted to better

identify and understand the environmental conditions that affect droplet density and mosquito mortality under field conditions. We looked at environmental conditions such as, wind speed, wind direction, ambient temperature and inversion layer heights. We attempted to compare these factors with the adult mosquito mortality. The findings of this study that variation of aircraft offsets, inversion layer heights have an effect on the efficacy of the product against wild *Cx. tarsalis*. We will use these findings to make more informed decisions on when aerial applications will provide the best results in Placer County.

61 Automatic aerial delivery of *Bacillus thuringiensis israelensis* (Bti) for control of spring woodlot *Aedes* spp. in Michigan

Carl Doud, cdoud@co.midland.mi.us, Charles Dinsmore

Spring woodlot mosquito species in the genus *Aedes* are a significant nuisance and disease threat during May and June in Midland County, Michigan. Midland County Mosquito Control (MCMC) has maintained an aerial larviciding program to control such species for 30 years. The current program covers 57,000 acres in the county and involves five aircraft. A new system that delivered granule/liquid Bti automatically to predetermined areas of treatment blocks was recently developed. The auto on/off system was tested in fall of 2016 and implemented among four of five aircraft during the 2017 program. A significant advantage of this capability is the ability to pre-direct Bti material based on the knowledge of MCMC crew. This also takes the burden off the pilot to make decisions on where to treat based on assessing ground conditions and identifying accumulated water while in flight. Overall system functioning and control results were encouraging and it is expected to be continued into the future.

62 Is a high-pressure aerial spray system an affordable and economical option?

Nicole Williams, williams@applicationdynamics.net

The development of the High-Pressure aerial spray technology has resulted in increased efficiencies. These efficiencies included: improved operations, a reduction of insecticide for aerial mosquito control programs and a decreased environmental impact. We will review some of the advancements made in technology along with a refinement in the High-Pressure System making operations more viable for districts today. However, the question remains can every district afford and operate a High-Pressure Spray System? Will it be a useful tool in my program?

63 Efficacy of aerial applied DeltaGard® against *Aedes aegypti* and *Culex quinquefasciatus* in Manatee County, FL

Katie Williams, k.williams@manateemosquito.com, Ming Huang, Neta Wicker, Jing Zhai, Christopher Lesser, Mark Latham, Eva Buckner, Ambyr Marsicano

DeltaGard® Insecticide, containing the active ingredient (AI) deltamethrin, is the only Type II pyrethroid registered in the United States for wide area mosquito control. It is currently registered for application with hand-held, backpack, portable and truck ultra-low volume (ULV) sprayers. It has been proposed for registration and use in aerial applications. This study was conducted under the Experimental Use Permit #432-EUP-12. The purpose of this study was to determine the efficacy of DeltaGard® Insecticide when applied via an aerial ULV spray application using a Hughes 500D helicopter and three side-boom PJ20 spray nozzles at 0.00089 lbs AI/acre and 0.00134 lbs AI/acre against lab-reared *Aedes aegypti* and *Culex quinquefasciatus*. Treatment stations were placed on a 3x3 grid at distances of 1100, 1300 and 1500 ft downwind from the helicopter path. Three control stations were placed upwind of the helicopter path for each treatment. Each station was equipped with mosquito cages and rotating 1x3 inch Teflon-coated slides for capturing data on droplet spectrum. Additionally, four sampling stations only equipped with rotating 1x3 inch Teflon-coated slides were placed along a transect at 700 ft, 900 ft, 1700 and 1900 ft from the flight path, outside of the treatment grid. Mosquito knockdown data was recorded approximately one hour post-treatment and mortality data was assessed approximately 12 hours post-treatment. Knockdown and mortality for controls was ≤2.2% for both applications and both species. No noticeable differences were found between the two treatment rates: 0.00089 lbs AI/acre and 0.00134 lbs AI/acre. The knockdown and mortality for *Ae. aegypti* was ≥98.7% and 100%, respectively, for both applications. *Cx. quinquefasciatus* had 100% knockdown and ≥99.5% mortality for both applications. This indicated that the aerial application of DeltaGard® Insecticide was effective when used as an adulticide against both *Ae. aegypti* and *Cx. quinquefasciatus*.

64 Effect of rice canopy height on the efficacy of aerial larviciding with Vectobac 12AS (active ingredient *Bacillus thuringiensis israelensis*) over rice fields in Placer County, California

Mary Sorensen, marys@placermosquito.org, Jake Hartle, Jason Smith, Mario Boisvert, Joel Buettner

In Placer County, California, rice fields are the largest source of mosquitoes, and the area in and around the rice fields has the greatest recorded West Nile virus activity. Traditionally, rice fields have been treated multiple times per year by aerial application of Vectobac 12AS (active ingredient *Bacillus thuringiensis israelensis*). Despite these frequent treatments, trap counts in these areas reach hundreds and sometimes thousands of *Culex tarsalis* and *Anopheles freeborni* mosquitoes per trap night. This study examined the

effect of the rice canopy height on the efficacy of the larvicide applications collecting deposited larvicide in cups at different heights within the rice canopy, then performing a bioassay to assess mortality in each of the cups. Results suggest that Vectobac 12AS applications continue to reach the underlying water in amounts sufficient to control mosquito larvae until the rice canopy is very tall, late in the summer growing season.

65 Texas Mosquito Control Response Following Hurricane Harvey

Mark Breidenbaugh, mbreiden@kent.edu, Karl Haagsma, Janet Mcallister

Following the torrential downpour of rain from Hurricane Harvey along the Texas coastline, the Texas Department of State Health Services was tasked with organizing aerial mosquito control to protect the public and responders in declared areas. This talk will focus on the logistics of organizing a spray event for 6.2 million acres, the efficacy of these spray missions, and emergency preparedness outcomes.

66 Aerial control of *Aedes aegypti* using etofenprox and/or methoprene via fixed wing aircraft in a hot-arid environment

Robert Aldridge, robert.aldridge@ars.usda.gov, Frances Golden, Seth Britch, Melissa Snelling, Arturo Gutierrez, Kim Hung, Jennifer Remmers, Mark Breidenbaugh, Kenneth Linthicum

Aedes aegypti, the key vector of Zika, dengue, yellow fever, and chikungunya viruses, is expanding into more areas of the U.S. southwest. Effective control of this species has proven difficult in this region, potentially due to the impact of the hot-arid environment on pesticides compounding the traditional challenges of *Ae. aegypti* control in urban areas. We used a natural desert area in southern California to investigate the capability of two aerially-applied larvicide formulations, one containing etofenprox and one containing methoprene, to penetrate partially-opened tents and effectively kill both susceptible and resistant colony-reared *Ae. aegypti* larvae. The tents served as a proxy for peridomestic refugia where adult and immature mosquitoes could be found. We discuss our results in the context of control of this species in southern California and in hot-arid environments in general.

67 Vertical distribution of mosquito mortality following aerial application of naled in open and canopied environments

Frances Golden, frances.golden@ars.usda.gov, Seth Britch, Robert Aldridge, Kenneth Linthicum, Mark Breidenbaugh, Karl Haagsma, Jennifer Remmers, James Clark, Joanna Lake

Aerial applications of insecticides are often used as part of integrated vector management programs to suppress populations of adult mosquitoes. These sprays need to move through the tree canopy to reach mosquitoes where they are resting or flying. Additionally, it is presumed that these sprays are just as likely to kill mosquitoes flying in the air as those resting near the ground. We investigated the ability of an adulticide, Dibrom (naled), to penetrate the tree canopy and kill mosquitoes distributed throughout the air column when applied aerially. We deployed sentinel cages containing colony reared *Culex quinquefasciatus* along vertical transects up to 18 m, as well as along ground transects, in two separate locations. One location was in an open field with no tree coverage, and the second location was within a dense pine-dominated forest. After spray applications, sentinel cages were collected and mortality recorded at approximately 15 min post-spray to measure knockdown and 7 hr later to determine possible delayed effects of the pesticide. We compare relative efficacy of Dibrom in the open environment vs. the tree canopy, as well as discuss the vertical distribution of mortality.

Latin American Student Competition

68 Mining activities associated with *Anopheles* larval habitats and malaria transmission in the northwest of Colombia

Marco Rojas, marandresro@gmail.com, María Yasnot, Lorena Orjuela

Areas of mining activities are associated with increase in malaria incidence in Latin America. Five species of *Anopheles* were found in larval habitats generated by mining activities in five localities in the northwest of Colombia. Six species of *Anopheles* found in the area, were positive for *Plasmodium* CS protein, confirming their role in transmission. Remaining larval habitats generated by mining activities are a risk factor for malaria and an appropriate intervention should be implemented.

69 Low insecticide resistance intensity in the three main malaria vectors in Colombia

Lorena Orjuela, loriza1983@gmail.com, Juliana Morales, Martha Ahumada, Juan Venegas, Maria Yasnot, Martha Quiñones

Information on the intensity of expression of resistance phenotypes is key for decision making on effective malaria control and elimination strategies. Insecticide resistance intensity was evaluated in three resistant

population of *Anopheles darlingi*, one of *An. albimanus* and two of *An. nuneztovari*, all from the highest malaria endemic sites in Colombia. All of them showed low resistance intensity with 100% mortality at 2X diagnostic concentration. Frequent monitoring is needed to follow the evolution of insecticide resistance.

70 Molecular characterization of the sexual pathway of *Aedes aegypti*

Gerado Trujillo-Rodriguez, entogerry36@gmail.com, Martha Lopez-Rodriguez, Adriana Flores-Suarez, Gustavo Ponce-Garcia, Iram Rodriguez-Sanchez

The mosquito *Aedes aegypti* is the main arbovirus vector in America. The control methods currently used do not function entirely because of different factors such as mutations at the target site and elevated metabolism, for this reason it is vital to develop new control methods. determining where and when the sexual differentiation is carried out would allow us to edit the genes of interest using CRISPR-Cas9.

71 Role of human genomics in presenting symptomatology of Chikungunya infection

Martha Lopez-Rodriguez, martha_a_a@hotmail.com, Gerardo Trujillo-Rodriguez, Karina Trujillo-Murillo, Adriana Flores-Suarez, Gustavo Ponce-Garcia, Iram Rodriguez -Sanchez

Chikungunya virus is transmitted to humans mostly by the vector mosquito *Aedes aegypti*, the most common symptoms are fever, debilitating polyarthralgias, etc. Studies have been documented on the influence of the genetic load that predisposes or protects the host against dengue and malaria; however there are only a few records on polymorphisms associated to Chikungunya infection. Using genomic tools it is sought a battery of polymorphisms that permit to discern the risk of the population.

72 New trap for catch and death of mosquitoes with emphasis on *Aedes aegypti* (Diptera: Culicidae)

Maria Vidal, mafevidal.0391@gmail.com, Hector Parra, Jonny Duque

A mosquito trap was designed according to entries, color, color contrasts and size. *Culex quinquefasciatus*, *Cx. nigripalpus* and *Aedes aegypti* were significantly caught in the large entry [Kw = 22.26 p = 0.0002], the contrast red/black [Kw = 64; p = 0.0000] and the size was not significant in the catch [Kw = 3.46; p = 0.8394]. Was evidenced 10% capture of mosquitoes in the traps installed in the field.

Operations

73 Comparison of three treatment methods utilized by Pasco County Mosquito Control District to reduce *Ae. aegypti* in Pasco County, FL

Aaron Lloyd, alloyd@pascomosquito.org, Agne Janusauskaite, Dennis Moore

The yellow fever mosquito, *Aedes aegypti* (Linnaeus), continues to be a concern in Florida for disease transmission. With the threat of imported and potential local transmission of dengue, chikungunya and Zika virus, *Ae. aegypti* has taken the mainstage for control efforts from mosquito control districts. Currently PCMCD utilizes three control methods when responding to imported cases of dengue, chikungunya and Zika virus. Our response efforts include either evening fogging of deltamethrin by truck, deltamethrin fogging from ATV in the late morning, or neighborhood source reduction/larviciding efforts by domestic inspection teams. The objective of this study is to evaluate our three treatment methods for controlling the container breeder, *Aedes aegypti*, and compare the effectiveness in decreasing the population in residential areas in Pasco County, FL. Results from this study and plans for future studies will be discussed.

74 Zika in Miami: What was learned

Frank Clarke, fclarke@clarke.com

The public health chapter on Zika wouldn't be complete without addressing what was learned. The overarching lesson for all mosquito control professionals to remember is: Readiness for response. Readiness at all levels made for the success of what was an unpredictable situation. Having surveillance history and neighborhood knowledge, ability to aggregate data in a meaningful way, having established lines of communications with public health departments at the local, county and state levels, reliance and close coordination with private contractors and internal readiness for public communications all were essential links in managing through a public emergency.

- 75 Capturing innovative ideas – How the Metropolitan Mosquito Control District is striving to improve**
Mark Smith, mmcd_mes@mmcd.org
- During the busy summer season, the Metropolitan Mosquito Control District employs about 260 staff members. Our seasonal and full-time employees generate many innovative concepts to improve operations and/or reduce costs. The District is developing a new process to capture, evaluate and build upon these ideas.
- 76 Evaluation of two surveillance traps for the collection of container mosquitoes in Pasco County, FL**
Agne Janusauskaite, ajanus@pascomosquito.org, Mike Greer, Aaron Lloyd, Dennis Moore
- The U.S. Centers for Disease Control and Prevention (CDC) miniature light trap has been used for surveillance by mosquito control districts for decades. Many Florida mosquito control districts currently use these traps for surveillance in their programs. More recently, the BG-Sentinel trap (Biogents AG) has become the gold standard for surveillance and trapping when targeting the Asian tiger mosquito *Aedes albopictus* (Skuse) and the yellow fever mosquito, *Aedes aegypti* (Linnaeus). The BG-sentinel traps have proven to be effective in trapping container mosquitoes but the high demand and associated costs have made it difficult for mosquito control districts to implement the traps into their program. Pasco County Mosquito Control District evaluated the two surveillance traps, BG-Sentinel trap (Biogents AG) and CDC miniature light trap model 512 (John W. Hock) for collecting adult container mosquitoes in Pasco County, FL. Results indicate that the CDC trap without light is similar in effectiveness to the BG Sentinel trap when trapping container mosquitoes. Results from this study and abundance of other species captured will be discussed.
- 77 Aerial treatments of larvicides for *Aedes aegypti* in a desert environment**
Jennifer Henke, JHenke@cvmvcd.org
- The Coachella Valley Mosquito and Vector Control District began combating *Aedes aegypti* in 2016 when it was detected in the City of Coachella. Throughout 2016 and 2017, the District has conducted door-to-door inspections and treatments. In 2016, the District examined the use of aerial applications of VectoBac WDG (*Bacillus thuringiensis israelensis*) to residences. In 2017, the District made additional applications of VectoBac WDG and also examined the efficacy of aerial applications of Altosid Liquid (methoprene). In this presentation, the author will present how the products were evaluated, what was the impact to the adult mosquito population, and what plans the District has for using aerial applications in the future.
- 78 Need to quickly kill a bunch of domestic mosquitoes over a wide area and suppress the population by 95% over a season? Here's how!**
Christopher Lesser, Christopher.Lesser@manateemosquito.com, Mark Latham
- Ae. aegypti* and *Ae. albopictus* populations have proven difficult to control due to a number of species-specific ecological and environmental factors. The Manatee County Mosquito Control District (FL) evaluated population control efficacy of IPM-based aerial larvicide applications of Altosid 5% (ai methoprene, Central Life Sciences) and aerial adulticide applications of Fyfanon (ai 97% malathion, FMC). All applications were based upon field surveillance of larval/adult mosquito population sizes. Studies were conducted on the popular vacation/resort community of Anna Maria Island located in Manatee County FL. Mosquito population dynamics were measured via landing rate counts and BG traps over 3 month period. Mosquito population size and species composition were also measured and evaluated in untreated control sites with the same methodologies. Overall reduction of *Ae. aegypti* & *Ae. albopictus* population was observed to be 95.5% on the island-community after multiple aerial larvicide & adulticide treatments. Control populations remained stable through the research duration. This study supports previously reported smaller-scale pilot research projects evaluating the effects of aerial larvicide/adulticide application on domestic mosquito population. This rapid-deployable method continues to be an effective tool for wide-area control for nuisance and disease vectoring populations.
- 79 Mosquito population dynamics during disaster events in Harris County, TX 2001- 2017**
Martin Reyna Nava, mreyna@hcphe.org, Lauren Wilkerson, Mustapha Debboun
- Mosquito Populations in Harris County have shown two main activity peaks. The first peak occurs in May – June and a smaller one in October – November. Harris County is located along the Gulf Coast, and its geographic location and topography makes it vulnerable to sudden flooding, especially during accumulated rainfall from Tropical Storm Systems and Hurricanes that make landfall in Texas and or nearby coastal areas. Mosquito populations decrease during these events as most eggs and larvae are flushed away from drainage systems and small stagnant pockets of water. However, populations of certain medically important species (*Culex quinquefasciatus*, *Aedes aegypti*, and *Ae. albopictus*) decrease within the 2-week period after the natural flooding disaster while some floodwater and temporary species increase more than two-fold

during extensive rainfall in this coastal area. The medically important species including container-breeding species rebound quickly. Seasonal timing of storm rainfall influences species diversity and abundance.

80 Evaluation of Biogents Sentinel 2 and Biogents-Bowl Traps to Collect *Aedes sierrensis* Mosquitoes in an suburban setting in the Greater Salt Lake Area of Utah

Gregory White, greg.white@slcmad.org, Ary Faraji, Scott Gordon, Martin Geier

Salt Lake City Mosquito Abatement District (SLCMAD) conducted trials with Biogents traps (BGS-2 and BG-Bowl) to determine the efficiency of the traps at collecting the Western Treehole Mosquito, *Aedes sierrensis* (Ludlow). This mosquito is a major nuisance to residents, causing many services requests at SLCMAD and is also a vector of *Dirofilaria immitis*, dog heartworm. Two different Biogents trap styles and lure combinations were tested: (1) BGS-2 trap with BG lure; (2) BGS-2 trap with BG lure and with CO₂; (3) BG-Bowl trap with BG lure; and Mosquito Magnet traps with CO₂. Mosquito Magnet traps were used as controls, as these traps were used in the past in by SLCMAD to collect *Ae. sierrensis* mosquitoes to reduce biting pressure to residents. The traps were set once a week at three different locations with historical high numbers of *Ae. sierrensis*. Traps were arranged at least 30 feet apart from each other at each site, and each week the traps were rotated through the four different areas within each site so that trap placement would not bias the average mosquito catch results. The trial lasted for 12 weeks. Results showed that the traps which used CO₂ as an attractant, the BGS-2 trap with BG lure and with CO₂, and the Mosquito Magnet traps were the most effective at collecting *Ae. sierrensis* mosquitoes. Our results show that the BGS-2 trap may be an efficient collection tool for the surveillance of *Ae. sierrensis*.

81 Successes and challenges of the vector control response during the Zika outbreak in the U.S. Virgin Islands

Krystal Seger, krystal.seger@doh.vi.gov, Brett Ellis, Amy Schnall, Joseph Roth

The advent of the Zika outbreak in the U.S. Virgin Islands (USVI) in late January 2016 prompted the need for rapid development of an effective vector control strategy. The proposed strategy entailed implementation and evaluation of multiple vector management activities. Such rapid program development posed programmatic, political, and financial challenges.

Federal support for rapid implementation of vector control was afforded via emergency funding from the Centers for Disease Control and Prevention (CDC). By March 2016, CDC contracted with an international vector control company to work with the USVI Department of Health (VIDOH) to build a tailored response. The team provided vector control services at pregnant women's homes during the initial months of the operation with inspection and source reduction being the primary objectives. Backpack application of larvicide and adulticide began in July 2016 with the approval of local authorities, targeting pregnant women's homes. In August 2016, eligibility expanded to all public and private locales and residences, as requested by homeowners, within a 150-meter radius of pregnant women's homes. *Aedes aegypti* surveillance with BG-Sentinel traps in high priority neighborhoods began in January 2017.

Truck application of larvicide was considered though ultimately not implemented due to lack of local regulatory approval. Despite the lack of regulatory support, the majority of USVI's population is in favor of truck spraying as affirmed by both a behavioral assessment and a Community Assessment for Public Health Emergency Response (CASPER) conducted during the outbreak.

VIDOH began to build capacity to continue vector control services when the federal contract concluded in July 2017. Transition of services from a high capacity international team to local management required a scaling back of service breadth and rapid development of the local program. The program was customized to meet the needs of the territory within the limitations of local capacity.

Student Competition Symposium III

82 Quantifying sources of insect specimen damage in CDC light trap collections

Jay Brown, BrownJ@stu.usd413.org, Adam Wilcox, Dustin Swanson, William Yarnell, Lee Cohnstaedt

CDC light traps are common mosquito monitoring tools and specimen preservation in the trap is vital for species identification. This study quantifies insect specimen damage (10 point scale: one point deduction for missing wings, antennae, and legs) at each of the various steps of processing trap collections (fan blades, dehydration during collection or storage, and sorting). Discussed are the optimal collection methods for suction traps and techniques to mitigate the specimen damage.

83 Circadian rhythms of activity and oviposition in *Phlebotomus papatasi*

Lindsey Faw, lrfaw@uncg.edu, Nima Hajhashemi, Tatsiana Shymanovich, Gideon Wasserberg

Circadian-rhythm of oviposition in sandflies is understudied. We assessed the responsiveness of sandflies to oviposition-attractants using three-hour time-windows over a 10:14 hours dark:light photoperiod. Experimental cups contained sand plus larval frass with either a sticky-mesh or moist filter paper for attraction and oviposition bioassays, respectively. The largest number of females were trapped during the

last three-hours of the dark-phase but the largest number of eggs were laid in the first three-hours of the night.

84 Invasive Mosquito Project 2017 updates

Julie Tsecouras, jtsec001@ucr.edu, William Walton, Lee Cohnstaedt, Russane Lowe

The Invasive Mosquito Project (IMP), started in 2014, is a national mosquito collection and surveillance network that uses professionals and citizen scientists. This 2017 update will cover challenges involving data management, dispersed collections, need for critical mass, and national collections of larvae and pupae of invasive mosquito species. Recent growth of IMP includes international partnerships in Peru, Brazil, and Bhutan. This update will also detail future goals including incorporating IMP into CDC Center for Excellence.

85 Genomic representation in an agent-based model of mosquito populations

William Nutt, wsn7@case.edu, Veena Mehta, Margaret MacDonell, Charles Macal, Jessica Trail

Mosquito-borne diseases affect most of the world's population, making them a key concern for global security. Gene editing techniques and gene drive mechanisms, such as homing endonuclease genes, CRISPR insertions, and Wolbachia infection, are used to suppress disease transmission by mosquitoes. We are developing approaches to incorporate these gene drive mechanisms into genomic representations of mosquitoes for agent-based modeling that could be used to guide vector control measures.

86 Mosquito-borne diseases: Understanding environmental factors for agent-based modeling

Veena Mehta, veena.mehta@macaulay.cuny.edu, William Nutt, Margaret MacDonell, Charles Macal, Jessica Trail

The threat of mosquito-borne diseases is increasing throughout the United States due to changing precipitation patterns and warmer temperatures that extend mosquito ranges. We analyzed data from Cook County, Illinois and identified correlations between temperature, relative humidity, precipitation and mosquito density. In this paper, we describe how location-specific environmental factors are incorporated into an agent-based model to predict the spread of mosquito-borne diseases in urban settings and to inform mosquito abatement programs.

87 Rearing and predation experiments of the predacious mosquito *Toxorhynchites christophi* (Diptera: Culicidae)

Sang Woo Seok, tkddnrns@gmail.com, Nattawut Sareein, Wang Gyu Kim, Yeon Jae Bae

The predacious mosquito *Toxorhynchites christophi* (Diptera: Culicidae) was successfully reared in the laboratory and its predation experiments were conducted. Additional ecological and biological data are provided for employing a biological mosquito control agent in Korea targeting on the larvae of *Aedes* spp. This research was supported by the Korea Ministry of Environment as "Public technology program based on Environmental Policy (2016000210003)."

Arbovirus Detection using Loop-Mediated Isothermal Amplification (LAMP) Technology Symposium

88 Pro-AmpRT arbovirus detection assays and their applications

Jackie Surls, jsurls@pro-lab.us

Arbovirus infection is an increasing human health-threatening issue throughout the world. Due to the lack of vaccines and specific treatments, efficient surveillance strategy for virus vectors is required to prevent disease outbreak and spreading. Antibody based serological tests, viral isolation and culture and molecular tests (qRT-PCR) have been developed for arbovirus identification from suspecting specimens. As effective as these diagnostics methods appear, their applications are limited to well-equipped laboratories and properly trained lab professionals and are turned out to be costly. In order to circumvent the above-mentioned limitations, reverse transcription-isothermal amplification (Pro-AmpRT) assays have been developed. The ProAmpRT arbovirus detection panel covers the most prominent arboviruses including West Nile Virus (WNV), Zika Virus (ZIKV), Eastern Equine Encephalitis Virus (EEEV), Western Equine Encephalitis Virus (WEEV), St. Louis Encephalitis Virus (SLEV), La Crosse Virus (LACV), Chikungunya Virus (CHIKV), Yellow Fever Virus (YFV), and Dengue Virus (DENV) serotypes 1-4. In Pro-AmpRT assay, RNA templates are directly added to ready-to-use enzyme and primer master mixes, following that RNA reverse transcription and cDNA amplification take place simultaneously at a constant temperature, thus sophisticated thermocyclers are not required and the reaction time for the tests are greatly shortened. Additionally, Pro-AmpRT assays employ fluorescence dye-based DNA detection method, enabling real-time monitoring of reaction progression. In summary, Pro-AmpRT arbovirus molecular tests are relatively inexpensive, rapid and simple to perform and are suitable to be adopted under low-resource settings for effective viral surveillance and disease control.

89 Laboratory and field evaluation of real time RT-LAMP and real time RT-PCR assays to detect West Nile virus in mosquito pools

Kristen Burkhalter, ktb3@cdc.gov, O'Keefe Michael, Zachary Watson, Theodore Green, Daniel Markowski

Although the specific cDNA amplification mechanisms of reverse-transcriptase polymerase chain reaction (RT-PCR) and RT loop-mediated isothermal amplification (RT-LAMP) are very different, both molecular assays serve as options to detect arboviral RNA in mosquito pools. Like RT-PCR, RT-LAMP uses a reverse transcription step to synthesize cDNA from an RNA template, and then uses target-specific primers to amplify cDNA to detectable levels in a single-tube reaction. Using laboratory-generated West Nile virus (WNV) samples and field-collected mosquito pools, we evaluated the sensitivity and specificity of a commercially available WNV real time RT-LAMP assay (Pro-AmpRT™ WNV; Pro-Lab Diagnostics, Inc.) and compared the results to a reference real-time RT-PCR assay. Lab-generated virus stock samples containing $\geq 2.6 \log_{10}$ plaque forming units (PFU)/ml and intrathoracically inoculated mosquitoes containing $\geq 3.1 \log_{10}$ PFU/ml consistently produced positive results in the Pro-AmpRT WNV assay. Field-collected mosquito pools that were collected as part of the Franklin County (Ohio) public health department's 2017 arbovirus surveillance program during epidemiological weeks 30-36 were identified to species, homogenized in bovine albumin fortified with Triton X-100, and sent to the Centers for Disease Control in Fort Collins, CO for WNV testing by real time RT-PCR and real time RT-LAMP. Of field-collected pools that were WNV positive by real time RT-PCR, 74.5% (70 of 94) were also positive by the Pro-AmpRT WNV assay, with ~80% of the RT-LAMP false negatives containing estimated WNV titers that were below the assay's established sensitivity limit for mosquito pools.

90 Assessment of the Pro-AmpRT LAMP assay to detect West Nile virus in the Franklin County Public Health Mosquito Management Program

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The Franklin County Public Health Mosquito Management Program conducts weekly surveillance for West Nile virus from May through October each year. The program has relied upon the RAMP assay platform since 2007 to allow for a rapid response to the presence of WNV within the county. All samples have historically been confirmed with the use of RT-PCR as performed by the Ohio Department of Health. In an effort to test mosquito pools in a faster, more reliable, and inexpensive manner, we assessed the benefits of using the Pro-AmpRT™ WNV RT-LAMP assay (Pro-Lab Diagnostics, Inc.) for WNV identification. All samples were tested with the assay by Franklin County, then were shipped to the Centers for Disease Control in Fort Collins, Colorado, for an independent evaluation of the assay and real-time RT-PCR confirmation of positive pools detected by Franklin County. To perform the new assay, additional equipment was required along with technician training. Over the span of 7 weeks a total of 278 pools (12,555 mosquitoes) were tested with the RT-LAMP assay. The benefits and programmatic challenges associated with adapting the RT-LAMP assay protocol for use in the program will be discussed.

91 West Nile virus Detection in Avian Samples using LAMP

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Loop-mediated isothermal amplification (LAMP) is a promising and rapidly developing detection technique that requires less extensive laboratory set up than PCR. In 2017, Harris County Public Health Mosquito and Vector Control Division (MVCD) pioneered the use of LAMP to detect West Nile virus (WNV) in avian whole blood samples collected throughout Harris County, and the City of Houston - an area roughly the size of the state of Connecticut. The LAMP testing was conducted on site at the MVCD Avian Laboratory with the Genie II using commercially available primers. Samples were concurrently tested for WNV, St. Louis Encephalitis (SLE), Eastern Equine Encephalitis (EEE), and Western Equine Encephalitis (WEE) antibodies at the University of Texas Medical Branch at Galveston by Hemagglutination Inhibition (HI). All samples HI positive for either WNV or SLE were confirmed with ELISA IgM at the MVCD Virology Laboratory. We report LAMP results, their correlation with HI and IgM results and comment on the practical aspects of using LAMP in a large-scale surveillance operation.

Latin American Symposium I

92 Life table analysis of two populations of *Aedes aegypti* (Diptera: Culicidae) under laboratory conditions in Bogotá (Colombia)

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Aedes aegypti is of importance in public health, because it is a transmitter of different arboviruses, such as chikungunya, Zika, and dengue. Proliferation of *Aedes aegypti* has been possible thanks to its versatility to adapt to new environments, which has been improved by climate change. Studies on adaptation and vector behavior are important because they generate relevant information to propose and execute efficient vector control measures. The objective of this project was to determine the adaptive capacity of a population of *Aedes aegypti* from Villeta (Cundinamarca) to immediate changes in temperature (T) and relative humidity

(RH). In total four colonies were established. Control colonies were maintained under conditions similar to those at their sites of origin and the experimental colonies were immediately subjected, after capture and identification, to temperature and HR conditions in Bogotá (2640 m.a.s.l, 18 ° C). Daily survival and mortality data were recorded in each colony and the response-effect analysis was performed on the life table of *Aedes aegypti* populations. Partial results show significant differences in the life table between control and experimental colonies; however, it has been possible to maintain the colonies until the generation F2 which could indicate a good capacity of adaptation of this mosquito to similar environmental conditions to those of Bogotá. It has been observed that this colony can be established under these environmental conditions although its biological cycle is longer than the control colony.

93 Reproductive capacity of *Aedes aegypti* females fed with blood of different hosts under insectary conditions.

Mauricio Casas-Martínez, Jesús Fernández-Herrera, Luis Fernando Díaz-Barrios, Miguel Muñoz-Reyes, José Luis Aguilar-Rodríguez, José Asunción Nettel-Cruz

The implementation of new strategies for dengue, Chikungunya and Zika vector control requires the release of high mosquito densities capable of competing successfully against wild mosquito populations. For this reason, the efficient and sustainable mass rearing of transgenic, sterilized and/or *Wolbachia* infected *Aedes aegypti* is a determining factor to diminish the occurrence of arboviral outbreaks in an area wide intervention program where this mosquito participate as a vector. In this study, a laboratory experiment was carried out to compare the fecundity, fertility and production of newly emerged adults from 85 *Ae. aegypti* parent females fed with dog, chicken, human, rabbit and mouse blood through an artificial system with membranes. The number of eggs, percentage of egg hatching and number of emerged adults by sex were statistically analyzed among the five groups of parent females. The results revealed that the fertility of females fed on human blood (53.9 eggs/female) was significantly lower compared to other hosts (94.4-102.9 eggs/female), without differences between percentage of egg hatching by groups (82.2-94.2%). Averages of female and male were similar between all experimental groups, however, females fed with human blood produced significantly fewer adults (23.2 females, 21.1 males) than the dog fed group (44.9 females, 47.4 males). Finally, it was concluded that dog blood significantly increases the reproductive capacity of *Ae. aegypti* females under insectary conditions and, therefore, can be considered as an alternative blood source for massive mosquito rearing.

94 Determination of irradiation dose for the sterilization of *Aedes aegypti* and *Aedes albopictus* for SIT-based vector control.

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There is a crucial need for innovative and effective means to control mosquitoes, such as the sterile insect technique (SIT). SIT is based on mass-rearing of the target species, sterilization and continuous release of sterile male insects into the target population. Sterilization by irradiation remains like the most practical way to sterilize mosquitoes. The objective of this studio was to determine the dose-sterility curves for *Aedes aegypti* and *Ae. albopictus*. The mosquito strain used was the genetically diverse strain (GDS) from Chiapas, Mexico. Pupae were exposed to gamma rays generated by a cobalt 60 source (Dry storage irradiator, Gamma Beam GB-127, Nordion) with a dose rate of 1.8 Gy/min. Pupae of *Ae. aegypti* were exposed to six doses: 0(control), 15, 30, 50, 70 and 90 Gy, whereas *Ae. albopictus* was exposed to 0, 15, 25, 35, 40 and 50 Gy. After irradiation, groups of 20 pupae were caged with non-irradiated pupae of the same strain. Five days post-emergence a blood fed was provided. Engorged females were individualized and allowed to oviposit for three days. Radiation treatments did not significantly affect survival of adults and pupae, adult emergence or flight ability of both species. Fecundity and fertility in both species were negatively correlated with dose. Eggs of females that mated with *Ae. aegypti* irradiated males were totally infertile at 70 to 90 Gy. Irradiated females of this species were totally infertile following a dose of 30 Gy. Irradiated males of *Ae. albopictus* were almost totally infertile at a dose of 50 Gy, whereas females were infertile following doses of 35 - 50 Gy. Future studies will focus on the efficacy of SIT as a vector control strategy in small villages in southern Mexico.

95 Vertical Transmission of Dengue Virus in *Aedes aegypti* during the Largest Epidemic of the Disease in Medellín, Colombia

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Dengue fever is a vector-borne viral disease of major public health importance. Globally, the disease shows an increasing trend in the number of cases and frequency of epidemics. This behavior could be favored by the vertical transmission of the virus in the vector. The virological surveillance in mosquitoes would provide relevant entomological information to developing more timely strategies. The main objective of this study was to analyze the epidemiological importance of vertical transmission of dengue virus in *Ae. aegypti* during the largest dengue epidemic in Medellín, Colombia. According to this, mosquitoes were collected in houses

near ovitraps during surveillance of entomological indices that were carried out in Medellín during 2016 (March, June, September, December). The specimens were identified and pools analyzed for viral detection by RT-PCR. 2.897 adult mosquitoes were collected, the most of them corresponding to *Ae. aegypti* and a few to *Ae. albopictus*. Of the 827 pools, 162 were positive for dengue virus, and 27 of these corresponded exclusively to male *Ae. aegypti* mosquitoes. Multiple infection with two dengue virus serotypes was detected in some individual mosquitoes and it was observed that the largest number of infected males occurred before the period of maximum transmission of dengue. Presence of male *Ae. aegypti* mosquitoes naturally infected suggests that vertical transmission is an event of epidemiological relevance. Therefore, larval control during epidemics would make a substantial contribution in mitigating the impact of the disease.

96 Fitness evaluation of *Aedes aegypti* with different levels of deltamethrin resistance.

Francisco González-Santillán, paco_1110@live.com.mx, Yamili Contreras-Perera, Ana Alcalá-Castillo, Gustavo Ponce-García, Beatriz López-Monroy, Olga Karina Villanueva-Segura, Selene Gutiérrez-Rodríguez, Adriana E. Flores

Aedes aegypti is the main dengue, Chikungunya and Zika vector virus in Latin America. In Mexico, pyrethroid insecticides have been commonly used for more than a decade. Although insecticides are the most important element in vector control, its use has led to the development of different mechanisms of resistance in target populations. Insecticide resistance has been associated with a fitness cost, this process can be considered a consequence of trade-offs between the allocation of energy underlying insecticide resistance mechanisms and insect fitness. In this study, we evaluated several fitness parameters in two populations of *Ae. aegypti* from Yucatan, Mexico, with the forward selection with deltamethrin. We analyzed the activity of detoxifying enzymes, energy performance (lipid, glycogen, and trehalose) and life parameters. The higher the fitness cost in resistant individuals, the longer it takes for them to spread in the population, which is one important factor in the design of successful management programs.

97 Thermal-fog effectiveness of Aqua K-Othrine® (a.i. Deltamethrin 2%) to control *Aedes aegypti* indoors populations in Chiapas, southeast Mexico

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During the present study, the effectiveness of a thermal fog Aqua K-Othrine (Deltamethrine 2%) formulation was evaluated against *Aedes aegypti* vector of dengue, chikungunya and Zika viruses. Study site was located in El Manzano, a rural locality 20 km away of Tapachula with endemic transmission of the arboviruses. Fifteen adult female *Ae. aegypti*, laboratory strain Tapachula, 1-3 d old, fed with 10% glucose solution, were placed in individual cages. Later, each of four mosquito cages mosquitoes were placed in typical indoor resting shelters such as living room, dining room, bedroom, kitchen and bathroom of each household. Then, 4-L of a formulation mixture (80.0 ml Aqua K-Othrine plus 3.9 ml water) were prepared and applied with a Swinfog® thermo-fog machine (Swingtec, Germany). A flow rate of 342 ml /min dispensing a dose of 0.4mg a.i./m³ was calculated.

Overall, hot mist penetration of Aqua K-Othrine caused a 24-h mortality of 100% in all the indoor areas of the dwellings: living room, dining room, bedroom, kitchen and bathroom. Our results showed that high effectiveness of Aqua K-Othrine may (deltamethrine 2%) be produced when using it also as thermal fogging treatment. Thermal application of Aqua K-Othrine may be considered as a valuable choice for house indoors in tropical rural locations to control *Ae. aegypti* in Mexico.

98 Field evaluation of ULV Lethal Mist 44EW (a.i. Malathion 40%) to control indoor and outdoor *Aedes aegypti* in Tapachula, Chiapas southeast Mexico

Luis Alberto Cisneros-Vázquez, lcisneros17@hotmail.com, José Genaro Ordóñez-González, Ildefonso Fernández-Salas

Prevention of dengue, chikungunya, and Zika viruses transmission is based mainly on the control of the mosquito *Aedes aegypti* through the application of space-spraying ULV insecticides.

In the present study, linear and obstacle tests were performed to evaluate the effectiveness of Lethal Mist® 44 EW adulticide (Malathion 40%). A dose of 112 gr of active ingredient per hectare, with a flow rate of 416 ml / min and droplet size of 23.5 µm were used. Formulation water-based mixture was prepared with 260 mL of LETHAL MIST 44EW (40% Malathion) plus 740 water mL.

Linear and obstacle tests were conducted in Tapachula Chiapas in the southeast region of Mexico. Environmental conditions during the obstacles test were 28.3 ° C, relative humidity of 70.7% and wind speed of 4.2 km / h. Twenty mosquito females 2-d old were placed in cages and distributed in bedroom, kitchen and backyards of each household. For linear test 20-mosquitoes per cage were hanged every 10 meters distances in a 100 m transect. Environmental conditions were 28.86 ° C, relative humidity of 70.3% and wind speed of 4.18 km / h.

Average 24 h mortality of mosquitoes *Ae. aegypti* exposed to Lethal Mist® 44 EW in the linear tests ranged from 90.8 to 96.7%, whereas in the obstacle tests the mortality in the bedrooms was 95.4%, followed by 93.75% in the kitchen, and A 91.8% in the backyard. Our results support the effectiveness of Lethal Mist® 44 EW (Malation 40%) to control *Ae. aegypti* during outbreaks of dengue, chikungunya, and Zika in endemic localities in Mexico.

99 IRS and ULV effectiveness of ACTELLIC® 300 CS (i.a. Pirimifós methyl 28.16%) and Actellic® Vectors / Actellic® 50 CE (Pirimiphos methyl 49% w / w) to control *Aedes aegypti* in Tapachula, Southern Mexico

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In the present study, adulticide efficacy of Actellic® 300CS (a.i. Pirimiphos-methyl 28.16%) and Actellic® Vectores/Actellic® 50CE (Pirimiphos-methyl 49%) were determined as residual and spatial spraying on *Aedes aegypti* Tapachula strain, F1, 2-3 d old.

Actellic® 300CS (a.i. Pirimiphos-methyl 28.16%) formulation was applied using a manual compression spraying pump (Hudson X-Pert®) at a dose of 1 g a.i./m² with WHO IRS methodology and 8002 nozzle, on wood, cement, ceramic tile and block surfaces, and the residual effect was measured during 120 days. The controls were untreated surfaces with the formulated. Every 15 days, four WHO cones per sprayed surface were used and 15 female *Ae. aegypti* mosquitoes were exposed to check for mortality rates.

Actellic® Vectores / Actellic® 50CE (i.a. Pirimiphos-methyl 49%) was applied by two ultra-low volume techniques for the evaluation of effectiveness by space spraying: for the space-spraying ULV tests, 15 female *Ae. aegypti* mosquitoes 2-3 days old were placed inside cages every 10 meters for a 100 m linear transect, while in the space-spraying ULV with obstacle tests, mosquito cages were placed in bedroom, kitchen and backyard houses. Subsequently, the formulation was applied with a ultra low volume (ULV) space mist generator London Fog® 18-20 with 18 HP compressor, dispensing a dose of 200 g a.i. / ha and 20 microns droplet size.

The average 24-hour mortality of *Ae. aegypti* mosquitoes in linear and obstacle tests was 95 and 91.8%, respectively. On the other hand, the residual effectiveness in the wood surface was 91.67% followed by ceramics with 90%, brick with 88.33% and cement 85%.

Our results support the effectiveness of Actellic® 300CS (a.i. Pirimiphos-methyl 28.16%) and Actellic® 50CE (Pirimiphos-methyl 49%) as a promising *Ae. aegypti* control during outbreaks in Mexico of Dengue, Chikungunya and Zika.

PR/Education

100 What role does public education play in integrated mosquito management and how to work it into your district?

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One element of productive Integrated Mosquito Management (IMM) is education and outreach. Not all districts have the personnel or time to implement the outreach piece. If your district doesn't have someone dedicated to public outreach this can raise quite a few questions, such as: Where do we start? How do we spread the word? Who should we contact? What is the most effective way to reach the community? Public Outreach also means something different for everyone. To some it's getting a manned booth at weekend or night events, for others it's talking in front of groups or to the media, and some may be getting into the classroom. For Pasco County Mosquito Control District (Florida), it is all of these elements and more. The goal of this presentation is to give a brief overview of the challenges faced and successes made during the process of starting a new outreach program. Hopefully, it also provides insight and tips that will be useful to you and your districts.

101 Zika virus prevention: A public health collaborative project

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Addressing the Zika virus prevention from a public health approach seeks to decrease the burden of Zika infections and improve health outcomes at the population level, such as communities, cities, or county, by reaching large numbers of individuals with effective interventions in a reasonable amount of time. The Zika virus prevention project was a Public Health Masters Capstone project designed to achieve a measureable impact at the population level, through the collaborative efforts of the local health department and mosquito control district. Families, especially pregnant women and their babies, are at risk of life changing health consequences from the Zika virus. The link between the Zika virus and microcephaly has increased the need to reduce transmission through community engagement and education around mosquito control and personal risk prevention, especially for pregnant women. The project was designed to implement a response strategy through which to reach the Hispanic population across Lee County, Florida. This is an effort to get

critical prevention information about Zika in the form of a brochure, directly in the hands of Hispanic families in Lee County. The brochure, in English and Spanish, address prevention methods including insect repellent, personal protection, standing water treatments around the home, sexual precautions, and family planning.

102 Mobile outreach in response to an unprecedented flood event on the Texas Gulf Coast-2017

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As Hurricane Harvey approached the Texas Gulf Coast, Harris County Public Health Mosquito & Vector Control made preparations for the expected rainfall and mosquito control efforts that would be needed once the skies cleared. The storm brought torrential rain for days dumping more rain in a week than we usually see in a year creating an unprecedented flood event affecting all areas of Harris County, Texas. Once the sun came out and the water began to drain, we launched a public education response throughout the community. This was one part of an overall public health response. Through this response effort we provided insect repellent, mosquito dunks, mosquito prevention information, and answered resident questions. This effort had its challenges and successes providing us with a "how to" and a "how not to" for responding to future events. This presentation will outline our efforts and lessons learned.

103 Larvicide Olympics, a mosquito field technician training program for success

Desireé Keeney, dkeeney@adaweb.net

Mosquito abatement districts often employ new or untrained larvicide field technicians that have little knowledge of mosquito control, product and insecticide application, or public health issues associated with vectors. Additionally, to become a professional applicator in Idaho (and in most states throughout the nation), seasonal technicians must be licensed through the Department of Agriculture, and pass written tests demonstrating knowledge and understanding of pesticides, application techniques, and pest identification. In previous years, field training has been limited, and seasonal employees were tasked with studying written materials to pass the tests. This resulted in very low success rates, and sometimes technicians would not pass the tests, even after multiple attempts. By revamping our training program to a comprehensive 2-week course (consisting of classroom and field activities, followed by our *Larvicide Olympics*), we have increased our passing rate significantly. Our technicians have become more knowledgeable in mosquito control and public health, and are well-trained to perform their duties. This presentation will discuss the new training and successes, and focus on our *Larvicide Olympics* activities, which include various stations that test new employees on public relations, identification of mosquito habitats, field safety, and product choices. The *Larvicide Olympics* activity also allows for the evaluation of our training program; we can begin to understand which training areas may be lacking, what a technician might know (or might not know), and what they might communicate to the public while in the field. Our goal is to make training a fun, learning experience, and to empower our employees before the real field work begins.

104 Phase I: Horse populations in Cape May County

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New Jersey experienced its first outbreak of eastern equine encephalitis in 1959 causing 21 human fatalities. While eastern equine encephalitis only contributes to a small percentage of human fatalities today, it is still a concern among New Jersey's equine population. Because of this concern Cape May County's goal will be to issue surveys to horse owners requesting equine vaccination information. With completion of this survey the Cape May County Department of Mosquito Control can better understand the horse populations to create effective surveillance procedures among the unvaccinated.

105 The role of community engagement in the control of *Aedes Aegypti* mosquitoes

Anh Ton, aton@broward.org, Odette Reza-Brown

The Broward County Mosquito Control Section (BCMCS) of Florida implemented an outreach campaign to curb the breeding of the *Aedes Aegypti* mosquito in order to cease the spread of the Zika virus in the County. The campaign focuses on face-to-face outreach to people involved in the care and counseling of high-risk populations (pregnant women and women of childbearing age) and uses these professionals to encourage their patients to actively participate in source reduction activities.

Broward County has had only one locally-transmitted case of the Zika virus, whereas counties to the north and south have endured many more cases. Broward County's success is credited in part, by its implementation of an integrated vector control outreach strategy that used OB-GYN service providers (clinics/doctors, health clinics) to dispense larvicide products to high-risk populations and to educate them on source reduction activities that limit breeding habitats of the *Ae. Aegypti* mosquito.

106 Measuring community engagement in Coachella Valley

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In May 2016, invasive *Aedes aegypti* were initially detected in Coachella, California. To better understand Coachella Valley residents' perception of local and invasive mosquitoes, the Coachella Valley Mosquito and Vector Control District (the District) organized two survey campaigns in neighborhoods where invasive *Ae. aegypti* mosquitoes were detected. The District conducted in-person surveys at residences before and after a focused mosquito education event to examine the behavioral change and knowledge growth of mosquitoes by residents in the area. Mosquito education events in this campaign included a community clean-up and neighborhood block party events in the affected communities surveyed. Survey results suggest that the targeted events, as well as information shared with residents during door-to-door inspections, improved their understanding of local and invasive mosquitoes. However, inspection data collected during the survey visits demonstrated that improved resident knowledge did not always result in resident behavior that would prevent mosquito breeding.

107 A Community Assessment for Public Health Emergency Response to inform the Zika outbreak response in the U.S. Virgin Islands

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The Community Assessment for Public Health Emergency Response (CASPER) is a quick and low-cost method providing household-level community information. CASPER has been under-utilized for vector-borne disease responses.

During June 26–29, 2017, the U.S. Virgin Islands Department of Health (VIDOH) conducted a CASPER exercise throughout the U.S. Virgin Islands (USVI) in collaboration with federal partners. The objectives included the assessment of residents' knowledge, attitudes, and practices regarding Zika virus prevention; identify information gaps to strengthen Zika education campaigns; and assess household and environmental factors associated with vector control.

We conducted two-stage cluster sampling. Thirty census blocks were selected with probability of selection proportional to the number of households within the cluster. Teams then systematically selected households within each cluster. An adult resident of selected households was invited to complete the in-person questionnaire.

Two-person teams of public health staff and volunteers interviewed 201 household representatives (96% completion rate). Seventy-four percent of respondents said television was their primary source of Zika information. Ninety-six percent knew Zika is spread by mosquitoes and 79% believed Zika can be prevented. Eighty-seven percent agreed that it is possible to control mosquitoes around the home and 67% claimed they have no barriers to controlling mosquitoes around their home, but only 47% always acted to protect themselves against mosquito bites. About 45% of respondents report emptying standing water around their home weekly. Forty-nine percent said they have no barriers to using mosquito repellent. However, 24% of all household respondents noted the way repellent feels/smells is a barrier. Seventy-six percent said VIDOH should spray for mosquitoes, although only 24% believe VIDOH should inspect property for mosquitoes.

CASPER provides valuable community information to improve and optimize vector-borne disease responses. Findings from this assessment will be used by VIDOH to develop improved Zika education, prevention, and response measures.

108 Greater Los Angeles Mosquito SWAT Lab

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Managing mosquitoes in our changing landscape requires an updated approach. No longer can Districts just rely on laboratory and operations staff to find and suppress *Culex* populations. With the establishment of invasive *Aedes* in our dense urban landscapes, and limited suite of tools for their control, public engagement and participation is critical. To succeed, outreach approaches - whether they are media campaigns or outreach programs - must stimulate the senses, elicit an emotional response, and inspire action.

When the Greater Los Angeles County Vector Control District's beloved mobile outreach vehicle, the VecMobile (aka: BugBus), finally reached its 'end of life', the District took a hard look at the program. While not cheap, the program is consistently in high demand by teachers, anticipated by younger students, and regularly requested by cities. Its possible closure led students and teachers to rally the Board to keep the program alive.

Justifying and paying for an expense of this magnitude challenges even the largest of districts, but through creativity, perseverance, and out-of-the-box thinking, the District was able to purchase and outfit an exciting, high-tech outreach vehicle that accomplishes many goals. Programmatic elements are designed to align with California Science Standards and incorporate STEAM (science, technology, engineering, art, & math) elements. Donated microscopes allow immersive hands-on study of the mosquito, inspiring and motivating our next generation; giant scanning electron microscopy (SEM) images, a 65" touch screen interface, and an anatomically correct 3D interactive provide that 'wow-factor'; and an edgy new look and catchy rap video provide the hook needed to leave a lasting impression on students and adults alike.

Fundraising and unique partnerships provide viable pathways to improve the outreach experience. Through perseverance, these tools have allowed this District to continue providing free outreach programs on the new *Mosquito SWAT Lab* for many years to come.

Public Health Entomology Research at Undergraduate Institutions, including Professional Career Development Considerations in Academia Symposium

110 Undergraduates in research: Encouraging and excite students in public health research

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Current undergraduate students represent the future of vector research, disease surveillance, and vector control agencies. However, students frequently do not enter a college setting with the specific goal of pursuing vector research or entering into a career field involving vector surveillance and control. Finding ways to entice students to enter the field, excite them about career and educational opportunities, and encourage their research efforts provides a means to motivate them and inspire them to pursue vector biology as a potential career option. Utilizing a multi-pronged approach allows undergraduates to explore potential career paths in the areas of public health and vector biology while encouraging their research interests. A ongoing biodiversity and surveillance effort serves as the entry point to public health and vector biology research. Students follow this by developing their own research project enabling them to become fully immersed in the process of science from experimental design to analysis and presentation of research results. Current and past laboratory projects have focused on areas such as feeding behavior, larval competition, species abundance and distribution patterns, and infection and dissemination studies. This methodology encourages students to pursue research questions that interest them, as well as teaches them the entirety of the scientific research process.

111 Undergraduate research in innovative mosquito control: A biology-chemistry initiative

William Dees, wdees@mcneese.edu, Omar Christian, Cecilia Richmond, Caroline Hennigan, Jill Hightower, Caleb Ardizzzone

This is a two-part presentation to provide information for (1) developing and implementing field and laboratory studies involving both the biological and chemical sciences and (2) faculty members who wish to encourage undergraduate research in disease vector biology for students pursuing graduate education or the health sciences. The first part describes an investigation of the effect of plant components and plant derivatives on the behavior and development of medically important arthropods. This is an interdisciplinary project involving entomology, botany and chemistry. Working with a resident field botanist, students and faculty mentors from the Departments of Biology (McNeese State University, Lake Charles, LA) and Chemistry and Biochemistry (North Carolina Central University, Durham, NC) are collecting and processing native plants from Louisiana to assess their effect on mosquitoes. Current studies focus on determining the effect of simply-obtained botanical components (e.g., freshly-cut plant parts and essential oils) on *Aedes aegypti*. Results from these investigations will be provided in a poster presented at the 2018 AMCA annual meeting. The second part addresses engagement opportunities for students interested in pursuing either graduate education or the health professions (e.g., medical school). Almost all post-baccalaureate graduate science programs encourage undergraduate research. Lessons learned through one-on-one and team concepts involving undergraduate students in medical/public health entomology research will be presented.

112 Undergraduate involvement in mosquito microbiome research

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This presentation will describe an effort by faculty members to increase undergraduate student participation in entomological and microbiological research by involving them in mosquito microbiome studies at McNeese State University (MSU). Many undergraduate students at a primarily undergraduate institution like MSU are health science focused and do not always seek research opportunities. When a student commits to conducting research with a faculty member, it can be a challenge for the student and faculty member to get quality research completed due to limited time or a lack of continued interest from the student. The main topics discussed in this presentation will include: determining what level of research is appropriate for undergraduate students considering time, money and student motivation; recruiting students for research; motivating students to continue with entomological and microbiological research throughout their undergraduate education; and dealing with conflicts that may arise with research students.

113 Undergraduate mosquito research as a high impact teaching practice in environmental health

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Educational high-impact practices (HIPS) include teaching methods that result in increases in student/faculty engagement in their respective disciplines and student persistence to degree completion. Authentic undergraduate research experiences may be a HIP if they connect key concepts and questions with systematic investigation and intentional problem solving. Here we review 10 years of undergraduate vector biology research experiences within an undergraduate environmental health sciences program. Specifically,

medical entomology research and engagement results are shared from student and faculty experiences both within the classroom (e.g., project based learning) and as part of a formal research laboratory (Western Carolina University Mosquito & Vector-borne Infectious Disease Laboratory). Exemplars are provided that resulted in peer-reviewed publications, development of mosquito identification keys, and effective community and professional engagement (e.g., 2016 Zika response). Student outcomes are reviewed in terms of professional mosquito control career choices, successful application to graduate and professional school in the biomedical sciences, and preparation for an environmental health science career.

Disease/Vector Studies I

115 Co-infection with Dengue and Zika virus in mosquitoes

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Co-infection describes multiple pathogens infecting a single host. For vector-borne diseases, a vector may become co-infected by feeding either on a single host that has multiple pathogens or feeding multiple hosts, each of which may be infected. Co-infection in non-vector hosts has been shown to influence immune response and eventual outcome of disease, and is likely to have a similar impact on vector species. Co-infection can exist due to multiple vector-borne diseases circulating in South Texas. For our study, we observed mosquitoes infected with one virus and subsequently infected with another. We hypothesize vectors would show an increase in dissemination rate and a shorter extrinsic incubation period on both primary and secondary infection. Based on previous studies, we hypothesize vectors will show an increase in transmission rate with the first virus but no change in the second virus, relative to controls. To test this, we used colony *Aedes albopictus* mosquitoes from South Texas. *Aedes albopictus* mosquitoes are vectors for Dengue virus and Zika virus. We infected them either with Zika virus and then dengue, or the reverse. We regularly removed and tested individuals to monitor infection rates, dissemination rates, and viral presence in saliva. Results are currently being analyzed and implications of these results for disease transmission will be discussed. This is the first examination of possible co-infection in US mosquito populations in locations where these two viruses are known to circulate.

116 March Temperatures Predict April-May Gravid Trap Counts in Iberia Parish, LA

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Predicting WNV outbreaks is difficult. The prevalence of WNV in a given year is not necessarily correlated with vector abundance over the course of the year. There may be a relationship to vector abundance in the spring, when most bird nesting occurs. In Iberia Parish, Louisiana, *Culex quinquefasciatus* is the primary WNV vector, and overwhelmingly the greatest contributor to gravid trap counts. Mean March temperatures are correlated with gravid trap counts in Apr-May. There is a suggestion of a negative relationship between Apr-May rainfall and Apr-May gravid trap counts, but more data are needed. Heavy rains may rinse larvae out of breeding sites and allow fish to penetrate them, reducing vector populations. High temperatures in early spring may be a signal to hit mosquito populations hard during the peak of bird nesting, well before the bulk of the WNV-positive mosquito pools appear, later in the season.

117 Are *Culex* mosquitoes vectors of Zika virus?

Harry Savage, hms1@cdc.gov, Joan Kenney

Aedes aegypti and *Aedes albopictus* have been considered the principal vectors of ZIKV in the New World due to viral isolation frequency and vector competence assessments. Limited reports of *Culex* transmission potential highlighted the need for additional vector competence assessments of North American *Culex* species. Accordingly, we (Kenney et al. 2017) orally exposed and intrathoracically inoculated North American *Culex pipiens* and *Culex quinquefasciatus* with the African prototype ZIKV strain and currently circulating Asian lineage ZIKV strains in order to assess infection, dissemination, and transmission potential. Results indicated that these two North American *Culex* mosquito species were highly refractory to oral infection with no dissemination or transmission observed with any ZIKV strains assessed. Furthermore, both *Culex* mosquito species intrathoracically inoculated with either Asian or African lineage ZIKVs failed to expectorate virus in saliva. These in vivo results were further supported by the observation that multiple mosquito cell lines of *Culex* species origin demonstrated significant growth restriction of ZIKV strains compared with *Aedes*-derived cell lines. In summation, no evidence for the potential of *Cx. pipiens* or *Cx. quinquefasciatus* to serve as a competent vector for ZIKV transmission in North America was observed. We compare and contrast our results with other published papers including the controversial paper by Guedes et al. 2017.

118 Mosquito microbiome: Analysis for endemic and emerging pathogens of public health concern in Faisalabad, Pakistan

Shabab Nasir, flourenceshabab@yahoo.com, Iqra Yousaf

The mosquito microbiome: analysis for endemic and emerging pathogens of public health significance in district Faisalabad, Pakistan Shabab Nasir*, Iqra Yousaf *Corresponding author: flourenceshabab@yahoo.com Mosquito-borne pathogens cause some of the more deadly worldwide

diseases, such as malaria, dengue and West Nile Virus etc. Tropical countries, characterized by poor socioeconomic conditions, are more exposed to these diseases. So, this study was proposed to know the prevalence of mosquito-borne diseases in Faisalabad district, Pakistan. For this, mosquito adult and larvae were collected from different habitats with aspirator and dippers respectively from eight towns of Faisalabad districts. These samples were carried alive to the department of Zoology, Government College University, Faisalabad and identified with the help of identification keys. *Aedes* female mosquitoes were stored at -20°C for RNA extraction. Slides were prepared from female *Anopheles* mosquitoes for the identification of plasmodium under microscope. The genome RNA for viruses were extracted as per commercially available kits according to manufacturer guidelines and stored at -40 °C for further use. Using online software, primers and probes for the known human pathogens were designed in consensus with the help of available genome database for different pathogens such as dengue virus. Plasmodium was detected from the mosquitoes that were mostly collected from rural areas and this was generally detected from the samples collected from Jaranwala and Samundri town. Dengue virus was detected generally from city areas and serotype 2 and 3 was detected from the *Aedes* mosquitoes. Dengue virus was mostly detected from Lyallpur, Madina and Jinnah towns. Mosquitoes were mostly collected after monsoon season in the months of August-September and in spring (March). The disease pathogens were also detected during these months. Through the surveillance of pathogens, we can focus our attention on the hot spots and apply control measures to control mosquitoes for better management.

119 *Aedes aegypti* abundance and infection rates during the 2014 chikungunya and 2016 Zika outbreaks in southern Puerto Rico

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The first confirmed human cases of chikungunya (CHIKV) and Zika (ZIKV) virus infections were detected in Puerto Rico in May 2014 and December 2015, respectively. There were over 31,000 suspected cases of CHIKV in 2014 and over 70,000 suspected cases of ZIKV in 2016. We investigated *Aedes aegypti* density and virus infection rates using sentinel AGO traps in each of four communities in southern Puerto Rico in 2014 and 2016. Two of the communities have had three AGO trap per home in most homes; one since December 2011 and the other one since March 2013. The other two communities were nearby locations without AGO control traps. We made pools (1 – 20 specimens) of female *Ae. aegypti* mosquitoes that were collected every week in all four locations and processed them by RT-PCR to identify viral RNA. Meteorological stations were placed in study sites to monitor rainfall, temperature, and relative humidity. Year 2016 was significantly wetter than 2014, but we did not find significant differences in mosquito abundance between years. Mosquito density was 6 – 10 times higher in untreated areas. We found 50 positive pools for CHIKV and 55 for ZIKV in untreated areas and 5 positive pools for CHIKV and 3 for ZIKV in treated areas. Infection rates of *Ae. aegypti* with CHIKV in 2014 and ZIKV in 2016 were not significantly different.

120 Re-emergence of St. Louis encephalitis virus in California

Vicki Kramer, vicki.kramer@cdph.ca.gov, Tina Feiszli, Robert Snyder, Kerry Padgett

Prior to the introduction of West Nile virus (WNV) into California in 2003, St. Louis encephalitis virus (SLEV) was routinely detected in mosquitoes and sentinel chickens in some regions of the state. The virus seemingly disappeared thereafter and was not detected again until 2015, when it was detected in both mosquitoes and sentinel chickens in Riverside County. In 2016, SLEV activity, including three human cases, was reported from 10 California counties. Through early September 2017, SLEV had been detected in 109 mosquito samples from 11 counties and in 7 sentinel chickens from 2 counties. In several of these counties, particularly in the northern Sacramento Valley region, SLEV-positive mosquitoes had not been detected in over 50 years and human cases had not been reported at least since 1968. Although most people who become infected with SLEV develop no symptoms or a mild flu-like illness, in high-risk groups, such as the elderly and immunocompromised, SLEV can cause severe neurologic illness and can be fatal, similar to WNV. Detection and monitoring of SLEV activity is critical to prompt enhanced mosquito surveillance and control and reduce the risk of virus transmission to California residents and visitors.

121 Platform MI-Aedes: a cost-effective mosquito surveillance used in large scale in Brazil.

Alvaro Eiras, alvaro@icb.ufmg.br, Amanda Freitas, Ana Paula Matos, Lucas Zanandrez, Victor Maia, Thais Rebouças

Since the introduction of Chikungunya and Zika virus in Brazil and subsequent dispersion in South America, there is a great deal to use novel technologies for adult mosquito surveillance for directing vector control. In Brazil, 90 cities routinely use the large-scalable MI-Aedes Platform, a low-cost integration of continuous vector monitoring by adult mosquito traps, at fine spatial and temporal scales. The information technology platform is near real-time data collection, analysis, and decision-making. In addition to mosquito abundance, trapped mosquitoes are submitted to PCR-RT and virus detection defined priority vector control areas for preventing outbreak of dengue, Zika, Chikungunya. This Platform has been shown to prevent dengue cases in many Brazilian cities when compared to those that did not use the technology and it costs about one

USD/person/year. In 2017, an outbreak of Chikungunya occurred in Governadores Valadares, (Minas Gerais States, Brazil) and the MI-Aedes was deployed to support the vector control activities. All collected mosquitoes were also submitted to virus detection. Mosquito abundance and infected mosquitoes by Chikungunya virus were highly detected at the first week of implementation. Vector control at the hot spot areas by UBV (Malathion) and source reduction and education, reduced significantly the number of cases and the mosquito abundance. When the vector control activities ceased after only weeks control, because of lack of vehicles resources, the mosquito population increased and the number of cases reduced, but infected mosquitoes were still collected by the traps. In Porto Alegre city, where the climate is similar to South of Florida (USA), the vector control activities rely thoroughly on the MI-Aedes Platform since 2012. A distinct fluctuation of mosquito abundance season is observed over the years, regardless of the vector control. The fast response to vector control have reduced significantly the number of dengue cases, when compared with other cities.

122 **The *Aedes* in the vision of Brazil**

Fabio Castelo Branco, [needed](#)

The Aedes in the vision of Brazil.

- a) History of vector colonization.
- b) Adaptation to different climates.
- c) Differentiated breeding sites.
- d) Updated numbers of the 05 diseases (dengue, zika, chikungunya, yellow fever and west nile).
- e) Brazil in numbers.
- f) Olympiads, decentralization and outsourcing.
- g) Call for business opportunities for American companies and suppliers.

123 **Variation in Mosquito species collections by trap type, 2012 to 2017**

Maximea Vigilant, mvigilant@hcuphes.org, Mustapha Debboun

About 85 different species of mosquitoes are found in Texas. Harris County Public Health - Mosquito and Vector Control Division have identified 56 species in Harris County and the City of Houston. On average, 34 different mosquito species were collected and identified from 2012 to 2017. The greatest number of species were collected from Biogent Sentinel (BG) traps (34), followed by Gravid traps (33) and Center for Disease Control and Prevention (CDC) miniature light traps (27) placed in storm sewers. During sorting and identification, some mosquito species were present in one trap but not the other. In addition, there were species which emerged in one year, only to be absent the next year due to seasonality, location and environmental conditions.

Latin American Symposium II

124 **Evaluation of indoor residual spraying equipment to control *Aedes aegypti* in urban areas**

Fabian Correa-Morales, fabiancorrea@msn.com, Felipe Dzul-Manzanilla, Pablo Manrique-Saide, Wilbert Bibiano-Marín, Evaristo Morales-Ríos, Anuar Medina-Barreiro, Gonzalo Vazquez-Prokopec, Mike Dunbar

The WHO has recently recommended Indoor Residual Spraying (IRS) as part of a vector control strategy to combat *Aedes*-borne diseases, including dengue, chikungunya, and Zika viruses. Manual-compression sprayers have been used in malaria prevention and control programs worldwide since the 1950's and are a standard for IRS application. However, there are technological advances that should be considered to improve IRS application (e.g., control flow valves, rechargeable-battery operated equipment, reduced drift nozzles, etc.), particularly if interventions are performed in urban areas to control *Ae. aegypti*. We performed a comparative evaluation of potential IRS equipment following procedures and specifications outlined by the World Health Organization. We evaluated the following spray equipment: 1) manual compression sprayers (Hudson X-pert, Goizper Vector Control Super), motorized sprayers (Honda WJR 2525, Kawashima AK35GX), and rechargeable battery sprayers (Solo 416, Birchmeier REC 15ABZ, Hudson NeverPump). Flow (the most important parameter) of the Hudson was stabilized at 550 ml/min by the use of a control flow valve (CFV). Goizper has integrated CFV and produced a similar flow as the Hudson. All motorized sprayers required CFVs to keep a constant flow, but their weight, high noise pollution when used indoors and high engine temperature made them highly unpleasant for the technician. Battery powered equipment provided constant flow with CFV as well as negligible noise. We identify alternatives to the Hudson X-pert equipment (Goisper and the 3 electric pumps) with technical and operational improvements for performing indoor residual spraying in urban areas.

125 **Improvements and challenges of Ultra Low Volume (ULV) aerial spray for mosquito control in Mexico**

Griffith Lizarraga, glizarraga@clarke.com, Abraham Torres Verduzco

ULV aerial applications and their measurement have been a topic of debate since their inception. As technology moves forward and ULV applications are well-established spraying techniques in the U.S., there is a greater need for sharing the details and knowledge to our neighboring countries. Latin America and Brazil have been fighting mosquito-borne diseases mainly malaria, dengue and yellow-fever since their local mosquito control services were established, but over the last decade a series of “new” mosquito-borne diseases have emerged including Chikungunya and Zika; this is increasing the pressure, for the local mosquito abatement authorities, to deploy techniques that “they” have not use before and at the same time balance their budget to decrease the ever looming threat of upcoming mosquito-borne diseases such as Mayaro (MV). Aerial ULV is a technique that can be paired with applications such as ground ULV and both ground and aerial larviciding to help in the reduction of the transmitting vector population. This presentation illustrates the improvements and challenges that entailed the conception and technologies required for the development of effective aerial ULV treatments done in Mexico over the last decade.

126 Characterizing the mating behavior of the malaria vector *Anopheles albimanus*

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Malaria is one of the most important mosquito-borne diseases worldwide. In Colombia, 83,295 cases of Malaria were reported in 2016. *Anopheles albimanus* is one the primary vector of malaria in Colombia, and containment of the disease there is currently focused on the use of insecticides and bed nets. However, due to changes in mosquito behavior and an increase in insecticide resistance, it is necessary to develop new methods of control that exploit the biological traits of *An. albimanus*, potentially allowing for more specific targeting of this disease vector. Reproduction is one of the main mosquito biological traits related to vectorial capacity. However, little is known about *An. albimanus* behavior(s) during courtship and mating. Our goal is to better understand mating biology and behavior of *An. albimanus* in order to develop and/or improve tools implemented in vector control. To gain insight into *An. albimanus* copulation behavior, we are using methods such as artificial vision and acoustic source separation techniques to dissect the basics of mating in this species under laboratory conditions, examining copulation position, copulation duration, swarming behavior and mating acoustics. We find that mating pairs copulate primarily in a “tail to tail” position, characteristic of other *Anopheles* species. Successful copulation lasts between 4 – 10 seconds. Finally, we are characterizing acoustic signals produced by individuals, males and females, during flight. We previously described that the fundamental frequency of *An. albimanus* females is around 376 (± 30.4) Hz and around 547 (± 61.2) Hz in males. However, we don't observe changes in fundamental frequency to be associated with the size of the individuals. Taken together, these results contribute to our knowledge of *An. albimanus* mating behavior and will potentially aid in future vector control efforts.

127 Transestadial composition of midgut microbiota in *Anopheles albimanus* from the Colombian Pacific region

Margarita Correa, margaritcorrea@gmail.com, Yadira Galeano-Castañeda, Paula Urrea, Stefani Piedrahita, Priscila Bascuñán-García, Nicola Segata, Francesco Beghini, David Serre

The insect microbiota plays an important role on the growth, metabolism and protection to pathogens. The mosquito microbiota is influenced by factors such as feeding source, female to egg and larvae to adult transitions; however, there is still lack of knowledge on the impact of each of these factors on the mosquito bacterial community composition. Various reports have revealed an important role of bacteria of the *Anopheles* midgut in reducing the *Plasmodium* parasite. The identification of native bacteria is relevant in the search for biocontrol candidates for malaria control. Therefore, in this study the gut bacteria of larvae, field-captured and emerged *Anopheles albimanus* mosquitoes of Colombia were characterized to elucidate the influence of the environment and transestadial transition on the bacterial community composition. Bacteria identification was performed by culture-dependent methods and 16S rDNA gene sequencing by Sanger and Illumina-Mi seq. A greater bacterial richness on field collected mosquitoes was detected with *Bacillus* spp. predominating while *Acinetobacter* spp. and *Enterobacter* spp. prevailed on the emerging mosquitoes. Additionally, a decrease in the number of taxa on the larvae to adult transition was evidenced. The results indicate a strong influence of the environment on the bacterial community composition of adult mosquitoes and bacterial colonization after the larvae to adult transition.

128 Evaluation of the efficacy of *Bacillus thuringiensis israelensis* and Spinosad on larval habitats of *Culex* sp. (Diptera: Culicidae) in the Pesqueria river in Santa Rosa, Apodaca, N.L., Mexico

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The aquatic systems in the state of Nuevo Leon have been threatened by the incorporation of external agents causing contamination increases over time, creating ideal sites for the development of mosquitoes of the genus *Culex*, a vector of diseases such as West Nile and lymphatic filariasis, being a risk factor for the health of the population. The aim of this study was to evaluate the efficacy of a local formulation of *Bti* and a Spinosad formulated in larval habitats of *Culex* sp. in the Pesqueria river in Santa Rosa, Apodaca,

N.L., Mexico. Three ponds were selected, the first for *Bti* (C1), the second for Spinosad (C2) and the last one as control (C). A pre-treatment sampling was performed on April 19, 2017. The next day, the formulation of *Bti* (3.55 g / m²) and Spinosad (1 tablet / 200L) was applied. The post-application samples were taken at 24, 48 and 72 h considering seven repetitions of each treatment. The material was transported to the laboratory and identified through the use of taxonomic keys to carry out the statistical analysis using ANOVA. The results showed that there is a significant difference between the treatments of *Bti* and Spinosad. The efficacy of the *Bti* and Spinosad formulations in *Culex* larval habitats was evaluated by observing a 100% decrease in the mosquito population at 72 h post-application of Spinosad larvicide while *Bti* did not show a good result in the control of the mosquito population.

129 Alpha and beta diversity of phlebotomine sand flies assemblage in a tropical forest of southern Mexico.

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The aim was to estimate the alpha and beta diversity of sandflies in an focus of cutaneous leishmaniasis in southern Mexico. Field work was in a tropical forest (18°59'26" N, 088°09'04" W; 21 masl). Sampling of sandflies was carried during three consecutive nights per month, from August 2013 to July 2014, and the sampling seasons were: 1) Rainy, 2) Cold and 3) Dry. On each night, twelve trapping were employed in every one of the four transects (Transect A to Transect D). The seasons and transects were grouped like Rainy-TA, Rainy-TB, Rainy-TC, Rainy-TD, Cold-TA, Cold-TB, Cold-TC, Cold-TD, Dry-TA, Dry-TB, Dry-TC and Dry-TD, adding up twelve groups of season-transects. The traps were Shannon traps, CDC light traps, Disney traps, Sticky traps and Delta traps. Specimens were mounting with Euparal®, and identified species level. The estimators of alpha diversity expressed as Hill numbers (q from 0 to 2) or effective number of species (D). Diversity of order $q = 0$ is the number of species, order $q = 1$ is the exponential of Shannon entropy, and order $q = 2$ is the inverse Simpsons concentration. Beta diversity in 12 seasons-transects were measured with Horn and Sorensen indexes. Capture effort was 1728 night-traps, 16,101 sandflies were collected, they were represented by of seven genera and thirteen species. For all seasons and transects, the richness estimated was ${}^0D = 13$ species, ${}^1D = 4.16$ effective species and ${}^2D = 3.25$ species most common. With the three values of q utilized, Rainy-TA had the highest diversity of sandflies, whilst Dry-TC, Cold-TD and Cold-TB obtained the fewer effective species of the order 0, 1 and 2, respectively. Horn and Sorensen indexes indicated high similarity in the incidence and abundances of sand flies species between the twelve transect-seasons, except in the Dry-TB.

130 Species composition and diversity of sand flies (Diptera: Psychodidae) in two localities of the Chiapas border region of Mexico and Guatemala.

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Fifty species of sand flies have been registered in Mexico, of which *Bichromomyia olmeca* is vector of cutaneous leishmaniasis (CL), and other seven species are suspected of transmitting leishmaniasis. This study was performed in a tropical forest fragment (named Guadalupe Miramar, GM) with vegetation of tropical forest fragmented at 432 m altitude, and mixed patches of tropical and pine-oak forest (San Antonio Buena Vista, SABV) at 1380 m altitude. This border region between Mexico and Guatemala is a zone of CL transmission. To compare phlebotomine diversity among vegetation types, samples were taken using miniature CDC light traps (mod. 512) at 50, 100, 250 and 500 m from the edge of each habitat at each site based on four transects from July 2009 to June 2010. In total 3989 sand flies were collected belonging to 10 genera and 23 species. Overall, 97.2% of phlebotomines was collected in GM comprising 23 species, compared with 7 species at SABV. The most prevalent species in GM was *Psychodopygus panamensis* (25.9% of captured individuals), followed by *Lutzomyia hartmanni* (5.7%) and *Psathyromyia carpenteri* (5.3%). In contrast, in SABV the most abundant species was *Lu. cruciata* (80.2%), followed by *Ps. shannoni* (5.4%) and *Pintomyia ovallesi* (4.5%). Five of these species have been implicated in the transmission of leishmaniasis. Species diversity and equity was highest in GM (Shannon's $H' = 2.31$, $E = 0.7$) and lowest in SABV ($H' = 0.84$, $E = 0.4$). Significant differences were observed in species diversity between coffee plantations and perturbed vegetation ($P < 0.05$), and at different distances ($P < 0.05$) at GM, but not at the SABV site ($P > 0.05$). Differences in the abundance and diversity of phlebotomines are likely due to climatic factors, habitat type and human perturbation.

Unmanned Aerial Systems in Mosquito Control Symposium I

131 Unmanned aerial systems (UAS) for mosquito control

TBD

Not Available

132 Mosquito Assessment and Control-Unmanned Aerial Systems (MAC-UAS) Program

Joel Buettner, joelb@placermosquito.org, Scott Schon, Everardo Ortiz

In the fall of 2016, Placer Mosquito and Vector Control District embarked on a pilot project with the purpose of identifying the technical and operational capabilities of unmanned aerial systems (UAS) in a local government agency mosquito and vector control program in California, USA. This project was implemented in four phases: 1) Training, Certification, Safety and Operations, 2) Mission Profile Development, 3) Evaluation of UAS technology and Regulatory Landscape, and 4) UAS-based Public Health Pesticide applications. After 12 months, the pilot project has grown into the MAC-UAS program, and regularly provides unique operational benefits in the assessment of mosquito habitat, while continuing to develop new mission profiles. We are currently working to develop a UAS-based application capability by the 2018 mosquito season. The speed at which this program has developed and its tremendous potential for use in mosquito control parallels the technological boom that UAS is experiencing globally. We are encouraged that we have shown that it is possible to integrate UAS technology at many levels of a mosquito control program, and observe measurable benefits.

133 Operational Use of Unmanned Aircraft Systems (UAS) in Placer County

Scott Schon, scottss@placermosquito.org, Joel Buettner, Everardo Ortiz

The Placer Mosquito and Vector Control District has two Federal Aviation Administration (FAA) part 107 certified remote pilots, who operate a DJI Phantom 3 quadcopter and a Quad H₂O V2 hexacopter in a variety of different mission types. Mission types include atmospheric measurements, visual assessment of mosquito habitat, aerial photographic monitoring, mosquitofish and mosquito larval detection, and deployment and retrieval of adult mosquito traps. Atmospheric measurements are taken with a weather sensor attached to a UAS with the purpose of detecting relative humidity and the presence or absence of temperature inversion in order to support manned aerial and truck adulticide operations. Typically atmospheric measurement missions are conducted in the late evenings to track changes in the weather before, during, and after aerial adulticide times. Visual assessment missions are used to detect the presence or absence of standing water or other important elements of mosquito habitat. This mission type is used to help vector control technicians view mosquito sources that may be hard to access, or to help with enhanced surveillance around positive trap locations. Aerial photographic monitoring missions are used to document change over time of a particular site with regard to standing water or other land use relevant to mosquito management. With the District's waterproof hexacopter, more complex mission types have been developed, including performing visual assessments of water mosquito larvae. Another feature on the hexacopter is a payload release, giving the remote pilot the option of releasing objects from the UAS while in flight. The District has developed a mission profile for deploying adult traps and retrieval of these traps. Starting with more basic missions and working towards more complex missions types have allowed us to build a strong foundation of skills and knowledge to conduct UAS-based larviciding and adulticiding missions in the near future.

134 Development of UAS Technologies to Augment Mosquito Control Operations at the Sacramento-Yolo Mosquito and Vector Control District

Samer Elkashef, selkashef@fightthebite.net, Marty Scholl, Ruben Rosas

The Sacramento-Yolo Mosquito and Vector Control District (Sac-Yolo) is in the process of building its unmanned aerial system (UAS) program. In addition to conducting numerous UAS trials with private industry, the District has begun in house testing of select UAS technologies. Sac-Yolo currently has two licensed UAS pilots and has actively been exploring UAS program elements that can help guide operational decisions in real time in an effort to save the District both time and money when it comes to pesticide applications and source reduction. Using off the shelf, business grade UAS units Sac-Yolo has performed proof of concept surveillance and atmospheric data collection using both Red Green Blue (RGB) color and Near Infrared (NIR) Imagery to find standing water in large areas in the fraction of the time it would take a technician to do so by conventional means. Furthermore, Sac-Yolo has utilized custom engineered on-board weather collection sensors in conjunction with the individual UAS prop algorithms to evaluate weather conditions to optimize release height of aerial ultra-low volume applications.

135 How to create a drone program

Ryan Wood, [needed](#)

Unmanned Aerial Vehicles, or drones, are beginning to be implemented in mosquito control. The physical drones are only a small piece of a Drone Program. There are many other items that need to be planned on for a successful drone program: including regulations, personnel and training. This presentation will address these issues as well as showcase current drone solutions for mosquito control.

Disease/Vector Studies II

137 Composition and structure of mosquito microbiota from six states in the United States

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Microbial communities found in association with mosquitoes can influence vector competence and understanding their spatial dynamics can inform development of novel disease control approaches. We investigated the microbial communities associated with diverse mosquito species collected from six states in continental United States. We found that the composition and diversity of whole-body microbiome of mosquitoes was strongly influenced by the site in which the mosquitoes were collected. These findings provide some important insights into how the local environment influences the microbiome assembly in mosquitoes.

138 Invasive *Aedes aegypti* in southern Nevada - a new finding

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2017 saw a dramatic change for the Southern Nevada Health District's (SNHD) Vector Surveillance program. In May the vector surveillance program identified the highly invasive *Aedes aegypti* (*Ae. aegypti*) mosquito for the first time in Southern Nevada. The identification was a result of a citizen complaint reporting aggressive daytime biting mosquitoes. In response, SNHD vector surveillance teams initiated a door to door campaign deploying surveillance traps in the affected area and providing residents with bite prevention and breeding source reduction education. The objective was to identify the boundaries of the *Ae. aegypti* outbreak and eradicate the invasive mosquito prior to it spreading to other areas in the community.

184 traps were set at 108 homes around the index case during the first week of the *Ae. aegypti* response. 17 sites yielded 24 specimens, of which 21 were female. Known larval sources were physically removed and the sites were treated with larvicide and adulticide using handheld Ultra Low Volume (ULV) fogging machines. Mosquito specimens were sent to the Nevada Department of Agriculture Lab for arbovirus testing. All *Ae. aegypti* collected during the initial response tested negative for arboviral disease. Geographic data compiled during the initial response indicated the *Ae. aegypti* population had extended throughout the entire community. As a result, SNHD conducted the first ever residential truck mounted fogging event in the affected area covering 500 acres. Post fogging surveillance continued to identify new *Ae. aegypti* sources.

From May – September of 2017 600 traps were set in the affected area and surrounding neighborhoods with a total of 161 female *Ae. aegypti* mosquitoes collected. A total of 4 truck mounted adulticide fogging events were conducted in an attempt to reduce the adult *Ae. aegypti* population. Surveillance activities continue to demonstrate that the *Ae. aegypti* mosquito is spreading throughout the localized geographic area.

139 The surprising diversity and abundance of non-culicid biting flies (Diptera) in a zoo environment

Dustin Swanson, dustin.swanson@ars.usda.gov, Nathaniel Kapaldo, Elin Maki, James Carpenter, Lee Cohnstaedt

Biting flies were collected in Sunset Zoo, Manhattan, Kansas, to assess non-culicid biting-fly diversity and how collection variables influence trap catches of these dipterans. Two trap types, two trapping periods, and eight trapping locations were sampled over an eight month period in the zoo. A total of 8,400 non-culicid biting flies representing 29 species and 5 families was collected. Within the zoo, 69.2% (18/26) of the *Culicoides* species and 37.5% (6/16) of the simuliid species known to be distributed in Kansas were collected. *Simulium bivittatum* also was collected for the first time in Kansas, bringing the state total to 17. The most abundant species collected was *Simulium meridionale* (n=4,384), one of the first major reports of black flies in a zoo environment. Five species, *Culicoides crepuscularis*, *Culicoides guttipennis*, *Culicoides haematopodus*, *Culicoides stellifer*, and *S. meridionale* were analyzed by a negative binomial generalized linear model for the effect of trap type, trapping period, trap location, and month on trap collections. Ultraviolet light CDC traps collected significantly more of the four *Culicoides* species than BG-Sentinel traps. Trap location was significant for four species, month for three species, and trap period for two species. The effect of biting-fly larval habitat on spatial distribution within the zoo will also be discussed. The diversity and abundance of non-culicid biting flies in the zoo indicates increased biting pressure and risk of disease transmission to the zoo fauna. These results demonstrate the importance of monitoring for insects in a zoo environment and diversifying surveillance methods beyond typical protocols for mosquitoes (Culicidae).

140 St. Louis Encephalitis Virus-unprecedented activity in southern Nevada

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2016 was a dynamic year for the Southern Nevada Health District's (SNHD) Vector Surveillance program. The SNHD vector surveillance program identified an unprecedented amount of St. Louis Encephalitis (SLE) virus primarily in *Culex* mosquitoes, and the first human cases of SLE since 2007 were reported to the SNHD Office of Epidemiology.

Louis encephalitis is a rare disease in Clark County. In 2015, 2 submission pools totaling 100 mosquitoes represented the only mosquitoes ever identified with the virus in Clark County, with the most recent human case being reported in 2007. In 2016, SLE was identified in 180 mosquito pools, totaling 5,655 mosquitoes. Of the 5,655 specimens 3,848 (68%) were *Culex quinquefasciatus*, 927 (16%) were *Culex stigmatasoma* and 566 (10%) were *Culex tarsalis*.

The unprecedented amount of activity captured the attention of the Centers of Disease Control and Prevention (CDC) and the University of California's Davis Arboviral Research and Training Lab (DART).

In an effort to identify the preferred avian host of the *Culex* mosquito, staff collected and submitted 200 individual, engorged female species to the CDC for blood meal analysis. It was thought the analysis would provide information on what bird species may be amplifying reservoirs for SLEV transmission. Additionally, SLEV positive isolates from mosquitoes were sent by the Nevada Department of Agriculture to DART for genetic sequencing to infer possible origin of the virus strain.

The blood meal analysis from the mosquito specimens submitted to the CDC identified 19 bird species as positive for SLE virus. Of the specimens tested 39.5% were common house finches (*Haemorrhous mexicanus*) and 27/154 were domestic chickens (*Gallus gallus*.) Blood meal analysis and SLEV isolation implicated these 2 bird species as the most likely candidates for amplifying SLEV in Southern Nevada.

141 Transcriptomic Evidence for *Aedes aegypti* from Florida in response to Zika virus

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Aedes aegypti is a vector of several arboviruses that affect human health and is of increasing concern because of the re-emergence of dengue and chikungunya viruses, and recent local transmission of Zika virus in Florida. Zika virus was first discovered in 1947. The epidemiology of Zika virus has changed in the last 10 years with major human outbreaks reported in the Pacific Islands and the Americas. Pesticide resistance in *Ae. aegypti* has been demonstrated in Puerto Rico and several neighboring countries throughout the Caribbean. The resistance status of local populations is of critical importance for effective management by control districts in Florida but little is known. According to USDA CMAVE laboratory study, the populations of *Ae. aegypti* collected from several locations in Florida showed up to 85-fold resistance to permethrin when compared to the susceptible Orlando-1952 strain of *Ae. Aegypti*. We use molecular approaches i.e., RNA-sequencing to examine whether permethrin-resistance in local populations of Florida *Ae. aegypti* affect their ability to transmit Zika virus. The RNA-seq data show that there are 624 genes significant differential express in the Key West resistant selected population between Control and ZIKV infection. However, only 248 genes in Orlando-1952 strain of *Ae. Aegypti* were significant differential expressed in response to Zika virus infection.

142 Updates on La Crosse encephalitis research in eastern Tennessee

Rebecca Trout Fryxell, rfryxell@utk.edu, Cassandra Urquhart, Abelardo Moncayo, Doris D'Souza, Suzanne Lenhart

In North America La Crosse encephalitis is the leading cause of arboviral disease among children and its incidence is rising in the southern Appalachian region. Because La Crosse virus (LACV) is heterogeneous in the landscape it is first necessary to identify infected-sites and uninfected-sites. To identify these sites efficiently, we identified best trapping methods, developed cost-effective procedures for screening mosquitoes for LACV (e.g., RT-LAMP), and mathematical models (based on temperature and precipitation data) to predict when infected mosquitoes are questing in the field. Here, we will share our surveillance and research efforts for LACV. We plan to use our newly developed and tested methods to identify risk factors for infection, identify vectors, determine prevalence rates, and describe areas with increased risk. We also plan to use these sites in future studies to compare entomological, biological, landscape, microbial, and/or genetic differences between the sites, and each site's vector and reservoir populations. Already, our LACV research connected infected mosquitoes with a fatal case in eastern Tennessee, confirmed the epidemiological importance of lineage I strains in the emergence of fatal LAC encephalitis, and verified transovarial transmission in the region.

143 Comparing commercial kit versus standard guanidine thiocyanate extraction protocols for nucleic acid extraction and purification

Phillip Spinks, phillips@placermosquito.org, Phillip Spinks, Joel Buettner

Extraction of nucleic acids (RNA/DNA) from arthropod samples followed by *reverse transcriptase polymerase chain reaction (RT-PCR)* is commonly used to detect pathogens. Accurate detection obviously depends upon extracting RNA and DNA of sufficient quantity and quality for subsequent RT-PCR experiments. Extraction protocols based on solid phase reversible immobilization (SPRI) paramagnetic beads are highly efficient and commonly used especially where high throughput is necessary. Commercially available SPRI-based viral RNA extraction kits are widely used because of their ease of use and reliability but can be relatively expensive. However, extracting and purifying nucleic acids is the cornerstone of molecular biology and there are

hundreds if not thousands of extraction protocols in use among the laboratories of the world. Non-commercial extraction protocols can be significantly less expensive but may or may not be as efficient as commercial kits. In some situations a decrease in efficiency is acceptable, but for pathogen detection any loss in efficiency would be unacceptable. Here, we extracted and purified viral RNA and bacterial DNA from mosquitoes (*Culex sp.*) and ticks (*Ixodes pacificus*), respectively using a commercially available viral RNA extraction kit and a guanidine thiocyanate protocol from the literature. We extracted viral RNA from mosquitoes infected with west Nile virus (WNV), and bacterial DNA from ticks infected with Lyme borreliosis bacteria (*Borrelia sp.*) and performed RT-PCR experiments using custom TaqMan probes. The relative performance of each extraction method was determined based on cycle threshold (Ct) values from the RT-PCR experiments. Cycle threshold scores from samples extracted using either method and for either target were very similar indicating that RNA and DNA extractions utilizing a typical guanidine thiocyanate extraction protocol suffered no loss in efficiency compared to a commercially available kit and would result in considerable cost savings.

144 Mosquitoes of the United States Virgin Islands

Krystal Seger, krystal.seger@doh.vi.gov, Brett Ellis, Carrie De Jesus

The United States Virgin Islands (USVI) is a United States territory located in the Caribbean Sea due east of Puerto Rico. The USVI has experienced multiple mosquito-borne disease outbreaks in the last decade. Outbreak-causing pathogens have included dengue virus, chikungunya virus, and most recently, Zika virus. Despite being prone to mosquito-borne disease outbreaks, the USVI has had only sporadic and limited vector control services and corresponding research in recent decades. As a result, little is known about the USVI's mosquito populations, including the vector of concern *Aedes aegypti*. Beginning in February 2017, *Aedes aegypti* surveillance began in two neighborhoods on the island of St. Croix. The surveillance neighborhoods were chosen because they experienced the highest human chikungunya infection rates during the 2014-2015 chikungunya virus outbreak. Thirty BG-Sentinel 2 traps were placed in each neighborhood. Collections are ongoing. Trap contents are collected one to three times per week. Preliminary results of mosquito collections, including seasonality and species not previously reported in the USVI, will be discussed.

New Product Trials

146 Real-time district-wide mosquito surveillance with the Biogents BG-Counter

Mark Kartzinel, mkartzinel@cmcd.org, Mark Clifton

In 2017, the Collier Mosquito Control District began implementation of a near real-time, web-connected, mosquito population surveillance network across 401 square miles of district territory using the BG-Counter from BioGents AG. The BG-Counter autonomously traps and counts mosquitoes over intervals as short as 15 min and uploads the data to a web-based program for viewing and analysis. The results from over two-months of data collected at 15 min intervals during a severe *Aedes taeniorhynchus* season has demonstrated some interesting patterns. Immense broods of *Ae. taeniorhynchus* were produced at cyclical intervals related to the phase of the moon and high tide levels over the 2 month observation period. The close relationship between moon phase, tide level, and mosquito production as measured by the BG-Counter has suggested a set of environmental circumstances which can be used to predict future broods of mosquitoes. Data collected later in the wet season was able to generate a similar set of predictive environmental conditions related to water table level and the production of freshwater mosquitoes. Hourly collection data during the evening over the trial period has indicated a surprisingly wide range of variability in nightly host-seeking behavior. Although a clear peak of activity near sunset occurred, the high level of day-to-day variability in host-seeking activity should be considered when planning adulticide treatments. The BG-Counter also proved useful for monitoring the efficacy of adulticide treatments. Five aerial adulticide treatments were monitored over a period of 30 d. Many treatments led to large reductions in mosquito population. However, evidence for new migration into the treatment zone was also observed. In addition to the new biological details the BG-Counter was able to illustrate, this trap proved to be "force-multiplier" in terms of routine surveillance effort and research effort required.

147 *Aedes aegypti* and *Aedes albopictus* response to four popular ovitraps in outdoor screen enclosures.

John Smith, jsmith@pc.fsu.edu, Taylor Thrall

The aim of this study initiated in the Spring of 2017 was to evaluate the efficacy of the BG-GAT, CDC-AGO, In2Care, and Springstar Trap-N-Kill ovitraps for control of *Aedes aegypti* and *Aedes albopictus* in outdoor screen enclosures supplemented with common breeding sites. The most significant findings relative to *Ae. aegypti* were: 1) black 5-gal buckets and bromeliad plants, *Aechmea fasciata*, generally provided more attraction for oviposition than did the ovitraps; 2) CDC-AGO consistently trapped more than 50% of released gravid; 3) the In2Care and BG-GAT produced the greatest amount of larval/pupal mortality compared to the control (72% and 52%, respectively); 3) the In2Care provided effective autodissemination of

pyriproxyfen; and, 4) very few adult emerged from seeded oviposition sites near the In2Care compared to other ovitraps evaluated. Results for *Ae. albopictus* are to be completed during the Fall of 2017 and will be presented as well.

148 Developing Sterile Insect Technique (SIT) as a tool Mosquito Control Districts can use for integrated *Aedes aegypti* control

Robert Aldridge, Robert.Aldridge@ars.usda.gov, Leah Boardman, Jedidiah Kline, Jordan Coburn, Daniel Kline, Seth Britch, Daniel Hahn, Kenneth Linthicum

Uncontrolled populations of *Aedes aegypti* pose a significant public health-risk to humans as a vector of dangerous arboviruses in most of the tropical and much of the temperate regions of the world. *Aedes aegypti* are difficult to control because they exploit abundant artificial containers around homes for larval development that are difficult to reach with larvicides and adults often rest in cryptic places difficult to reach with adulticide sprays. Mosquito control personnel are additionally challenged since typically they have neither the resources nor permissions to treat residential yards and businesses to attempt to treat these kinds of habitats. Conventional control measures like adulticide sprays or larvicides can suppress *Ae. aegypti*, but populations are difficult to eliminate and often rebound quickly after treatment, and difficulties are compounded by resistance to common pesticide formulations in many *Ae. aegypti* populations. New tools are clearly needed for integrated mosquito management of *Ae. aegypti*. We describe the sterile insect technique (SIT) that we are developing as a method to control *Ae. aegypti* by partnering with two prominent Florida mosquito control districts (Anastasia and Lee County MCDs) and the FAO/IAEA Insect Pest Control Subprogramme. Working with local strains from Anastasia (St. Augustine) and Lee County (Fort Myers), we developed dose-response relationships that produce sterile male mosquitoes and then measured mating performance. Then, we performed mark-release-recapture experiments in potential field sites to assess wild population densities, dispersal performance of sterile males, and estimated the number of sterile mosquitoes needed for field releases to suppress wild populations. Successful completion of these project goals will provide the foundation for mosquito control districts to use *Ae. aegypti* SIT as part of their integrated mosquito management programs for these dangerous and elusive vector mosquitoes.

149 Evaluation of mosquito repellent gel

Meiling Webb, meiling.webb@ars.usda.gov, McPhatte Lee, Dean Crockett, Jacob Hargrave, Mustapha Debboun, Kamlesh Chauhan

Hand sanitizers are developed as alcohol-based liquid gel formulations, generally used to decrease [infectious agents](#) on the hands. Verdegen proposed to prepare insect repellent gel for the public use when the recent outbreaks of Zika infection vectored through *Aedes* mosquitoes in American continents sought multi-facet emergency measures. Four different gel formulations comprising two most efficacious commercial insect repellent actives DEET and Picaridin at 33% and 20% were developed. Compliance with the use of topical repellents remains an issue among military personnel. One of the most common complaints by soldiers is that they do not like how the repellents feel on their skin (e.g. oily, greasy). If this product is proven to be effective, it may be a useful alternative for commonly used repellents by the military. When efficacy and protection time of these new gel formulations was compared to commercially available cream formulations of DEET and Picaridin at similar concentrations, the gel formulations with better topical attributes, exhibited equal or better biting protection up to 48 hrs against blood seeking *Aedes aegypti* female mosquitoes. The results of the efficacy trial of insect repellent gel formulations will be discussed.

150 New technologies and operational research at the Salt Lake City Mosquito Abatement District

Ary Faraji, ary@slcmad.org, Greg White, Andrew Dewsnap, Brad Sorensen

Salt Lake City Mosquito Abatement District has been in operation since 1924. The District provides surveillance and control services for the resident of Salt Lake City, encompassing over 100 square miles of rural, industrial, and suburban/urban habitats. The District routinely undertakes a variety of operational research projects to enhance its existing integrated mosquito management and surveillance methods. We highlight some of the new technologies and research projects undertaken during the 2017 season. These include the design/manufacture of our carbon dioxide-baited traps using a 3D printer, conversion from dry ice buckets to CO₂ canisters, incorporation of an online database for mosquito and pathogen surveillance (U-Surv), trap efficacy evaluations for *Aedes sierrensis*, field usage of the BG-Counter, efficacy of passive traps for floodwater mosquito collections, next generation sequencing for mosquito surveillance and detection of pathogens, mosquito adulticide bottle bioassay evaluations, mosquito larval resistance to *Lysinibacillus sphaericus* monitoring, catch basin pesticide evaluations using pyriproxyfen, the use of Unmanned Aerial Systems for control applications, and utilization of frogs through a heterodissemination technique for

mosquito control. This presentation will provide a brief overview of the above projects and provide insight into future objectives.

151 Efficacy trials of Sumilarv 0.5g in St. Paul, Minnesota catch basins

Kirk Johnson, kjohnson@mmcd.org, Stephen Manweiler

Control of mosquito larvae in catch basins is an integral part of the Metropolitan Mosquito Control District's West Nile virus risk reduction effort. Operationally, the majority of MMCD catch basins are treated monthly with Altosid® pellets (3.5 g/cb). We have evaluated several other larvicides in catch basins in an attempt to identify products that might improve our efforts through increased efficacy and/or reduced labor. In 2017 we evaluated the potential for season-long mosquito control of four doses of Sumilarv 0.5g applied to the sumps of catch basins (75, 100, 125 & 150 g/cb). These treatments were compared with catch basins treated operationally and catch basins left untreated. Bioassays of pupae from each treatment group were used to determine emergence inhibition. The results of these efficacy trials are presented here.

152 Efficacy of In2Care Mosquito Trap for control of Aedes aegypti on Captiva Island, Lee County FL

Rachel Morreale, morreale@lcmcd.org, Jessica Berman

A small-scale field trial was conducted on Captiva Island from March to May 2017. Twelve In2Care® Mosquito Traps were deployed throughout the 1 acre test site. A 2.5 acre control site was used to monitor the naturally occurring populations of *Aedes aegypti*. A 250 meter buffer separated the control and test sites. Populations of *Ae. aegypti* were monitored weekly using BG Sentinel Traps and LBJ ovicups. Background population data was collected for 4 weeks prior to deployment of the In2Care® Mosquito Traps. Bioassays were performed with *Ae. aegypti* exposed to water collected from the ovicups to ascertain the spread of pyriproxyfen through the test site. In2Care® Mosquito Traps were monitored weekly, underwent maintenance after 6 weeks, and continued for another 6 weeks.

153 Duet® HD – A New Adulticide Formulation Created Specifically for Aerial Application.

Yemi Bullen-McClain, Ph.D., ymclain@clarke.com

New Duet® HD combines the dual-action effectiveness of sumithrin and prallethrin with new inert ingredients selected to create a high density (HD) formulation specifically for aerial performance. This presentation will discuss the formulation design criteria and formulation optimization process the Clarke Development team followed to achieve the final formulation. The product profile, lab and ground results used for EPA submission will be reviewed. At the time of abstract submission only initial aerial characterization was completed. Any completed operational trials will be reviewed. These were delayed by the late 2017 hurricanes. Duet HD has received EPA registration and will have a stewarded introduction in 2018.

154 A Wolbachia-based autocidal approach to control Aedes mosquitoes.

Jimmy Mains, jmains@mosquitomate.com, Corey Brelsfoard, Stephen Dobson

The *Aedes aegypti* and *Aedes albopictus* are an invasive species and public health concerns due to their aggressive day-biting behavior and ability to transmit medically important pathogens (e.g., Zika, dengue, chikungunya). Despite intensive use of pesticides to manage this species, they have colonized much of the U.S.A., and continue to expand their range. A proposed autocidal approach for its control is based on Wolbachia, an endosymbiotic bacteria that is common in many insect species. Similar to sterile insect technique, the Wolbachia approach is based on the release of Wolbachia infected males, which cause a form of conditional sterility in the targeted populations. Presented here, are 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.

Unmanned Aerial Systems in Mosquito Control Symposium II

136 Hack your drone: Mosquito surveillance and control with consumer UAS

Gregory Williams, gwilliams@hudsonregionalhealth.org

Professional unmanned aerial systems (UAS) have been evolving at an exceedingly rapid pace. Major manufacturers have even begun to develop large agricultural UAS with potential use in mosquito control operations. While useful for a variety of missions, professional UAS are expensive and require training and experience to fly and maintain. Consumer UAS however, are low cost and very easy to fly. Unfortunately their capabilities are often limited to aerial photography and videography. In this talk we discuss the development and use of small, lightweight modules that attach to the DJI Phantom quadcopter for collecting mosquito larvae and dropping larvicide tablets. These devices, combined with the exceptional technology of the Phantom, offer a cheap and simple option for mosquito control programs looking to incorporate UAS into their programs.

155 The use of the Yamaha RMAX in operational applications of larvicides over the course of a season

Bill Reynolds, breynolds@leateam.com, Valkyrie Kimball, Shanon Kern

The Yamaha RMAX has been used worldwide in a variety of Unmanned Aerial System (UAS) applications ranging from aerial applications on rice fields in Japan to drying and protecting crops during wet or frost conditions. Leading Edge Associates will share the 2017 experiences of using the RMAX in operational mosquito control for the aerial application of liquid and granular larvicides. Many of the problems of traditional manned aircraft and ground rig applications are access to treatment locations that are too small or inaccessible for manned aircraft and are located near sensitive areas and ground obstructions that create safety hazards. Additional problems are the availability of manned aircraft during the agricultural season as mosquito control operations have similar demands for aerial application services. The characterization of droplet spectrums, swath analysis, bioassays and over all experiences using the Yamaha RMAX UAS in operational mosquito control will be presented.

156 How to create a drone program

J.T. VonLuen, **needed**

Unmanned Aerial Vehicles, or drones, are beginning to be implemented in mosquito control. The physical drones are only a small piece of a Drone Program. There are many other items that need to be planned on for a successful drone program: including regulations, personnel and training. This presentation will address these issues as well as showcase current drone solutions for mosquito control.

Arthropod Vector Highlights Symposium

159 Highlights in vector biology

Rajeev Vaidyanathan, **needed**

Not Available

160 Highlights of vector control

Micahel Doyle, michael.doyle@dhhs.nc.gov

Continuing concerns about Zika virus shifted 2017 mosquito suppression efforts towards container-breeding species such as *Aedes aegypti* and *Aedes albopictus*, including significant progress in use of the Sterile Insect Technique (SIT). On the opposite end of the behavioral spectrum, Hurricanes Harvey and Irma further required wide-scale mosquito suppression in Texas and Florida, thus highlighting the industry's dual, and sometimes conflicting, role of residential versus wide-scale suppression methods. This presentation will highlight some of the latest advancements in vector control based on papers published in 2017. We will trace the progress of control methods for several species, including advances in equipment, application methods, active ingredients, physical control, biological control, and new technologies. Advances in container-breeding species will be highlighted, along with reviews of both academic and applied impacts of research.

161 Recent news in triatomine biology, control, and disease transmission

Kyndall Dye-Braumuller, kdye@hcuphes.org

Triatomines (Reduviidae: Hemiptera), or kissing bugs / conenose bugs, vector one of the western hemisphere's neglected tropical diseases: Chagas disease, or American Trypanosomiasis. Over the past few years, Chagas disease has gained the spotlight in the public—and veterinary—health community. The difficulty in controlling these bugs and the pathogenesis of the *Trypanosoma cruzi* parasite in humans have both aided in creating a formidable opponent for public and veterinary health. Recent work published from 2017 will be discussed in regards to the biology and control of kissing bugs, as well as work on parasite epidemiology and treatment in the Americas.

Integrated Tick Management Symposium

162 Fighting the bite: tick-associated disease and integrated tick management

Kirby C. Stafford III, Kirby.Stafford@ct.gov

Increasing prevalence of Lyme disease and the emergence of other tick-associated human diseases in the United States have become a major public health concern. A wide variety of prevention and control strategies have been adapted or investigated to reduce human risk of disease, but field studies incorporating integrated pest management, ecological, and human behavior concepts are limited. The prevalence of tick-borne pathogens, human risk of tick-borne disease, the current status of integrated tick management (ITM) research, and ITM work conducted in Connecticut will be highlighted.

163 Host-targeted acaricides and landscape modifications for control of *Ixodes scapularis* in Wisconsin

Susan M Paskewitz, smpaskew@wisc.edu, Jordan Mandli

Ixodes scapularis is the vector of multiple human pathogens in the Upper Midwest, including *Borrelia burgdorferi* (Lyme Disease), *Anaplasma phagocytophilum* (human anaplasmosis) and Powassan/deer tick virus. Strategies for management of tick populations have not been tested in this region, although differences in tick phenology and reservoir communities might affect the efficacy of selected approaches. We tested the impacts of providing permethrin-treated nest materials for rodent hosts and removal of invasive plant species (buckthorn and honeysuckle) alone or in combination in 0.5 acre (0.2 hectare) plots in a forested urban area in southern Wisconsin. Results showed that the density of infected nymphal ticks and the intensity and prevalence of infestation on white footed mice were lower in plots treated with nest materials in comparison with untreated plots. Removal of invasive plants reduced tick density in the year following removal, with up to 80% reduction of infected nymphs in plots receiving both treatments. Reduction of the tick burden on mice was limited in June but was high in July and August, suggesting that adjustment of the time of deployment of the nest materials might improve results. Study results provide support for use of host-targeted nest materials as one tool for community-based or individual property integrated tick management practices.

164 Integrated management of an indoor pest, the brown dog tick

Emma Weeks, eniweeks@ufl.edu, Phillip E. Kaufman, Sandra A. Allan

Ticks parasitize dogs resulting in introductions into the peridomestic where they bite pets and people. In particular, dogs are the preferred host of brown dog ticks, *Rhipicephalus sanguineus*, which are capable of establishing breeding populations indoors. Acaricide resistant *R. sanguineus* have reduced the utility of pesticides for control. As a result, infestations can rapidly become a nuisance, with tick-borne diseases manifesting in dogs and people. Integrated pest management (IPM) could mitigate the effects of acaricide resistance for better control. The current recommendation for management of peridomestic *R. sanguineus* infestations is the use of on- and off-host pesticides in combination. However, due to cost limitations, this approach is rarely implemented. Furthermore, off-host pesticides are also applied outdoors through broadcast methods with associated environmental impacts. Valuable additions to a *R. sanguineus* IPM program will be discussed, including improvements to monitoring techniques, cultural practices and biopesticides. The goal of our program is to reduce the number of ticks on dogs, breaking the cycle of disease transmission, and to reduce untargeted use of pesticides.

165 Integrated tick management for livestock and domestic animals

Sonja Swiger, slswiger@ag.tamu.edu

The impact of ticks on livestock can be substantial and costly. Many time ticks go unnoticed on cattle and other livestock that remain on pasture for long periods of time or do not encounter regular human contact. Maintaining a minimal to zero tick population on livestock takes knowledge, dedication and an integrated approach. Although it can be difficult to reach all areas that livestock will travel to in large pastures, it is important to do as much integrated pest management that is feasible to minimize all the live stages of the various tick species that could be present.

Pesticide Resistance and Management – From Theory to Practice Symposium I

166 An update on *Aedes aegypti* pyrethroid resistance and testing in the southern U.S.

Adlen Estep, alden.estep@ars.usda.gov, Neil Sanscrainte, Christy Waits, James Becnel

Aedes aegypti has increasingly become a species of concern in the Southern US because of range expansion, reintroductions, and high competency as a host of human pathogenic diseases. Adult chemical treatment options are currently limited to pyrethroids and organophosphates. Because pyrethroid resistance is widespread outside the US and pyrethroids are the chemical class used in the US, it is critical to understand the distribution and intensity of the *kdr* mutations in local populations of *Ae. aegypti* to guide effective treatment decisions. We have previously shown that two *kdr* mutations observed in the Caribbean, V1016I and F1534C, are widely found in FL populations and that the frequency of the 1016I mutation correlates strongly with permethrin resistance. In this update, we expand on our previous work and show similar patterns of *kdr* mutations and permethrin resistance in *Ae. aegypti* populations from other Southern states. While we do not propose *kdr* testing as a replacement for regular toxicology testing, the ease of determining allele frequencies and the strong correlation with pyrethroid resistance make it a useful tool that allows resistance assessment even from dead surveillance specimens. This is a tool that can be and has been implemented at the local control district level.

167 Challenges and successes of implementing urban adult mosquito control for WNV suppression in high risk areas of Orange County, CA, amid public opposition to pesticides

Laura Krueger, lkrueger@ocvcd.org, Robert Cummings, Amber Semrow, Kiet Nguyen, Tim Morgan, Sokanary Sun, Jerry Sims, John Drake, Larry Shaw, Mary-Joy Coburn, Lora Young, Rick Howard

In response to intense West Nile virus (WNV) activity from 2014-2016 (388 WNV cases, 18 deaths) in Orange County, California, the Orange County Mosquito and Vector Control District (OCMVCD) defined a tiered-response, adult mosquito control (adulticiding) program as a part of a newly-adopted WNV Emergency Response Plan (Plan). In early 2017, OCMVCD trained city administrators from nine high-risk area (HRA) cities on the Plan and requested partnership with each city to effectively educate and notify residents of WNV risk. By August, the mosquito infection rate (Vector Index, VI) in the HRA city of La Habra had escalated to 7.1, well-above CDC-defined levels associated with WNV epidemics, despite increased city-wide larviciding and repeated ultra-low volume adulticiding efforts with AquaDuet™ in city parks and greenbelts. In response, OCMVCD expanded its adulticiding program to weekly (2 nights/week) area-wide truck-mounted applications in three WNV-active residential neighborhoods over a three week period. This presentation highlights the challenges and successes of implementing OCMVCD's IVM-based WNV Emergency Response Plan, which included notification of La Habra residents of the applications and collaboration with public officials and community stakeholders. It will also examine the meteorological conditions during applications, pesticide efficacy, and pre- and post-treatment mosquito abundance and infection rates. The lessons learned from the area-wide control effort will help improve the efficacy and efficiency of future residential truck-mounted adulticiding applications in Orange County.

168 Status of Insecticide Resistance in Arbovirus Vectors in China

Fengxia Meng, mengfengxia@icdc.cn, Cannan Shi, Yiguang Wang, Wenlong Kai, Qiyong Liu

Insecticide resistance surveillance program has been implemented since 2007 by ICDC, China CDC in 19 provinces, with WHO recommended methods. A Biological Vector Resistance Monitoring Data Management System was built in 2013 to manage the insecticide resistance surveillance data. From the collected data, we can see that *Culex pipiens pallens/quinquefasciatus* has developed resistance to most of the commonly used pyrethroids. *Anopheles sinensis* has developed higher resistance to organochlorine, organophosphate and pyrethroids. From 2000 to 2013, resistant populations of *An. Sinensis* was 73.69% (N=38) to malathion, 92.33% (N=44) to DDT, 92.95% (N=105) to deltamethrin; *Aedes albopictus* has developed resistance to commonly used pyrethroids in many areas such as Guangdong, Yunnan, but no significant resistance to organophosphate and carbamate. There are three populations of *Aedes aegypti* in Yunan has developed high resistance to pyrethroids. *Culex tritaeniorhynchus* two populations from Donggang (Liaoning) and Licheng (Shangdong) has developed very high resistance to temephos (40313.6- and 7977.8-fold), followed by DDVP (396.1- and 76.6-fold) and fenitrothion (34.0- and 256.5-fold). Therefore, insecticide resistance management is very importance to ensure efficacy of vector control in China and elsewhere.

169 Investigations on resistance in *Aedes vexans* (Diptera: Culicidae) field populations after 36 years of *Bacillus thuringiensis* var. *israelensis* (B.t.i.) applications in the Upper Rhine Valley, Germany

Norbert Becker, NorbertFBecker@web.de, Mario Ludwig, Tianyun Su

Bacillus thuringiensis var. *israelensis* (B.t.i.) has been widely and solely used against floodwater mosquitoes, mostly *Aedes vexans*, for 36 years in the Upper Rhine Valley by the German Mosquito Control Association (KABS). During this period, almost 5,000 tons of B.t.i. formulations were applied to an area of approximately 1 million acres. To investigate a possible resistance development after such a long-term and wide-spread application of B.t.i., the susceptibility of *Ae. vexans* larvae against B.t.i. in 3 untreated (Lake Constance) and 6 treated areas on both sides of the Rhine within the Upper Rhine Valley was assessed by bioassays following World Health Organization (WHO 1981) guidelines. Comparing log-probit-analyses, it was shown that neither the LC50 values nor slopes of the probit-lines of bioassays of the larvae deriving from treated and untreated areas showed significant differences. These results have been confirmed by resistance ratios which varied 0.80 - 1.12 in all tests. The results provided the evidence that no resistance in the target species *Ae. vexans* have yet developed in the areas of the Upper Rhine Valley, despite the large-scale application of B.t.i. for 36 years. The main reasons for the absence of resistance are the population migration and hatching behaviour of the floodwater mosquitoes and the co-evolution of the pathogen and the target organisms resulting in a steady gene-flow in the target populations, as well as a complex mode of action of the B.t.i. toxins.

Equipment/GIS

- 171 Laboratory and field results from an enhanced BG-Sentinel with a mosquito wingbeat analyzer**
Michael Weber, michael.weber@biogents.com, Martin Geier, Sergej Sperling, Ilyas Potamitis, Mario Boisvert, Joel Buettner, Charles Abadam, Jay Kiser, Karen Akaratovic

We have combined an opto-electronic mosquito wingbeat analyzer with a suction trap for mosquitoes, and tested this combination both in the laboratory and in the field. The mosquito trap is based on a BG-Sentinel (Biogents AG, Regensburg) with an enhanced air flow system. The opto-electronic wingbeat analyzer utilizes a novel optical system to observe mosquitoes while they are being sucked into the trap, thus avoiding multiple registrations of the same mosquito. Quantitative data on mosquito density and activity can thus be obtained using an established trapping technique, while the wingbeat analyzer provides information on species and sex composition. Data are transmitted via a cell phone link, allowing unattended measurements over extended periods of time.

The use cases investigated include the separation of simultaneously present related species (*Cx. tarsalis*, *Cx. pipiens* and *An. freeborni*), and the differentiation of female and male *Ae. albopictus* and *Ae. aegypti*, respectively. The former use case is important for operational aspects of mosquito control, while the latter relates to SIT, as previous work has demonstrated the effectiveness of the BG-Sentinel for attracting both males and females in monitoring before and during releases.

(The work presented here is being supported by the European Union's Horizon 2020 programme; grant 691131, project acronym REMOSIS).

- 172 The Buffalo Turbine - An emergency application solution turns into routine urban larviciding**
Frank Clarke, fclarke@clarke.com

The use of the Buffalo Turbine to apply liquid larvicide treatments was spawned from public pushback on aerial applications and the logistical challenges of treating cryptic container breeding sites. From Miami, FL to Brownsville, TX, the fit for the Buffalo Turbine in Public Health mosquito control programs has evolved rapidly. This presentation will discuss what has been learned about urban larviciding since 2016 and examine the refinements to the Buffalo Turbine allowing for expanded uses.

- 173 Using truck-mounted turbine engines sprayers for mosquito control**
Ahn Ton, aton@broward.org, Odette Reza-Brown, Adriana Toro

The Broward County Mosquito Control Section (BCMCS) of Florida has developed larviciding trucks capable of spraying populated areas with biological larvicide to effectively suppress *Aedes aegypti* populations. The system efficiently applies the larvicide product (VectoBac® WDG) by spraying it from the trucks upwards into the air by the turbine engine. The wind carries the product over an area as wide as 660 feet from the spray column.

The challenge presented by the manufacturer's configuration was that the nozzles equipped with the turbine engines are insufficient to achieve the flow-rate and droplet size needed to evenly distribute the larvicide product over large areas, and effectively kill larvae. Modifications to the nozzle configuration were assessed by performing droplet size and density characterization as well as bioassays to measure larval mortality rates. BCMCS' modifications to the turbine sprayer have been highly successful in the delivery of the larvicide product over populated areas allowing for the effective treatment of hundreds of residential yards that would take weeks to treat on-foot with hand-held sprayers.

- 174 Field observations from a BG-Counter used with a CDC light trap in Manatee County**
Barbara Bayer, Barbara.Bayer@manateemosquito.com, Mark Latham

The BG-Counter, originally developed for use with the BG-Sentinel, not only counts mosquitoes as they are pulled into a trap, but it is also a weather station. It takes temperature, relative humidity, and ambient light reading every 15 min. Because Manatee County Mosquito Control District uses an extensive network of CDC light traps to monitor mosquitoes throughout the county, we wanted to know if we could use a BG-Counter with a CDC light trap. We placed three of these BG-Counter/CDC light traps in the field and will present our observations.

- 175 BG-Counter: a very efficient multi-task tool**
Mario Boisvert, mariob@placermosquito.org, Mario Boisvert, Jake Hartle, Mary Sorensen, Joel Buettner

BG-Counter (Biogents) is a relatively new auto-counting adult mosquito device that is designed for use with a BG Sentinel Trap. During the summer of 2017, we field tested the BG-Counter in a variety of environments in Placer County, California. The primary objective was to determine the accuracy of the counter by comparing the number of adult mosquitoes recorded by the counter to actual counts of mosquitoes in the trap. The second objective was to assess if the BG-Counter could help determining the peak or peaks of adult mosquito activity in the field. We tested the counter over 15 and 17 consecutive day periods in an agricultural environment with predominantly *Culex tarsalis*, and in an urban environment with

predominantly *Culex pipiens*. By leaving the fan on and modifying the placement of the catch bag, the actual counts represented, on average, 93% (72% - 106%) of the numbers recorded by the counter. Peaks of activity for both *Cx pipiens* and *Cx tarsalis* were readily apparent from the BG counter data. In June, *Cx pipiens* populations showed a consistent peak around 9:30 pm while *Cx tarsalis* showed a peak before midnight and another in early morning consistently in July and August. We also observed peaks in the morning and the evening maintaining a consistent time interval either before or after sunrise or sunset, respectively. Finally, the CO₂-baited BG-Counter trap caught thousands of mosquitoes every day; much more than commonly used traps for West Nile surveillance. This new abundant source of live mosquitoes allowed us to do more pesticide resistance and efficacy trials than we would have been able to do otherwise. Overall, the BG-Counter is an effective and useful surveillance tool that holds great promise in helping provide a more robust assessment of mosquito abundance upon which treatment decisions can be made.

176 Unlock the power of your GIS - Key strengths and planned improvements

Chad Minter, chad@frontierprecision.com

Join us for a discussion of how to unlock the power of your GIS, whether you are new to geospatial solutions or have been using them for a while. Let our experience in developing, implementing, and supporting GIS-based mosquito control software solutions help you 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 cross-platform mobile application, new Web application, high-accuracy focus for new storm drain application, new reporting solutions, Esri platform routing tools, and updates for our Windows ULV Extension and the Juniper Mesa 2 tablet. We're anxious to show you what we've been up to!

177 The collection and public dissemination of mosquito abundance data, a follow up.

Samuel Rund, srund@nd.edu, Micaela Martinez, Cynthia Lord

At last year's AMCA meeting we held a symposium on the public dissemination of mosquito abundance data that is collected by mosquito control agencies as part of their routine trapping operations. There are many valuable benefits and insights that can be gained through sharing and aggregation of this data, as well as concerns about the public sharing of this data and its usability. Here a follow up on the lessons learned and progress made in the last year will be provided. We will provide an estimation of the scope of mosquito abundance surveillance efforts that are likely being performed (the 'extant data') the format and scope of this trapping data that is presently made openly available ('the available data'). This includes districts that regularly post their data on their own websites, as well as states with statewide surveillance networks. We highlight examples of the ways that aggregated abundance data can be used and visualized that have been performed using existing publically available data. We will also highlight the significant existing infrastructure already in place for the aggregation of abundance data, and provide a 'blueprint' for how a nationwide mosquito surveillance network could be designed, leveraging this existing infrastructure. We will highlight existing and new databases that have been developed in the last year that mosquito control agencies can start depositing/visualizing their data now. Finally, we discuss concerns of abundance data sharing such as privacy, administrative burden, reusability of data and address some possible solutions to these concerns.

178 Real time larval production site mapping with ArcGIS

Ron Montgomery, Montgomeryr@HCFLGOV.Net

The ArcGIS platform includes a host of components and technologies to support the operation of a mobile workforce, collecting data in the field, and communicating with a home office. Collector for ARCGIS is a free app that runs on supported iOS and Android devices. The app works in conjunction with Esri's ArcGIS Online cloud services providing a collaboration environment to create and manage larval production sites in real time. Using Collector for ARCGIS, Hillsborough County, Florida has improved operational efficiencies and productivity within the ground larvicide operations unit.

Mosquito SIT: The Ground and Air Assault Matures Symposium

180 FAO/IAEA

Hanano Yamada, **needed**

The sterile insect technique (SIT) has celebrated successes worldwide in suppressing, containing, and eradicating several dipteran and lepidopteran pests of agricultural importance. In view of increased risks of introducing exotic insect pests into new areas due to globalisation and climate change, strict government legislation, the current surge in emerging or re-emerging vector-borne diseases, and the increasing appearance of insecticide-resistance, novel and environmentally friendly solutions to these pest problems

are in urgent demand. This has created renewed interest to develop the SIT for use in area-wide integrated pest management (AW-IPM) programmes to sustainably manage vectors of such diseases. The SIT is an “autocidal” biological control tactic that agrees with present day concerns regarding human health and the environment. It requires the production of large numbers of the target insect that, after sterilisation are released in adequate overflooding ratios to reduce the reproductive potential of the wild population.

The components of the “SIT package” to manage disease transmitting mosquitoes are currently being developed, validated, or optimised at the FAO/IAEA Insect Pest Control Laboratory in Austria, where we are driving essential research on various aspects of mass-rearing, sex separation (including the development and characterization of genetic sexing strains for both *Aedes aegypti* and *Aedes albopictus*), irradiation, handling, transportation, release and QC, together with collaborating institutes and Member States around the globe. We will present recent developments on all the components of the mosquito “SIT package”.

181 The delivery of lethal doses of insecticide by males

Stephen Dobson, sdobson@uky.edu, Corey Brelsfoard, James Mains

Mosquito control is most commonly performed using chemical insecticides, with formulations that include larvicides and adulticides, sprayed by hand or by vehicles, e.g., truck- or aircraft. 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.

182 Programmatic use of Oxitec's OX513A Friendly™ mosquitoes to combat *Aedes aegypti*.

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 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 mating's die and the target population declines. Over 300 million genetically engineered Oxitec male mosquitoes have been released over the past 7 years in trials and programs around the world. Large scale production and deployment of Oxitec's OX513A technology has been ongoing for several years' in Brazil. Continued success and lessons learned in mass production, deployment of OX513A males and monitoring will be presented along with achievements and future prospects around the world and in the US.

183 Under the radar- Implementing SIT where it really matters

Nitzan Paldi, Nitzan@forrestinnovations.com

The release of mass-reared sterile mosquitoes is one of the fastest-growing alternatives for effectively controlling mosquito-borne diseases. Forrest Innovations operates the Natural Vector Control (NVC) system to reduce mosquito-borne disease, using our comprehensive innovative paradigm. The first stage is the deployment of the Modular Mobile Mosquito Mass production Units (MMMMUs), which enables local deployment and has all resources and capacity to weekly produce, pack and release millions of 100% sterile male mosquitoes. A team of mosquito experts conduct a survey and collect the local strain of the mosquito, which is then used for the mass production. The locally collected strain is verified to be virus free are then used to generate an egg producing colony that produces tens of millions of eggs a week. Forrest Innovations is now operating a state-of-the-art production site in Araucaria, Brazil with the capacity to produce tens of millions of mosquito eggs per week. In parallel we have now established a MMMMU with millions-per-week male-sterile production capabilities in the city of Jacarezinho, Paraná, Brazil, where we are conducting a project to assess overall efficacy. Working in complete synchronization with local municipality, state and federal health authorities, as well as putting great emphasis on community outreach programs, Forrest Innovations has been endorsed enthusiastically.

184 Implementing a Large-Scale SIT/IIT Study in a Residential Setting

Steve Mulligan, smulligan@mosquitobuzz.net, Jodi Holeman

During 2017, the Consolidated Mosquito Abatement District partnered with Verily Life Sciences and

MosquitoMate in Debug Fresno to evaluate an innovative mosquito control strategy against the newly invaded *Aedes aegypti* mosquitoes (2013). This SIT/IIT study involved the release of thousands of male mosquitoes with *Wolbachia* into selected residential neighborhoods with established infestations. When these males mate with local females, it results in infertile eggs which will not hatch. The role of CMAD in establishing the study areas, securing sites for placement of traps, and ongoing monitoring of mosquito population trends in areas of release and non-release will be reviewed. The program involved community outreach efforts to increase public awareness of Debug Fresno, including development of website, notifications and outreach events, as well as dealing with resident perceptions, responses and interactions. Debug Fresno also generated substantial media attention.

185 Scaling mosquito SIT for the real world, from automated sexing through mass distribution
 Ralph Breslauer, rsb5779@gmail.com

After years of successful trials, releasing sterile male mosquitos to combat disease, is ready to go main stream. The benefits of having targeted non biting male mosquitos aimed specifically and only at female disease spreading mosquitos is easily understood. In order to accomplish this at scale for cities and districts, large numbers of males only, have to be created and released. This requires a holistic solution from manufacturing through loading into cartridges for the appropriate distribution method for the specific project. This includes automated sex sorting capabilities and scalable consistent distribution methods from ground to drone to aircraft. Come and hear about the latest technology capable of delivering on these requirements so that you can feel comfortable including SIT in your vector control plans. Advancements in the worlds of Artificial Intelligence and robotics have enabled significant new breakthroughs allowing for faster and more cost effective production. Having a single platform that scales from initial ground release through aerial release is a huge benefit for anyone responsible for mosquito vector control.

Pesticide Resistance and Management – From Theory to Practice Symposium II

186 Statewide Results of insecticide susceptibility testing of using the CDC Bottle Bioassay - what is next for Florida?
 Roxanne Connelly, csz5@cdc.gov, Casey Parker

Aedes aegypti and *Ae. albopictus* are invasive mosquito species that have increased their range in Florida since their introduction. In recent years, local transmission of dengue, chikungunya, and Zika has highlighted the public health importance of these two species. These species have proven difficult to control due to their feeding behavior, cryptic larval habitats, and resistance to insecticides used to target the adult stage. Susceptibility to insecticides is critical to effective mosquito control and little is known about the widespread susceptibility status of populations throughout Florida. Through a partnership with Florida mosquito control programs, extension offices, and the Florida Department of Health, a surveillance program was launched in the summer of 2016 that incorporated egg, larval, and adult surveillance to monitor for the insecticide susceptibility status of *Ae. aegypti* and *Ae. albopictus*. Populations from different areas were tested for phenotypic susceptibility using the CDC bottle bioassay protocol for susceptibility to various active ingredients including permethrin and malathion. This information was incorporated into different maps to provide a more detailed picture of the insecticide susceptibility status of these two species in Florida. Results from the study show that resistance to pyrethroids and organophosphates has been detected in both species in multiple counties throughout Florida. Additionally, susceptibility to permethrin has not been detected in any *Ae. aegypti* populations tested.

187 Resistance Status of *Culex tarsalis* in Sacramento and Yolo Counties
 Samer Elkashef, selkashef@fightthebite.net, Deborah Dritz, Kara Kelley, Marcia Reed, Sarah Wheeler, Paula Macedo

In Sacramento and Yolo counties there were nearly 34,000 acres of rice planted in 2017 of which approximately 11% were grown organically. Rice fields can produce large numbers of *Culex tarsalis*, a competent vector for West Nile virus, and are often located in close proximity to densely populated areas. As such, an important component of the integrated vector management program at the Sacramento-Yolo Mosquito and Vector Control District (Sac-Yolo) is routine agricultural ultra-low volume spraying of adulticides by both air and ground application. An equally important component is monitoring mosquito populations for pesticide resistance to determine when shifts in pesticide usage are operationally necessary. At Sac-Yolo insecticide resistance in *Culex tarsalis* is routinely monitored by both bottle bioassay and microplate assay. Here we discuss an overview of the resistance status of *Culex tarsalis* from agricultural areas from both Sacramento and Yolo counties and the results of field trials designed to evaluate product efficacy in the face of resistance, especially in organic rice fields where product choice is highly constrained.

188 Resistance detection in *Culex tarsalis*: from conventional bioassay to molecular approach

Tara Thiemann, tthiemann@pacific.edu, Bridgette Hughes, Eva Choi

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 molecular 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* (both leucine to phenylalanine and, to a lesser extent, leucine to serine mutations) may be prevalent in some populations, but thus far, no *ace-1* mutations have been detected.

189 Resistance management and mosquito control operations

Kim Hung, khung@cvmvcd.org, Melissa Snelling, Chris Cavanaugh, Jennifer Henke

At the Coachella Valley Mosquito and Vector Control District, we regularly assess the efficacy of adulticide products towards our field mosquito populations by using bottle bioassays, molecular testing, and field assays. The results from these assays play a large part in the decision-making process for which product to use for current mosquito management practices. This past year, we collected *Culex quinquefasciatus* mosquitoes from our cities and *Culex tarsalis* from rural areas. The adults were used in bottle bioassays and signs of resistance were observed in certain populations. We will discuss our latest mosquito resistance assay results from the lab and the field and review the impacts of these results on our mosquito control operations.

190 Resistance to *Lysinibacillus sphaericus* and cross resistance to other pesticides in field *Culex pipiens* populations

Jennifer Thieme, jthieme@wvmvcd.org, Tianyun Su, Greg White, Chris Ocegueda, Taylor Lura, Ary Faraji, Matt Ball, Min-Lee Cheng

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 the USA in 1990s, 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 field populations of *Cx. pipiens* in Chico, California and Salt Lake City, Utah, USA. Susceptibility profile to other groups of pesticide in these field collections was also evaluated. Resistance management and susceptibility monitoring strategies are discussed.

Vector Borne Diseases Centers of Excellence Symposium

191 Introduction and Comments

Jeff Borchert

240 Midwestern CoE mosquito research and training programs for professionals

Susan Paskewitz, [needed](#)

The Midwest Center of Excellence for Vector Borne Disease (MCE-VBD) was established in 2017 to build capacity for responses to VBDs. Research goals and training programs have been developed by partners in 5 states (Wisconsin, Minnesota, Illinois, Iowa, Michigan) and focus on a "research to action" model. For example, research on modeling West Nile virus disease dynamics was linked to training programs for professionals in the use of forecasting models. Other research projects include partnerships with mosquito abatement districts or environmental health partners to test efficacy of current larval and adult control practices and to investigate the level of insecticide resistance in vector populations. Research on mosquitoes also focuses on the status, control, and vector competence of invasive species, including *Aedes japonicus* and *Aedes albopictus* and the modes of introduction into the region. Finally, partners are

developing a pipeline of new products for mosquito control, including biologically derived larvicides, adulticides, and repellents.

241 The interaction of Zika and Dengue in the emergence of Zika in the Americas

Derek Cummings

Not Available

242 Pacific Southwest Center of Excellence

Christopher Barker, cmbarker@ucdavis.edu, William Walton

The Pacific Southwest Regional Center of Excellence in Vector-Borne Diseases addresses the urgent public health challenges presented by ongoing spread of invasive vectors, exotic pathogens such as Zika virus, and several endemic pathogens transmitted by mosquitoes and ticks. UC Davis and UC Riverside, along with public-health and vector-control partners, aim to increase the capacity of the United States to respond to vector-borne disease threats by (1) conducting applied research to develop and validate effective prevention and control tools and methods to anticipate and respond to invasive mosquitoes and disease outbreaks, (2) training vector biologists, entomologists, and physicians in the knowledge and skills required to address vector-borne disease concerns, and (3) strengthening and expanding already effective collaboration between researchers and public health organizations for surveillance, prevention, and response. This presentation will include a brief overview of the center and highlight research on invasive *Aedes aegypti* and *Aedes albopictus*, which have continued to spread throughout urban southern California.

243 Western Gulf Center of Excellence for Vector-Borne Disease

Chris Vitek, christopher.vitek@utrgv.edu

The Western Gulf Center of Excellence for Vector-Borne Disease was established in 2016 through funding from the CDC. This center is headquartered at the University of Texas Medical Branch, with multiple academic partners including the University of Texas Rio Grande Valley and Texas A&M University, as well as state and local public health partners. The goals of this center are to advance research in the areas of vector-borne disease, including disease surveillance, insecticide resistance, vector biology and ecology, and control strategies, and to educate current and future public health scientists through diverse educational and outreach programs. Multiple applied research projects are being led by individuals within the center, and will be conducted alongside outreach, education, and training programs for both vector-control personnel and students interested in vector-borne disease. In addition to these efforts, we are also engaged in active disease and vector surveillance efforts in the lower Rio Grande Valley, the site of recent circulation of Zika, chikungunya, dengue and West Nile viruses as well as Chagas disease parasites. The lower Rio Grande Valley (RGV) region of Texas remains a high-risk region for introduction of new vector borne diseases due to extensive land immigration from Latin America. Multiple surveillance and monitoring efforts currently underway in the RGV, supported by the Center, will be described.

244 Northeast CoE mosquito research training programs for professionals

Ted Andreadis, **NEEDED**

The Northeast Regional Center of Excellence in Vector-Borne Diseases encompasses the following states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Pennsylvania, Vermont, and West Virginia. The leadership team includes medical entomologists, vector biologists, virologists, epidemiologists, ecologists, modelers and molecular biologists from the Department of Entomology at Cornell University (center hub), the Center for Vector Biology & Zoonotic Diseases at The Connecticut Agricultural Experiment Station, the Wadsworth Center and New York State Department of Health, and the Department of Ecology, Evolution & Environmental Biology at Columbia University. Over 60 regional partners across more than 20 organizations in the northeast are also involved. The primary goals of the Center are to (1) Train a cadre of public health entomologists with the knowledge and skills required to rapidly detect, prevent and respond to vector-borne disease threats in the US, (2) Build effective communities of practice via collaborations between academic communities and public health organizations at federal, state, and local levels for vector borne disease surveillance, response and prevention, and (3) Conduct applied research to develop and validate effective vector-borne disease prevention and control tools and methods necessary to anticipate and respond to disease outbreaks. Our network is structured to span our goals in public health practice, through enhanced training and applied research each collectively contributing to improving lives in the community. Academic training efforts will include a new MS/MPH program in vector biology at Cornell University and a postdoctoral training program at each of the lead institutions. Public health practitioner training efforts will focus on a vector biology boot camp, webinars and regional seminars. Research Clusters include: (1) Evaluation of novel trapping and surveillance methods for mosquito vectors, (2) Predicting current and future human risk of infection with vector-borne pathogens in the Northeast and the US, (3) Vector-pathogen interactions and vectorial

capacity, (4) Vector ecology (biology, feeding preferences) and impact of climate change on overwintering survival and (5) Chemical control, resistance monitoring, and management of vectors.

Adult Control II

192 **Collection performance of a new CDC type trap in comparison to standard CDC miniature light traps and EVS traps in two different locations in Germany and the US**

Ulla Gordon, ulla.gordon@biogents.com, Martin Geier, Scott Gordon, Charles Abadam, Jay Kiser, Karen Akaratovic

CDC light traps have been in use for decades since their introduction in 1962 (Sudia & Chamberlain). They were the first portable traps that could easily be operated in almost any field setting and allowed live capture of mosquitoes, which is especially important for arbovirus isolation. A standard CDC light trap consists of plastic cylinder containing a motor unit with 4-bladed fan to draw in approaching mosquitoes, incandescent light, lid and catch bag. The fan and light are powered by a 6V battery. Light alone is not a strong attractor but when traps are supplied with CO₂, collection rates usually increase significantly.

We have developed and tested a new CDC style prototype trap that uses a novel catch bag and a 3-bladed fan. The prototype incorporated the same style lid and incandescent light as the standard CDC miniature light trap. The novel catch bag has a conical shape and an airtight bottom part that creates a different airflow around the trap compared to standard CDC traps. The 3-bladed fan is waterproof and can be powered by a 6V as well as a 12V battery. While moving a higher air volume even at 6V, the fan draws less amperage compared to the standard CDC fan. The lower power consumption will increase battery life by 30-40%. Due to a lower rotational frequency and the design of the blade the sucked-in mosquitoes are also better preserved.

The performance of the new prototype was compared to the standard CDC miniature light trap and EVS trap in two locations in the US and Germany. The new prototype collected more species and more total mosquitoes than the CDC or EVS traps.

193 **Sustainable resident based mosquito control using mass deployment of lethal ovitraps**

Dina Fonseca, dina.fonseca@rutgers.edu, Brian Johnson

Following up on the call for increased interaction between scientists and the general public Citizen Action through Science (Citizen ACTS) aims to provide communities with scientific support to develop projects that directly benefit them. We developed a community based approach to control invasive *Aedes* mosquitoes using lethal ovitraps. Starting in mid-June 2017 residents of a MD town purchased, deployed and maintained two Gravid *Aedes* Traps (GAT) in their yards for a total of over 900 traps deployed in the town of approximately 975 single homes. Continuing an intense campaign to control the Asian tiger mosquito initiated in 2012 and funded by the township, residents deploying GATs were also repeatedly informed of the need to remove or treat standing water in outdoor containers. Names, street and email addresses and phone numbers were kept on file and used to communicate updates and obtain consent for GAT and later BG Sentinel (BGS) trap surveillance. In early August 2017 when populations of *Aedes albopictus* were starting to peak we deployed 20 BGS traps across the town in areas differing in GAT coverage (proportion of neighboring yards with GATs) to examine the effect of GAT coverage on biting pressure (i.e. *Aedes* mosquito capture). BGS-based monitoring events repeated until the end of September revealed a consistent and highly significant negative relationship between biting pressure and GAT coverage. In areas where GAT coverage was higher than 80% captures of *Aedes albopictus* did not exceed 10 while numbers in areas with low GAT coverage often soared above 30. Researchers purposely refrained from developing any intervention besides providing *ad lib* information and BGS surveillance. The community network created for the resident-based mosquito control program is now considered an asset for additional community enriching programs.

194 **Resistance profiling of *Aedes aegypti* in Miami-Dade, Florida**

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Challenges force new perspectives. In supportive response to the Miami-Dade Zika outbreak of 2016, Clarke conducted an in-depth regional look at species susceptibility to pyrethroids and organophosphate products. Work was done in collaboration with USDA-Gainesville. The results revealed a new perspective on the realities of resistance.

The objective of this study was to determine the susceptibility of adult *Aedes aegypti* in Miami/Dade, Florida, to four mosquito adulticides: MosquitoMist® 2, Mosquito Master® 412, Duet®, and Merus®. From 2016 to 2017, *Ae. aegypti* eggs were collected from thirteen neighborhoods in and around Miami, FL. F1 females were tested by bottle bioassays using formulated product. Diagnostic time (DT) and diagnostic dose (DD) were calculated for each product using a susceptible *Ae. aegypti* strain. MosquitoMist® 2 was as or more effective against field-collected mosquitoes compared to the colony strain. *Ae. aegypti* from the Miami area exhibited delayed time-to-mortality against Duet® and Merus®, which contain pyrethroids and

pyrethrin, respectively. Despite the delay in time-to-mortality, 90-100% of *Ae. aegypti* from seven neighborhoods died within one hour. These results indicate local heterogeneity in *Ae. aegypti* to formulated pyrethroid products. Because the CDC bottle bioassay does not reflect field-applied rates, these results indicate the need for field testing with product at the label rate to determine field efficacy.

195 Analysis of insecticide resistance in *Culex quinquefasciatus* from Greenville, MS

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In order to effectively control mosquito populations and prevent the spread of vector-borne diseases, responsible use of insecticides is required. Inappropriate administration of insecticides can contribute to the development of insecticide resistance in some mosquitoes, which could become a public health hazard. With the assistance of Vector Disease Control International, *Culex quinquefasciatus* mosquitoes were collected as egg rafts from known larval production sites in Greenville, MS. After being reared to adulthood in the insectary at the Center for Disease Control and Prevention's Division of Vector-Borne Diseases, bottle bioassays and microplate assays were performed on these mosquitoes. Permethrin is the primary insecticide used by mosquito control programs in Greenville (along with deltamethrin and malathion in lesser amounts), while pyrethroids are applied almost daily by the agricultural industry in the surrounding areas. Therefore, these three insecticides were chosen for use in bottle bioassays to assess the levels of resistance present in *Cx. quinquefasciatus* from Greenville. The bottle bioassays showed phenotypic resistance to each of the insecticides, and knockdown resistance (kdr) was present in the mosquitoes that were tested against permethrin and deltamethrin. Microplate assays were performed to detect the altered ACE-1 target site and to calculate the levels of detoxifying enzymes and protein. These assays showed a statistically significant difference in all enzymes when comparing the *Cx. quinquefasciatus* from Greenville to those from the susceptible colony, with higher levels calculated in the Greenville mosquitoes for each enzyme. The size of the *Cx. quinquefasciatus* from Greenville was significantly smaller than the susceptible colony. Future studies monitoring insecticide resistance in Greenville, MS will be critical in developing a mosquito control program that limits populations of possibly harmful mosquitoes.

196 Space Spray Applications, how do we demonstrate evidence of impact?

David Malone, david.malone@ivcc.com, Mark Latham, Daniel McDermott

Insecticidal space spray applications (ground and aerial) form an important component of mosquito control programs in North America. However, the World Health Organization (WHO) does not endorse their use as a control tool against malaria vectors. What evidence exists relating space spray applications and impacts on malaria transmission, and can operational mosquito control data be used to build evidence in support of their use?

197 Efficacy of lambda-cyhalothrin and pyriproxyfen in controlling mosquitoes in residential backyards

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Mosquitoes have always been a key vector of pathogens to humans. The recent surge of diseases such as Chikungunya, and Zika along with a historical presence of West Nile Virus in the United States has brought a new focus on mosquito management. Due to the behavior and preference for container breeding of *Aedes* mosquitoes, management practices for control of this mosquito have to be re-evaluated. More recently, backyard treatments along with historical area wide management have both proven to be effective against *Aedes* mosquitoes. In the current study, backyard treatments with mister blowers using lambda-cyhalothrin and pyriproxyfen were employed against *Aedes* mosquitoes. Data was taken pre-treatment for two weeks and post-treatment for 16 weeks. Ovitrap were placed in ideal breeding locations within each treatment yard and eggs were utilized as a measure of control. Post-treatment means for number of *Aedes* eggs per treatment group were 38.57 ± 7.61 (controls), 4.25 ± 1.59 (lambda-cyhalothrin), and 0.86 ± 0.3 (lambda-cyhalothrin plus pyriproxyfen), respectively. This data revealed a significant decline in *Aedes* populations in backyards treated as compared to untreated controls.

198 Characterization of Targeted Swarm Spraying with Rechargeable Handheld Sprayers Compared to Broadcast Space-Spray Applications via a Backpack Sprayer

Jane Bonds, jasbonds@gmail.com, Mark Latham, Abdoulaye Diabate, Fredros Okumu

Malaria control strategies in Africa have focused on Indoor Residual Spraying IRS and Long-lasting Insecticide-treated Nets (LLINs). While these strategies have made a significant impact on the prevalence of Malaria they are insufficient for eradication due to an increase in outdoor biting. This means an effective and sustainable method is required to control outdoor biting mosquitoes. Recognizing that male *Anopheles* mosquitoes gather in mating swarms at dusk creating a concentration in the population, it was hypothesized that targeted spraying of these swarms will knock back the mosquito population with less chemical than conventional space spray application techniques. Field trials in 2016 showed that swarm spraying was a point source precision application that would use less chemical than a conventional space spray application.

The selected pesticide formulation, Actellic 50EC (pirimiphos methyl), was assessed for longevity of activity after dilution, showing a decline at five days after mixing. Because Actellic does not have a rapid knockdown, it takes ~ 1 hour till mortality, the question was can a mosquito still mate after being sprayed. No insemination was observed with lethal or sub-lethal doses whereas control cages showed 12% of the females were inseminated. In 2017 the targeted swarm spraying technique has been put into practice in four villages, four further villages received a conventional space spray with a backpack aerosol generator and two control villages received no outdoor biting spray intervention. This work is in continuation but it would appear that population decline is significant and less chemical was used with the handheld sprayers compared to the conventional application. These positive results provide confidence that this technique could be a sustainable, community based precision pesticide application for mosquito control, and another step toward Malaria eradication.

199 Experimental evaluation of the effect of passive metofluthrin emanators on landing and mortality of pyrethroid-resistant *Aedes aegypti*

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Control of *Aedes aegypti* is currently challenged by the evolution of insecticide resistance, particularly to pyrethroids. One new management tactic with potential for large-scale implementation is indoor deployment of passive emanators (small units containing 10% metofluthrin-impregnated nets) that are advantageous because they are rapidly installed, require no source of heat, and (at the doses that we used) act as confusants rather than repellents. We tested whether exposure to metofluthrin emanators installed in experimental houses located in Mérida, Mexico, affected landing and mortality among differing field-derived strains of *Ae. aegypti*. Strains included a lab insecticide-susceptible strain (New Orleans) and three locally-derived field strains; one susceptible and two pyrethroid-resistant strains. Experimental houses ($n = 8$) had similar layouts and standardized contents. They were sealed to prevent mosquitoes from escaping. Each mosquito strain was released into two houses ($n = 25$ mosquitoes per house): one with emanators and one control. Landing counts were performed before, 30 min after, and 24 hrs after the installation of emanators. Mortality was measured 24 hrs post-mosquito introduction. The experiment was replicated three times. Landing counts did not differ among houses before the introduction of emanators ($F = 3.2$; $p = 0.09$), but were significantly reduced 30 minutes after emanator introduction among all four strains in treated houses compared to control houses ($F = 59.8$; $p < 0.0001$). After 24 hrs mortality was significantly greater in treated compared to control houses across all strains ($F = 21.9$; $p = 0.0002$), but landing counts recovered ($F = 3.42$; $p = 0.043$) possibly as the result of increasing "hunger" among released mosquitoes. Given the effects on *Ae. aegypti* mortality and landing, metofluthrin emanators could be an important addition to the vector control toolbox, however, additional research is still needed to explore how resistant populations will react to long-term exposure.

200 Characterization of resistance in *Aedes aegypti* (Diptera: Culicidae) from Puerto Rico: what works, what doesn't

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Puerto Rico (PR) has a long history of vector-borne disease and insecticide-resistant *Aedes aegypti* (L.). We examined the resistance profile of *Ae. aegypti* collected from San Juan, PR, in 2012. Adult topical bioassays compared the PR strain to the lab susceptible Orlando (ORL1952) strain against representative pyrethroids (type I, type II, and nonester), a sodium channel blocker, a sodium channel blocking inhibitor, fipronil, and chlorfenapyr, which has been suggested as an alternative public health insecticide. Topical bioassays with the synergist piperonyl butoxide (PBO) were used to determine how cytochrome P450-mediated detoxification affects the resistance profile. Transcript expression screening of cytochrome P450s and glutathione-S-transferases identified the presence of overexpressed transcripts and genetic analysis of the sodium channel indicated the presence of *kdr* mutations in the PR strain. Larval bioassays were conducted to determine susceptibility to the common larvicides Bti and methoprene. This study of Puerto Rican *Ae. aegypti* highlights the importance of continued adulticide development as well as the necessity of monitoring for resistance and defining resistance mechanisms to inform more effective mosquito control.

Behavior/Biology I

201 Interspecific competition from *Aedes albopictus* on *Culex pipiens* varies across container types in urban areas: Social drivers and disease implications

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The invasion of the Asian tiger mosquito, *Aedes albopictus*, in the eastern United States has had important public health and ecological impacts. There have been well-documented declines in the abundances of resident mosquito species, often to local extinction, following invasion of *Ae. albopictus*. Considerable experimental evidence suggests that interspecific competition among larvae is the main mechanism by which *Ae. albopictus* displaces resident species. In the northeastern United States, the resident mosquito

Culex pipiens has persisted in many urban areas despite the invasion of *Ae. albopictus*, and frequently co-occurs with the invader across a range of container habitats. The few studies that have tested interspecific competition between *Ae. albopictus* and *Cx. pipiens* show competitive superiority of *Ae. albopictus*, but none have tested competition between these species across different container types that are common in urban landscapes. The goal of this study was to test whether the effect of interspecific competition from *Ae. albopictus* on *Cx. pipiens* differed between managed containers from residential yards versus trash containers from vacant lots in Baltimore, Maryland, USA. Field surveys showed a greater proportional decrease of *Cx. pipiens* in trash versus managed containers from early to late summer, when the densities of *Ae. albopictus*, and presumably associated competition, increased. An accompanying laboratory experiment showed greater decreases in *Cx. pipiens* survival and development with increasing *Ae. albopictus* density in trash versus managed container treatments. The results of this study suggest that coexistence of *Cx. pipiens* with *Ae. albopictus* is more likely in managed containers in residential yards than in trash containers in vacant lots. These findings have important implications for public health, especially the spatial distribution of pestiferous biting and the transmission of the most common mosquito-borne disease in the region, West Nile virus.

202 **Variability in mosquito midgut microbiomes**

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Symbiotic relationships between gut bacteria and their host's interactions are not well understood. However, research has shown that there is high variability among microbiomes from specimens collected from different field sites and environments. Recent studies suggest potential interactions between the gut microbiomes and their host may influence susceptibility to disease, and if the host is also a vector for another pathogen, potentially influence the ability of the vector to transmit disease. By examining variability between different locations and species, it may be possible to generalize about the overall variability in mosquito midgut microbiomes. Once that variability is understood, it will be easier to identify the potential of using midgut microbiome manipulation as a control measure or to prevent spread of disease. We collected two different species of mosquitoes, *Aedes albopictus* and *Aedes aegypti*, which are common vectors for diseases like Zika and Dengue virus. The female mosquitoes of both species were collected from multiple field sites and from a laboratory reared population. The field sites used for collection of the field specimens were located in the Rio Grande Valley area of deep South Texas, and the laboratory specimens were reared from a colony strain. The midgut microbiomes of all specimens were characterized by performing real time PCR (qRT-PCR) and next generation sequencing to identify bacterial composition. The comparison of the midgut composition between field and laboratory mosquito populations and between the two species is currently underway. By examining the differences in midgut microbiomes from varying environments and species, we can identify target species of bacteria that may inhabit midguts ubiquitously in all mosquito populations. These data may be useful for identify target bacterial species for vector control as well as the role of the bacterial species in disease transmission

203 **Mosquito Larvae Dorsal Tracheal Trunk Physiological and Morphological Dimensions Enabling Effective Acoustic Larvicide**

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Acoustic larvicide rapidly kills or injures all stages and species of mosquito larvae and pupa following the application of pulses of high-energy sound waves into the larval aquatic habitat. This lethality is caused by matching the resonance frequency of some mosquito structure, in the same manner as how glass shatters at high sound frequencies such as those produced by an opera singer. Interestingly, despite rapid and highly efficacious killing and damage to the mosquito, the exact mechanism of action cannot be explained using currently described mosquito physiology. Our acoustical investigations have revealed that that this lethality is caused by matching the resonance frequency of some mosquito structure. When exposed to acoustic larvicide, mosquitoes display irregular swimming, have an altered physical orientation ('bent'), delayed mortality, irregular development in subsequent molts such as deformed wings and legs, or development is permanently arrested. The larvae always display pronounced internal damage to their dorsal tracheal trunks (DTTs), indeed often the DTTs appear to be completely destroyed (no longer visible). The larval dorsal tracheal trunk are two gas filled tubes extending the length of the thorax and abdomen. The specific mechanism by which the DTT becomes damaged has not been reported. Closer observations of dead larvae reveal an air bubble always becomes visible either in the surrounding tissue, if not violently injected from the mosquito body. This presentation will reveal some unique physiological aspects of the DTT that specifically enable such dramatic trauma to abdominal tissue and organs.

204 **Monitoring larval *Aedes albopictus* populations along an urban to rural gradient in Saint Louis, MO: are abundance patterns driven by differences in habitat quality by land-use type?**

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As one of the most invasive species globally, *Aedes albopictus* has become a major nuisance species and, in some instances has displaced native mosquito species where it has invaded. In temperate North America,

however, *Ae. albopictus* remains rare in forested and rural habitats. To explore this pattern, we monitored larval abundance of *Ae. albopictus* during summer 2017 along an urban to rural land-use gradient in St. Louis, MO. We established four, 900 mL black oviposition cups at each of four urban, four suburban, and six rural locations (56 larval habitats). We collected larvae and pupae from each cup weekly from June 20 – September 5 and returned them to the laboratory for identification. At the end of the surveillance period, we collected oviposition cups and quantified water volume, total nitrogen, total tannins, and pH for each habitat. *Ae. albopictus* was significantly more abundant in urban and suburban habitat than in rural habitat, and most abundant in suburban habitat. We also detected significant differences in water chemistry; total nitrogen was significantly higher in cups placed in rural habitat, pH was higher in urban cups and urban cups had significantly greater water loss compared to suburban and rural cups. These data suggest that the types of larval habitats created along a land-use gradient may influence population dynamics for this species. Upcoming work will include experimentally determining the relative suitability of cups within each land-use type to support positive population growth for experimental cohorts of larvae.

205 **Effects of Fungal Entomopathogen Infection on Mosquito Survival and Pathogen Defense Mechanisms**

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Microbe-derived biopesticides represent alternative methods of mosquito control that can be integrated in vector control programs. Fungal entomopathogenic spores infect their hosts on contact by direct penetration of their cuticle, proliferating inside the body and eventually leading to host death. The virulence of fungal entomopathogens can vary greatly according to the isolate and/or insect host. This study presents a comparative pathogenicity of several entomopathogenic fungi and their effects on mosquito physiology as it pertains to immune defense mechanisms.

206 **Results from a Massachusetts statewide survey for *Aedes albopictus* and limited control interventions**

Priscilla Matton, brismoqpc@comcast.net, Matthew Osborne

The Asian tiger mosquito (*Aedes albopictus*, Skuse) has been collected from one site in southeastern Massachusetts yearly since 2009. In 2017, the Massachusetts Department of Public Health in conjunction with local mosquito control districts began an extensive statewide survey for the presence of *Ae. albopictus*. Ovitrap distributed throughout the state determined presence or absence of the species. In addition, limited control interventions were conducted at a historical site in southeastern Massachusetts where *Ae. albopictus* is routinely collected. This included source reduction, backpack larviciding, truck-based ULV and backpack barrier applications.

207 **First record of *Culex coronator* in Virginia with a look at its recent rapid range expansion**

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Culex coronator was first described by Dyar and Knab in Trinidad in 1906 and during the mid-20th century was documented in the southwestern United States (in order of discovery: Texas, Arizona, New Mexico). Since the early 2000s *Cx. coronator* has significantly expanded its range into the southeastern US; from 2003-2008, 8 states discovered their first specimen (in order of discovery: Oklahoma, Louisiana, Mississippi, Florida, Alabama, Georgia, South Carolina, and North Carolina). *Culex coronator* has been discovered as far south as Patagonia, Argentina and as far north as Sallisaw, Oklahoma until now. A single female *Cx. coronator* was collected on November 1, 2016 in Suffolk, Virginia from a BG-Sentinel 2® trap during routine citywide mosquito surveillance. This is the first record of this species in the state of Virginia and the new northernmost record in the US. Although there are 5 species in the *Cx. coronator* complex, based on male specimens examined from Texas and Mississippi, *Cx. coronator sensu stricto* seems to be the only species from the complex expanding into the southeastern US.

208 **Development and Optimization of an Environmental DNA (eDNA) Approach to Salt Marsh Mosquito Surveillance**

Brian Johnson, johnson.brian@rutgers.edu, Dina Fonseca

There is a clear need to improve current salt marsh mosquito sampling strategies, which are primarily based on past knowledge of the location of hotspots, and are becoming dated as marshes respond to sea level rise. Further, Integrated Marsh Management (IMM) in the coastal marshes and elsewhere is critically bound to the ability to identify productive sites and specific mosquito species. This is primarily because current strategies require direct application of larvicides to productive sites. Because immature salt marsh mosquitoes are present only temporarily, often for less than week, and adults are mobile, obtaining true knowledge of the spatial and temporal distribution of species is difficult. While eggs and egg shells have a longer presence in the marsh, their collection and identification can be logistically problematic and laborious. Here, we describe the development and optimization of an environmental DNA approach (eDNA) to detect and quantitate the relative abundance of *Aedes sollicitans*, *Aedes taeniorhynchus*, and *Aedes cantator* from eDNA obtained from small (<5 g) soil samples. The developed multiplexed, real-time PCR (qPCR) tool will

help pinpoint the specific locations chosen by females to deposit eggs, increasing knowledge of the associations among physical and/or biological characteristics of the marsh and female oviposition behavior, resulting in improved IMM. The method is being further developed to enable operators to detect larval presence and/or absence at low densities and even after brood emergence.

209 Some like it hot? Water temperatures predict the presence of *Aedes atropalpus* and *Aedes japonicus* in southern Appalachian rock pools

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Aedes atropalpus is a native rock pool species historically established throughout much of the eastern United States. *Aedes japonicus* is an invasive mosquito that has been found in many types of artificial and natural containers, including rock pools. Little is known about the ecology of these two species in habitats where they co-occur, although multiple investigators have reported the decline of the native species concurrent with the spread of the invasive species. Here we report the results of riverine rock pool surveys in the southern Appalachian Mountains between 2009-2015. A total of 503 rock pools collections yielded 28,859 immature mosquitoes (26,049 larvae and 2,810 pupae). *Aedes japonicus* (n=14,893) and *Ae. atropalpus* (n=8,827) were the most commonly collected species representing 91.1% of the total collections. Both species were present in 32.2% of the samples. Surface water temperatures in the rock pools strongly predicted the presence of the two species across a broad range of observed temperatures (11-39.8°C). For every unit of increase in temperature (°C) the odds of collecting *Ae. atropalpus* larvae increased by 0.34 while the odds of collecting *Ae. j. japonicus* larvae decreased by 0.28. No *Ae. japonicus* larvae or pupae were collected at temperatures greater than 36°C; immature *Ae. atropalpus* were found in pools with temperatures up to 39.8°C. In contrast, *Ae. japonicus* were highly abundant in cooler pools (< 17°C) where *Ae. atropalpus* were infrequent or absent. Our findings suggest that in spite of the successful invasion by *Ae. japonicus*, *Ae. atropalpus* remains well established in certain riverine rock pools, likely due to higher thermal tolerance. Given the strong correlation of temperature with the presence or absence of the two species, the role of thermal conditions should be explored in the context of biotic and abiotic factors influencing the range and abundance of the species.

Bridging the Gap between Research and Operation Symposium I

210 Going for gold: Academia's relationship with operational vector control

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The association between university researchers and operational vector control has a long and productive history. As vector control districts (VCDs) have added university-trained researchers to their staffs, research interactions between VCDs and university researchers have become more collaborative while some of the research that might have been carried out previously by university personnel is now done by district staff. Universities have hired fewer broadly-trained medical entomologists than in the past and have focused hiring on researchers with more specialized expertise. Research with an applied focus on improving surveillance and vector control is still an important component of VCD-university collaborations. Many of the latest technologies focus on basic science and there will be a time lag before becoming widely operational, but the application of technologies that increase automation and promote auto-dissemination of biological and chemical control agents are likely to be increasingly important for operational vector control.

211 Overview of Recent Accomplishments in USDA-ARS National Program 104: Veterinary, Medical, and Urban Entomology

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USDA-ARS National Program 104 is comprised of nearly 40 scientists with diverse disciplines who collaborate internally and externally to conduct basic and applied research in veterinary, medical, and urban entomology. Arthropods can cause structural damage and their can transmit pathogens that cause disease in humans and other animals. When not causing diseases, arthropod bites are a nuisance to humans and result in production losses in livestock due to animal stress from the bites. Some of the recent advances generated by or contributed to as a result of this research program include: biological control fire ants; a better understanding of how house flies live in bacteria-rich environments and how they process bacteria; improved understanding of how DEET works to repel mosquitoes; registration of etofenprox for clothing and discovery of new mosquito repellents; sequencing of the genome of the cattle fever tick and horn fly; new lead compounds for insecticides; and the use of Arundo wasp to reduce the amount of Giant cane in South Texas.

212 Autocidal techniques against *Aedes* mosquitoes

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New mosquito control methods are needed for reasons including invasive vector species, increasing resistance to existing pesticides and the global spread of mosquito-borne pathogens. Multiple vector control approaches are based on autocidal methods, which employ 'self-delivering' strategies of 'mosquitoes against

themselves.' Data from laboratory and field trials will be presented from two autocidal methods that target *Aedes aegypti* and *Ae. albopictus* as globally invasive and medically important vectors. One method is based on *Wolbachia*, an endosymbiotic bacteria that is common in many invertebrate species. Similar to the sterile insect technique, the *Wolbachia* approach is based on repeated, inundative releases of *Wolbachia*-infected males to cause a form of conditional sterility in the targeted populations. A second method employs adult male mosquitoes to directly and indirectly deposit a potent inhibitor of immature mosquito development into breeding sites. Presented here, will be a summary of experimental data, public engagement efforts, and the communication and coordination between industry, federal and local regulators, experts in insect rearing, and abatement district manager

213 Mosquito and Fly Surveillance and Control Research at the USDA-ARS Center for Medical, Agricultural and Veterinary Entomology: Solving Operational Challenges

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The Mosquito and Fly Research Unit of the USDA-ARS Center for Medical, Agricultural and Veterinary Entomology located in Gainesville Florida is the largest Federal laboratory devoted to specifically solving operational mosquito and fly surveillance and control challenges in the U.S. and internationally. Utilizing a team of very experienced and well-respected scientists and technical staff, a well developed laboratory facility and associated infrastructure, and a widespread network of collaborators throughout the world the Unit focuses on a well established sequence of laboratory, semi-field and field research to accurately and rapidly answer the operational challenges posed by hundreds of stakeholders. We describe examples of (1) surveillance and control challenges, (2) the development of research strategies to meet these challenges, (3) the conduct of research, (4) the products and technologies developed, and (5) the transfer of products and technologies to Mosquito and Fly Control Operators and Operations.

214 How to Square Science with a Well-Rounded Program

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As mosquito control programs are challenged by invasion and spread of vectors, emergence of mosquito-borne diseases, and insecticide resistance, the development and implementation of new mosquito control products and innovative technologies and strategies is ever more critical. Further, as these programs respond to newly invaded mosquito species, more specific knowledge about their biology and ecology is needed. Such products and knowledge can only result through sound scientific experimentation and research. The wherewithal, expertise, staff and funds to accomplish such research projects are generally beyond the avail and ability of local mosquito control programs. However, control programs can and should contribute to research and science by promoting partnership, collaboration, and in-kind support of research. Such support does come with a cost of staff time, funds and materiel. But by participating, the program becomes more well-rounded and the staff develops a better understanding and perspective. The experiences of the Consolidated Mosquito Abatement District in research collaborations will be discussed.

215 Boots, Bombs and Bugs: Synergizing U.S. Navy Research Initiatives with Operational Commitments

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Navy entomologists provide protection against numerous arthropods of public health importance for Marines and Sailors deployed across the globe. Navy entomologists have deployed with Marines and other DoD Forces in response to armed conflicts, humanitarian disasters, and international medical missions to disease endemic regions. Controlling vector-borne diseases remains paramount in maintaining a healthy military force despite the numerous challenges and environments. We discuss the vector-borne disease challenges facing deployed forces, DoD programs focused on research and development, and how the current deployments have benefited from these new technological advancements.

Adult Control III

216 Evaluation of two residual spray products Demand CS® and Archer® IGR for *Aedes albopictus* management in urban areas

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The majority of intervention methods for control of the Asian tiger mosquito, *Aedes albopictus* (Skuse), described in the literature are either labor and time intensive (i.e. source reduction) or provide short term control (ultra-low-volume adulticiding). Mosquito control programs in the United States are still searching for the best management practices to control *Ae. albopictus*. This study looked at barrier pesticide application as a medium range control strategy using before-after-control-impact (BACI) approach in New Jersey. Demand CS (lambda-cyhalothrin) only or combined Demand CS and Archer IGR (pyriproxyfen) applications resulted in significant and similar decreases in adult mosquito abundance post treatment: from 10.8 ± 1.5 to

4.6±0.5 (-78%) and from 16.9±3.3 to 8.4±1.1 (-74%), respectively, compared to the control group. Both lambda-cyhalothrin and combination of lambda-cyhalothrin and pyriproxyfen exceeded 70% reduction threshold considered as effective for *Ae. albopictus* control for 4 weeks until obscured by the natural downward fluctuations of populations in the control group. Existing *Ae. albopictus* control is transient in urban areas, but the increasing evidence on the efficacy and duration of barrier treatments is encouraging and is deserving of further investigation.

217 A game changer for vector control: a novel mechanical (non-chemical) insecticide for mosquito control

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Traditionally, adult mosquito control has relied heavily on the use of chemical insecticides beginning with organochlorines like DDT and moving to organophosphates, carbamates, and pyrethroids. Human and wild-life off target effects and the evolution of mosquito insecticide resistance has rendered some of these compounds useless and/or threatens their future. New alternatives are vital to the control of mosquito-vectored human and animal disease causing organisms. We have developed an inert mechanical insecticide which can be applied by several methods including a water soluble suspension to a variety of materials ranging from bed nets or other textiles to walls or vegetation for adult mosquito control. The insecticidal activity requires only short exposure times, kills the mosquito in hours, works on different mosquito species, is more active against pyrethroid resistant *Anopheles gambiae* than the susceptible strain, remains active for at least nine months (longer assays times not conducted), and is active under environmental conditions (high temperature and humidity) common to mosquito habitats. When applied to bed nets or as a wall treatment, we obtain 80% mosquito control in a single sleep cycle. The technology when combined with chemical insecticides has the potential to enhance the chemical action. The mode of action of the mechanical insecticides is under study.

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

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Mosquito populations are 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 potent lure that attracts male and female mosquitoes of many genera by mimicking the mosquito-specific attractive components of 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 CO₂ 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 effectively targets 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 attracts and kills outdoor mosquitoes before they can bite a host, and indoor biters before they can enter households in search of blood meals. As an inexpensive, efficacious, 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 indoor biting mosquitoes. This will ultimately help to improve the health and quality of life of people and animals living in areas where mosquitoes are a problem.

219 Surveillance and control of *Aedes aegypti* and *Aedes albopictus* in Saint Johns County

Daniel Dixon, ddixonamcd@gmail.com, Joseph D'Amato, Rui-de Xue

Ae. aegypti and *Ae. albopictus* are found throughout Saint Augustine, FL. The surveillance of these two species is part and parcel to the control efforts that prevent the introduction and spread of arboviruses such as Dengue, Chikungunya, and Zika. Two trap types are used to monitor the populations of *Ae. aegypti* and *Ae. albopictus* in St. Johns County: Biogents Sentinel (BG) traps and ovicups. Twelve BG traps are placed overnight in designated sites each week, and each trap is baited with dry ice and BG lure. Ovicups are placed in eight designated sites as another layer of monitoring for the presence of *Aedes* species, and each ovicup is baited with a hay-infusion water. *Ae. aegypti* and *Ae. albopictus* are pooled from BG trap collections and sent to the Bronson Animal Disease Diagnostic Laboratory for Zika, Dengue, and Chikungunya testing. To control these two species, Anastasia Mosquito Control District (AMCD) primarily targets the larvae using BTI and Natular DT in artificial containers. Finally, in an effort to eradicate *Ae. aegypti* from downtown Saint Augustine, AMCD engaged in a street by street, door-by-door campaign to remove artificial containers and treat larvae and adults. The eradication campaign failed to eradicate *Ae.*

aegypti, but through those efforts valuable knowledge about container context and species composition was found. This new information will play a critical role in future control efforts in the tourist district of downtown Saint Augustine.

220 Penetration of ULV sprays at different distances in to dwellings to suppress dengue vectors in urban areas

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The effect of application distance from a dwelling on the control of indoor dengue vector *Aedes aegypti* (L.) with outdoor ULV applications was investigated. Three applications of AquaReslin with 4 replications at maximum rate were made with a truck mounted sprayer at 7.6, 15.2, and 23m from a house during summer 2017. All doors and windows of the house were open during the spray while the nozzle was horizontal and travel speed was 24 km/h. Mortality of 25 caged female mosquitoes 30cm above ground was assessed at 19 locations. Two cages were placed on each side of the house and three each at the front and back. Five cages were placed inside rooms. Four cages were placed inside in sheltered sites as storage, closet, and cardboard boxes (cryptic sites). Thirty minutes after application, cages were removed, mosquitoes were transferred to clean cages, and mortality was assessed at 24h.

Spray at 7.6, 15.2 and 23m had 75.4%, 65.8%, and 58.7% mean mortality, respectively. Mortality from all sprays outside was 100% except for four locations from 23m spray. Mortality outside from 23m spray was statistically lower (92.9%) than other two distances (100%). Mortality inside from 15.2m (67.5%) and 23m (54.1%) spray was statistically lower than 7.6m (93.4%). At cryptic sites, 7.6, 15.2, and 23m sprays had statically similar mortality (49.0, 27.1, and 26.6%, respectively). Lowest mortality at cryptic sites was recorded inside cardboard boxes, which were only half open from one side and were extremely difficult places for spray to penetrate.

In conclusion, outdoor ULV spray from 7.6m from the dwelling proved successful in controlling indoor mosquitoes.

Disclaimer: The views expressed in this abstract are those of the authors and don't necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the U. S. Government.

221 Two plus one: The combination of two passive and one active mosquito trap may well be an Aedes (Stegomyia) control tool worthy of attention

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Source reduction, traps for host-seeking females, or traps for gravid females may each significantly reduce mosquito populations. We argue that a combination of these methods would provide a robust and sustained vector control program.

Recent years have seen the establishment of a highly efficient trap for host-seeking *Aedes* (*Stegomyia*) spp., the BG-Sentinel (BGS). Originally used in surveillance and monitoring, research has also demonstrated its potential as a control tool, showing a significant reduction in *Stegomyia* abundance in intervention sites. The BG-Bowl is a novel BGS-type trap with the same efficacy, but made to be constantly deployed in a household. It is cheaper, smaller, sturdy, and silent, with an energy consumption of less than 2.5 W.

The development of improved passive traps for oviposition site-seeking *Stegomyia* females has been equally successful, resulting in various new trap types, one being the Gravid *Aedes* Trap (BG-GAT). The BG-GAT can be a useful tool for capturing adult *Ae. aegypti* and *Ae. albopictus*. The low cost, practicality of operation and the high catch rates make the BG-GAT suitable for vector surveillance and projects requiring monitoring of mosquitoes for arboviruses, especially in developing countries. In Brazil, studies showed significant reduction abundance of gravid *Ae. aegypti* by BG-GAT. It has also outperformed the CDC's Autocidal Gravid Ovitrap (AGO) in Australian field comparisons.

We propose an area-wide *Aedes* (*Stegomyia*) spp. control strategy, based on an initial source reduction and a subsequent and permanent mass trapping using one active mosquito trap and two lethal ovitraps per household.

222 Programmatic use of Oxitec's OX513A Friendly™ mosquitoes to combat Aedes aegypti.

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 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 mating's

die and the target population declines. Over 300 million genetically engineered Oxitec male mosquitoes have been released over the past 7 years in trials and programs around the world. Large scale production and deployment of Oxitec's OX513A technology has been ongoing for several years' in Brazil. Continued success and lessons learned in mass production, deployment of OX513A males and monitoring will be presented along with achievements and future prospects around the world and in the US.

223 An introduction to Fyfanon® EW, a new water-based malathion formulation for ground-based space-spray mosquito control applications

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Fyfanon® EW Insecticide is a recently registered water-based malathion formulation for outdoor, ground based space-spray applications. It is being introduced to the US mosquito market in 2018. Key attributes include odor-reduction technology and improved handling characteristics. Efficacy is comparable with the original Fyfanon ULV Mosquito formulation. This paper provides a review of information on the new formulation, including efficacy trials.

224 Spatial Repellents on Strips of Camouflage Netting Reduce Mosquito Collections in a Field Environment

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Barrier treatments can be effective in reducing host seeking mosquito vectors and provide an additional layer of passive defense, reducing disease risk. Devices designed to release spatial repellents or direct application of spatial repellents to artificial surfaces can serve as efficient barriers reducing human-mosquito contact. In military settings camouflage netting provides cover and concealment and is widespread in its use. In this study we compared the efficacy of permethrin-treated and transfluthrin-treated strips of desert-pattern radar-scattering camouflage netting in preventing mosquitoes from entering small enclosures covered in camouflage netting in a field environment in Florida. Fewer mosquitoes were collected in enclosures with treated strips when compared to enclosures with strips that were not treated. Two treated strips significantly reduced mosquito collections when compared with enclosures with a single treated strip. Transfluthrin treated strips reduced mosquito collections more than permethrin treated strips. Application of spatial repellents to military camouflage nettings offers a promising technique to reduce the threat from mosquito and possibly other vector populations to military troops in deployed settings.

The views expressed in this presentation are those of the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the U. S. Government.

Behavior/Biology II

225 Bionomics and phenology of *Culiseta particeps* mosquitoes in Lake County, California

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Culiseta particeps is an uncommon and rarely studied mammalophilic mosquito species with a known range along the west coast of the United States and Canada, with some collections made in Arizona and Alaska. One southern California study determined host seeking activity to be highest in the spring time but otherwise very little research has been done on the seasonality or overall bionomics of the species. The goal of this study was to address gaps in previous research and investigate aspects on the bionomics of *Cs. particeps* including host selection, parity, overwintering behavior, and larval and adult seasonality in Lake County, California. Adult collections were made to target both host-seeking and resting mosquitoes using CO₂-baited and active resting traps in addition to vacuum aspirated collections from underground, man-made environments. Larval collections were made via dip sampling from two locations at Highland Springs Reservoir. All mosquitoes were identified to species, where possible. Determination of aestivation or overwintering status was evaluated through dissections of ovaries of empty (non blood-fed or gravid) adult females. A total of 52 blood-fed *Cs. particeps* were collected in Lake County and bloodmeals identified to determine host preference. This study will provide future investigators with additional knowledge of this species, aiding in the broader understanding of mosquito biology and ecology

226 Overwintering survival of *Aedes albopictus* eggs in North Florida

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Abstract Field collected *Aedes albopictus* eggs were exposed to outdoor during 2016-2017 winter seasons (November to February) in the City of Gainesville North Florida to evaluate its overwinter survival rate. Individual egg paper (strip) was clipped with flower pots and exposed to the natural conditions under five different treatments: A, flower pot open; B, flower pot covered with mesh and saucer; C, flower pot covered with saucer only; D, flower pot open but under the shade and E, flower pot open but with bottom sealed. Statistical analysis shows that there were significantly differences among 5 treatments in terms of egg

survival rate (%). Treatment E had highest survival rate (16%). No significant differences were observed on egg missing rate (%) and egg intact rate (%) among the treatments. However, significant higher egg collapsed rate (%) was observed on treatment D compared with the others. *Ae. albopictus* egg overwinter survival rate varies under the field conditions in the North Florida.

227 Distribution and blood feeding preferences of *Culex pipiens* complex mosquitoes in areas of North Greece with a recent history of WNV transmission

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Culex pipiens sensu lato species are considered the most widespread mosquitoes in temperate latitudes. They are of great medical importance in Europe, since they constitute the principal vectors of several arboviruses, such as the West Nile Virus (WNV). *Cx. pipiens* sensu lato comprises of 2 morphologically indistinguishable species, namely *Cx. quinquefasciatus* and *Cx. pipiens*, with the latter being further subdivided into two biotypes, *pipiens* and *molestus* which can form hybrids. Despite their morphological similarity, the members of the *Cx. pipiens* complex display distinct behavioral profiles. More specifically, regarding the host preference of the two biotypes, the *pipiens* form has been characterized as ornithophilic, whereas the *molestus* form as mammophilic. Due to its preference for bird hosts, the *pipiens* form is known to play an important role in the enzootic transmission cycle of WNV. Further more investigating the feeding patterns of the hybrid forms is of high importance as they may display an intermediate host preference which makes them ideal bridge vectors of WNV from birds to mammals. While the two biotypes are found in distinct habitats in several regions, in Southern Europe they occur sympatrically. In the present study we investigated the distribution and seasonality of *Culex* mosquitoes with a focus on *Cx. pipiens* complex collected from different environments (urban, agricultural, natural wetlands) of Northern Greece with a history of WNV transmission. Their blood feeding preferences were also investigated. On account of their indistinguishable morphological features, species identification was conducted based on PCR diagnostic assays targeting on polymorphisms of the second intron of the acetylcholinesterase-2 locus of *Cx. quinquefasciatus* versus *Cx. pipiens* and of a specific microsatellite region for the two biotypes. For the blood meal analysis a combination of different molecular methods were applied in order to reliably identify the host source.

228 Preliminary findings on study results where adults of the U.S. native mosquito assassin, *Toxorhynchites rutilus* were released weekly and their impact measured as population disrupter/reducer of peri-domestic, container breeding pest mosquitoes

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Harris County, Texas is situated along the central Gulf Coast and is separated from the gulf waters by adjoining Brazoria-, Galveston-, and Chambers Counties. The municipal City of Houston is centrally located within Harris County and takes up about a quarter of its land mass. Being situated on the crossroads of temperate and sub-tropical zones as well as ecological transitions allows for a myriad of mosquito diversity. Over 55 different mosquito species are recorded for the area and include the non-native species *Aedes albopictus* and *Aedes aegypti*. Both species are identified as competent vectors of Zika, Dengue and Chikungunya viruses and they prefer to live in close proximity to people. They share the ability to breed in containers with *Ae. triseriatus* and *Culex quinquefasciatus*, vectors of La Crosse and West Nile Virus, respectively. As its common name implies, the native mosquito assassin, *Toxorhynchites rutilus* targets other mosquitoes as larval food. Except for sugar, all of the adults' nutritional requirements are met during the larval phase, thus the adult does not take nor is capable of taking a blood meal. We initiated a season long study at four similar, yet separate sites in Harris County Precinct 4 and released weekly 200 mixed gender, pre-mated *Tox. rutilus* adults into three sites, leaving one control site monitored but with no releases.

We share the study methods, initial findings and observations on the impact these predator releases alone had on the target pest mosquito populations.

229 Entomological Investigations Following a Zika Outbreak in Brownsville, TX

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In mid-January 2017, a CDC vector team was deployed to Brownsville, TX for 2 weeks (1/10/17 – 1/24/17). The mission was to provide vector assistance to the City of Brownsville following the detection of Zika cases in the city late in 2016. The team sampled mosquito populations daily by using 18 – 40 BG sentinel traps. A total of 2,220 adult mosquitoes belonging to 15 different species were collected. The most abundant species was *Cx. quinquefasciatus*, 1,434 (64.6%) followed by *Ae. aegypti* 381 (17.2%) and *Ae. albopictus* 159 (7.2%). The other 12 species contributed 11% of the total collection. The high abundance of *Cx. quinquefasciatus* was not surprising since this species prefers high organic content water for larval habitats and the trip took place during the dry season in Brownsville. The presence of detectable populations of *Ae. aegypti* and *Ae. albopictus* especially the males suggested continuous breeding despite the dry season and

suggests presence of cryptic larval sites especially since more than 95% of the containers we examined were dry. However, the relative abundance of both *Ae. aegypti* was 0.4 – 3.1 mosquitoes per trap/day and *Ae. albopictus* 0.1 – 0.14 mosquitoes/trap/day was low and not likely to initiate and/or sustain ZIKV transmission.

230 Longitudinal surveillance of *Phlebotomus* and *Sergentomyia* sand fly species in Kenya, 2008-2015, and regional environmental correlates

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Long-term sampling of populations of medically important vector insects from sentinel locations, i.e., longitudinal surveillance, may provide insight on environmental correlates with population change that are not observable with short term surveys. However, funding and other resource restrictions pose real challenges to establishing informative sentinel sites and maintaining routine collections (and uniform collection methods) at these sites for subsequent years. We compiled data from both long and short term surveillance of *Phlebotomus* and *Sergentomyia* sand fly species from various projects across several collection sites in Kenya from 2008-2015 to investigate candidate locations for sentinel longitudinal sites. We considered ecological region boundaries that could enable clustering of sites separated by administrative boundaries, increasing capability to identify locations where population dynamics seem to track key environmental dynamics. Routine collections across seasons and years at focal sites such as these would be unprecedented and extremely valuable for modeling sand fly population dynamics in the context of environmental patterns. These models could in turn be leveraged to develop predictive disease-risk models that are more biologically realistic compared to static habitat suitability index models. Risk models could have immediate operational relevance for more effectively coordinating public health action in *Leishmania*-endemic areas.

231 Distinguishing populations of living *Anopheles gambiae* s.s. and *Anopheles arabiensis* using a non-invasive opto-acoustic analysis of wing beat patterns.

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Two important malaria vectors in equatorial Africa are *Anopheles gambiae* s.s. and *Anopheles arabiensis*. The ecology and behaviour of these sibling species is markedly different. With the implementation of control methods successfully targeting the largely endophilic and anthropophilic *An. gambiae* s.s., the more versatile *An. arabiensis* (which feeds on a wider range of hosts, both outdoors and indoors) has taken over the role of the major malaria vector in many regions. To tell which of these species is present on a given location is however difficult, since both species are morphologically indistinguishable; their identification therefore relies on molecular methods.

We now report that we were able to discriminate between two laboratory strains of *An. gambiae* s.s. and *An. arabiensis*, using a non-invasive, opto-acoustic analysis. Test mosquitoes of both species were reared following the same protocol and had the same age. Among other variables, wing lengths and wing beat frequencies were compared. Wing beat patterns of individual female mosquitoes released into a small, mobile flight chamber were recorded using a device with IR-LEDs and sensors. An initial analysis showed that the two species had highly significant differences in median wing lengths and in median wing beat frequencies (*An. gambiae* s.s.: 2.79 mm, 575.0 Hz, N=125 vs. *An. arabiensis*: 2.93 mm, 533.6 Hz, N=138). Selecting subsets of the two species with the same wing lengths however still showed highly significantly different wing beat frequencies (*An. gambiae* s.s.: 2.84 mm, 582.9 Hz, n=32 vs. *An. arabiensis*: 2.83 mm, 540.4 Hz, n=32).

(The work presented here is being supported by the European Union's Horizon 2020 programme; grant 691131, project acronym REMOSIS).

232 Development of an attract and kill device for stable flies, *Stomoxys calcitrans*, using commercially available materials

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There are several affective traps on the market that can be used for management of stable flies, *Stomoxys calcitrans*. These traps attract the flies, then flies are captured on the sticky surface of the trap. Although these traps are effective, they require regular servicing, i.e., changing out sticky glue boards, for traps to function properly. An ideal device would be one that employs the attractiveness of a trap with the killing properties of an impregnated fabric. In this care we selected the Knight Stick Sticky Fly Trap to use as the attractive trap, and D-Terrence pesticide-treated cloth as the killing device. Studies were conducted in a large 9 x 18 x 3.6 m high (30 x 60 x 12 ft high) outdoor cage. Two traps were place 9 m apart in opposite ends of the cage. Traps were enclosed in several materials, including cylinders of light wire fence and screen fabric, to determine the effects of these materials on numbers of flies captured. When treatments were in place, 300 adult stable flies were released and numbers captured were counted the next day. Any

enclosure adversely affects the expected fly catch. Alteration of fabric enclosures are underway and slits in fabric should increase attractiveness of the trap and force flies to land on treated fabric as they try to pass through the slits and reach the trap. After optimum slit width is determined, additional trials will be conducted in the field.

233 Identification of blood meal sources in *Aedes aegypti* in the Florida Keys

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Aedes aegypti is the mosquito species responsible for the small outbreak of dengue in Key West, Florida in 2009-2010. However, no locally-acquired cases of dengue, chikungunya, or Zika viruses were reported in the Florida Keys in the past seven years. In order to understand the vectorial capacity of the local population, it is necessary to evaluate the presence of human blood meals in field-collected blood-engorged *Aedes aegypti*. In this experiment, blooded *Aedes aegypti* females were collected using BG Sentinel traps with BG Lure and carbon dioxide throughout various habitats in urban and suburban areas in the Florida Keys from June 2014 through August 2017. A total of 117 blood meals were identified to species by polymerase chain reaction targeting the vertebrate cytochrome B gene and sequenced.

Bridging the Gap between Research and Operation Symposium II

234 Bridging the gap - Bringing in outside research to a district

Jennifer Henke, JHenke@cvmvcd.org, Jeremy Wittie

The Coachella Valley Mosquito and Vector Control District has a long history of working with researchers across the country to benefit surveillance and control operations at the District. The District has a Laboratory Department which examines pesticide efficacy and resistance on local mosquito populations. The District partners with USDA Center for Medical, Agricultural, and Veterinary Entomology to evaluate techniques and products for performing mosquito and filth fly control in a desert habitat. The District also maintains a research program that funds and establishes partnerships with external researchers to develop and evaluate applied vector and vector-borne disease surveillance or vector management strategies. These partnerships result in the professional development and growth of District staff. Outcomes of these collaborations not only enhance the District's integrated vector management program but also add to the field of vector and vector-borne disease surveillance and control.

235 Bringing new products to market: Collaborative efforts leading to innovative solutions in vector control

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IVCC is a Product Development Partnership investing donor funds in R&D to overcome barriers to innovation in vector control. Its purpose is to facilitate the development and delivery of novel and improved vector control tools and solutions in failed markets to combat the rapidly growing problem of insecticide resistance. The major IVCC funding partners include the Bill & Melinda Gates Foundation, USAID, Unitaid, UKaid and the Swiss Agency for Development and Cooperation. Since 2008, research-based agrochemical companies have provided access to their chemical libraries, with 4.5 million chemical compounds reviewed for activity against public health vectors. After evaluating 27 classes of chemistry and several major synthesis programs, nine compounds from five chemical classes have been identified as having potential for vector control use. Within the next year, several compounds will be promoted to full development, eventually providing a suite of new chemical tools to support global vector control efforts. Multiple classes of insecticide with different modes of action will facilitate vector control insecticide resistance management and reduce the risk of insecticide resistance developing in the future. Co-developed repurposed and dual active ingredient long lasting insecticide treated nets and indoor residual spray (IRS) formulations are in the market or close to launch. IVCC is also focused on developing technologies to prevent outdoor transmission of insect-borne disease. Other critical initiatives to ensure delivery of new tools include the GLP certification of selected field trials sites in Africa and the Unitaid-funded NgenIRS initiative to minimizing time to market, optimize coverage and provide evidence for impact of new IRS products.

236 Lethal Ovitraps and Autocidal Gravid Ovitraps Commercialization

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Research effort rarely translates directly into commercial products. There is, of course, no expectation that basic research will create a product: its goal is to learn new things without regard to immediate applicability, and is often the fundamental basis behind new products. But applied research often fails to lead to commercial products, even when that works show applicability, utility and sound economic value. I discuss some of the possible reasons for the commercialization "valley of death" and how two products were brought to the market. The lethal ovitrap of Perich and Ziechner took 15 years after being patented to be commercialized. The Barrera et. al. Autocidal Gravid Ovitraps took 7 years from inception to be commercialized. The path to retail products is considered a lesson for bringing other products to market.

237 Collaboration and applied research benefit to Anastasia mosquito control operation

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Since 2003 Anastasia Mosquito Control District, St. Augustine, Florida has started to collaborate with USDA/ARS/CMAVE, University of Florida/IFAS, University of North Florida, University of Miami, Navy, and several private companies to conduct applied research about surveillance techniques for mosquito population and control technology included evaluation of new formulation of adulticide and larvicides, and equipment. The collaboration with universities and institutes about applied research bridged the gap between research and operation and the Anastasia Mosquito Control District's mosquito control operation received significant benefits from the collaboration and applied research, such as the improvement of employee training and knowledge, control of mosquito by using more scientific sound method and technology, save of labors and cost, also, receiving partial funds, free equipment and samples to assist the local mosquito control program.

238 Seasonal patterns of mosquitoes and other biting flies at a horse boarding facility near Cedar Key, Florida

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For more than five years the seasonal abundance of mosquitoes and other biting flies have been monitored at a horse boarding facility near Cedar Key, Florida. Various species of mosquitoes, ceratopogonids and tabanids are abundant at this site almost year round. Various types of traps have been used including several models of Mosquito Magnet, the H-trap, Nzi trap and sticky Olson Trap. Mosquito species composition and relative abundance varied from year to year largely in response to rainfall patterns. Ceratopogonid and tabanid species seasonal incidence and relative abundance seemed to be consistent from year to year. Occasionally, large populations of stable flies were observed, usually after a weather front moved through the area.

Poster Session Abstracts

Adult Control

P-01 Briquet Washout/Dissolution and the Illusion of Long-Term Mosquito Control of Catch Basins

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West Nile virus (WNV) is a mosquito-borne flavivirus and human neuropathogen capable of causing a broad range of clinical syndromes, including fever, meningitis, encephalitis, and paralysis. WNV is most commonly transmitted by the bite of an infected *Culex* mosquito, which is known to breed in stagnant pools of water, including storm sewer catch basins. In order to help manage the spread of WNV, the Champaign-Urbana Public Health District (CUPHD) evaluates roughly 22,000 catch basins and treats all potentially problematic catch basins in Champaign, Urbana, and Savoy, Illinois. These catch basins have varying sump depths and past field studies have shown wash out rates of extended release larvicide briquets, during rain events, to be of particular concern.

A simulated catch basin was created by the University of Illinois Facilities and Services Metal Shop to run tests on three extended release larvicide briquets at the University of Illinois Hydrology Lab. These tests looked at washout rates at varying sump depths and briquet dissolution in flowing and standing water.

P-02 Field evaluation of the BG-Sentinel trap baited with different attractants for collecting *Aedes albopictus* in Thailand

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There is major public health concern regarding the global spread of chikungunya virus by *Aedes albopictus*. In Thailand, more than 49,000 chikungunya cases were reported to the Thai Ministry of Public Health in 2009. To avoid human contact with mosquito vectors, a variety of mosquito traps have been developed for *Aedes* mosquito surveillance. In the current study, we evaluated the efficacy of the BG-Sentinel traps baited with different attractants for the collection of *Ae. albopictus* under field conditions in Thailand. Trap comparison experiments were carried out in the villages located in Chanthaburi province using a Latin square design. A total of 1,135 female mosquitoes representing 5 genera were collected. The mosquito species collected included *Ae. albopictus* (96.30 %), *Anopheles spp.* (0.70 %), *Armigeres spp.* (1.85 %), *Culex spp.* (0.70 %), and *Mansonia spp.* (0.40 %). A total of 1,293 *Ae. albopictus* were collected in this study (1,093 females and 200 males). The BG sentinel trap baited with the combination of dry ice, BG lure®, and the attractive sugar bait made from local fruit juice, sugar, and sweet fermented rice captured *Ae. albopictus* more than other trap types. The parity rates were observed in *Aedes albopictus* populations collected by different trap types. Analysis revealed that the frequency of physiological states varied

significantly between attractants. The findings demonstrated here will assist researchers in selecting the appropriate tools for *Ae. albopictus* surveillance.

P-03 Field Comparisons of the Gravid *Aedes* Trap (GAT), BG-Sentinel 2 Trap, and Autocidal Gravid Ovitrap (AGO) for Monitoring *Aedes aegypti* Populations in Miami, FL and New Orleans, LA

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Monitoring vector abundance is a key objective of local integrated vector management programs to reduce the risk of exposure to mosquito-borne diseases. *Aedes aegypti* mosquitoes are one of the most competent vectors of chikungunya, dengue, yellow fever, and Zika viruses. Targeted trapping of *Ae. Aegypti* plays an important role in surveillance and control. Numerous types of traps are available to monitor adult-host seeking and gravid mosquitoes. The Biogents Gravid *Aedes* Trap (GAT) and Autocidal Gravid Ovitrap (AGO) use a yeast infusion as an attractant for gravid mosquitoes. The BG-Sentinel 2 trap attracts adult-host seeking mosquitoes by visual cues and the addition of lures. We conducted a study to compare the effectiveness of the BG-GAT, BG-Sentinel 2, and AGO traps in Miami, FL and New Orleans, LA. A 5 x 6 grid covering 40 km² in Miami, FL and 20 km² in New Orleans, LA was selected for the study. All three trap types were placed at thirty sites within each grid. Mosquitoes were collected daily during the 14 d study from each of the traps and stored in a -80 freezer for identification at a later date. Preliminary results showed that the BG-Sentinel 2 trap was the most sensitive trap in measuring abundance. Further analysis of the data will be forthcoming.

P-04 Evaluation of a commercialized Autocidal Gravid Ovitrap for the control of *Aedes aegypti* and *Aedes albopictus* in three regions of the United States

Emily Kuhns, ekuhns@springstar.net, Samantha Whiteside, Daniel Murdock, Isik Unlu, Rudy Xue, Daniel Dixon, Donald Ward, Dawn Wesson, Michael Banfield

A commercial version of the CDC Autocidal Gravid Ovitrap (AGO) was evaluated in Mercer County, New Jersey, St. Augustine, Florida, and New Orleans, Louisiana. In each region, three replications of intervention and reference sites were selected that were expected to have populations of either *Aedes aegypti*, *Aedes albopictus*, or both species. Acceptance of the AGO traps by local residents differed between regions and even within communities, with some communities being very supportive and others less accommodating. Socially optimized strategies will need to be considered when developing AGO-based abatement plans.

P-07 Field evaluation of CDC light traps for malaria vector surveillance in Thailand

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Malaria is a significant cause of morbidity and has reemerged to become a major public health problem in many countries including Thailand, where malaria remains a major concern particularly in areas bordering other developing countries. Sampling for adult mosquito populations is a means of determining the intensity of disease transmission and evaluating the efficiency of vector control operations. The overall goal of this research was to evaluate the efficacy of the standard CDC light trap and the modified CDC light trap (using a fan of BG-sentinel trap) lured with different attractants for the collection of malaria vectors under field conditions in Thailand. To limit effects of differences between test-days and location, traps were rotated so that each treatment was tested in each trapping station following a Latin square design (the total of 54 trap nights). In total, 4,572 female mosquitoes from five genera were captured over the course of this study. A total of 2,565 anopheline females representing 22 species were collected. The most common species were *An. sawadwongporni* (44.41 %), *An. minimus* (20.74 %), and *An. maculatus* (17.35 %). The CDC light trap and modified CDC light traps collected 1,531 and 1,034 anopheline females, respectively. The combination of dry ice, BG-lure®, and the attractive sugar bait made from local fruit juice, sugar, and sweet fermented rice increased the efficacy of CDC light traps. In this study, our results confirmed that CO₂ is the most important bait for both CDC light traps and modified CDC light traps for malaria vector collection.

P-08 Implementation of Smart Mosquito Monitoring System at the Three Different Cities in South Korea

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Our three regional governments (Seoul city, Incheon city, Ansan city) in South Korea want to monitor mosquitoes at the people living areas and to build up the mosquito control policy. Therefore, the governments used the smart mosquito monitoring system (height 1080mm × width 560mm × diameter 320mm, 220V 60Hz 30W) which can attract the blood sucking female mosquitoes by emitting CO₂ gas (300ml/min). The monitoring system can count the number of the captured mosquitoes by an infra-red beam area sensor, and can send the captured mosquitoes' number through the CDMA module at real time. Seoul city operated the 50 smart mosquito monitoring systems at Seoul city areas (605 km²) of South Korea for one year (2016), Incheon city and Ansan city operated the 10 smart mosquito monitoring systems,

especially for one year (2016). Our research groups analyzed each city's data based on the mosquito frequency, specified local characteristics and the weather condition. By using the 2016 data from three cities, we calculated mosquito model formulas. Seoul city implemented the mosquito forecast and performed the mosquito forecast on the website in 2017. Seoul citizens were satisfied with the predicted mosquito forecast. Other two cities were classified mosquito population into 5 levels by using Poisson distribution and they used their website to let their citizens know the mosquito occurrence of everyday. From Ansan city, we asked to many citizens how Ansan city was doing about mosquito control and they were satisfied with the mosquito control method by using the smart mosquito monitoring systems. We are sure that the smart mosquito monitoring system is capable of running in other countries with a little complicated manners. Conclusively we believe that the using of systems can be a big help to prevent getting the mosquito-borne diseases in the world.

P-09 The effect of plant components and plant derivatives on *Aedes aegypti*

William Dees, wdees@mcneese.edu, Caleb Ardizzzone, Omar Christian

We are investigating the effect of plant components and plant derivatives on the behavior and development of medically important arthropods. Current studies focus on the effect of botanical components on mosquito mortality. We evaluated the effects of freshly-cut plant parts, including essential oils, from eight plant families on female *Aedes aegypti*. We obtained essential oils from plant parts by hydrodistillation using a Clevenger-type apparatus. Glass and plastic Petri dishes were used to test essential oils and cut plant parts, respectively. Percent mortality was recorded at 24 and 48 h. Mosquitoes exposed to fresh-cut flowers/petals, buds, leaves, stems, and seeds from Apiaceae, Asteraceae and Lamiaceae exhibited over 50% mortality when compared with the controls. Genera of interest include: *Chrysanthemum*, *Eryngium*, *Eupatorium*, *Rudbeckia*, *Monarda*, *Solidago*, and *Pycnanthemum*. Mosquitoes exposed to different parts of a chrysanthemum plant (flowers, buds, leaves, stems and seeds) exhibited 100% mortality in 24 h. Mosquitoes exposed to cut buds of *Pycnanthemum muticum*, *P. tenuifolium*, and *Monarda fistulosa* as well as crushed seeds of *M. fistulosa* exhibited 100% mortality in 24 h. Mosquitoes exposed to essential oils of *M. fistulosa* and *Eryngium yuccifolium* buds and *Solidago gigantea* seeds exhibited 100% mortality in 24 h.

P-10 Mosquitocidal activity of the essential oils from two Louisiana native plant species: *Monarda fistulosa* and *Solidago gigantea*

William Dees, wdees@mcneese.edu, Caleb Ardizzzone, Nicholas DeVito, Omar Christian

We examined the mosquitocidal activity of the essential oils of two plant species native to southwest Louisiana - *Monarda fistulosa* and *Solidago gigantea*. In Petri dish assays, female *Aedes aegypti* exposed to crushed seeds and buds of *M. fistulosa* exhibited 100% mortality in 24 h. We obtained essential oils from seeds and deseeded buds of *M. fistulosa* by hydrodistillation using a Clevenger-type apparatus. The GC-MS analysis of the buds identified carvacrol, durenene, thymol, terpinene-4-ol, and caryophyllene oxide as the major components of the buds. The oil derived from the buds displayed moderate mosquitocidal activity. Interestingly, in mosquitocidal investigations using freshly ground plant parts of *S. gigantea*, we detected no mortality in Petri dish assays using female mosquitoes. Usually, tests that show no evidence of mosquito mortality preclude us from conducting further studies due to the many plant species under investigation. However, due to the abundance of plant material, we decided to investigate the essential oil from *S. gigantea*. Investigations of the essential oil of *S. gigantea* displayed concentration-dependent toxicity toward *Aedes aegypti* in Petri dish contact assays. The essential oil from *S. gigantea* seeds yielded 17 compounds.

Behavior/Biology

P-11 *Wolbachia* infections in mosquitoes of Merced County California

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Wolbachia are bacteria present in mosquitoes as well as in many other arthropods. These bacteria can influence reproduction, and thus are currently employed in mosquito release programs for *Aedes aegypti* control. Several subgroups and strains exist for *Wolbachia*, and they have yet to be characterized for some mosquito species in the Central Valley of California. In this study, the presence of *Wolbachia* was examined in mosquitoes found in Merced County. To accomplish this, mosquitoes were trapped and frozen and then identified to species. Ten mosquito species were abundant in our region, and these were the focus of this study. DNA was extracted from mosquitoes, and PCR was used to investigate the presence or absence of *Wolbachia* and which subgroup it belonged to. Finally, *Wolbachia* strains were sequenced and compared to others previously characterized. This information will improve current knowledge and provide baseline information for future discussion of releases of *Wolbachia* infected mosquitoes in the region.

P-12 Predicting interannual variation in West Nile virus risk: is it for the birds

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Predicting the net effects of climate change for vector-borne disease risk remains a significant challenge because multiple meteorological and environmental factors interact to influence transmission dynamics in nonlinear ways. West Nile virus is primarily transmitted between birds and mosquitoes, but it can also cause a potentially fatal disease when in humans. The number of human cases fluctuates dramatically from year to year, and weather variables alone are only moderate predictors of the severity of a WNV season. West Nile virus has a complex ecology, infecting over 300 bird species, each of which has a different capacity to transmit the pathogen to mosquitoes. To clarify the relative contribution of various host species to WNV transmission, we identified the bloodmeal source from over 200 *Culex spp.* mosquitoes collected in the WNV hotspot of Ft. Collins, CO in 2016. We combined this information on feeding preference with data on the efficiency with which each host species transmits WNV and variations in the density of each host species using historical bird survey data to create a "community competence index" (CCI) for each site and year. We show that drought and the CCI were good predictors of year-to-year fluctuations in WNV prevalence in mosquitoes. Additionally, using July bird surveys to calculate the CCI, we were able to predict local-scale spatial variation in WNV prevalence in mosquitoes in August. We are collecting additional data this year to confirm whether time-lagged bird surveys would be a useful advance-warning system of WNV hotspots within mosquitoes.

P-14 Elimination or Management? Dealing with the Ever-Growing Expansion of Populations of Invasive *Aedes albopictus* and *Aedes aegypti* in Southern California

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The infestations of two invasive *Aedes* mosquitoes of public health concern, the Asian tiger mosquito *Aedes albopictus* (Skuse) and the yellow fever mosquito *Aedes aegypti* (Linnaeus) have been considerably expanded in southern California since 2011. As of September 15, 2017, 103 cities have confirmed infestation of *Ae. aegypti* and 52 cities with *Ae. albopictus* in counties of Imperial, Los Angeles, Orange, Riverside, San Bernardino and San Diego. In West Valley MVD, *Ae. albopictus* was detected in city of Upland on August 2, 2017 by BGS trap with CO₂ lure (BGS-CO₂ trap). The infestations of *Ae. aegypti* were confirmed in city of Chino Hills on August 22, 2017, by the same trap, and in city of Chino on September 18 by dip samples and net sweeping. Upon confirmation of infestations, strategic trappings with BGS-CO₂ and EVS traps and intensive habitat inspections were initiated immediately to define the scope and magnitude of the infestations. By defining the intensity of the infestation and examining the geographical and topographical parameters, protocols were developed to focus efforts on elimination or management of the populations below nuisance or disease transmission thresholds.

Disease Vector Studies

P-15 Resistance Monitoring in *Aedes aegypti* and *Ae. albopictus* in New Orleans, Louisiana

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With the threat of emerging arbovirus like Zika and chikungunya, ULV residual insecticide applications are a key tool in reducing the risk of disease transmission. In order to evaluate the efficacy of commonly used insecticides, the CDC Bottle Bioassay was used to measure insecticide tolerance in local mosquito populations. Using ovitraps, mosquito eggs of *Aedes aegypti* (the yellow fever mosquito) and *Ae. albopictus* (the Asian tiger mosquito) were sampled systematically throughout New Orleans during the summer of 2017. Egg papers were allowed to dry and reared at standard laboratory conditions. The assays were conducted according to CDC methodology using insecticides in current use (malathion and naled), those with future operational potential (deltamethrin and chlorpyrifos), adulticides that have been rotated out of operational use for a period of greater than 5 years (resmethrin). Results will be reported geographically and discussed in the context of a broader integrated mosquito management (IMM) plan. It is essential for municipalities to strengthen response capacity in order to make evidence-based control recommendations and to plan for operational interventions following arbovirus transmission.

P-16 Development of an Environmental DNA Assay to Detect Mosquito Larvae

George Peck, **needed**

Not Available

P-17 Bridging Basic and Applied Vector Research for Public Health: NIAID's Vector Translational Research Program

Ghiorghis Ghenbot, ghiorghis.ghenbot@nih.gov, Adriana Costero-Saint Denis, John Pesce

The National Institute of Allergy and Infectious Diseases (NIAID) of the National Institute of Health (NIH) supports a comprehensive portfolio of Vector Biology Research Program with the purpose of advancing the science and identifying approaches that help control or prevent the transmission of vector-borne pathogens to humans. Our strategy involves sponsoring a variety of basic research projects that will contribute to a

better understanding of key aspects of the biology of arthropod vectors. In some cases, the knowledge may be translatable to products or to approaches that can be advanced to large-scale implementation to control or prevent human diseases. The space between basic research and its application is referred to here as Translational Research. NIAID is developing a Vector Translational Research Program to bridge this space. This poster presents areas of basic vector biology research that form the foundation for discovery, and describes the processes being developed to identify and move promising concepts through translational research for enhancing existing products and developing new vector-borne pathogen countermeasures. Links to information regarding funding opportunities, resources for research, and Program Officer are provided.

P-18 A baseline assessment of mosquito surveillance and control capabilities across the U.S.

Grace McClain, gmccclain@naccho.org, Chelsea Gridley-Smith, Jennifer Li, Oscar Alleyne

Mosquito-borne diseases are a constant public health concern in the United States, with over 2,000 cases of endemic West Nile Virus (WNV) reported in 2016. In addition to WNV-carrying *Culex* mosquitoes, the United States has a known presence of *Aedes* species capable of transmitting Zika virus (ZIKV), dengue, and chikungunya. While local health departments are on the front lines of defense against these diseases, almost no data exists on whether local agencies are prepared for a mosquito-borne virus outbreak.

The National Association of County and City Health Officials, in partnership with the Centers for Disease Control and Prevention, developed and distributed an electronic survey to assess mosquito surveillance and control capacity among almost 2,000 local vector control programs. The assessment utilized a quantitative scoring matrix, as determined by subject matter experts, to distinguish the evidence-based activities that a local vector control program must perform to demonstrate competency. Completed assessments ranked each vector control program in one of three categories: "Fully Capable," "Competent," or "Needs Improvement." Results from nearly 1,100 programs (57% response rate) revealed that 84% of respondents needed improvement in at least one of five core competency areas. Pesticide resistance testing was the most widely absent competency with an additional 46% of respondents failing to conduct routine surveillance through standardized trapping and species identification.

This assessment gathers previously unavailable baseline data on local mosquito control and surveillance in the United States. A majority of local agencies reported significant gaps in programmatic activities, indicating susceptibility to mosquito-borne diseases like WNV and ZIKV. By addressing these gaps, local agencies and their partners can be better equipped to develop targeted approaches for scaling up prevention and preparedness. Suggested uses of this assessment for capacity-building include developing peer mentorship programs, training networks, and resource-sharing, as well as a follow-up to this baseline study.

P-19 Malaria incidence risk map for endemic region the Urabá-Bajo Cauca-Alto Sinú, Colombia

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The design of cost-effective strategies for malaria control interventions could benefit with the use of contemporary tools such as high-spatial-resolution maps of disease distribution. Thus, in this study, the risk of malaria incidence was modeled for a Colombian endemic region the Urabá -Bajo Cauca-Alto Sinú. The association between environmental and topographic variables obtained from remote sensors and the annual parasitic index (API) for the years 2013-2015 was estimated using multiple regression analysis; subsequently, a model was constructed to estimate a projected API for the entire endemic region and a risk map was design. The model was validated by relating the obtained API values with the presence of the three main Colombian malaria vectors, *Anopheles darlingi*, *Anopheles albimanus* and *Anopheles nuneztovari*. Temperature and Normalized Difference Water Index (NDWI) showed a significant correlation with the observed API ($R^2 = 0.66$, $p \leq 0.05$). The risk map of malaria incidence showed that the zones at higher risk were located in the Urabá and Bajo Cauca subregions, while the north of Alto Sinú subregion presented low malaria risk. *The results from this work provide evidence of the utility of risk maps to identify environmentally vulnerable areas at fine spatial resolution.* This information should help local health authorities to focus intervention efforts on areas of high malaria risk, at the microgeographic scale.

P-20 Anopheles species and their relation to land covers in a malaria endemic region of Colombia

Juan Hernández Valencia, Daniel Rincón, Juan Sánchez Rodríguez, Stiven Quintero, Nelson

Margarita Correa, margaritcorrea@gmail.com, Alba Marín Valencia, Naranjo-Díaz

Land cover strongly influences the composition and diversity of the *Anopheles* mosquito community. This work explored the relation between land cover and *Anopheles* composition and diversity in five localities highly influenced by human transformation, from an important endemic malaria region of Colombia. Mosquitoes were collected at six different sites per locality and land cover types were characterized within 1.5 km from the collection site using orthorectified aerial photographs. Overall, seven types of land cover were found: forest, water body, grass, bare soil, crop and wetland; the latter mostly related to mining

activities. A total of 2458 mosquitoes corresponding to 10 species were collected, being *Anopheles braziliensis* (n = 874, 35.6%), *Anopheles nuneztovari* (n = 581, 23.6%) and *Anopheles darlingi* (n = 495, 20.1%) the most abundant. The accumulation curve estimated 10 species for the region, reaching a horizontal asymptote and indicating that the sampling effort was sufficient. The highest species richness was registered in Puerto Triana (8) and the lowest in La Lucha and Villa Grande (5). The highest diversity was registered in Cuturú and Puerto Triana (Simpson = 0.714 and 0.701, respectively) and the lowest in La Lucha (Simpson = 0.239). A significant negative correlation was detected between *An. nuneztovari* and wetland (S = -0.97; $p < 0.05$) and between *An. braziliensis* and forest (S = -0.9, $p < 0.05$); also, a significant positive correlation was found between *An. darlingi* and wetland (P = 0.88; $p < 0.05$). Canonical correspondence analysis showed a relation between abundance of *An. darlingi* and *An. albitarsis* with wetland and grass cover, *An. braziliensis* and *Anopheles punctimacula* with bare soil and water body, and *Anopheles triannulatus* with crop. Together, these association results indicate that the presence and abundance of anopheline species are favored by the increase of anthropic activities that modify land cover.

P-21 Understanding the factors shaping the gut microbiota structure of two Colombian malaria vectors

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The influence of mosquito innate microbiota on several life traits such as mosquito survival and reproduction, as well as on the malaria parasite development has been described. Yet, little is known about the factors driving the bacterial communities structure and their interplay to modulate the mosquito bacterial composition. In this study two host-intrinsic (developmental stage and species) and two environmental (geographical location and feeding status) factors were analyzed for two malaria vectors, *Anopheles darlingi* and *Anopheles nuneztovari*, collected in localities of two malaria-endemic regions of Colombia. The bacterial microbiome of 64 adult (A) mosquito guts, 12 larvae (L) guts and 7 breeding sites (BS) were examined. A total of 15,909,048 bacterial 16S rRNA reads were grouped into 274,990 swarms, from which 14,440 unique OTUs were identified. Results showed that both host-intrinsic and environmental factors are important determinants of the mosquito gut innate bacterial structure, however, developmental stage was a major modulator of the gut bacterial assemblage, followed by geographic location. Interestingly, and contrary to some studies, no differences in the microbiota were detected between species and feeding status. An improved understanding of the interactions of factors shaping the malaria vectors' microbiota assemblages is valuable when assessing bacterial candidates for vector control strategies.

P-22 Vector competence of northern California mosquitoes for *Dirofilaria immitis*

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Caused by the parasitic, filarial roundworm *Dirofilaria immitis*, dog heartworm leads to several fatal cardiovascular diseases, including heartworm in domestic canines (*Canis familiaris*), as well as respiratory-associated diseases in domestic felines (*Felis catus*). California has experienced a recent increase in the prevalence of heartworm, including in San Joaquin and Lake Counties. To prevent the spread of heartworm infections, it is necessary to focus on vector competence, which is the ability for the mosquito vector to cultivate and aid *D. immitis* in its development to the infective (L3) stage. *Culiseta incidens*, *Culex erythrorhox*, *Cx. pipiens* complex, and *Cx. tarsalis* were the target mosquitoes in this study. They have each displayed high rates of natural *D. immitis* infections when caught in the wild throughout Northern California, which is evidence that they are potential heartworm vectors. However, laboratory transmission studies were needed on these local species to further demonstrate their strength as a vector. Reared to adulthood in a controlled-environment insectary, mosquitoes were experimentally infected with *D. immitis*-infected canine blood (2.5-5 mf/μl), then decapitated at days 15, 18, and 21 to count emerging *D. immitis* L3 larvae. To further assess the extent of infection, decapitated mosquitoes had their abdomens separated from the head-thoraces, and underwent quantitative PCR to assess remaining parasite load intensity. Preliminary results confirm that *Aedes sierrensis* colonies, the control in this study, were competent vectors for *D. immitis*. Decapitation on days 15, 18, and 21 at high titers (5 mf/μl) showed infective rates of 93.7%, 67%, and 50%, respectively. This data confirmed the success of our artificial feeding apparatus and laboratory techniques, and will be used as a standard in the analyses of the target species in this study.

P-23 Are uninhabited houses important producers of *Aedes aegypti* mosquitoes?

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Abandoned lots and other public areas can produce *Aedes aegypti* mosquitoes, where trash containers accumulate, such as discarded tires. However, there is virtually no information on the role of uninhabited houses on *Ae. aegypti* productivity (abandoned, for sale/rent, vacation homes, etc.). Deterioration of social, economic or political situations can produce the exodus of inhabitants, leaving many properties uninhabited. Current vector control approaches rely on visiting houses and other buildings to conduct source reduction,

larviciding, and community education. One of the limitations to achieving adequate household coverage is the presence of uninhabited houses. However, the role of uninhabited houses and possible containers within them has not been investigated in Puerto Rico or elsewhere. The main goal of this study is to determine the importance of uninhabited (vacant, abandoned) properties to mosquito productivity and the main types of containers contributing most *Ae. aegypti* mosquitoes. Sampling design included inspecting an abandoned or vacant house, and neighboring uninhabited houses in neighborhoods with low, medium and high-income levels. Pupal surveys were conducted to determine mosquito prevalence and productivity. The average number of *Ae. aegypti* pupae per house in low-income areas was 38.50 in abandoned, 6.50 in vacant and 27.82 in inhabited houses; in medium-income was 1.50 in abandoned, 1.00 in vacant and 6.81 in inhabited houses. The most productive containers per house type in low-income areas were, 1. abandoned: discarded implements, tires and junk; 2. vacant: pails, discarded food containers and water meters; 3. inhabited: tires, discarded kitchen utensils and pails. In medium-income were, 1. abandoned: water meters; 2. vacant: water meters and discarded food containers; 3. inhabited: plant pots, tires and water meters. High-income level has not been completed yet.

P-24 A review of arthropod-borne disease outbreaks world-wide over the past twenty years

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Over the past twenty years the World Health Organization has reported disease outbreaks from all over the world via Disease Outbreak News (DON; www.who.int). We reviewed arthropod-borne disease outbreaks occurring since 1996 using DON and other sources. The arthropod-borne diseases reported by DON include: dengue/dengue hemorrhagic fever, yellow fever, chikungunya, Rift Valley fever, Zika, malaria, O'nyong-nyong, Japanese encephalitis, St. Louis encephalitis, Venezuelan equine encephalitis, West Nile fever, leishmaniasis, Crimean-Congo hemorrhagic fever, relapsing fever, tularemia, typhus (louse-borne), and plague. We categorized these outbreaks by disease, country, and biome. As we categorized disease outbreaks, we recognized patterns in the biomes where disease outbreaks occurred. The five most reported diseases were yellow fever, dengue/dengue hemorrhagic fever, Zika virus, plague, and Rift Valley fever. The biome in which four out of the five most reported diseases occurred was tropical. Zika and dengue/dengue hemorrhagic fever occurred mainly in humid tropical regions; whereas plague and yellow fever occurred mainly in semi-arid tropical regions. Rift Valley fever occurred mainly in the desert (tropical) region. *Aedes* species vectored the majority of disease pathogens reported. A time-line of disease outbreaks as well as other epidemiological information will be presented.

P-25 Mosquito surveillance in a residential park: A six-year seasonal survey

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We are conducting a seasonal longitudinal survey of mosquitoes at a 24-acre woodland park in an urban area of Lake Charles, Louisiana. The park is separated into two distinct areas: one is an open area with playground equipment, picnic tables, open shelters, a small conference center, exhibits, wetland ponds, and concrete walking paths with benches; the other is a preserved forest with nature trails. The mosquito survey was initiated in the summer of 2011. We use Centers for Disease Control and Prevention (CDC) light traps baited with CO₂ in the form of dry ice to collect mosquitoes. Mosquitoes are collected in the open area near the preserved forest in each of the four seasons. Temperature and humidity data are recorded during each trap night. To date, the predominant species collected (i.e. >50 in one trap night) are *Aedes atlanticus*, *Ae. taeniorhynchus*, *Ae. vexans*, *Coquillettidia perturbans*, *Culex erraticus*, *Cx. nigripalpus*, *Cx. salinarius*, and *Psorophora columbiana*. *Coquillettidia perturbans* numbers reached a record high in Spring 2016 (n = 81); no more than 50 of these mosquitoes had been trapped in one season since Spring 2013.

P-26 Determining Comparative WNV Prevalence in Lubbock County Texas, 2010-2017

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West Nile virus (WNV) is a potentially fatal vector-borne pathogen transmitted to humans by the bite of infected mosquitoes. This infectious virus is a member of the *Flavivirus* genus, first appearing in the United States in 1999. Dating from 2002, mosquito surveillance efforts have been ongoing in Lubbock, Texas, aiming to find arboviral pathogen presence, specifically WNV in mosquito populations. For this project, I am determining comparative WNV prevalence in Lubbock, Texas between 2010 and 2017 in an effort to understand best mosquito control practices for the public health. A total of 41,651 female *Aedes vexans*, *Culex tarsalis*, and *Culex quinquefasciatus* were collected in Lubbock, Texas from May 2010 to July 2017, using encephalitis vector surveillance (EVS) CO₂-baited light-traps. Each week mosquitos were identified, pooled by date, species and trapping site, and then screened for the presence of *Flavivirus* spp. using a reverse transcription-polymerase chain reaction (RT-PCR) assay. If mosquitos were positive for *Flavivirus* spp. they were further screened for WNV. During the past seven years, a total of 62 mosquito pools tested positive for *Flavivirus* spp., 50 of which were tested positive for WNV. The majority of positives for both *Flavivirus* and WNV were from the 2010, 2013, and 2015 pools, with 23 testing positive for WNV in 2010. Results show that WNV is enzootic in Lubbock, TX, however fewer positives for WNV are recorded each

year. Mosquito surveillance efforts need to continue in order to ensure public health, principally during the months of June, July, August, and September.

Education

P-27 From Microbes to Mosquitoes: Undergraduate student engagement in biology

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The Microbes to Mosquitoes (MtM) Project is an interdisciplinary, multi-institutional approach to student immersion in the biological sciences, specifically medical/public health entomology and microbiology. This project provides undergraduate students the opportunity to: (1) participate in undergraduate research, (2) visit facilities supporting scientific operations, and (3) participate in scientific conferences. We recruited science majors, some of whom were potentially at risk of academic failure, changing majors or leaving their academic pursuits altogether. We also recruited student peer mentors who worked along-side the other students. We developed two field and laboratory projects emphasizing multidisciplinary science concepts. Twelve students participated in these projects. In addition, 18 students attended and/or participated in scientific conferences. Eight seminars were held throughout the year with an average attendance of 53 students per seminar. This project provides freshmen and first-semester sophomores with opportunities to personally engage with and experience the world of science beyond the classroom.

Equipment

P-28 CO₂-baited no light CDC traps are a more a sensitive *West Nile virus* collection method than CDC gravid traps

Kevin Caillouet, caillouet@stpmad.org, Nicholas DeLisi, Viki Taylor

The gold standard for collection of *Culex quinquefasciatus* and the detection of West Nile virus (WNV), the Gravid trap is inexpensive and easy to operate. However, since the Gravid trap selectively collects gravid *Cx. quinquefasciatus* mosquitoes, other species, including those that may transmit WNV are frequently underrepresented. Often WNV mosquito surveillance employs the use of multiple trap types to assess other WNV vector species. Beginning in March and biweekly throughout the 2017 mosquito season, St. Tammany Parish Mosquito Abatement (STPMAD) placed CO₂-baited CDC Light traps with the light bulbs removed adjacent to CDC Gravid traps at each of the 90 WNV surveillance sites. As of 20 September 2017, a total of 44,519 mosquitoes were collected in CDC Gravid traps, and 178,115 in CO₂-baited No light CDC traps. Though the WNV infection rate and proportion WNV-infected among the two traps was not statistically different, the CO₂-baited No light CDC traps collected 2.4 times more WNV-infected pools (29 WNV-infected pools) than did the CDC Gravid trap (12 WNV-infected pools). A greater diversity of mosquitoes collected in the CO₂-baited No light CDC traps and a greater diversity of WNV-infected mosquito pools (four species compared to two) suggest that the CO₂-baited No light CDC traps may eliminate the need for multiple trap types for effective WNV surveillance.

Latin America

P-05 Open-Field Efficacy Trials of Aerial Ultra-Low Volume Application of Insecticides Against Cages *Aedes aegypti* in Mexico

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We evaluated the efficacy of aerial ultra-low volume (AULV) applied mosquito adulticides against caged *Aedes aegypti* in open-field bioassays. Evaluations were conducted in 2017 at Puerto Vallarta Jalisco, Mexico. Two insecticides were tested; an organophosphate (MOSQUITOCIDA UNO ULV) applied undiluted at a rate of 199.4 ml/ha and a neonicotinoid-pyrethroid (CIELO) applied undiluted at a rate of 73.07 ml/ha. Meteorological conditions during the evaluation were favorable for mosquito control and represent conditions which would occur during spatial adulticide applications. Temperature oscillated between 24-26 C and the wind between 6-10 km/h. The majority of droplets met the droplet distribution criteria required for the insecticides: volume median diameter (VMD) droplet size characterized at 31.3 µm for MOSQUITOCIDA UNO ULV and 37.3 µm for CIELO. Caged mosquitoes used in the bioassays were a susceptible laboratory strain of *Ae. aegypti* (New Orleans) and a locally-derived, pyrethroid-resistant field strain of *Ae. aegypti* from Puerto Vallarta. When exposed to AULV applied adulticides, knockdown after 1 hr with both insecticides exceeded 97.0% and 96.5 % for the susceptible and field-derived strains, respectively. Efficacy, measured as 24 hr mortality, of both insecticides applied via AULV was ≥ 98% both the susceptible and field-derived strains. These data demonstrated that MOSQUITOCIDA ONE ULV and CIELO were effective against adult *Ae. aegypti* and may be useful tools for mosquito control programs managing pyrethroid-resistant populations.

P-06 Evaluation of the effectiveness of Aqua K Othrine® (deltametrin 2%) applied with portable thermosbulizing machine for mosquito *Aedes aegypti* control in tests with interior space treatment

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The present study was carried out to evaluate the effectiveness of the Aqua K-Othrine® insecticide mist (Deltametrin 2%) applied with a portable thermonebulizer machine inside houses, on female mosquitoes of *Aedes aegypti* at a doses of 0.4 mg IA / m³. A mixture of: 80 ml of Aqua K-Othrine® + 3,920 ml of water, with a discharge rate of 145 ml / min, was applied using a thermonebulizer equipment IGEBA® TF-35. Insecticide mist penetration caused 100% mortality at 24 h of exposure in all indoor areas of housing where mosquito cages were housed: living room, dining room, bedrooms, kitchen and bathroom.

P-13 Housing characteristics and environmental factors of an endemic zone for Chagas disease with unique presence of *Triatoma venosa* in Colombia

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Triatoma venosa is one of the main vectors of Chagas disease in Colombia. To date there are not analytical reports on this species. A cross sectional study was carried out to identify infestation explicative variables. Poor plastering quality, wild animals and peridomestic structures were present in 71,2%, 49,6% and 81,6% of infested households. Of these, plastering quality (RP: 3,2 CI95%: 1,3-8) and bushes around the house (RP: 0,27; CI95%: 0,08-0,9) were the major explicative variables

Larval Control

P-29 Comparing larvicide oils and *Bti* in septic ditches of southeastern Louisiana: making the best of a stinky situation

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St. Tammany Parish, Louisiana contains over 400 linear miles of open septic ditches that foster development of *Culex quinquefasciatus* year-round, and are the primary focus of larvicide treatments by St. Tammany Parish Mosquito Abatement District (STPMAD). Comparison trials were performed in both lab and field scenarios using BVA2 oil, CocoBear oil, and VectoBac 12AS (*Bacillus thuringiensis* subspecies *israelensis*, Bti). Lab trials examined the effect of application rate on each mosquito life stage and field trials measured the immediate mosquito control provided in septic ditches, in addition to the amount of time elapsed before re-treatment was required. Lab trials indicated that while BVA2 oil was effective (>70% control) against 3rd and 4th instar larvae, CocoBear oil and VectoBac were highly effective (>95% control) against all larval instars, with both oils providing 100% control against pupae. Field trials suggested similar levels of control (approx. 80%) between both oils and Bti, with tests examining time required between retreatment currently underway. Combining efficacy results from these trials with product pricing and an ongoing study examining the seasonal development rate of *Cx. quinquefasciatus* will assist STPMAD in choosing the best suite of products for our specific environment.

Management

P-30 Insecticide resistance evaluation of *Culex quinquefasciatus* in Ruston, Louisiana

Milena Guajardo, KRI2@cdc.gov, Mariah Scott, Broox Boze, Janet McAllister

When it comes to vector management, utilizing insecticides appropriately 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 collaboration with Vector Disease Control International, bottle bioassays and microplate assays were performed on *Culex quinquefasciatus* mosquitoes collected as egg rafts from known larval production sites in Ruston, LA. The reared adult mosquitoes were evaluated to determine whether there was existence of resistance to resmethrin or permethrin, which are insecticides used in their mosquito control program. Microplate assays were performed to measure levels of detoxifying enzymes, protein, and presence of altered target sites. The bottle bioassay showed no phenotypic resistance to either insecticide. The microplate assays showed a significant difference in size of mosquitoes between field sample mosquitoes and susceptible colony mosquitoes. Differences in β -esterases were also detected between the Ruston, LA *Cx. quinquefasciatus* and the susceptible lab colony. Programmatically, the use of resmethrin and permethrin is effective at controlling *Cx. quinquefasciatus* in these areas of Ruston, LA. Insecticide resistance surveillance is essential to guide future management strategies in Ruston, LA.

New Product Trials

P-31 A Mechanical Insecticide Approach to Non-Chemical, Low-Cost Mosquito Control

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Overdependence on the use of insecticides has led to the resistance in mosquito populations and has created significant challenges in controlling mosquitoes globally. In 2016, the City of New Orleans Mosquito Control Board evaluated an engineered perlite product (Imergard-WP, Imerys, Paris, France) against 3 species of mosquitoes in the field and in the laboratory. Control of the mosquitoes was strictly mechanical and formulation did not contain a chemical insecticide. Twenty sites were selected, 10 treated (Imergard) and 10 control (water) with similar structure and yard size. Yards were inspected for breeding-sites and assessed for optimal-application. A 2-week baseline survey was taken to attain preliminary mosquito populations. The exterior of residences were treated as well as wood chips which were placed under houses with subsamples pulled weekly for bioassay. Imergard had a 96% mortality rate against *Aedes aegypti*, a mortality rate of 85% against *Aedes albopictus* and a 93% mortality rate against *Culex quinquefasciatus* in the bioassay, 8 weeks after application. The study was repeated in Monte Verde, Honduras in 2017. This location is an area of active dengue, chikungunya and Zika virus transmission and the houses were open to mosquito invasion. Mosquito pressure was monitored by BG Sentinel-2 traps (Biogents AG, Regensburg, Germany) and interior and exterior ovicups. A reduction in oviposition ($P < 0.001$) occurred in houses treated with Imergard for the duration of the study. A mechanical insecticide such as Imergard, is another tool that can be used in an Integrated Mosquito Control program. A non-chemical, low-cost option would provide greater access to mosquito control around the world.

Operations

P-32 Protecting public health by integrating vector and communicable disease control in Saint Louis County

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The Saint Louis County Department of Public Health (DPH) has established an integrated public health framework linking its communicable disease and vector control efforts. DPH's Vector Control, Communicable Disease Investigation, and Epidemiology Programs are all housed within the Division of Communicable Disease Control Services, reflecting our belief in a unified, evidence-based public health approach for the surveillance and control of disease-carrying vectors and vector-borne illness. This coordinated infrastructure creates expedient and efficient notification to the Vector Control Program (VCP) of human cases of mosquito-borne illness, allowing for enhanced local mosquito control efforts, if applicable. Surveillance and control of mosquito larva and adult mosquito populations are coordinated and implemented by the VCP, data are then analyzed in conjunction with the Epidemiology Program and compiled into a comprehensive annual report. This report summarizes local mosquito populations, vector control efforts, and human cases of vector-borne illness. Summary data, including notable trends or hot spots, are reported back to the community and also used to direct any adjustments to VCP operations. Additional benefits of integrating vector and communicable disease control efforts include expanded education and outreach efforts through traditional public health channels (e.g., the DPH website and social media posts, health fairs, and community events) and coordination with surrounding jurisdictions' local health agencies and community partners to maximize the effectiveness of regional efforts. We believe that the integrated framework used in Saint Louis County is unique among public health systems, where VCPs are typically located in environmental services divisions or even outside departments of health entirely. Our approach - with vector control staff, epidemiologist, and communicable disease nurses working collaboratively - promotes effective communication and streamlines public health efforts, ultimately preventing illness and better protecting Saint Louis County residents and visitors.

Other

P-33 Residual activity of pyriproxyfen against mosquitoes developmental stages inhabiting catch basins in Riverside County, Southern CA

Lal Mian, lmian@csusb.edu, Jesus Ramos, Angela Caranci, Major Dhillon

A field study has been carried out on the season-long efficacy of the insect growth regulator, pyriproxyfen (Nylar 0.5% G) in comparison with methoprene (Altosid XRP Pellets) against mosquito developmental stages in catch basins in Riverside County, Southern California. Pyriproxyfen was applied at 75, 100, 125, 150, 175 g/basin and methoprene at 3.5 g /basin. A total of 80 catch basins (10 per each treatment and 20 for control) were used. Posttreatment observations of catch basins and pupal collection and rearing them to adults have been carried out at weekly intervals. Activity of both IGRs was expressed as percent inhibition of adult emergence (% IAE). Early data on % IAE indicate encouraging results for the first five weeks. Mosquito species composition, consisting mostly of *Culex* species, was predominated by *Cx. quinquefasciatus*. A more detailed analysis of the data collected over the 26-week period will be presented at the poster session.

P-34 Mosquito identification using infrared spectroscopy and chemometrics

Lamyae Srout, lsroute1@catamount.wcu.edu, Scott Huffman, Brian Byrd

Mosquito control interventions are more effective when informed by routine entomologic surveillance. Thus, accurate and rapid species identification remains a critical component of operational mosquito control. Current methods to identify adult mosquitoes rely chiefly on microscopic identification by trained personnel. In some larger mosquito control programs, molecular methods may be used for species or pathogen identification and advanced techniques (e.g., age-grading by ovarian dissection) may be used to further assess the mosquito population structure. Each of these methods are labor intensive and subject to a series of operator or laboratory errors. Therefore, there is a need for rapid and non-destructive species identification techniques that can be used on a scale that is ecologically, economically, and epidemiologically meaningful. Our current research aims to develop methods of biochemical discrimination between different mosquito species using infrared spectroscopy. Infrared spectroscopy is a sensitive, information rich technique that is capable of detecting a wide range of molecular signals ranging from subtle changes in protein secondary structure to transmembrane protein-lipid interactions. The resulting spectral data, when coupled with numerical analysis (chemometric) methods such as principal component analysis, linear discriminant analysis and partial least squares may be used to classify mosquitoes by species or physiologic status. Herein, we have applied Fourier transform infrared (FT-IR) microspectroscopy to identify four container-inhabiting *Aedes* species (*Ae. aegypti*, *Ae. albopictus*, *Ae. japonicus*, and *Ae. triseriatus*) obtained from both field and laboratory conditions. At present, our FT-IR classification success rate, when compared to identification by a trained entomologist, is approximately 92%. This method, which is rapid and easy to use, has the potential to decrease the labor costs and time associated with mosquito species identification. Further development coupled with process automation may provide operationally useful methods for rapid identification of many mosquito species and their physiologic status.

P-35 Evaluation of a sectorial approach to *Aedes aegypti* control using traditional mosquito control methods

Alan Wheeler, **needed**

Not available

P-36 Sepik virus

Daniel Rafael Saldaña Torres

Not Available

P-37 Development of an economical compressed CO₂-baited mosquito trap

Gregory White, **needed**, Nadja Mayerle, Andrew Dewsnap, Ary Faraji

The Salt Lake City Mosquito Abatement District has primarily utilized dry ice in carbon dioxide (CO₂)-baited American Biophysics Corporation (ABC) traps to estimate mosquito abundances and conduct arbovirus surveillance. The ABC traps have been very efficient, but can be expensive and labor intensive to transport and set up. Our goal was to design a CO₂ trap that is easier to transport, uses a more cost-effective form of CO₂ than dry ice, and uses a fan and motor configuration that is also more affordable. Here, we present the development of an efficacious design for a compressed CO₂-baited trap. The trap uses a 20 oz CO₂ tank designed for paintball guns and a regulator/restrictor to set the flow of CO₂ to 200 ml/min. All trap materials can be broken down and stored in an ammo can (16.5"x 12" x 6.25") for convenient transportation to the field. Furthermore, different trap styles for various fans and motors were designed and created with the use of a 3-D printer. Finally, we compared the efficacy of the compressed CO₂ trap to the dry ice baited trap and the different fan and motor trap designs to the ABC trap. Results show that while dry ice baited traps collected the most mosquitoes, compressed CO₂ baited traps were also effective for operational mosquito surveillance. Also, one of our own 3-D printed trap designs was equally effective as the commercially available ABC trap in collecting mosquitoes. In conclusion, these new trap innovations have proven to be efficient and have substantially reduced costs in our mosquito surveillance program. These traps and methods can be easily adopted by other mosquito control organizations.

P-38 Decreased infection and transmission of Zika virus in *Aedes aegypti* infected with an insect-specific flavivirus

Hannah Romo, **needed**, Joan L. Kenney, Aaron C. Brault

Previous studies have demonstrated that an insect-specific flavivirus, Nhumirim virus (NHUV), can suppress the *in vitro* growth of West Nile virus (WNV) and similarly decrease WNV transmission rates in NHUV/WNV co-inoculated *Culex quinquefasciatus*. To assess whether NHUV might similarly interfere with flaviviruses that infect *Aedes aegypti*, the ability of NHUV to suppress *in vitro* viral growth of Zika virus (ZIKV), Dengue-2 virus (DENV2) and Chikungunya (CHIKV) was assessed. *Aedes albopictus* (C6/36) cells were concurrently inoculated with ZIKV, DENV2 or CHIKV and NHUV or infected with NHUV 1-5 days prior to ZIKV, DENV or CHIKV infection. Results demonstrated that ZIKV titers were reduced 100,000-fold in cultures either pre- or concurrently inoculated with NHUV/ZIKV as compared to only ZIKV. A 1,000-fold reduction in DENV2 titer

was observed for concurrent infections with NHUV/ DENV compared to DENV alone. Interestingly, DENV2 virus was not detected in C6/36 cells infected with NHUV 3 days prior to DENV2 ($<1.8 \log_{10}$ PFU/mL). In contrast, the alphavirus, CHIKV, exhibited only a transient 10-fold reduction in titer observed only when cells were pre-inoculated with NHUV 3 days prior to CHIKV infection, indicating a potential low-level non-specific interference. To assess whether NHUV could impact ZIKV transmission in mosquitoes, *Aedes aegypti* were intrathoracically (IT) inoculated with ZIKV alone or NHUV/ZIKV and the resulting ZIKV infection and transmission rates assessed. Infection rates of 100% were observed in both groups. In contrast, the transmission rate for mosquitoes from the NHUV/ZIKV dually inoculated group was 41% compared to 78% for ZIKV-only inoculated mosquitoes ($p<0.0001$). Differences in ZIKV titers from bodies or saliva were not observed. Mosquitoes that had been IT inoculated with NHUV prior to a ZIKV infectious blood meal demonstrated significantly lower infection rates (18%) as compared to sham IT inoculated mosquitoes (51%) ($p<0.002$), suggesting that NHUV can potentiate both midgut infection and salivary gland barriers that are restrictive to ZIKV in *Aedes aegypti*. These results indicate NHUV mosquito infection could be used as a model to assess superinfection exclusion mechanisms and to study the potential for the mosquito virome to impact vector competence of medically important flaviviruses.

P-39 Modeling the efficacy of aerial spraying on the relative abundance of *Culex tarsalis* and *Culex pipiens*

Karen Holcomb, **needed**, Robert C. Reiner, Christopher M. Barker

Not Available

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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. Glasgow (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)	2017	Randy Gaugler (NJ)
	William C. Reeves (CA)	2000	Judy A. Hansen (NJ)		Allan Inman (CA)

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 Lluberis (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)	2017	Michael Turell (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	William H. Meredith (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)	1998	Ralph E. Harbach (UK)
1982	Lloyd E. Rozeboom (IL)	1999	Yiau-Min Huang (DC)
1983	Kenneth L. Knight (NC)	2000	Lewis T. Nielsen (UT)
1984	Thomas J. Zavortink (CA)	2001	John F. Reinert (FL)
1985	Stanley J. Carpenter (CA)	2002	Richard F. Darsie (FL)
1986	Elizabeth P. Marks & John Reid (Australia)	2003	Richard C. Wilkerson (MD)
1987	James B. Kitzmiller (FL)	2004	Kazuo Tanaka (Japan)
1988	Allan R. Stone (MD)	2005	Ronald A. Ward (MD)
1989	Pedro Galindo (Panama)	2006	William K. Reisen (CA)
1990	Peter F. Mattingly (UK)	2008	Maria-Anice Sallum (Brazil)
1991	Jose P. Duret (Argentina)	2010	Daniel Strickman (MD)
1992	Bruce A. Harrison (NC)	2011	Rampa Rattanarithikul, Ph.D. (Thailand)
1993	Edward L. Peyton (DC)	2012	Maureen Coetzee, Ph. D. (South Africa)
1994	Theodore H. G. Aitken (CT)	2013	John F. Anderson (CT)
1995	Oswaldo P. Forattini (Brazil)	2014	Graham White (FL)
1996	A. Ralph Barr (CA)	2015	Elena B. Vinogradova (Russia)
	Michael W. Service (UK)	2016	
1997	Christine J. Dahl (Sweden)	2017	George F. O'Meara (FL)

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. Knippling	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	
2017	Jimmy Olson	Bill Sames	

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)	2009	Clarke Hudson (IL)
1998	William German (FL)		Bill Strange (ID)
1999	Gary A. Mount (FL)	2010	Peter Connelly (FL)
	Daniel F. Boyd (GA)	2011	David Sullivan (MT)
	David W. Waldron (GA)	2012	Stephanie Whitman (WY)
	J. David Waldron (GA)	2013	Larry Erickson (IL)
2002	Robert E. Richard (TX)	2014	Gerry Hutney (FL)
2003	Allen W. Wooldridge	2015	Joe Strickhouser (NC)
2004	John L. Clarke, Jr. (IL)	2016	Terry Couch (FL)
2005	Ernest Danko (IL)	2017	Clark Wood (IL)
2006	Willie N. Cox (IL)		Malcom Williams (AR)
2007	Bob Bonnett (MN)		

GRASSROOTS AWARD

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

2005	Omar S. Akbari	Reno Washoe County, 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	Butte 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

GRASSROOTS AWARD (Continued)

	Gaby Perezchica-Harvey	Coachella Valley MVCD, California
	Geneva Ginn	Coachella Valley MVCD, California
2015	Kevin Hill	
	Richard Ortiz	
	Terry Sanderson	
	Melissa Snelling	
2016	Patrick Morgan	
	Janet Nelson	
	Richard Weaver	
2017	Hailey Bastian	
	Gregorio Alvarado	
	Aaron Lumsden	
	Danny Ray Hood	

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.	2006	Robert D. Anderson	University of Winnipeg
1990	Andrea Brown	Peru State Coll.		Linda O'Connor**	University of Delaware
1991	John Paul Mutebi	Notre Dame U.		Joshua R. Ogawa*	Oregon State University
1992	Rosmarie Kelly	U. Massachusetts		Matthew Eaton*	Concordia College
1993	Merry L. Holliday-	U. California, Davis		Linda M. Styer*	U. California, Davis
1994	John E. Gimnig	U. California, Davis	2007	Jennifer Armistead	University of Florida
	Alice Shaeffer*	U. Mainz, Germany		Robert D. Anderson*	University of Delaware
1995	Glen Scoles	Notre Dame U.		Thomas M. Mascari*	Louisiana State U.
	Jittawadee Rochaeroen*	U. California, Riverside	2008	Jerome Schleier	Montana State University
1996	Esther Chow Schaeffer	U. Maryland		Christopher Barker*	U. California, Davis
1997	Lynn Cooper	U. Maryland		Lisa Reimer*	U. California, Davis
1998	C. Roxanne Rutledge	Louisiana State U.	2009	Alexandra	University of Florida
	Emmalee Kennedy*	U. Illinois		Stephanie Larick*	University of Florida
	Timothy Schaub*	U. Illinois	2010	Sarah Wheeler	University of California,
1999	Laura Harrington	U. Massachusetts		Kimmy Mains*	University of Kentucky
	Adam S. Jones*	U. Massachusetts		Holly Tuten*	Clemson University
	Hillary Reno*	U. Illinois	2011	Logan Minter	University of Kentucky
2000	Jason L. Rasgon	U. California, Davis		Kristen Meckel-	San Diego County Vector
	Hope Q. Liu*	Virginia Polytechnic	2012	Jerome Schleier	Montana State University
2001	No competition			Elizabeth Andrews*	University of Kentucky
2002	Laura B. Goddard	U. California, Davis		Jennifer Gordon*	University of Kentucky
	Sharon L. Minnick*	U. California, Davis		Joseph Iberg*	University of Georgia
	Margaret Sherriffs*	Yale U.	2013	Brian Johnson	Rutgers University
2003	Sarah Yaremych	U. Illinois		Andrea Egizi	Rutgers University
	Laura Goddard*	U. California		Brittany Nelms	U. California, Davis - CVEC
	Jason L. Rasgon*	U. California, Davis	2014	James Ricci**	University of California
2004	Gregory M. Williams	U. Delaware		Eva Bickner***	University of Florida
	Stephen Aspen*	Colorado State U.		Allison Gardner***	U of IL Urbana - Champaign
	Christian Kaufmann*	U. Zurich	2015		
2005	Wesley Rubio	San Diego State U.	2016		
	Whitney Qualls*	Auburn University	2017		
	Rebecca Trout*	University of Kentucky			

* \$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	2017-2018	Wayne Gale
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	Executive 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
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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. Glasgow
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