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Oral Presentation Abstracts

Plenary Session

PL-1 "The use of *Wolbachia* to disrupt dengue, Zika, and chikungunya transmission by *Aedes aegypti*"

Peter Ryan (peter.ryan@worldmosquito.org)

The World Mosquito Program is using inherited bacterial symbionts of insects known as Wolbachia to reduce dengue virus transmission by Aedes aegypti. The presence of Wolbachia in Aedes aegypti has been shown to reduce their susceptibility to dengue, Zika and chikungunya viruses. Field implementations involving releases of Wolbachia infected mosquitoes have resulted in the establishment of Wolbachia in local mosquito populations, without the need to suppress the mosquito population. Recent results indicate that deployments can be done at scale and current indications are that this approach is having large positive impacts on the reduction of disease in human populations. Moreover, the approach appears sustainable with Wolbachia persisting in mosquito populations for over 8 years without the need for reapplication, and therefore this approach may represent a cost saving intervention for governments to reduce Aedes transmitted disease burden.

PL-2 Frugal science: from toys to global innovations

Manu Prakash
TBD

Adult Control I

1 Promising new tools to fight Aedes mosquitoes in Thailand

Alongkot Ponlawat (AlongkotP@afrims.org), Thanyalak Fansiri, Arissara Pongsiri, Wachiraphan Chittham, Silas A Davidson, Robert L Aldridge, Seth C Britch, Kenneth J Linthicum

Aedes aegypti is the most important arthropod borne viral disease vector which affects human health in tropical areas. Due to changes in mosquito behavior and an increase in insecticide resistance, new Ae. aegypti control techniques are crucially needed. Our goal is to investigate the efficacy of new tools implemented in Aedes vector control under the field conditions in Thailand. We performed the field experiments to determine the efficacy of the pyriproxyfen/spinosad-treated device, the different insect growth regulators (IGRs) on fecundity, fertility in female Ae. aegypti and sperm production in male Ae. aegypti, the application of non-insecticidal sticky gravid traps, and the ULV application of spinosad larvicide as a residual in a tropical environment against Aedes mosquitoes. These investigations show promise as effective tools for Ae. aegypti control. The number of deposited eggs significantly decreased when females Ae. aegypti exposed to the pyriproxyfen/spinosad-treated device. Results from our study demonstrated that many IGRs affected fecundity and reproduction of Aedes mosquitoes. We proved that ULV application of spinosad larvicide significantly increased the larval mortality. The current research conducted in the department of Entomology, AFRIMS will be discussed in regards to the Aedes mosquito control in Thailand.

2 Improved algorithms behind VectorWEB and pending deployment

Laura Scavo (Lscavo1@jhu.edu), Adam Goodwin, Margaret Glancey, Tristan Ford, Jewell Brey, Collyn Heier, Soumyadipta Acharya

Despite its importance, mosquito surveillance remains logistically challenging and highly human-resource intensive. Our team is developing the VectorWeb system for semi-autonomous mosquito surveillance. This system comprises a smartrap Internet-of-Things (IoT) attachment for a BG-GAT trap, a phone app, an online dashboard, and a computer vision identification algorithm. An identification algorithm is the key enabling factor in any autonomous surveillance system. The database supporting our algorithm has grown to 80,000 images of various imaging modalities, with identification of the specimens validated by PCR. The algorithm currently reaches 81.20% +- 2.31% sensitivity and 97.93% +- 0.36% specificity across 11 wild caught mosquito species, including *Aedes aegypti*, *Aedes Albopictus*, *Anopheles gambiae*, and *Anopheles funestus*. Inclusion in the algorithm is based on a threshold number of specimens. Current pending work includes continued growth of the database and species included in the algorithm, and testing the algorithm deployed in the phone app and in the smartrap IoT attachment.

3 Transfluthrin on US military materials reduces mosquito populations in a hot humid tropical environment in eastern Thailand

Seth Carroll Britch (seth.britch@ars.usda.gov), Kenneth J Linthicum, Alongkot Ponlawat, Daniel L Kline,

Wendy L Helmey, Arissara Pongsiri, Robert L Aldridge, Frances V Golden

Recent field research has demonstrated that treating US military field materials like camouflage netting with residual pesticides creates a passive layer of pest and vector insect reduction that could enhance the existing Department of Defense (DoD) pest management system. However, we lack information on the potential efficacy of spatial repellents on US military field materials that could work in place of or in concert with residual pesticides. Use of spatial repellents such as transfluthrin are gaining traction as viable outdoor pest and vector reduction techniques, and could reduce the risk of evolution of resistance in target medically important arthropods. In this study we investigated the efficacy of transfluthrin applied to US military camouflage netting and HESCO blast protection wall geotextile in a hot tropical environment in eastern Thailand targeting mosquitoes. Presence of transfluthrin treated strips significantly reduced mosquito collections in small protected enclosures of both materials compared to untreated control enclosures, providing evidence that spatial repellent treatments of US military materials could serve as an effective layer of passive control in the DoD pest management system.

4 Protocol for field and laboratory evaluating acute toxicity of aerial naled on Danaus plexippus (monarch butterflies) and Aedes taeniorhynchus (black salt marsh mosquitoes)
John P Smith (jsmith@pc.fsu.edu), Taylor J Taylor, Cami I Adams, Karen Fleming

A plan for testing the acute toxicity of aerial naled on larval and adult monarch butterflies as applied operationally for the control of salt marsh mosquitoes will be reviewed. The purpose of the presentation is to glean suggestions for improving the protocol for studies to ensue spring 2019 in Panama City Beach, Florida.

5 Insecticide Resistance trials in North Chicago Suburbs
Patrick M Irwin (pirwin@nwmadil.com), Mark Clifton, Justin Harbison, Chris Xamplas

With the formation of the Centers for Disease Control (CDC) Centers of Excellence for Vector-Borne Diseases an emphasis was placed on conducting insecticide resistance (IR) testing, especially for those who have not done so in the past. Northshore Mosquito Abatement District (NSMAD) and Northwest Mosquito Abatement District (NWMAD) began insecticide resistance testing during the 2018 summer season utilizing the CDC bottle assay protocol. Several challenges needed to be overcome to conduct the assays including: Acquiring adult *Culex pipiens* from the area to conduct the assay. It was not as easy as trapping adult *Culex pipiens* for the test. In the Midwest we have both *Cx. pipiens* and *Culex restuans*, which are morphologically indistinguishable. Also, the CDC does not have a diagnostic time for *Cx. restuans*. Adding to this issue is both districts are known to have the *Cx. pipiens molestus* subspecies, again, morphologically indistinguishable from each other. For certain insecticides the diagnostic time is significantly different depending on which subspecies is used in the bottle bioassay. Other difficulties had to be overcome to conduct the insecticide resistance testing and our hope is to elucidate these issues to help other groups conduct IR testing in the future.

6 Adult mosquito control treatments exert temporary reductions in mosquito abundance but long-lasting effects on the population dynamics of urban Culex pipiens mosquitoes
Mark Clifton (mclifton@nsmad.com), Chris Xamplas, Justin Harbison

During the summer of 2018 the North Shore Mosquito Abatement District conducted a season-long adulticide efficacy trial in the Northern Chicago suburb of Skokie, Illinois. Both gravid and host-seeking populations were simultaneously and continuously monitored within a 1 square mile area by ten Biogents BG-Counters for nearly two months. A series of weekly truck ULV treatments were conducted during July and August of 2018. Host-seeking populations were temporarily reduced by 68% while gravid mosquito populations were only reduced by 36% on average. After each trial, host-seeking populations rebounded completely within 36-48 hours while gravid populations showed no rapid rebound. Physiological, behavioral and biochemical changes that occur after a blood meal in female *Culex pipiens* mosquitoes create a profound but temporary resistance to pyrethroid insecticides. The mortality of host-seeking but not gravid mosquitoes after adulticide treatments introduced a dramatic oscillation in the host-seeking mosquito population that persisted for weeks after the trial was completed. Taken together, these results illustrate that ground-based ULV did not cause long-term reductions in *Cx. pipiens* populations but instead induced alterations to the population structure and population dynamics that are likely to influence disease transmission.

7 Comparing and contrasting deltamethrin formulations: implications for resistance management

Samer Elkashef (selkashef@fightthebite.net), Sarah S Wheeler, Marcia Reed, Steve Ramos

In an effort to optimize adult control strategies in urban areas where mosquito populations have shown resistance to pyrethrins and pyrethroids, the Sacramento-Yolo Mosquito and Vector Control District (District) examined two distinct product formulations that use deltamethrin as an active ingredient, Suspend Polyzone and DeltaGard. Early studies with barrier treatments using Suspend Polyzone indicated that the product remained active on foliage well beyond the 90 days that the product advertises. However, subsequent studies comparing control between susceptible and resistant populations of *Culex pipiens* revealed that the product had limited efficacy against resistant populations. In tandem the District also challenged the same populations with Ultra Low Volume treatments of DeltaGard. These applications yielded high rates of mortality in both susceptible and resistant populations. The contrasting results observed between the application methodologies is forcing the District to analyze the incorporation of this active ingredient into its adult control program with resistance management strategies in mind.

8 Long-lasting spatial repellents: isovalerate esters of monoterpenoids

Joel R Coats (jcoats@iastate.edu), James S. Klimavicz, Edmund J. Norris, Caleb Lee Corona

Individual monoterpenoids from plant essential oils are good repellents, but are not long-lasting. We have used the naturally-occurring organic acid isovaleric acid to esterify 21 individual monoterpenes or phenpropanoids from plant essential oils. We tested them on the northern house mosquito, *Culex pipiens*, in a spatial repellency chamber, by applying 1 ml of 0.5% solution to a 9-mm filter paper affixed to one end of the chamber. We then determined: (1) the relative repellent potency and (2) short-term and long-term repellency activity. The best repellents among those compounds demonstrated excellent repellency out to 7.5 hours.

9 Advancing insecticide application technology to protect populations in low and middle income countries from malaria and arboviral diseases.

Jason Richardson (jason.richardson@ivcc.com), Nick Hamon, Julian Entwistle, Clint Hoffmann

Unlike mosquito abatement in the Americas, malaria and dengue vector control technology in low and middle-income countries has remained largely static for decades. There is a pressing need for innovative control tools and methodology to radically improve the quality and efficiency of current vector control practices to protect those most in need. The Innovative Vector Control Consortium (IVCC) is working with multiple donors and partners to address this gap. This presentation will address key limitations with current tools and techniques used in many vector control programs across the globe and explore technology innovation to improve efficacy and quality and truly disrupt application technology to protect those in need.

Mosquito Lightning Symposium

10 Love to hate you! The world's weirdest mosquito species!

Ary Faraji (ary@slcmad.org), Stephen Doggett, Christina Liew

Mosquitoes are the true vixens of the insect world. Some species are absolutely beautiful and mesmerizing, and yet some can carry debilitating and deadly diseases with global impact. They are by far the deadliest animal on our planet, having determined the outcomes of war for thousands of years. This presentation will outline the workings of a new book titled "Earth's Weirdest Mosquitoes". We will provide photographic examples of mosquito species with unique and enchanting features.

11 Mosquito revelations

Nathan Burkett-Cadena (nburkettcadena@ufl.edu)

Despite more that 100 years of intense study, mosquitoes are still poorly understood. Field research of mosquito ecology continues to reveal exciting revelations and unexpected aspects of mosquito diversity. Feeding upon host blood is perhaps the most characteristic and important aspect of mosquito biology, from the human perspective. Through photography and molecular investigations unexpected patterns of host by Florida mosquitoes have been revealed. *Culex cedecei*, the vector of Everglades virus has shifted its host use in response to mammal decline precipitated by the invasive Burmese python. *Culiseta melanura*, the enzootic vector of eastern equine encephalitis virus, feeds upon reptiles to a much greater extent than previously recognized. The mosquito *Uranotaenia sapphirina*does not feed upon the blood of vertebrates. It

is the only mosquito known to specialize on the blood of annelids (earthworms and leeches). These recent findings illustrate that there is still a lot to discover about the diverse mosquitoes that inhabit our world.

12 Everybody loves the zoo, even the mosquitoes

Lee Cohnstaedt (lee.cohnstaedt@ars.usda.gov)

Everybody loves going to the zoo, even the mosquitoes and other biting insects. Zoological parks are filled with a wide diversity of animals and their corresponding habitats. The animals provide a range of blood meal options and larval habitats. One summer of trapping using BG sentinels and CDC light traps uncovered an incredible diversity of mosquito and biting insects in a small 4 acre area comprising more than 50% of the mosquito and biting insect species identified in the entire state. This talk will present what we have learned and how we can conduct better insect surveillance using zoos.

13 Transfluthrin on US military materials reduces mosquito and sand fly populations in a warm temperate Mediterranean environment in Greece

Seth Carroll Britch (seth.britch@ars.usda.gov), Alexandra Chaskopoulou, Kenneth J Linthicum, Wendy L Helmey, Daniel L Kline, Frances V Golden, Robert L Aldridge, Ioannis A Giantsis, Michail Miaoulis

Recent field research has demonstrated that treating US military field materials like camouflage netting with residual pesticides creates a passive layer of pest and vector insect reduction that could enhance the existing Department of Defense (DoD) pest management system. However, we lack information on the potential efficacy of spatial repellents on US military field materials that could work in place of or in concert with residual pesticides. Use of spatial repellents such as transfluthrin are gaining traction as viable outdoor pest and vector reduction techniques, and could reduce the risk of evolution of resistance in target medically important arthropods. In this study we investigated the efficacy of transfluthrin applied to US military camouflage netting and HESCO blast protection wall geotextile in a warm temperate/Mediterranean environment in Greece targeting mosquitoes and sand flies. Presence of transfluthrin treated strips significantly reduced mosquito and sand fly collections in small protected enclosures of both materials compared to untreated control enclosures, providing evidence that spatial repellent treatments of US military materials could serve as an effective layer of passive control in the DoD pest management system.

14 A mosquito toilet to optimise arbovirus surveillance

Scott Ritchie (scott.ritchie@jcu.edu.au), Dagmar Meyer

Mosquitoes shed virus when they poo. Indeed, more viral RNA is detected in excreta, and detected days earlier, than is found in saliva. Thus, we have developed a mosquito toilet "a mozzie loo for mozzie poo" that can be used to enhance detection of arboviruses from field captured mosquitoes.

15 Innovation in vector control from IVCC and its partners

Jason Richardson (jason.richardson@ivcc.com), Nick Hamon

IVCC is a unique Product Development Partnership (PDP) dedicated to the development of innovative vector control solutions. Established in 2005, our work is already delivering a robust pipeline of solutions to support the global eradication of malaria; a pipeline that has the potential and expectation to extend beyond malaria to other Neglected Tropical Diseases and beyond sub-Saharan Africa. Our portfolio is focused in 4 areas:I 1. The discovery, development and launch of novel public health insecticides with new modes of action to address and prevent resistance. 2. The repurposing of insecticides already developed for agricultural or animal health uses, adapting them for vector control. 3. The development of innovative solutions to prevent outdoor/residual transmission of vector borne diseases. 4. The assessment and promotion of integrated vector management (IVM) and insecticide resistance management (IRM) strategies. In addition, IVCC is working with our partners to remove the many roadblocks to innovation through: 1. Catalysing innovation in vector control and accelerating adoption of new tools to ensure that products developed through IVCC and its partners will be made quickly available to control programs in endemic countries. 2. Development of solutions to facilitate the optimal delivery, application and use of novel products. IVCC is funded by the Bill & Melinda Gates Foundation, Unitaid, DFID (UKaid), USAID, the Swiss Agency for Development and Cooperation (SDC), and the Australian Government's Department of Foreign Affairs and Trade (DFAT).

16 Role of Harris County Public Health mosquito control in community education and outreach
Mustapha Debboun (mustapha.debboun@phs.hctx.net)

Harris County Public Health Mosquito & Vector Control Division (HCPH MVCD) disseminates ongoing prevention messages to Harris County & the City of Houston residents to alter their attitudes and beliefs toward mosquito-borne diseases. Its community education and outreach footprint is currently expanding with the addition of 2 mobile outreach vehicles, allowing MVCD personnel to engage the community in an innovative and interactive learning experience. One is a Skeeter School Bus which targets elementary -age children and the other is a Mobile Vector Unit which is a museum-style interactive, exploratory unit that includes information panels, video screens, interactive quiz, microscopes with mosquito specimens, etc....

17 Anatomy of a molecular arbovirus detection lab
Kristy Burkhalter (ktb3@cdc.gov)

Nucleic acid detection assays are powerful and sensitive tools to detect arboviruses in mosquito and tick pools, but careful considerations must be made to ensure an entity's proficiency to deliver accurate and contamination-free results. Lessons learned and answers to frequently asked questions will be distilled into an overview of the requirements and challenges that should be considered when developing molecular testing capacities.

18 The influence of mosquito larvae on structure and function of food webs across a nutrient gradient
William Walton (william.walton@ucr.edu), Jessica Coolidge

The effects of mosquito larvae on the function and structure of aquatic food webs were studied across an enrichment gradient in replicated 0.3 m^3 mesocosms. Water quality variables (total nitrogen, nitrates, nitrites, ammonium, total phosphorus, reactive phosphorus, and chemical oxygen demand), mosquito oviposition rates, invertebrate taxa and the microbiomes in the water column and mosquitoes were quantified at three levels (high, low and ambient) of enrichment with organic and inorganic nutrients. Oviposition rate of *Culex* was directly related to enrichment level. The presence of *Culex* larvae at high nutrient levels increased photosynthetic production in the water column, with a corresponding decrease in overall bacterial diversity as compared to mesocosms lacking mosquito larvae. Bacterial diversity increased with increasing nutrient concentrations. The effects of larval mosquito presence on food web structure and function differed as a function of nutrient level. Larval mosquitoes can have profound impacts on aquatic ecosystems especially when those ecosystems are affected by high nutrient input such as from residential or agricultural runoff and can potentially shift water column function from domination by heterotrophic to autotrophic processes.

19 If you can't beat 'em, blow 'em up! Mosquito control with larvicide mortar shells.
Gregory M Williams (gwilliams@hudsonregionalhealth.org)

In three of the most exciting minutes of your life you will be introduced to the latest tool in the war against mosquitoes, the Mosquito Mortar. The Mosquito Mortar is a portable air-powered cannon capable of launching mortar shells filled with larvicide hundreds of feet. With the use of ballistic tables and aerial maps, very accurate placement of mortars is possible.The shells are constructed of non-toxic dissolvable and biodegradeable plastic. Upon impact the shells break or dissolve and release the larvicide contents. This talk will focus on the construction and use of the system complete with a flight video from the mortar's perspective!

20 Natular T30 for mosquito control: Two sides of the same coin
Tianyun Su (tsu@wvmvcd.org), Samanta Negrete, Michelle Brown

Natular T30 is a newly developed pharmaceutical grade, dust-free tablet formulation to control mosquito larvae breeding in confined water bodies. This product has average weight 6.2 g/tablet with a specific gravity 1.9 g/cm^3, containing 8.33% spinosad. After the tablet was applied directly by tossing to the water to a 7-feet catch basin, it sank immediately, and no larval reduction was observed up to 22 days post-treatment. When the tablet was suspended just below the water surface, however, complete control was achieved on day 5 and lasted at least 44 days post-treatment under the same test conditions. Evidence was generated using 24-in deep simulated catch basins, top-inch water showed high level of larvicidal activity on day 1 post-treatment and remained high throughout 21 days of test period when the tablet was suspended. However, larvicidal activity started low on day 1 post-treatment, and gradually increased and reached the comparable level on day 21 when the tablet was applied directly by dropping to the water. Sunken tablet not only provided low efficacy, but also created a sublethal exposure which is conducive to resistance

evolution. Each Natular T30 contains approximately 516 mg spinosad, control efficacy can be remarkably different if it is applied in the different ways – floating or sinking. After looking at the two sides of the same coin, effort is warranted to modify the buoyancy of the product to ensure the delivery of the active ingredients to the feeding zone of mosquito larvae.

21 **The importance of connection - government organizations and private companies working together in the mosquito control industry.**
Mark Edwin Smith (mmcd_mes@mmcd.org)

As more private companies enter the mosquito control market, the needs for improved communication and specific training are growing. Government agencies can help to fill that niche by reaching out and inviting these private companies to be a part of local, regional and national associations. The overall mosquito control industry and citizens will be better served by a well-trained, knowledgeable workforce.

22 **What constitutes a good trap?**
Daniel L. Kline (dan.kline@ars.usda.gov)

This lightning presentation will present the essential features of a good trap. A good trap must be well designed, well constructed, cost effective, effective at capturing target species, accepted for use by members of the intended market and well named.

23 **Effects of vaporized organophosphates (Dibrom and Fyfanon) on adult mosquitoes**
Christopher Lesser (Christopher.Lesser@manateemosquito.com)

The efficacy of aerosolized organophosphates, such as Dibrom and Fyfanon, used to control adult mosquitoes are well documented. After spraying through a high-pressure or rotary atomizing nozzle system and developing a spray cloud with an average droplet size of 30-60 microns, these small liquid droplets can vaporize into a gaseous form with undocumented effects on adult mosquitoes. This research evaluates the lethal effects of vaporized Dibrom and Fyfanon on wild-caught F-1 generation Aedes taeniorhynchus mosquitoes in a controlled environment of a wind-tunnel.

24 **Who owns the night?... aerial spraying after dark to control mosquitoes and midges**
Mark Breidenbaugh (mbreiden@kent.edu)

The U.S. Air Force has developed a night time aerial spray capability as part of their charge to maintain the ability to control insects of medical importance over large areas for troop health protection worldwide. Mosquitoes and biting midges are often described as crepuscular in their activity periods but we know there are variations in host seeking behavior between species. Furthermore, it is possible that mosquito activity within a 24 hour period can vary within species depending on the location, weather, time of year, or even the phase of the moon. This mosquito lightning talk will examine the results of nighttime aerial sprays against various mosquito and biting midge species that have been the aim of pest management projects in different locations in the United States.

25 **How does age and strain of colony mosquitoes influence susceptibility to pyrethroids?**
Derek Drews (ddrews@clarke.com)

I will present dose-response results for multiple active ingredients (AIs) against different laboratory strains of *Ae. aegypti* (Orlando, Liverpool, Rockefeller) and the effect of female age on susceptibility to pyrethroids. What is the relevance of female age and susceptibility to vector control?

26 **Residentially linked La Crosse encephalitis cases suggest need for improved environmental assessments and mosquito control**
Mike Doyle (michael.doyle@dhhs.nc.gov), Brian Byrd

La Crosse encephalitis (LACE) remains the most common cause of pediatric arboviral encephalitis in North America. At present there are no effective clinical therapies or vaccinations available to treat or prevent infection with La Crosse virus. Although overshadowed by the recent public health responses to exotic mosquito-borne diseases, endemic arboviral diseases such as LACE continue to persistent as important environmental health hazards. Indeed, recent epidemiological evidence suggests that the focal risk of La

Crosse virus infection may be linked to residence and disease may occur in siblings and non-sibling both coincidently and asynchronously. Disease may even occur in non-siblings linked by place of residence after a change in house-hold ownership. In this "lighting" talk, the need for rapid and meaningful mosquito control responses to La Crosse encephalitis cases will be made in the context of emerging epidemiological data, recent advances in mosquito control. A case will be made for researchers to evaluate the use of novel mosquito control measures (e.g., autocidal gravid ovitraps, lethal ovitraps, or autodissemination techniques) and traditional control measures such as residual barrier sprays, in the context of LACE prevention.

27 **New ideas often come from unexpected places**
Kristen Healy (khealy@lsu.edu)

Being at a university exposes you to a wealth of expertise and resources that can allow you to create and innovate, and collaborate with individuals outside your discipline. In this brief presentation, I will discuss ways in which we continue to think outside the box to help mosquito control.

28 **Eradication of Aedes aegypti on Grand Cayman**
James McNelly (jim.mcnelly@gov.ky)

The Mosquito Research and Control Unit (MRCU) on Grand Cayman, Cayman Islands, British West Indies was created in 1965. The first Director, Dr. Marco Giglioli, OBE previously directed efforts that successfully eradicated *Aedes aegypti* from the islands. Cayman Island Government has tasked MRCU with eradicating *Ae. aegypti* from Grand Cayman; to that end, plans are being developed to achieve this goal. The presentation will discuss eradication of *Ae. aegypti* in the Cayman Islands: past, present and future.

29 **The Penultimate Lecture**
Randy Gaugler (gaugler@sebs.rutgers.edu)

Everyone knows a career is finite, that it has an ending as well as a beginning, but still it snuck up on me. I have delievered many hundreds of talks over the past five decades, and now I wish to share bits and pieces of the insights I've accumulated from that long experience, abeit mostly via trial-and-error. Topics may include Serendipity Now!, Fear & Curiosity, Science & Opinion, The Key Leadership Tool, and Legacy.

considerations for expansion of sterile male mosquito releases to the city, state and even national levels.

Student Paper Competition I

30 The 30th Annual Student Paper Competition of the American Mosquito Control Association
Brian Byrd (bdbyrd@wcu.edu)

Since 1989 the American Mosquito Control Association has encouraged student participation by providing student members a forum to present their research. This venue is judged competitively and winners receive the Hollandsworth Prize, which honors AMCA member Gerald Hollandsworth. Each participating student will have 15 minutes to present their paper.

31 Death by cattle: zooprophylaxis and eprinomectin endectocide efficacy in the management of malaria mosquitoes (Anopheles quadrimaculatus)
Annie Elizabeth Rich (annie.rich@dph.ga.gov), Nancy C Hinkle, Seth Irish, T. Dean Pringle

Insecticidal zooprophylaxis holds promise in rural agricultural communities impacted by malaria. Technical grade and LongRange® formulations of eprinomectin were fed to *Anopheles quadrimaculatus* in the lab (preliminary) and on cattle post-injection (field). Mosquitoes fed on lab-treated blood had an LC_{50} of 317 ng eprinomectin per ml of bovine blood. Mosquitoes fed on single and double dose-treated animals showed little difference in survival, fertility, and fecundity from those fed on control animals.

32 Efficacy of ground ULV adulticide application on West Nile Virus vectors in the Chicago suburbs
Kristina Lopez (kalopez@wisc.edu), Patrick M Irwin, Susan Paskewitz, Lyric Bartholomay

We evaluated the impacts of multiple applications of Zenivex E20 on adult *Culex* abundance and age structure. Sites were either treated once or once per week for 5 weeks. Mosquitoes were trapped daily and parity was estimated by ovary tracheation. Results showed no difference in abundance between treatments but a significant increase in nulliparous mosquitoes at sites treated for five weeks.

34 Select biodegradable nanoparticles localize internally within Aedes aegypti mosquitoes and may represent a new means to deliver insecticides

Edmund J Norris (ejnorris@iastate.edu), Adam Mullis, Yashdeep Phanse, Balaji Narasimhan, Lyric Bartholomay, Joel R. Coats

Surprisingly little is known about how insecticides move within target pests. To better undestand and take advantage of these processes, we exposed adult female *Aedes aegypti* mosquitoes via three routes of exposure to rhodamine-labeled nanoparticles: 1) contact with a treated surface, 2) topical application, and 3) ingestion. We then characterized the degree of labeling in specific tissues to better understand nanoparticle movement. These studies will highlight the potential of nanoparticles to deliver insecticides more effectively.

35 Using biorational products as spatial repellents against mosquitoes of multiple genera

Caleb Lee Corona (clcorona@iastate.edu), James S. Klimavicz, Edmund J. Norris, Joel R. Coats

The development of pyrethroid resistance has led to the need for new tools to be developed to control mosquito populations. Biorational products designed based on monoterpenoid chemistries have proven to be effective spatial repellents when screened using a repellency assay developed in our lab in both short- and long-term assays. This class of compounds have been shown to repel mosquitoes of three genera: *Culex*, *Aedes*, and *Anopheles*.

36 A comparison of the efficacy of infusion water for the attraction of gravid Culex mosquitoes using locally collected Silver Maple leaves vs. purchased Alfalfa pellets and pasteurized chicken manure.

Katherine Bowman (katherine.bowman@slu.edu), Trey Hull, Cameron Harvey

To first establish mosquito transmitted disease prevalence, surveillance programs must collect the vector, in the case of West Nile Virus, *Culex* sp. The CDC Gravid Trap is traditionally prepared by steeping water with commercially-available organic matter. This study seeks to determine if the matter's regionality effects the trap's efficacy. This was done by comparing the effectiveness of alfalfa/chicken manure vs locally collected silver-maple leaves. These results may help increase the effectiveness of traditional surveillance and model breeding sites.

37 Effects of diet and sex on thermal tolerance of Aedes aegypti and Culex quinquefasciatus

Madeleine Chura (mchura@agcenter.lsu.edu), Kristen Healy

We examined differences in thermal tolerance in *Aedes aegypti* and *Culex quinquefasciatus* based on species, sex, and diet. Diets examined included various sugars, sugar alcohols, and blood. Preliminary results suggest greater cold tolerance in *Cx. quinquefasciatus* as compared to *Ae. aegypti* with no significant differences between sexes in either species. In *Cx. quinquefasciatus*, the data suggest that diet does not influence cold tolerance, while heat tolerance parameters have not yet been explored.

38 Introducing midgut microbes to mosquitoes: The effects of native and non-native strains of bacteria

Flor Alicia Martinez (flor.a.martinez01@utrgv.edu), Erin Schuenzel, Grant Hughes, Christopher Vitek

Mosquito midgut microbes are crucial for development and suggested to influence the vector competency of mosquitoes. Understanding the effects that native and non-native strains of *Cedecea* bacteria have on *Aedes aegypti* and *Aedes albopictus* mosquitoes may elucidate the potential for the microbiome to influence vector competency and the potential of midgut bacteria to act as a control mechanism for disease transmission. Comparisons within and across species were performed on a time series analysis.

Post Regulatory Approval SIT Adoption Symposium

280 Automation for large scale SIT deployment
Ralph Breslauer (rsb5779@gmail.com)

After many years of field trials in many countries, over 20 states in the US have been approved for the release of sterile male mosquitos. This opens the doors for many districts to plan to include SIT in their overall mosquito abatement strategy. In order to be able to expand this capability beyond the trial phase a number of leading edge technologies have had to be developed. Come and learn about the latest in Deep Learning to identify the sex of mosquitos en masse, automatically loading them into cartridges and then distributing them by van, drone or aircraft. Thereby enabling more cost efficient use of this effective vector control option for projects of all sizes. Regardless of the difficulty of the terrain, the sterile male mosquitos target the females wherever they may be hiding and do not impact any other fauna. Stay up to date with the latest information.

281 A Wolbachia-based autocidal approach to control Aedes mosquitoes
Jimmy Mains (jmains@mosquitomate.com)

After many years of field trials in many countries, over 20 states in the US have been approved for the release of sterile male mosquitos. This opens the doors for many districts to plan to include SIT in their overall mosquito abatement strategy. In order to be able to expand this capability beyond the trial phase a number of leading edge technologies have had to be developed. Come and learn about the latest in Deep Learning to identify the sex of mosquitos en masse, automatically loading them into cartridges and then distributing them by van, drone or aircraft. Thereby enabling more cost efficient use of this effective vector control option for projects of all sizes. Regardless of the difficulty of the terrain, the sterile male mosquitos target the females wherever they may be hiding and do not impact any other fauna. Stay up to date with the latest information.

282 Oxitec's 2nd generation self-limiting mosquitoes
Kevin Gorman (Kevin.Gorman@oxitec.com)

TBD

283 The path to widescale releases of Wolbachia-infected male mosquitoes
Jodi Holeman (jholeman@mosquitobuzz.net)

Debug Fresno is a partnership between the Consolidated Mosquito Abatement District (CMAD), MosquitoMate and Verily to evaluate the use of Wolbachia infected male mosquitoes as a sterile insect technique for control of Aedes aegypti mosquitoes. In 2018, the Debug Fresno study included three neighborhoods, two in the City of Clovis and one in the City of Fresno, in Fresno County, California. Results of the study achieved greater than 95% suppression of adult Aedes aegypti female mosquitoes in neighborhoods where sterile male mosquitoes were released, demonstrating that the use of Wolbachia infected males to control Aedes aegypti is effective. This presentation will discuss the next steps and considerations for expansion of sterile male mosquito releases to the city, state and even national levels.

6th Arthropod Vector Highlights symposium

39 Highlights of vector biology
Roxanne Connelly (Csz5@cdc.gov)

Mosquito researchers produce results that are often used to support public health messaging in ways that are meant to help the public reduce their risk of exposure to mosquito borne pathogens. It is critical that

this information is disseminated widely and through numerous media outlets. Controlling the message is often a major challenge and unfortunately, sensational headlines and fake news occur and dilute the intended message. The 2018 highlights of vector biology will focus on the latest advances in mosquito biology, ecology, and pathogen transmission research Important for public health messaging. The public health implications of each article will be provided and accompanied by a discussion of the potential for the article to make headline news. For the selection process, the table of contents from the top five "go to" journals listed by selected mosquito researchers from across the globe were scanned for relevant keywords to generate a list of articles for consideration. From that list, the author used a highly subjective and pseudo-scientific filter, the "H-factor", developed and perfected over the past 17 years, to select those with the highest H-factor for inclusion. A brief discussion of the elements of the H-factor and several articles will be presented.

40 Highlights of Vector Control

Christopher Stephen Bibbs (cbibbsamcd@bellsouth.net)

A recap of lessons learned from 2018 in vector control! Articles were selected with the intent of avoiding redundancy with the other highlights talks. This will be a relatively quick paced presentation covering two handfuls of articles the author/presenter selected for exposure. Criteria were primarily for innovation and priority knowledge.

41 Highlights from Latin America

Catalina Alfonso (catalfonso@gmail.com)

Although half of the world's population is at risk of Dengue infection, the recent epidemics of Dengue, chikungunya and Zika that swept through the Caribbean and Central and South America highlight the importance of vector control in parts of the New World. Today, *Aedes aegypti* and *Ae. albopictus* are present in Mexico, Brazil, Colombia, Peru, Venezuela, and other countries in the Caribbean and South America. Public and private institutions are researching many aspects of these mosquitoes to increase our general knowledge of their behavior and biology, thereby working to improve and/or develop tools that will aid mosquito surveillance and control. I will review the latest mosquito research that have been reported in Central and South America, highlighting mosquito behavior, physiology, ecology, genetics as well as newly developed methods of mosquito control. This overview will demonstrate the importance of looking outward to learn from the experiences of countries greatly affected by these *Aedes* species and the diseases they transmit.

Adult Control II

42 Integrating Space Sprays into Existing Malaria Control Programs

Wesley Clint Hoffmann (clint.hoffmann@gmail.com), Daniel McDermott, Jason Richardson, Graham Small, Julian Entwistle

Space sprays for controlling adult mosquitoes have been used for decades around the world but are not typically part of malaria control programs. This paper will cover some of the history of space spraying as well as the efficacy of spraying on different species and in different environments. Using data collected in a recent systematic review of space sprays, the potential integration of space spraying into established malaria control and elimination programs will be explored. The pros and cons of this proposed integration will also be discussed.

43 Volcano to Vector Control: Its time for nature to fight back…

David Stewart (david.stewart@imerys.com), Richard Michael Roe, Charles Apperson, Claudia Reigel, Erin Cloherty-Duvernay, J Marcel Deguenon, R Mitchell, A Dhammi, J Strider, J Zhu, M McCord, Q Shi, G Cave, F Agossa, M Akogbeto

A mechanical insecticide is defined as an industrial mineral particle that produces a mortal response on contact. Absorption of the epicuticular lipids of the mosquito leads to excessive water loss through the cuticle. Imergard™WP is a new EPA approved biopesticide designed to be applied as a targeted indoor and/or outdoor residual spray to control mosquito populations. In 2015, Imergard™WP demonstrated over 85% control of *Aedes aegypti*, *Ae. albopictus* and *Culex quinquefasciatus* mosquito populations over 12 weeks of monitoring when applied as a targeted outdoor residual spray under stilt houses in New Orleans, LA. Small-scale trials conducted in 2016 in Monte Verde, Honduras, resulted in 70% less adult *Ae. aegypti*

and a significant reduction in oviposition in structures treated with Imergard™WP when applied as a targeted indoor residual spray. In Phase II testing as an indoor residual spray in Cové, Benin, Imergard™WP achieved over 80% mortality of wild, resistant *Anopheles gambiae* over 6 months of continuous monitoring. Phase III testing is currently in progress in Ifakara, Tanzania with an end 2019 WHO PQ target. Imergard™WP provides a physical, non-chemical mode of action that should deter cross-chemical resistance development and introduces a new vector management tool. Imergard™WP is produced from a sustainable resource and was recently awarded the 2018 European Industrial Minerals Award for innovation.

44 Effects of Plant Substrate, Insecticide, and Physiological State on the Efficacy of Barrier Treatments Against Aedes albopictus.

Benjamin E McMillan (benm93@vt.edu), Brandi L. Benedict, Carlyle C. Brewster, Nicola T. Gallagher, Sally L. Paulson

The effect of 3 plant species (rhododendron, holly, and dogwood), 3 barrier sprays (lambda-cyhalothrin, bifenthrin, and deltamethrin), and 2 physiological states (unfed and bloodfed) on knockdown (1 h) and mortality (24 h) of adult female *Aedes albopictus* was evaluated over an 8-wk period. Across all treatments and physiological states, plant species did not have a significant impact on knockdown or mortality. Physiological state had a significant impact on the effectiveness of the chemical treatments, and were analyzed separately. In terms of knockdown, lambda-cyhalothrin was the most effective treatment against unfed mosquitoes, followed by deltamethrin and bifenthrin, which were both comparable. In terms of mortality, lambda-cyhalothrin was again the most effective treatment against unfed mosquitoes, followed by deltamethrin, then by bifenthrin. All treatments were significantly different from the controls for the unfed mosquito trials. Against the bloodfed mosquitoes, lambda-cyhalothrin was the most effective treatment in terms of knockdown, followed by deltamethrin, and then by bifenthrin. Adult mortality for bloodfed mosquitoes was highest for deltamethrin and lambda-cyhalothrin, which were comparable, followed by bifenthrin. All treatment groups were again statistically different from the control groups. Evaluation of the chemical treatments over time also had significant interactive effects. The results of this study suggest that lambda-cyhalothrin can be an effective barrier spray treatment against *Ae. albopictus* adults due to its fast-acting toxicity and its long residual timeframe. Lambda-cyhalothrin also remains effective on the target adult mosquito regardless of physiological state.

45 Impact of radiation on Wolbachia treated Ae. Aegypti

Robert L Aldridge (robert.aldridge@ars.usda.gov), Seth C Britch, Daniel A. Hahn, Dylan Tussey, Chao Chen, Tatiana L Gerena, Jedidiah Kline, Kenneth J Linthicum

The use of Wolbachia for population control of *Aedes aegypti* has been a subject of interest recently; gaining attention not only through positive evaluations from the EPA, but as a potential tool for mosquito control districts to eliminate *Ae. aegypti* and the diseases they transmit. Control efforts that utilize Wolbachia depend on the fact that it not become established within the local population. In order to ensure that Wolbachia does not become established, males and females must be carefully sorted so that only males are released. Exposure to ionizing radiation negatively impacts female *Ae. aegypti*, significantly reducing their bloodfeeding efficiency, as well as their oviposition, and fecundity. We present data to show that the use of radiation can act to assure that *Wolbachia* are not introduced into nature by treating all pupae with a low dose of radiation prior to release.

46 Determination of pyrethroid and organophosphate susceptibility in Aedes aegypti (Diptera: Culicidae) from Yuma County, Arizona

Christy Marie Waits (christy.waits@ars.usda.gov), Alden S Estep, Chris Sumner, Elene Stefanakos, James J. Becnel

Insecticide-resistant *Aedes aegypti* (L.) are becoming more common in the U.S. We examined the resistance profile of *Ae. aegypti* collected from Somerton, Mesa, and Yuma in 2017 and 2018. In 2017, topical application of permethrin, a type I pyrethroid, was conducted to generate resistance ratios and knockdown resistance (*kdr*) melt curve analysis was performed to determine the resistance genotype. Results indicated variable levels of resistance to permethrin and variable frequencies of *kdr* alleles. To follow up in 2018, bottle bioassays compared the AZ strains to the lab susceptible Orlando (ORL1952) strain against the type II pyrethroid, deltamethrin, and the organophosphate, chlorpyrifos. Individuals from the bottle bioassays were examined for the presence of *kdr* mutations. This study of *Ae. aegypti* from Arizona demonstrated that pyrethroid resistance extends to type I and II pyrethroids and showed that chlorpyrifos, representative of a different class of insecticides, is an effective tool against these mosquitoes. It also highlights the importance of monitoring for resistance and defining resistance mechanisms to inform more effective mosquito control operations.

47 Automatic identification of the species and sex of captured mosquitoes in an advanced, remotely operated mosquito trapping system: technical background and results from the laboratory and field

Michael Weber (michael.weber@biogents.com), Martin Geier, Andreas Rose, Sergej Sperling, Ilyas Potamitis

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 3D 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 times can thus be obtained using an established trapping technique, while the wingbeat analyzer uses Machine Learning to provide 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 vector species from nuisance mosquitoes and the differentiation of female and male *Aedes albopictus* and *Aedes 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. We also trained the system with ca. 280.000 recordings obtained from 6 mosquito species (*Aedes albopoictus*, *Aedes aegypti*, *Anopheles gambiae*, *Anopheles arabiensis*, *Culex pipiens*, *Culex quinquefasciatus*), demonstrating that with Deep Learning closely related species can be distinguished with accuracies from 85 to more than 95%. (The work presented here is supported in part by the European Union's Horizon 2020 programme; grant 691131, project acronym REMOSIS).

48 Estimating the efficacy of aerial spraying on reducing the relative abundance of Culex tarsalis and Culex pipiens: a model-based approach

Karen Holcomb (kmholcomb@ucdavis.edu), Robert Reiner, Christopher Barker

Aerial adulticides are among the most effective tools for minimizing transmission of West Nile virus to humans during periods of epidemic risk, but estimates of its efficacy in reducing abundance vary widely due to stochastic variation in trapping success unrelated to the treatment. In order to overcome the limitations of assessing the efficacy of single aerial spray events, we fitted generalized additive models to mosquito collection data from CO_2-baited traps in Sacramento and Yolo counties, California from 2006-2015. The models accounted for the expected spatial and temporal trends in abundance of adult female *Culex tarsalis* and *Culex pipiens* in the absence of treatment. Estimates for the magnitude and duration of reduction in relative abundance for each species following aerial spray events were obtained from the model. One-week post-treatment, aerial sprays reduced *Cx. pipiens* by an estimated mean of 77.3% (95% CI: 68.9 - 83.5%) and *Cx. tarsalis* populations by an estimated mean of 62.4% (95% CI: 49.3 - 72.1%). Reductions persisted over several weeks for both species, with longer population suppression for *Cx. pipiens* compared to *Cx. tarsalis*. Taken together, our results indicate that aerial adulticides are effective for rapid and sustained reduction of West Nile virus vectors, and further research will consider whether these effects also result in reduced virus transmission in the same areas.

49 Effect of passive metofluthrin emanators on landing and mortality of pyrethroid-resistant Aedes aegypti

Mike W Dunbar (dunbar17@gmail.com), Gregor J Devine, Pablo Manrique-Saide, José Vadillo-Sanchez, Evaristo Morales Rios, Wilberth Bibiano-Marín, Anuar Medina-Barreiro, Gonzalo Vázquez-Prokopec

Management of urban *Aedes aegypti* is currently challenged by the evolution of pyrethroid resistance. A tactic with potential for large-scale implementation is indoor deployment of passive emanators (small, 10% metofluthrin-impregnated nets) that are advantageous because they are rapidly installed, require no source of heat, and can 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 field-derived strains of *Ae. aegypti* that differed in pyrethroid susceptibility. Experimental houses were rented houses in Mérida where emanators could be deployed, and were modified for experimentation with doubled screed entrances and standardized contents. Mosquitoes were released into paired houses (n = 25 per house): one house with emanators and one control. Landing counts were performed before and 30 min and 24 hrs after emanator deployment; mortality was measured 24 hrs post-mosquito introduction. The experiment was repeated 5 times using different combinations of 5 *Ae. aegypti* strains; a lab insecticide-susceptible strain (New Orleans), 2 locally-derived susceptible strains, and 2 locally-derived pyrethroid-resistant strains. Landing counts did not differ among houses before emanator introduction ($p = 0.09$), but

were significantly reduced 30 minutes after emanator introduction among all strains in treated houses compared to control houses ($p < 0.0001$). After 24 hrs, mortality was significantly greater in treated compared to control houses across all strains ($p = 0.0002$), but landing counts recovered ($p = 0.043$). Additionally, emanators were deployed to 100 homes and abundance of *Ae. aegypti* was compared between treated and untreated houses. Preliminary data suggests that emanators reduced mosquito abundance compared to control homes. Given these effects on *Ae. aegypti*, metofluthrin emanators could be an important addition to vector control; however, additional research is still needed to explore how resistant populations will react to long-term exposure.

50 Indoor residual spraying for Aedes aegypti control in the Dominican Republic: challenges and lessons learned.

Patricio Murgueytio (Patricio_Murgueytio@abtassoc.com), Ingrid Marbella Miranda, Gavino Guzman, Griselda Herrera, Nelson Grisales, Mauricio Otalora, Candida Melendez, Angel Solis

In 2016, the Dominican Republic experienced an outbreak of Zika that affected a large portion of the population. Recent studies have shown that residual spraying of resting sites of *Aedes aegypti* can be effective in reducing indoor mosquito density. The Ministry of Health and the United States Agency for International Development (USAID)-funded Zika AIRS Project (ZAP) conducted a pilot study to test indoor residual spraying (IRS) in San Cristobal province. A quasi-experimental design was used. A total of 54 clusters, 27 control and 27 intervention, were selected. In each structure in the intervention site, 25% deltamethrin was sprayed on surfaces where *Aedes aegypti* rest, such as wall surfaces below 1.5 m or dark, moist areas, during a 20-day period in June-July 2017. The study performed entomological monitoring before, during and after the spray campaign, using BG sentinel and Prokopack traps to collect adult mosquitoes, as well as cone bioassays to test residual effects of the insecticide. The intervention covered 11,739 households, using an average of 2.3 deltamethrin sachets per structure. There was an increase of adult *A. aegypti* from 49% to 76% collected with BG traps and 62% to 63% with Prokopack in the intervention site. Similar results were observed in the control sites (BG 57% to 75%, and Prokopack 59% to 73%). After 24h mosquito mortality ranged from 99% on cement surfaces to 58% on surfaces with oil-based paint; after 2 months mortality was below 50%. This pilot study failed to demonstrate a reduction in density of adult A. aegypti, as expected due to several potential reasons; suspected resistance to deltamethrin; insecticide application only below 1.5 meters from the floor; cultural practices of washing walls may have reduced efficacy of the insecticide. The study revealed that a single vector control intervention can be ineffective in significantly reducing mosquito density.

Management

51 Making vector control sustainable

Manuel F LLuberas (lluberas@hdhudson.com)

Hurricane Maria was a vicious monster. Five months after it visited Puerto Rico and virtually wiped it out, over half of the population remained in the dark or lacked reliable power. Roads we impassable. Food, fuel, medicine and medical services were beyond the reach of a large portion of the population. Making matters more challenging, Hurricane Maria dumped about fifty inches of rain (127 cm) in less than a week; a record that everyone hopes will remain unbroken. The unprecedented amount of precipitation filled every puddle, pond, lake and river beyond their capacity and produced widespread flooding in areas with no history of flooding. The huge volumes of water that remained in the swelled rivers flowed downstream at high speeds as the rivers rushed to relieve themselves into the Atlantic Ocean or the Caribbean Sea. As they reached the coastline, an exceptionally high storm surge estimated to be in the range of eight to twelve feet (2.5 to 3.0 meters) impeded it. The ensuing flooding could only be described as biblical. The vast majority of the coastal communities disappeared under raging sea water with swells well beyond twenty feet (6 meters). Dozens of villages on the pluvial plains several miles inland were swallowed by river water after swollen rivers went over their banks and many close to shore succumbed to a combination of both. Shortly after the sun came out, mosquitoes made their presence known. Under these conditions, the first line of defense were the communities themselves. Examples of community engagement activities that significantly reduced mosquito/human contact are provided.

52 Building capacity in local vector control programs

Chelsea Gridley-Smith (cgridley-smith@naccho.org), Grace McClain, Oscar Alleyne

Mosquito-borne diseases are an ongoing public health concern in the United States. In 2017 alone, mosquitoes caused over 2,000 cases of endemic West Nile Virus (WNV) and 433 emerging Zika virus (ZIKV) disease cases. 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. In 2017, the National Association of County and City Health Officials (NACCHO), surveyed almost 2,000 local vector control programs nationwide and found that 84% of programs lack the capability or capacity to perform essential, evidence-based vector control activities. This assessment revealed top vector control priorities include pesticide resistance testing and using surveillance data to inform treatment and abatement decisions. It also revealed gaps and challenges of preparedness for mosquito-borne virus outbreaks. On the heels of this assessment, NACCHO partnered with the American Mosquito Control Association (AMCA), the Entomological Society of America (ESA), and local vector control professionals across the country to develop technical assistance and capacity-building opportunities to increase the number of fully capable local vector control programs. In 2018, NACCHO held its first Vector Control Summit. The Summit was an opportunity for local vector control professionals to hear presentations from subject matter experts; engage with panelists from federal, state, and local levels; gain experience through hands-on training and workshops; and network with their colleagues and industry partners. NACCHO is actively connecting local vector control programs with regional and state-wide experts and resources through its one-on-one technical assistance program. This presentation will discuss NACCHO's approach to providing technical assistance and capacity-building opportunities – to include best practices and lessons learned along the way.

53 Post Hurricane Harvey- rebirth of a rebel-rousing program

Anita Schiller (aschiller@hcp4.net)

Despite three major flood events from tropical storms and Hurricance Harvey, the Harris County Precinct 4's Biological Control Mosquito Initiative managed to overcome, rebuild and restructure three times in 13 months. The main lab endured up to 7 1/2 feet of floodwater during Harvey leaving behind a recently described endemic crayfish specimen and mosquito fish inside mosquito traps and stranding the team without a home base. Realization the program was in jeopardy and several experimentally developed biocontrol agents at risk, prompted officials to seek another, drier location for the program. Full tear down, renovation of the property, built to design was prioritized and move in completed in 7 months. The year 2018 was a busy one for the team with running multiple quality control and environmental manipulation experiments on Native Mosquito Assassin production colonies; a 35 week long field study with the same agent and increasing our colonies of endomopathogenic nematodes. Here we share images of natures' attempt to shut us down and our determination to use her wrath to our advantage. We present the Before and After and the most important lessons learned.

55 Mobile technology applications for entomological surveillance and vector control in the Dominican Republic: Achievements and challenges

Ingrid Marbella Miranda (Ingrid_Miranda@abtassoc.com), Martin Ismael Batista, Watson Luis Rodriguez, Quang Truong, Matthew Boddie, Jillian Berkowitz, Gavino Guzman, Griselda Herrera, Grey Benoit, Juan Leonidas Castro

An essential component of an Integrated Vector Management (IVM) strategy is an efficient entomological monitoring system that ensures timely and complete information flow. In the Dominican Republic, paper-based data collection is commonly used, often delaying the collection and analysis of data. In April 2018, the United States Agency for International Development (USAID)-funded Zika AIRS Project (ZAP) began implementation of a pilot data collection activity using digital open-source tools. Real-time monitoring with cloud-based technologies for data processing and storage, as well as the configuration of mobile devices for data capture, enabled a timely response for the analysis, visualization, and interpretation of results. The development of the online system required technical involvement by entomological and vector control teams to ensure digital tools met data collection and reporting requirements. Results demonstrated improvements in data accuracy with data collection errors greatly minimized. Databases were easily accessed for real time monitoring purposes, with data easily visualized through dashboards. Notably there was a significant decrease in the timeline for data collection, validation and analysis. This innovative solution complements the Ministry of Health's efforts to standardize and apply modern data collection technologies in entomological monitoring. Local stakeholder collaboration to share experiences and develop local capabilities can contribute to strengthening a national entomological surveillance system and support programmatic

decision making. A few challenges remain: (a) Internet access and connectivity can pose some technical difficulties, although data can be entered and uploaded when there is internet connection, (b) usage of this software requires an initial investment in mobile devices and skilled technicians for programming the data collection tools and training field technicians; and (c) some threats of mobile theft maybe more likely in insecure areas.

56 Linking science and policy with practice: a mosquito control example

Patricia Dale (p.dale@griffith.edu.au), Jon Knight

For optimal management outcomes management practices should be informed by science and policy. However, the connections between science, policy and practice are often fragmented or missing. We have developed a general model based on a synthesis of experience and published literature that enables both understanding of connections and tracking of processes. The model's cornerstones are Science, Policy and Practice which are linked respectively by the need for knowledge, policy drivers or external regulators. Connections between the three corners are mediated by facilitators, inhibiters or issues such as public awareness and concern/support. As well there are internal barriers including overlapping boundaries and communication issues. We apply the model to a mosquito management source reduction example, illustrating the multiple and complex interactions that can be identified in the model and which can be adapted to enhance management quality. However, the model could also show that management outcomes were inhibited or prevented and potentially identify the reason. One situation would be where there are multiple feedback loops that do not result in resolution of an issue, resulting in inaction either temporary or permanent.

57 Towards a New Global Framework for Advancing Vector Control Innovations to Market

Grey Frandsen (GFrandsen@DNA.com), Michael Jooste

We are today at a unique crossroads in the fight against vector-borne diseases. Our generation of public health practitioners is powering an unprecedented period of technological advancement in the fight against vectors, giving us hope that we can make significant contributions to disease elimination in our lifetime. However, the advancement of new technologies has not been matched with similar advancements in how we advance them to market. Groundbreaking innovations are now being slowed by national and international regimes that were built decades ago, which is creating a log-jam for novel interventions to get to the field. Given these challenges and the costs associated with advancing new innovations to market, innovators, entrepreneurs, and investors – public and private – are thwarted, creating a ripple effect that stifles, not promotes, innovation in our field. This needs to change. Grey Frandsen will present a set of considerations formed by experience in leadership roles in government and as the CEO of Oxitec that may help advance the discussion on how we, as a community, must innovate in how we advance innovations to market.

58 Florida Mosquito Control Association's premier training event, The Dodd Short Courses.

Aaron Lloyd (alloyd@pascomosquito.org), Eric Jackson, Wade Brennan

The Florida Mosquito Control Association's (FMCA) annual Dodd Short Courses (DSC) has offered world class training to public health personnel in the state of Florida and beyond for the last 35 years. Each year, volunteer instructors from various mosquito control agencies, federal and state agencies, and universities/colleges come together and teach a wide range of courses to provide continuing education to public health professionals. The week-long DSC has educated over 15,000 students from Florida, several other states and US territories since its inception in 1984. The DSC offers an average of 30 courses each year to improve and enhance the student knowledge and ability to protect public health. The DSC provides the most current knowledge in our field to address the ever-evolving issues associated with controlling mosquitoes. What started as a simple round table discussion in 1984 has blossomed into one of the largest and, arguably, the best set of training courses for mosquito control in the world today.

59 Survey of Regional Capacity for Vector Control by the Midwest Center of Excellence for Vector-Borne Disease

Trisha R Dubie (dubietri@msu.edu), Edward Walker

A survey by Michigan State University partners of the Midwest Center of Excellence for Vector-Borne Disease (MCE-VBD) aimed to gather information about mosquito control practices and insecticide resistance monitoring within the region. Results of this survey could contribute to the understanding of various mosquito control practices within the MCE-VBD region, support efforts to assess and understand regional

insecticide resistance monitoring, and aid in collaboration with the MCE-VBD to increase knowledge of regional vectors and their associated diseases, and whether insecticide resistance interferes with control measures. The survey, consisting of 41 questions containing both quantitative and qualitative assessment, was sent to a total of 421 contacts by email or U.S. mail, specifically enrolling professionals in vector control in public and private sectors, public health practitioners, and other individuals involved in mosquito control and surveillance. Participants were given the option to return paper copies or complete the survey by following a link or scanning a QR code leading to a digital version. A total of 59 (14.2%) respondents returned the completed survey, of which 33 of 59 individuals provided additional contact information. Most respondents (70%) answered "no" when asked if their organization conducts regular insecticide resistance testing, and 76% of participants indicated that they would be interested in future workshops focused on insecticide resistance. Many respondents added that they do not currently have the capacity, would like to learn the techniques, or plan to add insecticide resistance monitoring to their programs in the future. Results of this survey demonstrate a need for increased communication and training associated with insecticide resistance monitoring.

Student Paper Competition II

60 Identifying localized predictors of Aedes vectors of La Crosse virus in a hot spot (Knox County, Tennessee)

Robert Devin Rowe (rrowe5@vols.utk.edu), Abelardo Moncayo, Agricola Odoi, Dave Paulsen, Rebecca Trout Fryxell

Discovering where *Aedes* mosquitoes occur in a given region is fundamental for mosquito control. We hypothesize that environmental and socioeconomic factors may explain/predict local variations in *Aedes* oviposition and host-seeking behavior. The goal of this project is to identify those significant predictors for La Crosse virus vectors (*Aedes albopictus*, *Aedes japonicus*, and *Aedes triseriatus*) within a La Crosse encephalitis endemic county and then map occurrence, abundance, and relative risk for that county.

61 Presence of Jamestown Canyon Virus in White-Tailed Deer (Odocoileus virginianus) of the Florida Parishes in Louisiana

Jared Mark Robinson (jaredrobinson@lsu.edu), Timothy Daniel McNamara, Kristen Healy

Jamestown Canyon Virus (JCV) is a bunyavirus resevoired primarily in White-Tailed Deer (*Odocoileus virginianus*). While JCV was first identified in humans in Colorado in 1961, the first reported locally transmitted human case in Louisiana occurred in 2017. We are collecting hunter-killed *Od. virginianus* blood for JCV testing to determine presence and distribution within Louisiana. The Florida Parishes were selected for surveillance due to proximity to previous JCV cases in Mississippi.

62 Pyrethroid resistance influences susceptibility to infection of Aedes aegypti with Zika virus

Casey Parker (caseyparker@ufl.edu), Anna Carels, Bradley Eastmond, Keenan Wiggins, C. Roxanne Connelly, Barry Alto

Studies aimed to determine the effect of pyrethroid resistance on transmission of Zika virus (ZIKV). Pyrethroid-susceptible (ORL) and pyrethroid-resistant (R-ORL) *Aedes aegypti* populations were orally infected with ZIKV (~6 $\log_{10}$ PFU/ml). Susceptibility, dissemination, and transmission potential were evaluated at six time points post-infection. Results show higher susceptibility to infection in R-ORL, but a delay in the progression of infection compared to the ORL strain. This differential susceptibility could have major impacts on public health

63 Rickettsia Diversity of Amblyomma americanum in Florida

Carrie E De Jesus (carriedejesus@ufl.edu), Zoe White, Greg Glass, Samantha Wisely

Amblyomma americanum is the most commonly found tick on humans in the southeastern United States and hosts a variety of *Rickettsia* species that range from symbionts to etiologic agents of human disease ranging from mild to severe life threating illnesses. *Amblyomma americanum* were collected from 20/33 field sites in Florida and 208/465 of ticks were positive for *Rickettsia*. The primary *Rickettsia* found was *Rickettsia amblyommatis*, which is associated with a mild rickettsiosis illness.

64 The ecology of dog heartworm disease
Meredith R Spence Beaulieu (mrspenc2@ncsu.edu), Michael Hay Reiskind, Robert R Dunn

Suburbanization impacts arthropod abundance and diversity, including for mosquitoes of medical and veterinary importance. Dog heartworm, *Dirofilaria immitis*, is an ideal system for studying how changes in diversity and abundance affect disease spread in suburban landscapes. Host-seeking mosquito sampling revealed that as neighborhoods aged, diversity decreased and species assemblage changed. Molecular analysis was performed to assess heartworm prevalence within the mosquitoes. Findings from this system can be applied to other multi-vectored diseases in changing landscapes.

65 The extrinsic incubation of Zika virus in New Orleans Aedes aegypti and Ae. albopictus mosquitoes
Matthew John Ward (mward11@tulane.edu), Rebecca Christofferson, Joshua O yukich, Dawn M Wesson

The extrinsic incubation period (EIP) is a component of mosquito vector capacity and factor in the design of data-driven mosquito control efforts. To determine the EIP of Zika in New Orleans *Aedes aegypti* and *Ae. albopictus*, both species were challenged with infectious blood meals and transmission assays were performed at 6, 12 and 15 dpi. PCR is ongoing to determine when the challenged mosquitoes were first capable of transmitting Zika and when vector competence peaked.

66 Vector-borne and zoonotic diseases: consideration given by local healthcare providers during initial diagnosis
Steven T Peper (steve.peper@ttu.edu), Adam C Jones, Mark Lacy, Steven M Presley

Incidence of vector-borne and zoonotic (VBnZ) diseases are on the rise in the United States. Unfortunately, VBnZ diseases are often mis- or under-diagnosed by healthcare providers. We investigated the education and training received by healthcare providers, and their awareness to consider VBnZ diseases during the initial differential diagnosis based on specific clinical signs and symptoms. These results suggest a need for improved education and training regarding the awareness of VBnZ diseases by healthcare providers.

67 Invasive Mosquito Project: Raising Scientific and Environmental Awareness in the Community through Citizen Science
Julie Tsecouras (julie.t.2400@gmail.com), William Walton, Lee Cohnstaedt

The Invasive Mosquito Project (IMP) is a national mosquito collection and surveillance network that uses professionals and citizen scientists. Recent outbreaks of mosquito-transmitted pathogens demonstrate the need to educate children and adults. New larval collection methods, in addition to previous egg collection methods, were recently written and provided to educators to expand IMP. To establish crowdsourced mosquito collections, which will be used for genetic studies, network researchers must recruit, reward, and retain contributors to the project.

68 Ir8a mutant mosquitoes lose strong attraction to human odor
Joshua Ibukun Raji (joxsyraji@gmail.com), Nadia Melo, Sheyla Gonzalez, Valeria Saldana, John Castillo, Marcus Stensmyr, Matthew DeGennaro

The genetic ablation of the odorant receptors is insufficient to reduce host-seeking in *Aedes aegypti* when CO_2 is present. The olfactory receptors that remain, such as the ionotropic receptors, could be crucial for host-seeking. We disrupted *Ir8a* gene function using CRISPR/Cas9. *Ir8a* mutant mosquitoes lack odor-evoked responses to acidic human odor volatiles, and showed impaired host-seeking behavior in an olfactometer. Our study reveals that the *Ir8a* gene is crucial for anthropophilic mosquitoes to effectively host-seek.

Trustee/Commissioner Session

69 Importance of Mosquito Control to the Development of the Kennedy Space Center
Gordon M Patterson (patterso@fit.edu)
TBD

70 Overview of Impoundments Along the Indian River Lagoon and Management at the Merritt Island & Pelican Island National Wildlife Refuges

Douglas Carlson (doug.carlson@irmosquito2.org)
TBD

Latin American Student Competition

71 DNA Barcodes and Evidence of Cryptic Diversity of Anthropophagous Mosquitoes in Quintana Roo, Mexico

Rahuel Jeremías Chan-Chable (rahuel_jere_1990@hotmail.com), Arely Martínez Arce, Pedro Christian Mis Avila, Aldo Ivan Ortega Morales, RAFAEL VAZQUEZ MARROQUIN

Identification of mosquitoes is the first step during surveillance and control of diseases they transmit. However, this can be problematic given that diagnostic morphological features can be damaged during collection and storage of specimens. Recent studies have demonstrated the advantages of using DNA sequences as a complementary tool in the identification of species. In this work, the diversity of anthropophagous mosquitoes was evaluated in three localities (Sacxan, Palmar and Ramonal) in southern Quintana Roo, using morphological and DNA barcoding. A total of 1,413 adult females mosquitoes belonging to 8 genera and 31 morphospecies were collected. Most species formed well-supported clades. The intraspecific Kimura-2-parameters (K2P) average was 0.75%, and a maximum observed distance of 4.40% for *Anopheles crucians* s.l. Automatic Barcode Gap Discovery (ABGD) identified 28 Molecular Operational Taxonomic Unit (MOTUs) while Barcode of Life Database (BOLD) generated 32 Binary Index Number (BINs). No clear genetic division was found between *Culex interrogator* and *Cx. nigripalpus*, and between two closely related species, *Aedes angustivittatus* and an undescribed species of the *Aedes* genus (*Ae. n*. sp.). A maximum intraspecific K2P distance greater than 2.7% was observed in *An. apicimacula* (8.10%), *An. crucians* s.l. (4.4%), *Ae. serratus* (3.9%), *Haemagogus equinus* (3.9%), *Psorophora ferox* (4.5%), *Cx. erraticus* (5.0%) and *Cx. taeniopus* (3.7%), suggesting evidence of cryptic diversity. This study demonstrate that DNA barcoding provides a reliable framework for the identification of mosquito species in the state of Quintana Roo, with the exception of some closely related species in which it is recommended to use additional genetic markers with a higher mutational rate.

72 Evaluation of different trap configurations for collection of Lutzomyia sand flies naturally infected with Leishmania and Bartonella in Peru

Victor Osiel Zorrilla (victorzorrilla01@gmail.com), Marisa Lozano, Liz Espada, Michael Kosoy, Clifton McKee, Lynn Osikowicz, Heriberto Arévalo, Mario Troyes, Craig Stoops, Michael Fisher, Gissella M. Vásquez

The efficacy of the Mosquito Magnet trap, CDC light trap, UV and LED-CDC light traps for sand fly collection in Leishmania and Bartonella endemic regions of Peru was evaluated. The Mosquito Magnet trap caught the highest number of sand flies. Using optimized and new nested PCR/sequencing approaches, we detected infected sand flies in all trap configurations evaluated. Leishmania naiffi and Bartonella spp. were detected for the first time in sand flies from the Peruvian Amazon.

73 Repellent effect of terpenes against Aedes aegypti (Diptera: Culicidae): in silico simulations with Odorant Binding Protein AaegOBP1

Johan Sebastián Portilla (johanportilla3@hotmail.com), Ruth Mariela Castillo, Stelia Carolina Méndez, Jonny Edward Duque

The repellent effect of different terpenes against *Aedes aegypti* with *in silico* analysis and *in vivo* tests was analyzed. We determined the affinity of terpenes with AaegOBP1 protein and described the toxicity compared with DEET and IR3535. Geranyl acetate, nerolidol and their mixtures (5% and 10%) showed 100% repellency on one hour of exposition on the arms of volunteers. Terpenes over *Vero* cell line no-showed cytotoxicity effect. Metabolites mentioned are candidates for repellent formulations.

74 microRNAs from Insecta organisms conserved de novo in Aedes aegypti

Daniel Rafael Saldaña-Torres (danielixdaniel09@gmail.com), Chen-Yu Zhang, Gustavo Ponce-Garcia, Adriana E Flores-Suarez, Iram Pablo Rodríguez-Sanchez

Aedes aegypti is the principal vector of arbovirus , affecting millions of people per year influencing health and tourism systems indirectly by a huge monetary loss. miRNA´s are ~22nt long non-coding RNAs involved in post-transcriptional regulation of genes in physiological and pathological processes. miRNAs present critical roles in all life stages of *Ae. aegypti* like insecticide resistance, develpoment or sexual dimorphism.

This is the first descriptive and comparative report that proposes new target for alternative strategies of *Ae. aegypti* biological control.

75 Role of human genomics in presenting symptomatology of Chikungunya infection

Martha Patricia Lopez (martha.fcb@gmail.com), Karina Trujillo, Ivan A Marino, Gerardo de jesus Trujillo, Gustavo Ponce-Garcia, Iram Pablo Rodríguez-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.

76 Distribution and frequency of the kdr mutation, V410L in 28 natural populations of Aedes aegypti from Mexico

Kevin Aaron Ontiveros-Zapata (kevinontiveroz@gmail.com), Olga Karina Villanueva-Segura, Gustavo Ponce-Garcia, Beatriz Lopez-Monroy, Selene Marlen Gutierrez-Rodriguez, Adriana E Flores-Suarez

The kdr mutation in the voltage-gated sodium channel (*vgsc*) V410L has been related with pyrethroid resistance in *Aedes aegypti*. In this study, 28 populations of *Ae. aegypti* collected between 2017 and 2018 from the northeast and southeast Mexico were genotyped. Resistant genotype frequencies varied between 0.56-0.68 with values of F_{IS} <0. The results show that all populations carry the V410L mutation. The evaluation of genetic resistance to pyrethroids is essential to develop effective control programs.

77 Simultaneous detection of kdr mutations, V1016I/F1534C in populations of Aedes aegypti from Mexico resistant to pyrethroids

Francisco Javier Gonzalez-Santillan (paco_1110@live.com.mx), Olga Karina Villanueva-Segura, Lucia Camero-Perales, Kevin A Ontiveros-Zapata, Esteban Jesus Mora-Jasso, Beatriz Lopez-Monroy, Gustavo Ponce-Garcia, Selene Marlen Gutierrez-Rodriguez, Adriana E Flores-Suarez

To carry out an exhaustive analysis of the mutations present in the sodium channel we standardized a multiple end-point PCR for the simultaneous detection of the two main kdr mutations registered in *Aedes aegypti* in Mexico, V1016I and F1534C. Fourteen populations of *Ae. aegypti* were genotyped by allele-specific PCR for both mutations and compared with our Multiplex PCR which resulted highly accurate.

78 Mitochondrial respiratory parameters in Aedes aegypti (Diptera:Culicidae) larvae

Diana Lizeth Urbina (durbina9606@gmail.com), Ruth Mariela Castillo, Stelia Mendez, Jonny Duque

The determination of mitochondrial respiration is an important parameter to know *Aedes aegypti* fitness in normal conditions. The respiratory control ratio (RCR) describe the coupling or uncoupling state mitochondrial. We used an oxygraph-2k (Oroboros-Instruments) to measure the RCR of permeabilized larvae (L4) and isolated mitochondria of *Ae. aegypti*. The results showed RCR similar values with different substrates. Additionally, mitochondrial soluble and membrane proteins were extracted and analyzed for see it´s expression.

79 Morphometric variations on populations of An. darlingi and An. albitarsis F (Diptera: Culicidae) in Colombia

Miguel Alfonso Pacheco (mapachecog@unal.edu.co), Helena L Brochero, Ranulfo González

Nineteen wings spots patterns of the Costa vein were found for *An. darlingi* and two for *An. albitarsis* F. The proportion of the basal dark area of hind tarsomere-II and the length of hind tarsomere-II constituted a robust diagnostic character for both species. A PHD/HP ratio of 1.17-1.19 was diagnostic for *An. albitarsis* F. Significant differences in the wing shape and the wing size among populations were found. Implications in their bionomy is discussed.

Legislative and Regulatory

80 Coordination among public health organizations
Angela Beehler (angela@mosquitocontrol.org)

The American Mosquito Control Association (AMCA) is the premier organization for mosquito control knowledge in the United States, but to truly increase vector control capacity in this country we must share our expertise with other public health organizations, be open to learning from them, and willing to share resources. This presentation will serve as an introduction to the 2019 Legislative and Regulatory Symposium, and to summarize the cooperation between AMCA and numerous outside organizations with the goal of the continued protection of public health.

81 Update on legislation impacting mosquito control operations
Gary Goodman (GWGOODMAN@FIGHTTHEBITE.NET)

The need to remain diligent and maintain a strong presence to law makers and regulatory agencies that could impact or hinder our ability to protect public health in the future is imperative. This discussion will focus on the history of the AMCA's legislative efforts, explanation of our progress, and provide direction for the Association moving forward.

82 USFWS releases new "Handbook for Mosquito Management on National Wildlife Refuges"
William Howard Meredith (William.Meredith@state.de.us)

In September, 2018 the U.S. Fish and Wildlife Service issued/published their long-awaited "Handbook for Mosquito Management on National Wildlife Refuges," a 44-page guidance document for Refuge Managers concerning mosquito control needs and practices on-refuge. This document has been over 20 years in the making, with over that time the AMCA providing considerable comments and recommendations to the Service about the Handbook's contents. The latest input from the AMCA occurred in May, 2017 via an invitation from the Service for an 8-member AMCA Refuge Handbook work group to meet with Service staff to discuss a penultimate version of the Handbook. This was followed in June, 2017 by the AMCA providing the Service with a detailed written analysis of the document. An initial review last fall (2018) of the now "final" Handbook by the AMCA's Refuge Handbook work group, aided by the AMCA L&R Federal Lands Subcommittee, shows an overall commendable product. For some refuge situations, the Handbook's guidance might enable local mosquito control programs to perform some types of control practices on-refuge that up until now might not have been allowed by the Service, a most laudable outcome. Nevertheless, despite the AMCA's previous inputs, the Handbook still has 4 substantive problems potentially having adverse consequences for mosquito control operations on-refuge. These 4 problems will be reviewed during the presentation. The AMCA Refuge Handbook work group also prepared a set of comments to the Service regarding these 4 problems, requesting additional clarifications. It is not clear what the Service's reaction will be to further input from AMCA on this matter. What we want to do for the Service is identify potential flashpoints in the "final" Handbook that could be avoided if addressed. We hopefully can then collaboratively work with the Service to mitigate such potential sources of friction.

83 2019 AMCA Washington Conference
Thomas Wayne Gale (galetw@msn.com)

The AMCA Washington Conference provides an opportunity for Association members to receive updates on legislative and regulatory issues of greatest concern to mosquito control professionals and to become active participants in American democracy. After an afternoon of discussion and training , AMCA members travel to Capitol Hill to meet with elected representatives and staff. Only by working together can we most effectively influence regulators and legislators. Following an election year we may have some new law makers to ediucate about our important issues so please plan to join us at the 2019 Washington Conference in May.

84 Speak when they are actually listening: alternative strategies to improve interagency collaboration

Jared Dever, MPA (jdever@sgvmosquito.org)
TBD

85 Incorporating usage data to identify areas where pesticide exposure to listed species is most likely to occur
Melissa Panger, Angela Beeher

The United States (US) Environmental Protection Agency registers uses of pesticides in the US and its territories. As such, a national level registration of a pesticide may have potential exposure to large portions of the ranges of endangered and threatened species. For registrations that apply to agricultural uses (e.g., corn, apples), the US Department of Agriculture's cropland data layer (CDL) can be used to identify potential pesticide use sites in the 48 conterminous states. Additional data are also available to identify where a pesticide has been applied (termed "usage" data). Combining usage data with CDL landcovers can help identify areas where pesticide applications are most likely to occur. Subsequently, likely use sites can be compared with listed species ranges to determine the most likely proportion of the species range or population that may be exposed. Major challenges to this approach involves fitting data from different scales and identifying sources of usage data for different non-agricultural uses (e.g., mosquito adulticide uses). Combining these data requires some assumptions related to distributions of sites where the pesticide is applied relative to the species range. This presentation will discuss some of the benefits and challenges of incorporating usage data into risk assessments and some options to overcome the challenges.

Student Paper Competition III

86 Mirnomics on diferentes approaches in Aedes aegypti
Iram Pablo-Rodríguez (iramrodriguez@gmail.com), Daniel Rafael Saldaña-Torres, Adriana E Flores-Suarez, Gustavo Ponce-Garcia, Laura E Martínez-de-Villarreal, Chen-Yu Zhang

The disease vectors are growing and the control strategies are becoming less efective, due to the bad implementation of the control programs, insecticide resistance, environmental pollution, others.To date, the mirnomic footprint of the different life stages of *Aedes aegypti* are unknown, and determine it will provide information to new direct and effective biological control strategies. We reported the first systematic analysis of the microRNAs expression for *Ae. aegypti* from the different life stages , sex and feeding chronology .

87 Population and landscape genetics of Aedes aegypti in Florida
Evlyn Pless (evlyn.pless@yale.edu), Giuseppe Amatulli, Kristen Hopperstad, Jeffrey Powell

Understanding the natural and human-mediated dispersal patterns of *Aedes aegypti* can inform vector control, especially the release of genetically modified or Wolbachia-infected mosquitoes. In this study we use a landscape genetics approach to investigate how environmental and anthropogenic features affect the gene flow of Ae. aegypti in Florida. Ongoing studies will extend the geographic scale of this work to the southern tier of the US, Caribbean, and northern Mexico.

88 Fine-scale ecological niche modeling of Aedes aegypti and Aedes albopictus mosquitoes in eastern Florida, USA
Kristen Hopperstad (kahopper@ncsu.edu), Mohamed Sallam, Michael Reiskind

Many distribution maps indicate *Aedes aegypti* and *Aedes albopictus* are nearly equally widespread in Florida despite empirical evidence of spatial segregation. Using mosquito collection data and climatic, landscape, and anthropic variables in a maximum entropy model, we generated predictive species distributions. Human density was the primary influential factor for both species, followed by some climate and urbanization variables. Peri-urban areas were generally suitable for *Ae. albopictus* but not Ae. aegypti, indicative of fine-scale spatial segregation.

89 Likelihood of Overcompensation for Aedes in the Field
Katherine Evans (evans.kate29@gmail.com), Steven A. Juliano

Our research goal was to determine the likelihood of overcompensation for natural populations of *Aedes triseriatus*, *Aedes albopictus*, and *Aedes aegypti*. We estimated natural larval densities by removing and counting colonizing larvae in experimental containers. We then stocked containers with even-aged cohorts

spanning the range of natural densities and monitored larval survival over 14 days. Overcompensation appears likely if natural populations suffer extrinsic mortality because numbers of survivors decreased at the greatest observed densities.

90 From spatial repellent to harborage treatment adulticide: pilot tests of metofluthrin for point-source mosquito abatement.

Christopher Stephen Bibbs (cbibbsamcd@bellsouth.net), Phil Kaufman, Rui-De Xue

Volatile pyrethroids are unique active ingredients that can function as vapor-active insecticides. To facilitate integrated vector management, residual formulations were developed by MGK and Sumitomo (collaborators). Tests were conducted against *Aedes albopictus* (Skuse) in St. Augustine field sites. Surveillance was conducted both proximal to treatment and on adjacent properties to examine push effects. In all, both low and high rates for treatment resulted in 60-80% reduction of both adults and eggs for 2-4 weeks at both treated and adjacent properties.

91 DIY Mosquito Trap For Catching Gravid Aedes Mosquitoes Using a Recycled Two Liter plastic Bottle

Laura Scavo (Lscavo1@jhu.edu), Sophie Soltanian, Margaret Glancey, Adam Goodwin, Tristan Ford, Soumyadipta Acharya

Three low-cost DIY gravid *Aedes* trap designs were tested over four weeks compared to the BG-GAT as control. One DIY trap design caught an average of 2.25 +- 1.26 mosquitoes per week, while the control caught an average of 2.8 +- 1.71 mosquitoes per week and the other two DIY trap designs caught no mosquitoes. These preliminary results suggest that a DIY design comparable in performance to the BG-GAT has been developed.

92 Molecular Barcoding and Niche Modeling Analysis of Horse Flies in the Southeastern United States

Travis Mitchell Davis (tdavi113@vols.utk.edu), Daniel L Kline, Bradley Mullens, Monica Papes, John Kevin Moulton, Rebecca Trout Fryxell

The blood-feeding behavior of *Tabanus* species (horse flies) cause economic losses to human systems. Variable morphological characters and high-species diversity are restraints on *Tabanus* research for management. Our goal is to improve methods of *Tabanus* identification in the Southeastern United States by compiling 16S and/or COI DNA barcodes and producing ecological niche models of *Tabanus* flies. These data will provide the basis for development of *Tabanus* fly management focused on species specific biology and behaviors.

93 Breeding ground: ovicup trapping in Lexington KY

Christopher William Kositzke (cwko223@g.uky.edu), Caitlin Stamper, Stephen L. Dobson

Lexington, Kentucky is a model mid-size North American city which provides an ideal setting for investigating mosquito distribution in urban areas. During the 2018 mosquito season (May-September) weekly trapping was conducted at 34 independent sites. Population factors were evaluated using oviposition cup trapping, with egg number and species identification recorded for analysis. Although data collection is ongoing, our data on localized mosquito species diversity will contribute to the development of optimized municipal control programs.

94 Mating acoustic behavior of the malaria vector Anopheles albimanus

Hoover Esteban Pantoja (hoover.pantoja@udea.edu.co), Sebastian Gomez, Viviana Velez, Fredy Ruiz, Frank Avila, Catalina Alfonso

The sound produced by the wingbeat plays a major role in the mating behavior of mosquitos. However, the information about the acoustic behavior of free flying mosquitos is scarce. By analyzing recordings of *Anopheles albimanus* during free flight, we characterized a female-specific behavior that predicts mating rejection and described male acoustic interactions related to swarm-like flight patterns. Overall, this study provides novel information about the role of sound in *An. albimanus* mating behavior.

95 Resurgence of Aedes aegypti and its Control Efforts at the Anastasia Mosquito Control District, Northeastern Florida

Rui-De Xue (xueamcd@gmail.com)

Aedes aegypti is a major vector for ZIka, yellow fever, Dengue, and Chikungunya viruses. Recently *Aedes aegypti* has spread to the wester part of the USA and other place worldwide. Also, *Aedes aegypti* was a major container-inhabiting mosquitoes in the northeastern Florida before the 1990's and gradually disappeared after the invasive *Aedes albopictus* in the middle of the 1980's. After more than 20 years, *Aedes aegypti* has gradually resurged in the northeastern Florida and spread to many areas. When *Aedes aegypti* resurged in St. Augustine, Northeastern Florida in early 2016, Anastasia Mosquito Control Distirct (AMCD) launched a control program and try to limit the further spread and eradication. After a couple of year efforts, the species of mosquitoes has not been stopped for spread. There are new challenges for surveillance and control of *Aedes aegypti* in northeastern Florida due to insecticide rsistance and many other unknown reasons. AMCD has collaborated with USDA/CMAVE, University of Florida, SpringStar, and MosquitoMate to test SIT, Wolbachia, and AGO technology to control the *Aedes* mosquitoes in St. Augustine. These collaborative projects received welcome and appreciation from the local residents and show positive control effectiveness.

96 Study of invading Aedes aegypti of Yunnan Province in China

Tongyan Zhao (tongyanzhao @126.com)

Study of invading *Aedes aegypti* of Yunnan Province in China Tongyan Zhao State Key Laboratory of Pathogen and Biosecurity, Beijing Institute of Microbiology and Epidemiology, *Aedes aegypti*, an important vector species of dengue, zika, distributed in Hainan, Taiwan, Guangdong provinces in China based on mosquito fauna. There was no distribution record of the species in Yunnan until 2002, *Ae. aegypti* is now continuously found in nine cities and counties in this province. It is important to study population genetics(including of invasion strategies, colonization and dispersal), vector competence to zika, and insecticide resistance, It was found continuous invasion contributes to maintenance of genetic diversity and different invasion accidents result in the genetic difference among populations of *Ae. aegypti* in Yunnan based on microsatellite DNA analysis, a strain of *Ae. aegypti* from Yunnan showed high level of midgut infection and highly disseminated infection of salivary glands and ovaries. It was found the evidence of transovarial transmission of the population to zika virus. Three sodium channel mutations were common in *Ae. aegypti* strains sampled from Yunnan, the V1016G mutation appeared to be most important kdr mutation

97 Study of Aedes surveillance,early-warning and management in China

Qiyong Liu, Rudy Xue

In China,Aedes albopictus and Ae.aegypti are two major vectors of Aedes-borne diseases including dengue,chikungunya,imported zika,et al. China CDC have formulated and issued Aedes surveillance and control guidelines and established Aedes surveillance networks which covering 23 provinces of China since 2014. Routine and emergency surveillance are carried out based on Aedes-borne diseases epidemic profile.Using the surveillance data, combined with other natural and social factors,risk assessment and early-warning are counducted based on fixed threshould or prediction results calculated by mathematical and statistical models. Furthermore,the risk areas of dengue and Ae.albopicuts projections are also conducted using different climatic scenarios.In future, Ae. albopictusis and dengue projected to be larger areas compared with the current distribution areas.To better cope with this challenges,a Chinese model put forwarded by Prof Qiyong Liu with great potential,that is from Integrated vector management (IVM) to Sustainable vectormanagement (IVM).

98 Toward a global partnership for the control of insecticide resistant Arbovirus vectors: The WIN initiative

Vincent CORBEL (vincent.corbel@ird.fr), Jean Philippe David, Claire Durot

Arbovirus transmitted by *Aedes* mosquitoes, such as dengue, zika, chikungunya and yellow fever have been re-emerging all over the world. Vector control, mainly by the use of insecticides, play a key role in the prevention and control of those diseases but the use of the same chemicals for decades, together with the dissemination of vectors resulted in the global spread of insecticide resistance. To reduce the burden and

threat of Aedes-borne diseases, it is crucial to identify countries and regions where resistance represents an obstacle for vector control and to provide national authorities with robust evidence to support the deployment of safe and locally adapted vector control tools. Managing resistance to public health pesticides will require global, integrated and coordinated actions and strong engagement of scientists, decision-makers, stakeholders and donors. Supported by the WHO Special Programme for Research and Training in Tropical Diseases (TDR) and the Department of Neglected Tropical Diseases (NTDs) since 2016, the **Worldwide Insecticide resistance Network** known as "WIN" (http://win-network.ird.fr/) bring together 19 internationally recognized institutions to track insecticide resistance in arbovirus vectors worldwide. The WIN aims to support the implementation of the WHO-Global Vector Control Response (GVCR) by strengthening mosquito control and surveillance efforts and guide decision-making for resistance management. The network has gained international recognition for its role in mosquito resistance and is now expanding to a membership organization aiming at gathering all actors involved in vector-borne disease control (i.e. academia, International organizations, NGOs and not for profit organization, private sector). This presentation will provide an overview of WIN achievements and present the future scheme of the network to mitigate insecticide resistance and reduce the global burden of *Aedes*-transmitted arboviruses.

99 Surveillance of Aedes albopictus in Jiangsu, China
Hongliang Chu

TBD

100 History of urban-Aedes surveillance in Texas: Past, present, and future.
Whitney Qualls (whitney.qualls@dshs.texas.gov), Bethany Bolling

Prior to the introduction of Zika virus (ZIKV) in the Americas, mosquito control programs in Texas mainly focused on West Nile Virus surveillance by targeting *Culex* vectors with Centers for Disease Control and Prevention (CDC) gravid traps and light traps. However, due to the concerns of ZIKV transmission, many of the mosquito control programs in Texas enhanced their surveillance capacity to monitor for *Aedes aegypti* and *Aedes albopictus*. Additionally, funding from the CDC allowed the Texas Department of State Health Services (DSHS) Arbovirus Laboratory and Zoonosis Control Branch, to develop collaborations to better understand the temporal and spatial patterns of urban-*Aedes* container breeding species across the state and areas of ZIKV risk. The current presentation will focus on mosquito control programs' development and implementation of urban-*Aedes* surveillance and the outcomes of the DSHS collaborations.

UAS in Mosquito Surveillance and Control Symposium

272 Drone spraying operations & the Federal Aviation Regulations
J. Rupprecht (jon@jrupprechtlaw.com)

Drone technology has become more affordable and easier to implement into spraying operations. They give the ability to easily access unreachable / dangerous areas or cover a greater amount of area. Drones are aircraft; thus, the Federal Aviation Regulations ("FARs") apply to their operation in the United States. The FARs list out a multitude of requirements, ranging from pilot certification to operating restrictions; however, some of the FARs were created in the 1960's which do not work well for drone spraying operations today. This talk will discuss the different legal methods to getting your drone operation airborne and how current legal issues are being remedied with various regulatory options (exemptions, waivers, and authorizations).

273 Certification process for conducting aerial agricultural operations via small unmanned aircraft systems (sUAS) in Placer County
S. Schon (scotts@placermosquito.org)

In October 2016, the Placer Mosquito and Vector Control District started the Mosquito Assessment and Control - Unmanned Aircraft Systems (MAC-UAS) Program. The District has two Federal Aviation Administration (FAA) part 107 certified remote pilots, who operate a DJI Phantom 3 Standard, Quad H2O Pro V2, Matrice M210, and an AGRAS MG-1S in a variety of different mission types. Mission types include atmospheric measurements, visual assessment of mosquito habitat, larval mosquito detection, and aerial pesticide applications. With the exception of UAS aerial pesticide applications, all other mission types can be conducted under the small UAS rules under Title 14 of the Code of Federal Regulations (14 CFR) part 107

without any additional certificates. In order for the District to use a sUAS for aerial applications, while operating within the parameters of 14 CFR 107, it was necessary to obtain a part 137 Agricultural Aircraft Operator Certificate. Because part 107 restricts the carriage of hazardous material and part 137 was originally written for manned aircraft, the District had to file a petition for exemption from certain provisions of 14 CFR 107 and 137 that restricted applying public health insecticides from sUAS. After our exemption was granted we were able to work with our local FAA Flight Standards District Office who conduct the certification process for agricultural aircraft operators. The certification process is divided into 5 phases consisting of the pre-application, formal application, document compliance, demonstration and inspection, and the certification phase. As of August 2018, the District have successfully completed all phases and have met the Federal requirements for applying public health insecticides via sUAS. Currently, the District is waiting for California Department of Pesticide Regulations to incorporate unmanned aircraft systems into their Pest Control Aircraft Pilot certification process.

274 Bravo! The Flight of the Unmanned Aircraft: Setting Up an Unmanned Aerial Program in Congested Bravo Airspace and an Update on Custom Application Equipment for an MG1S Drone
B. Sorensen (Brad@slcmad.org), Andrew Dewsnup, Gregory White, Ary Faraji

The advancements of Unmanned Aerial Systems (UAS) in recent years has made the use of UAS in mosquito control a more viable option; however, with almost all of the airspace within the boundaries of the Salt Lake City Mosquito Abatement District being the restricted Bravo Airspace that surrounds the Salt Lake City International Airport, our District has had many challenges in getting the UAS program off the ground. Finding the right regulations to work under and communicating with the FAA has helped the District launch our program to inspect and treat mosquito sources with UAS. We will provide an update on the compliance and regulatory hurdles associated with setting up a new UAS program, and further provide details on innovations the District has undertaken for our UAS equipment to create a useful and effective program.

275 The Use of UAS Operationally in 2018 for Aerial Applications in Multiple Markets
Bill Reynolds (breynolds@leateam.com)

The use of unmanned aircraft systems (UAS) or remote piloted aircraft (RPA) has grown exponentially in the last 12-18 months in many market segments. This presentation will focus on the operational experiences of aerial applications performed in the noxious weed, vector control and agriculture industries in 2018. In addition, the use of multispectral imagery for the rapid identification of larval breeding habitats and precision location identification of noxious weeds and the seamless workflow from multispectral imagery to precision aerial applications using UAS will be presented.

276 Operational Savings with UAS Larvicide Spray Technologies
M. Scholl (mscholl@fightthebite.net)

Since 2016 the Sacramento-Yolo Mosquito and Vector Control District has been operating an Unmanned Aircraft System (UAS) program under the FAA Part 107 rules. Since the programs inception spray technologies have always been a major goal that the District has been working towards thru collaboration with the private sector. In the meantime, the District began by purchasing a series of smaller units used for various field, meteorological, and precise imagery data collection. Over one year ago the District purchased its first spray unit; however the California Department of Pesticide Regulations has not yet released or authorized final UAS Spray regulations. In an effort to continue the development of spray technologies, the District hired a private contractor to treat various mosquito larval sources during the 2018 mosquito season. UAS treatments have proven to be an effective application method when compared to many traditional ground based technologies. Successful liquid larvicide treatments using Vectobac WDG and Natular 2EC were completed with granular applications being investigated at the end of the season. As UAS Spray regulations are implemented at the State level, the District intends to add UAS applications as part of routine mosquito control operations.

277 Fog from the clouds: A new ultra-low volume applicator for UAS adulticide missions
G. M. Williams (gwilliams@hudsonregionalhealth.org), Randy Gaugler

Adulticide missions are one of the most challenging mosquito control operations for UAS. Successful ultra-low volume (ULV) spray missions rely on precision equipment to deliver accurate flow rates and predictable droplet spectra. To meet these demands we modified the proven Longray Pioneer Eco-Handheld electric ULV sprayer for use on a DJI S1000+ octocopter. The sprayer was stripped to the bare minimum and repackaged into a compact unit. Overall weight was reduced from 6.1 to 1.75 kg and the controls were

adapted for autonomous operation through the UAS flight control system. In this talk, we present the design and construction of the unit along with results from experimental field trials.

278 Assessing mosquito breeding sites and abundance from above

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Terrestrial ecosystems are impacted by anthropogenic climate change with increased extreme weather events and rising sea levels. Due to these effects, the pattern of water accumulation on the landscape may alter the distribution and duration of aquatic habitats that promote mosquito breeding. Moreover, marsh habitats around the San Francisco Bay will be expanded substantially over the coming 20 years with $500 million in voter-approved funding. It is, therefore, crucial to assess the impacts that human adaptations to climate change and habitat restoration projects have on mosquito production. We show that an unmanned air system (UAS) that is equipped with multispectral and zoom cameras provides an economical means for vector control agencies to assess the landscape rapidly for the presence of standing water and mosquito larvae. Time series analysis of UAS-acquired, spectral data from field sites may provide better predictive models for mosquito population dynamics that further economize inspection and treatment programs.

Adult Control III/Disease/Vector Studies I

101 Insecticide Resistance in Aedes aegypti and Aedes albopictus mosquitoes along the TX/MX Border

Heather Hernandez (heather.hernandez01@utrgv.edu), Christopher Vitek

The threat of insecticide resistance is a predominant concern when considering control options for vector-borne diseases. Increased mosquito resistance will result in less effective control efforts and an increased risk of disease transmission. Insecticide resistance is not routinely tested for mosquitoes along the rural areas of the Texas/ Mexico border. We initiated a long-term monitoring effort to assess the resistance status of two mosquito species, *Aedes Aegypti* and *Ae. albopictus*, along the border counties between Texas and Mexico. Eggs were collected in the field throughout the year from multiple cities along the border, representing distinct populations of mosquitoes. The cities represented a 350 mile long region, and included the cities of Del Rio, Eagle Pass, Laredo, Rio Grande City, McAllen, Progreso, and Harlingen. We hatched the eggs and reared the larvae in the laboratory under controlled environments. Using the CDC Bottle Bioassay method, we tested mosquitoes from these field collection to assess any resistance to commonly used insecticides. Our results are reported and the potential for control efforts are discussed.

102 Assessing citywide control of Aedes aegypti and Zika, chikungunya and dengue virus transmission by integrating community outreach, education, source reduction, larviciding, and mass trapping

Roberto Barrera (rbarrera@cdc.gov), Angela Harris, Ryan R Hemme, Gilberto E Felix, Nicole Nazario, Damaris Rodriguez, Julieanne Miranda, Eunice Soto, Stephanie Martinez, Kyle Ryff, Carmen Perez, Veronica Acevedo, Jorge L Munoz, Manuel Amador, Steven Waterman

Earlier studies and further investigations carried out at the beginning of the 2016 Zika virus (ZIKV) epidemic in Puerto Rico, showed that *Aedes aegypti* was resistant to pyrethroids and Malathion; limiting vector and arbovirus control options. Because this species had been successfully controlled for several years in small communities in southern Puerto Rico without the use of insecticides, such an approach was applied at the level of a medium-size city undergoing a ZIKV outbreak. The city was subdivided in eight clusters that were sequentially and randomly treated following a cluster randomized stepped-wedge design, so that all areas of the city would be treated. Vector control consisted in: approaching community leaders about the acceptability of this vector control approach, providing educational materials, obtaining permission to eliminate small disposable containers and apply larvicide, and installing three Autocidal Gravid Ovitraps (AGO) per home from October 2016 to August 2017. There were 61511 inhabitants and 25363 buildings in the area under treatment. Female mosquito density and the presence of dengue (DENV), chikungunya (CHIKV), and ZIKV (Trioplex RT- PCR) were monitored using 360 sentinel AGO traps that were monitored every week. Weather stations were installed in each of the clusters to control for co-variates known to influence temporal mosquito population dynamics. Results showed an overall 80% reduction in mosquito numbers. Mosquito density significantly decreased to two females per trap per week when treatment coverage (percentage of buildings treated) was 60% and less than two when coverage was about 80%. All three arboviruses were detected in *Ae. aegypti* from October 2016 until March 2017, mostly ZIKV. No more positive pools were detected after vector control coverage reached or exceeded 60%.

103 A comparison of lambda-cyhalothrin and deltamethrin barrier treatments against Aedes albopictus in Mercer County, NJ

Nicholas Indelicato (nindelicato@mercercounty.org), Isik Unlu

Aedes albopictus is a back yard mosquito which requires a back yard solution. Although source reduction and area-wide adulticiding are effective, source reduction can be labor intensive and area- wide adulticiding may not address resting adult mosquitoes protected by dense vegetation. For these reasons, we sought to evaluate two barrier treatments, one containing lambda-cyhalothrin and the other containing deltamethrin to reduce adult *Ae. albopictus* populations during peak season in Mercer County, NJ. Our findings suggest that lambda-cyhalothrin had a greater effect than deltamethrin.

104 New developments in the use of the Sterile Insect Technique (SIT) against mosquitoes

Jérémy Bouyer, Hanano Yamada, Hamidou Maiga, Wadaka Mamai, Nicole Culbert, Antonios Avgoustinos, Danilo Oliveira Carvalho, Rafael Argiles Herrero, Kostas Bourtzis, Marc Vreysen,

In their global vector control response 2017-2030 the World Health Organization (WHO) pointed out the urgent need for alternative mosquito control methods, particularly against *Aedes* vectors. One of these alternatives are genetic control approaches that include e.g. the Sterile Insect Technique (SIT). SIT is based on the release of irradiated sterile males that compete sexually with their wild counterparts to induce sterility in the target population. The development of the SIT package against mosquitoes has recently received great momentum and is now being tested in pilot trials as a component of integrated pest management strategies. Here we present recent developments and refinements of the SIT package as a result of research conducted at the FAO/IAEA Insect Pest Control Laboratory, in strong collaboration with partners from FAO and IAEA Member States. This includes: - a strong reduction of costs of mass-rearing cages and larval and adult diets; - a new larval counter allowing a better standardization of mass-rearing processes; - new sex-sorting systems with the potential to combine phenotypic markers to sexual dimorphism to sex *Aedes* pupae; - the identification of variation factors in irradiation procedures of *Aedes spp.* allowing the development of standardized irradiation protocols; - a new rapid control test allowing to measure flight ability in less than two hours, that was validated against other quality control parameters; - new protocols for marking and mark-release-recapture of sterile males, allowing the estimation of their mortality, survival and competitiveness in the field; - field validation of a drone-release system for mosquitoes in Brazil; - some recent results in field trials against *Aedes albopictus* in Europe.

105 Development of attract and kill systems for mosquitoes using readily available materials

Jerome Hogsette (jerry.hogsette@ars.usda.gov), Daniel L Kline

Development of attract and kill systems are important because, unlike traps, they can be placed in the field for extended periods with no servicing involved. Materials are available for development of such systems but the materials we are evaluating have not be used together for this purpose with mosquitoes. One of several available impregnated fabrics will be used to prevent mosquitoes from accessing an attractant device, e.g., a trap. Evaluations of mosquito behavior related to this barrier effect are in the final stages and will allow us to fine tune the system. Measurement of the effect of the system is difficult because mosquitoes are killed but are not captured. Final evaluations are being made in large (9 x 18 x 3.6 m high) outdoor cages and final results will be presented at the meeting. The success of this system will allow for the development of similar systems using other attractive devices.

106 Investigation on possible influence of drought on mosquito population

Hadis Hosseinzadehnaseri (hadis@municipalmosquito.com), Erin Plaisance, Eleanor Kirkscey

Factors considered to be influential on mosquito population and used for prediction for their behavior and intensity of the coming season, were mainly focused on temperature, humidity and precipitation. In this study drought is introduced as a new parameter which may have a potential influence on mosquito population for the upcoming studies. The focus of this study is *Culex quinquefasciatus* in Dallas Fort Worth area. The weekly surveillance reports from Tarrant County Department of Public Health and Dallas County Health and Human Services were obtained for the mosquito population and positive test pools data source. The Drought Severity and Coverage Index (DSCI) will be collected from United States Drought Monitor Website. It has been observed that when drought increased in a week or didn't change for a couple of weeks, the number of mosquitoes per trap increased. On the other hand, when drought decreased by precipitation the number of West Nile virus positive mosquito pools increased. This observation might be related to the rearing behavior of mosquitoes. When the environmental conditions are optimal, they seek more hosts for blood feeding, which can be the cause of the increase in positive pools. After a week of

reduction in drought, the average number of mosquitoes per trap increased as well. Results will be updated per changes in the upcoming weeks. The findings show that drought has the potential to influence the spread of West Nile virus by *Cx. quinquefasciatus*. Regarding to the worldwide trend of climate change and global warming, more areas in the world are experiencing drought currently. Although no strong correlation or significant statistical relation between drought and mosquitoes per trap or positive pools are observed in this study, the effect of drought has been detected which can be considered for further studies.

107 Comparison of Vector Test to RT-PCR during a rampant West Nile Virus year in Suffolk, Virginia

Jay P Kiser (jkiser@suffolkva.us), Karen I Akaratovic, Charles Felipe Abadam

Due to state laboratory funding limitations, cities in the southeastern region of Virginia started using Vector Test™, an in-house antigen assay, in 2012 to test their mosquito pools for both West Nile Virus (WNV) and Eastern Equine Encephalitis Virus (EEEV). During the next six years of using this testing method, the region found surprising confirmation rates of 95-100% (using RT-PCR) for *Culex pipiens* and *Culiseta melanura* pools positive for WNV and EEEV, respectively. In the summer of 2018, southeastern Virginia experienced one of the highest years of WNV in regards to positive mosquito pools, since the introduction of the virus to Virginia in 2001. Over 200 pools of *Culex pipiens* were discovered positive for WNV in this region, with the City of Suffolk accounting for nearly 35% of those positives. Seizing this opportunity, the City of Suffolk sent 377 *Cx. pipiens* pools that had been tested with Vector Test to be retested with RT-PCR. The secondary testing will take place in the fall of 2018 with those results being presented. Through this comparison of Vector Test and RT-PCR, the goal is not only to see how many VectorTest positives are confirmed but how many false negatives may exist. When using a less sensitive test like Vector Test, fully understanding its comparison to RT-PCR can give the confidence one needs to interpret and utilize its results.

108 Resurgence of St. Louis Encephalitis Virus in Tennessee

Abelardo C. Moncayo (abelardo.moncayo@tn.gov), Thomas Moore, Nathen E. Bopp, Patricia V. Aguilar, Mayme Van Meveren, Kelly Orejuela, Rebecca Trout Fryxell, Graham Hickling, John Dunn

Since 2008, the Tennessee Department of Health (TDH) has useda multiplex real-time reverse transcription polymerase chain reaction assay to detect the RNA of West Nile virus (WNV), Flanders virus (FLAV) and St. Louis encephalitis virus (SLEV) from field collected mosquito specimens. All three viruses can co-infect *Culex* mosquitoes and have previously been found in Tennessee. However, Tennessee has not reported a human case of SLE since 2005, prior to developing the capacity to detect SLEV in mosquito pools. TDH has detected very low numbers of SLEV positive mosquito pools sporadically since 2008, with all of these detections being in Shelby County in the Mississippi River Valley. Here we report the resurgence of SLEV in Tennessee in 2017 and 2018. Beginning in September of 2017, in response to the death of a bontebok, mosquito trappingwas conducted at the Nashville Zoo. Fresh brain tissue from the bontebok was submitted to TDH for arbovirus testing and molecular analysis identified WNV as the etiologic agent for the acute onset of meningoencephalitis in this animal. We also detected an elevated prevalence of WNV in mosquitoes (28 pools) and, interestingly, 13 SLEV positive pools were also identified at the zoo. Additionally, routine testing in 2017 identified SLEV positive pools in two counties in eastern Tennessee (9 pools) and in Shelby County (5 pools). In 2018, SLEV was detected in 150 of the 4440 (3.4%) pools tested from counties throughout Tennessee. As of mid-September 2018, there have been similar numbers of SLEV (26) and WNV (28) positive pools detected in Nashville. We are currently sequencing these isolates and coordinating plaque reduction neutralization testing of all WN human cases to determine if any are SLE. Our findings suggest a need for increased vigilance and testing for SLEV throughout the state of Tennessee.

109 Modeling Environment-Vector Interactions to Predict Disease Vulnerability

Margaret MacDonell (macdonell@anl.gov), Jessica Trail, E. Zvolanek, Charles Macal

Vector ranges continue to change with our changing climate, which has brought the threat of mosquito-borne diseases to new areas. Predicting the potential for mosquito populations under evolving environmental conditions provides insight into vulnerability to these diseases, to inform preparedness and response plans. Factors that affect disease outbreaks include human populations, land cover/land use, and meteorological conditions, or atmospheric processes and phenomena (weather events). More than half the world's population now lives in urban areas, and this fraction is projected to reach two-thirds within a few decades. Meteorological influences on vectors and implications for disease vulnerability are amplified in urban areas. For example, higher temperatures are linked to faster maturity rates, higher feeding frequency and disease transmission, and higher survival rates; higher rainfall is linked to increased habitat (catchments), higher breeding rates and increased reproductive success; and higher humidity is linked to

increased mating and dispersal, higher survival rates, and increased longevity. A novel agent-based modeling approach is being developed to assess the vulnerability of a large metropolitan area to mosquito-borne diseases under various environmental conditions. This computational model incorporates geospatial data for land cover/land use as well as meteorological conditions, notably temperature, precipitation, and wind speed. The model represents individual components and their characteristics, such as hourly activity patterns for human populations and flight distance and biting behavior for mosquito populations. By simulating various environmental conditions and accounting for trillions of interactions among mosquitoes and humans, the model can be used to identify locations vulnerable to mosquito-borne diseases, to help target interventions.

Beekeepers and Mosquito Control: Building A Bridge Symposium I

110 Are honey bees really dying

Jamie Ellis (jdellis@ufl.edu)

Since 2006, the yearly gross loss rate of managed western honey bee (*Apis mellifera* L.) colonies has averaged around 30% in the U.S. During the same time, the net number of honey bee colonies in the U.S. has averaged more than a 1% increase yearly. This leads one to ask, "are honey bees really dying?". The answer is complicated. The research suggests that economics drives the net number of colonies managed in the U.S. When the economic climate is favorable (i.e. high honey and pollination prices), beekeepers find it profitable to split colonies and recover their losses. When the economic climate is not favorable, beekeepers manage fewer colonies. The gross loss rate, however, is driven by various biotic and abiotic stressors that beekeepers work to manage actively. Honey bees and their colonies are under constant attack from several biotic (living) stressors. These include bacteria, fungi, viruses, mites, other insects, etc. Furthermore, many abiotic stressors threaten bee health. The most notable of these are nutrition, queen quality, management, weather, and pesticides. Beekeepers spend considerable time inspecting colonies for and remedying problems related to these stressors. Many scientists believe the high gross loss rates are caused by interacting stressors that together reduce colony fecundity and productivity, ultimately leading to their demise. When surveyed, beekeepers list *Varroa destructor* (a parasitic, disease-spreading mite), nutrition, queen quality, and weather as the most significant stressors impacting honey bees, thus allowing scientists to focus their research efforts on those stressors. In conclusion, it is true that the beekeeping industry is experiencing high gross loss rates of managed colonies yearly due to biotic and abiotic stressors, but these losses have been mitigated by beekeeping practices that result in an actual increase in the number of managed colonies.

111 Fostering Relationships between Mosquito Control and Beekeepers

Caitlin Gill (Caitlin.Gill@freshfromflorida.com)

The relationship between mosquito control programs and beekeepers can be a difficult relationship to establish and maintain. Caitlin Gill, Mosquito Control Outreach Specialist and the Apiary Inspection Staff of the Florida Department of Agriculture and Consumer Services (FDACS) have created a course that aims to create or mend such relationships. This Florida Mosquito Control Association's Dodd Short Course focuses primarily on honey bee education and communication development for mosquito control personnel. The course objectives are to provide mosquito control personnel feasible ideas and approaches to utilize in the establishment of these connections. After the initial teaching of this course, it was realized how vital and engaging these topics were for mosquito control programs. The knowledge and concepts conveyed in this course could be applied in other regions of the United States for mosquito control programs.

112 Factors affecting insecticide sensitivity in the honey bee

Frank David Rinkevich (frank.rinkevich@ars.usda.gov)

The effects of insecticides on honey bee colony health is a concern to beekeepers, mosquito control professionals, and the general public. Honey bee colonies are complex and dymanic that are influenced by genetics, seasonal changes, and management practices. These diverse factors can afffect insecticide sensitivity and may act as a source of variation among research projects and can affect translation of lab results to outcomes in the field. Recent research shows that honey bee stocks show signficant differences in insecticide sensitivity and insecticide sensitivity changes with honey bee age. Synergist bioassays and esterase activity assays demonstated physiologiocal differences among stocks that may underlie the differences in insecticide sensitivity. Varroa infestation appears to have limited impacts on insecticide sensitivity and synergistic interactions with amitraz used as presecribed in the colony did not appear to

affect insecticide sensitivity in the honey bee. Investigations in pesticide exposure in commercial beekeeping operations show that high levels of pesticides in colonies does not always translate to poor colony health. These results indicate that a better understanding of fundamental toxicology as well as the physiological processes that may influence pesticide sensitivity is needed to build more data-driven risk assessment models to accurately assess the impacts of pesticides on honey bees.

113 The Rusty-Patched Bumble Bee is now endangered: Implications for mosquito control districts
Mark Clifton (mclifton@nsmad.com)

In January of 2017 the Rusty-patched bumblebee (*Bombus affinis*) was listed under the federal endangered species act (ESA) as endangered. This marks the first time a bee in the continental United States has been listed under the ESA. Critical habitat for this species was identified within the boundaries of the North Shore Mosquito Abatement District as well as the states of Illinois, Maine, Massachusetts, Virginia, West Virginia, Ohio, Indiana, Iowa, Wisconsin and Minnesota. Another species, the yellow-banded bumble bee (*Bombus terricola*), is currently under review by the Fish and Wildlife service and may also be listed. What might the listing of these native pollinators mean for mosquito abatement operations across the Northeast and Midwest? The possible implications of this development will be discussed from the perspective of a mosquito abatement district.

114 Mosquito control professionals and beekeepers – we're more alike than you might think
Michael Hudon (m.hudon@irmosquito2.org)

The challenges mosquito control personnel and beekeepers face are similar; pests and pathogens, incorrect public perceptions, constant inspection and surveillance, availability of pesticides and resistance issues, hurricanes and flooding, the list goes on and on. As fellow entomologists we can be allies and learn from each other's advice and concerns.

115 Optimizing communication between applicators and beekeepers to protect pollinators: Lessons learned from the FieldWatch collaboration
Bob Walters (stephanie@fieldwatch.com), Stephanie Regagnon

FieldWatch, Inc® is a non-profit company that promotes communication between producers of specialty crops, beekeepers and pesticide applicators in support of ongoing stewardship activities. DriftWatch™ and BeeCheck™ are programs of FieldWatch and are free, voluntary mapping platforms used to promote awareness and collaboration on the ground. Our tool features an easy-to-use Google Maps™ interface that clearly shows pesticide applicators the locations of registered areas so they can utilize the data as they plan and prepare for their applications. FieldWatch data can be viewed and live-streamed through other software developers so that applicators can easily access our data through other programs they may be using. Our collaboration tool was originally designed by the Purdue University Agricultural and Biological Engineering Department with input and support from Purdue University Cooperative Extension. It is now operated by FieldWatch, Inc, an independent non-profit company created in collaboration with interested stakeholder groups who represent the agriculture value chain. FieldWatch is currently operating in nineteen states and one Canadian province and is expanding its footprint rapidly throughout the United States. During this presentation the audience will learn more about how we engage stakeholders to inform the continued development and innovation of our stewardship tool and what we've learned in that process over the 10 years since our founding at Purdue University. We will cover the basics of how to use our tool most effectively as well as how to expand our platform into your area and what new innovations are on the horizon for 2019. For more information please visit: www.fieldwatch.com.

Worldwide Management of Aedes aegypti and Aedes albopictus Symposium II

116 Barrier Treatments with Lambda-Cyhalothrin are Effective for Aedes albopictus Management
Isik Unlu (ioguzoglu@hotmail.com), Gregory M Williams, Ilia Rochlin, Yi Wang, Randy Gaugler

Barrier applications, treating vegetation and other mosquito resting sites with residual pesticides, have become standard practice for commercial pest management professionals offering mosquito control services. These treatments are generally effective in reducing populations of the Asian tiger mosquito, *Aedes albopictus*. Applications of Demand® CSR pyrethroid (9.7% lambda-cyhalothrin) only or combined Demand® CSR and Archer® IGR insect growth regulator (1.3% pyriproxyfen) applications resulted in

significant and similar decreases in adult mosquito abundance of 78 and 74% respectively, compared with the untreated control. Both insecticides exceeded the 70% reduction threshold considered effective for *Ae. albopictus* control for 2 to 4 weeks. In temperate climates, adult *Ae. albopictus* populations are naturally eliminated each winter and must be rebuilt from diapausing eggs the following spring. We tested if early control interventions directed at the small spring population would slow population growth compared to interventions that take place after the population has peaked. We compared early (June 1) barrier applications of the adulticide Demand® CS mixed with the pupicide Archer® IGR to late applications (July 31) in urban and suburban residential parcels in New Jersey. These applications resulted in 43% and 51% reductions in adult *Aedes albopictus* populations in the early and late intervention study parcels, respectively, when compared with untreated controls. Our study provides support for the efficacy of barrier applications and illustrates the importance of timing barrier treatments to coincide with *Ae. albopictus* action thresholds.

117 Debug Fresno Round Two: Implementing Large-scale SIT/IIT in Residential Neighborhoods

F. Steve Mulligan (smulligan@mosquitobuzz.net)

Debug Fresno is a partnership between the Consolidated Mosquito Abatement District (CMAD), MosquitoMate and Verily Life Sciences to evaluate an innovative mosquito control strategy against *Aedes aegypti* mosquitoes, recently established in California (2013). The SIT/IIT strategy involves the release of male mosquitoes infected with *Wolbachia* into selected residential neighborhoods with established infestations of *Ae. aegypti*. Mating of released males with local females results in conditional sterility. Daily male mosquito releases began in one neighborhood in the City of Fresno during the 2017 mosquito season. In 2018, the Debug Fresno study was expanded to include three neighborhoods in the City of Clovis and the same City of Fresno neighborhood. All release sites are in Fresno County, California. The presentation will discuss results and summarize the role of CMAD in establishing the study areas and ongoing monitoring of mosquito population trends in release and non-release areas. Also discussed will be community outreach efforts to increase public awareness of Debug Fresno and dealing with resident perceptions, responses and interactions.

118 Efficacy of aerially-applied adulticides and larvicides for the area-wide control of Aedes aegypti and Ae. albopictus populations in Florida

Christopher Lesser (Christopher.Lesser@manateemosquito.com)

Aedes aegypti and Ae. albopictus mosquito 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). Timing and frequency of all chemical applications were based upon field surveillance of larval/adult mosquito population. 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. Ae. aegypti & Ae. albopictus populations were documented to be reduced 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.

119 Large-scale field evaluation of the In2Care Mosquito Trap against Aedes aegypti mosquitoes in Manatee County, Florida

Eva Buckner (eva.a.buckner@gmail.com), Katie Williams, Christopher Lesser, Mark Latham

The In2Care Mosquito Trap utilizes autodissemination of pyriproxyfen and *Beauveria bassiana* fungus spores to kill larval and adult stages of skip-ovipositing *Aedes aegypti* and *Ae. albopictus* mosquitoes. We conducted the largest field evaluation to date of In2Care mosquito traps from April to August 2018 in Manatee County, Florida against wild *Ae. aegypti* mosquitoes. During our field trial, we compared the ability of approximately 600 In2Care mosquito traps alone to reduce the *Ae. aegypti* population in an area to the ability of conventional *Ae. aegypti* reduction techniques to reduce the population in another area. The *Ae. aegypti* population as measured by weekly egg and adult counts was higher in the conventional control area compared to the In2Care trap area. Also, no citizen complaints were logged in the In2Care trap area during

the trial, which is a reduction in complaints compared to previous years. The cost of treatment methods in the two areas will be compared.

120 The mass deployment of Autocidal Gravid Ovitraps for the control of Aedes aegypti and Aedes albopictus in Saint Johns County

Daniel Dixon (ddixonamcd@gmail.com), Lagan Mullin, Dena Autry, Kay Gaines, Michael Banfield, Rudy Xue

The Anastasia Mosquito Control District partnered with the insect trap manufacturer Springstar on an NIH grant to test the effectiveness of the Autocidal Gravid Ovitrap (AGO). AGO traps target *Aedes aegypti* and *Aedes albopictus*, two major vectors of Yellow Fever, Dengue, Zika, and Chikungunya viruses. The trap is comprised of a black five-gallon bucket containing infusion water and a specialized lid with a sticky matrix for the trapping of gravid mosquitoes. Over 2000 traps were spread across three 40-acre plots designated as the treatment areas and were compared to paired control areas. Each treatment and control area had a set of 24 Sentinel AGO (SAGO) traps that were monitored weekly for the collection of both mosquitoes and non-target organisms. Along with the monitoring of SAGOs, three Biogents Sentinel Traps were set each week in both treatment and control areas to monitor population levels in all areas. All AGO traps were deployed in early June and the study ended in October. According to the SAGO collections, gravid *Aedes aegypti* and *Aedes albopictus* were collected at a rate of 1 – 5 mosquitoes per week, but this resulted in little to no change between treatment and control conditions. The non-target capture rate was very high, and these included gnats, fruit-flies, roaches, moths, midges, and other species. Despite our tests showing little difference in population levels between treatment and control areas, citizen perceptions of the traps were overwhelmingly positive. Most Saint Johns County residents perceive the traps as removing mosquitoes and requested that they be placed in their yards. To conclude, AGO traps were not as successful on a mass-deployment scale for the knockdown of *Aedes* mosquitoes. However, their high customer satisfaction level coupled with the collection of non-mosquito human pests makes them a potential general pest control trap for residential outdoor use.

121 Review of recent, autocidal mosquito introductions in the USA, with a focus on Wolbachia and ADAM approaches

Stephen L. Dobson (sdobson@uky.edu)

New mosquito control methods are needed for reasons including resistance to existing pesticides and the global spread of mosquitoes and the pathogens that they transmit. 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 autocidal methods that target *Aedes* mosquitoes as globally invasive pests and medically important vectors. One method is based on *Wolbachia*, an endosymbiotic bacterium that is common in many invertebrate species. Similar to the Sterile Insect Technique (SIT), 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 *Wolbachia*-based approach has recently received approval from the Environmental Protection Agency. The presentation will also summarize recent work with a second approach known as "Auto Dissemination Augmented by Males" (ADAM). The latter approach employs repeated, inundative introductions of male *Aedes* mosquitoes to distribute pyriproxyfen as an inhibitor of immature *Aedes* development. 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 managers.

122 Sugar feeding behavior of Aedes aegypti and Aedes albopictus and control with Attractive Toxic Sugar Baits (ATSB) in Mali and Florida.

Gunter C. Muller (GunterCMuller@hotmail.com), E. Revay, M. Traore, Sekou F. Traore, Vasiliy D. Kravchenko, John C. Beier, Rui-De Xue

Facing the increasing threat of arboviruses there is an urgent public health need for new vector control tools against *Aedes aegypti* and *Aedes albopictus*. The objective of the studies was to investigate the sugar feeding habits of *Ae. aegypti* in Bamako Mali and of *Aedes albopictus* in Florida, and test whether attractive toxic sugar baits (ATSB) methods are a feasible approach for their control. The studies show that *Ae. aegypti* and *Ae. albopictus* frequently feed in the field and laboratory on a variety of sugar sources. The field trials suggest that if properly applied in the right environment ATSB as a spray as well as within bait-stations is a highly efficient method for *Aedes* control. Experimental set ups and results of the trials will be presented in detail.

123 What role can spatial repellents play in the management of peridomestic mosquitoes?
Daniel L. Kline (dan.kline@ars.usda.gov)

Control of peridomestic mosquito species, such as *Aedes aegypti* and *Ae.albopictus*, is not easy. Life cycle patterns of these species make the use of traditional methods challenging. Adult control utilizing ULV applications of insecticide either from truck-mounted units or from airplanes is largely ineffective. Many studies have shown that these traditional methods don't work because the insecticides simply do not reach these target species. This is due partially to the fact that they are primarily daybiters. These species are highly domesticated and in some locations adults utilize indoor resting sites such as closets, or outdoor cryptic resting sites. In recent years there has been an increased emphasis on evaluating what role spatial repellents might play in managing these species of mosquitoes. Spatial repellents are generally vapor-phase insecticides that induce sub-lethal responses , such as repellency, deterrence, feeding inhibition and reduced fecundity. Of particular interest is the use of passive delivery devices (emanators), which do not require heating or electricity and usually require minimal compliance by the users. This talk will present recent research conducted to determine the potential role(s) for passive spatial repellent emanators in population management programs targeting peridomestic mosquito species.

Latin American Symposium I

124 Barcoding of mosquitoes from communities close to the Mexican Lacandone Jungle: A study to support incrimination of arboviruses on vectors
Aldo Ortega (agrortega@hotmail.com), Alfonso Garza, Luis Hernández, Quetzaly Siller, Vicente González, Mario Rodríguez

As a previous step for methodical studies of vector-borne diseases, such arboviruses, vectorial incrimination studies, as integrated systematics approach was implemented using morphometric and DNA barcoding taxonomy to examine and identify the mosquitoes (Diptera: Culicidae) species diversity collected in fifteen households of four sylvan communities (n= 60) close to the Mexican Lacandone Jungle. A total of 429 specimens (adult stages) were identified by classical morphometry, recognizing a total of 56 species belonging to 12 genera (in boldface) and 29 subgenera (***Anopheles***: *Anopheles, Kerteszia, Nyssorhynchus;* ***Aedes***: *Georgecraigius, Howardina, Ochlerotatus, Protomacleaya, Stegomyia;* ***Haemagogus***: *Haemagogus;* ***Psorophora***: *Grabhamia, Janthinosoma, Psorophora;* ***Culex***: *Anoedioprapa, Culex, Melanoconion, Microculex, Phenacomyia;* ***Mansonia***: *Mansonia;* ***Johnbelkinia***; ***Limatus***; ***Sabethes***: *Sabethes, Sabethoides;* ***Shannoniana***; ***Trichoprospopon***; ***Wyeomyia***: *Decamyia, Triamyia, Wyeomyia;* ***Toxorhynchites***: *Lynchiella*); Of these, three species are new records for the mosquito fauna of Mexico, and from Chiapas state. Afterward, to analyze barcode sequence variation, 95 specimens were selected to amplify and sequence the mitochondrial cytochrome C Oxidase I gene. Although by morphology 56 species were recognized (with 25 new barcode index number), we discover taxonomic uncertainties among specimens of *Wyeomyia* and *Trichoprospopon* genera (discussed in the poster). Nevertheless, the Neighbour Joining tree (NJ) derived from the DNA barcodes resolved this ambiguity, grouping the most specimens according to species recognized by morphometric studies. Moreover, the specimens identified as *Ae*. (*Howardina*) *guatemala* (Berlin 1969), and *Ae*. (Howardina) *allotecnon* (Kumm, Komp, and Ruiz, 1940) was shown to comprise as equal species, with a mean divergence between barcode sequences of 0.06 %. Finally, the taxonomic checklist is provided, with a detailed list of reported arbovirus vector capacity for each species.

125 Epidemiological importance of Aedes albopictus in Medellín, Colombia
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Medellín is a hyperendemic city for dengue transmission, and the vector traditionally involved has been *Aedes aegypti*. However, since 2011 the presence of *Ae. albopictus* was reported in the city, a species that according to previous studies could displace *Ae. aegypti* in urban and suburban areas where they coexist. Due to the potential risk of *Ae. albopictus* in dengue transmission and other arbovirosis, in 2011, the Secretary of Health of Medellín implemented a monitoring system through larvitraps spatially distributed using a Thiessen´s polygons. As a result of this tracking, it has been possible to document the gradual dispersion of *Ae. albopictus* in the city, and after seven years of its first recording, it is reported in 68% of Medellín's neighborhoods. In addition, it has been observed that *Ae. albopictus* is found ovipositing inside homes in highly urbanized areas, findings that could indicate an urbanization process. Finally, entomovirological analysis by RT-PCR with wild mosquitoes have shown that *Ae. albopictus* is frequently infected with dengue virus. Although, *Ae. albopictus* has been identified as the main vector of dengue in

some countries of Asia, in Colombia its role in the transmission of this disease has not yet been specified. *Ae. albopictus* should, however, be regarded as a mosquito of epidemiological relevance in Colombia, given its accelerated dispersion, urbanization process, and frequent reports of natural infection with dengue virus. It is necessary additional studies on vector competence are required to assess its importance in the transmission of dengue virus and other arboviruses in the country.

126 Potential vectors of dengue, Zika and chikungunya in two municipalities of Cundinamarca department, Colombia.

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The high prevalence of dengue (DENV), and the quick spread of Zika (ZIKV) and chikungunya (CHIKV) in Colombia despite the control strategies applied for *Aedes aegypti* its main vector, could be an indication of other mosquitoes species involved in the transmission of these arboviruses. The aim of this study was to evaluate the intra-domiciliary Culicidae richness and its natural infection by DENV, ZIKV, and CHIKV in urban areas in the municipalities of Anapoima and Viotá Cundinamarca, Colombia. Entomological surveys for adult mosquitoes using Prokopack aspirators, CDC and BG-sentinel traps from houses selected randomly by block sizes during wet and dry season on 2017 were applied. The mosquitoes were taxonomically determined and in some cases they processed whole individuals or separated in the head-thorax and abdomen, pooled and preserved in RNAlater® for molecular detection of the viruses. Mosquito presence, infestation, and richness were analyzed in terms of spatial distribution and some environmental factors. 8820 individuals from 17 species were collected, of which *Aedes aegypti* (8060 individuals), *Culex quinquefasciatus* (665 individuals), *Limatus durhamii* (25 individuals) and *Mansonia titillans* (23 individuals) were the most common species. Changes were observed in the spatial distribution of mosquito´s richness between seasons, as well as a contrasting pattern in the spatial and temporal distribution of *A. aegypti* and *C. quinquefasciatus* infestation. This could be explained by changes in ecological conditions which favor the presence of one species over others. Positive amplification for DENV (DENV-1 and DENV-3), CHIKV and ZIKV were obtained from *C. quinquefasciatus* and *A. aegypti*, and for CHIKV in *M. titillans* The mosquito's richness intra-domiciliary, the distribution and infestation *C. quinquefasciatus* and the presence of natural infection in this species, highlight the importance to study the implication and ability for transmission of other species besides *A. aegypti* for these arboviruses.

127 Is Anopheles (Nyssorhynchus) albitarsis F the only species of the Albitarsis Complex present in Venezuela?

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Studies based on morphological and random amplified polymorphic DNA-polymerase chain reaction (RAPD-PCR) reported that An. marajoara was the only species of the An. albitarsis Complex Group in Venezuela. However, recently An. albitarsis F was found in Zulia, Cojedes, Bolívar and Portuguesa States. Because An. albitarsis F has been confirmed in eastern Colombia and in Trinidad and Tobago it has been suggested a much wider range of distribution for this taxon in Venezuela. The barcode region of the mtDNA sequences of mosquitoes collected landing on humans in large rice field plantations and in a gold mining camp in the States of Guarico and Bolivar respectively, were analysed by comparison to publicly available sequences for An. albitarsis Complex members in the GenBank and the Barcoding f Life System (BOLD). Haplotypes, nucleotidic differences found and Neighbour Joining trees based on the Kimura-2 parameter distances are presented. The importance of these results in the epidemiology of malaria in Venezuela is discussed.

128 Automatic and high accuracy identification of Aedes aegypti and Aedes albopictus larva based on deep neural networks

Antonio Arista-Jalife (arista.antonio@gmail.com), Mariko Nakano, Hector Perez-Meana, Daniel Robles-Camarillo

The *Aedes aegypti* and *Aedes albopictus* are vectors of Dengue, Chikungunya and Zika. The larvarian stage control task nowadays requires laboratories, equipment, transportation and recognition, which may be nonexistent in under-developed countries. To automatize such tasks, a Deep Neural Network is presented that automatically highlights the silks of larvae, which are crucial for the identification of the *Ae.* genus. With this research, it is possible the implementation of a fast, reliable and cost-efective identification system.

129 Exon conservation and knockdown resistance mutations in the Voltage-sensitive sodium channel in Aedes aegpyti

Juan Jose Silva (js3274@cornell.edu), Jeffrey Graham Scott

Aedes aegypti is a primary vector of pathogens and responsible for millions of human infections annually. Pyrethroids are the most commonly used insecticide to control *Ae. aegypti*. Unfortunately, pyrethroid resistance has been reported worldwide due to target-site mutations in the *voltage-sensitive sodium channel* (*knockdown resistance* mutations). We found that 18 out of 22 *kdr* mutations confirmed to confer pyrethroid sensitivity are present in exons that are highly conserved across insect orders.

130 Metabolic detoxification and target site insensitivity to pyrethroids in Aedes aegypti from Veracruz, Mexico

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In Mexico like other zones near to the tropics, insecticides are still an important strategy in *Aedes aegypti* control programs. However, increasing insecticide resistance in natural populations might hinder insecticide effectiveness. The development of such resistance is a complex and dynamic process dependent of many factors, for this reason, its management involves a monitoring resistance program to know the frequency of resistance in vector populations and the mechanisms associated. In the present study, female mosquitoes of *Ae. aegypti* from 7 different localities of Veracruz which were exposed to 8 pyrethroid insecticides (d-phenothrin, permethrin, deltamethrin, cypermethrin, alfa-cypermethrin, lambda-cyhalothrin, and bifenthrin) using bottle bioassays and survived the process, were used in biochemical and molecular tests to determine mechanism involved in resistance. We found that mosquitoes that survived to pyrethroids exposition had a y b esterases incremented, particularly in mosquitoes exposed to cypermethrin and z-cypermethrin followed by lambda-cyhalothrin, which was also associated with glutathione S-transferases. Elevated levels of mixed-function oxidases were determined in mosquitoes survived to d-phenothrin followed by cypermethrin. Coefficients of determination were calculated between the $RRLC_{50}$ to pyrethroids and the different enzyme levels. Results showed a esterases and mixed-function oxidases associated with permethrin resistance (R^2= 0.75, P≤0.05 and R^2= 0.58, P≤0.05 respectively). Also, target site insensitivity in acetylcholinesterase associated with lambda-cyhalothrin resistance (R^2= 0.80, P≤0.05). Molecular assays revealed the presence of kdr mutations V1016I and F1534C in an allelic frequency range of 0.25 to 0.87 and 0.5 to 0.7, respectively. Genotypic frequencies of homozygous mutant C1534/C1534, heterozygous genotype F1634/C1534, and heterozygous genotype V1016/I1016 were associated to high $RRKD_{50}$ found in populations exposed to alfa-cypermethrin (R^2= 0.75, P≤0.05; R^2= 0.72, P≤0.05 and R^2= 0.60, P≤0.05, respectively). While heterozygous genotype F1634/C1534 frequencies were also associated with permethrin resistance (R^2= 0.62, P≤0.05).

131 Analysis of variations in the gonotrophic cycle of two colombian populations of Aedes aegypti, subjected to uncontrolled climatic conditions in Bogotá

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The *Aedes aegypti* mosquito is considered one of the most important arthropods in the transmission of causative agents of viral diseases to humans worldwide, like Dengue, Zika and Chkungunya. This phenomenon of proliferation has been associated both with anthropogenic movements and climatic variables, with temperature being one of the main factors that affect the biological cycle and the reproduction of the vector, particularly the gonotrophic cycle. The objective of this study is to determine and compare the gonotrophic cycle, fertility and fertility of Colombia populations of *Ae. aegypti* coming from temperate climate 22 ^{0}C (Villeta) and warm 26^{0}C (Yopal), maintained in the environmental conditions of 18^{0}C (Bogotá), city that is 2,600 m.a.s.l. Individual follow-up was performed on 50 females of each of the colonies. The average oviposition rate per female, hatching rate and retained eggs was recorded. Preliminary results show for the Yopal colony maintained at 26 ^{0}C a gonotrophic cycle of 3 days and for this same colony maintained under conditions of 18 ^{0}C it shows an average cycle of 10 days. The influence of temperature on the process of embryogenesis and oviposition is evidenced. The information generated by this project will contribute to the knowledge of the vector and, therefore, to optimize its control.

Attract, Trap, and Train Your Mosquito Control Dream Team

132 Introduction
Allison Allen (aallen@pestworld.org)

133 Partners in vector control: mosquito control done by pest control companies & local health departments
Allison Allen (aallen@pestworld.org), Chelsea L. Gridley-Smith

In the US, our line of defense against public health pests includes over 20,000 private pest control companies and 2,800 local health departments. Just like vector control districts, these organizations must find, hire, train, and retain quality staff. According to a July news release from the US Bureau of Labor Statistics, unemployment is 3.9%. This is the lowest it has been in almost two decades. All employers, regardless of sector, are competing for talent. What can we do to attract people to vector control? The National Pest Management Association (NPMA) helps pest control companies with their human resource (HR) challenges by engaging committees that develop resources for the whole industry; running QualityPro, a company accreditation program that helps companies hire right; and maintaining http://workforce.npmapestworld.org. Local health departments and mosquito abatement districts may have different criteria for hiring based on institutional requirements, but these governmental organizations share the need to retain skilled workers. By sharing HR strategies and showing employees the variety of career paths available to pest management professionals, we can win the war for talent.

134 Building Mosquito Control Capacity on a Shoestring Budget
Shaun Craig May (shaun.may@amarillo.gov)

The City of Amarillo's Mosqutio Control program manages over 90 square miles with a population of just under 200,000. While the program has been in existence for decades, the program has historically lacked funding and technical sophistication. The average number of confirmed and suspected human cases of West Nile Virus (WNV) was approximetly 12 per 100,000. In 2015, the program began implementation of the an intergrated mosqutio contol plan that sought to use diverse methodologies aimed at reducing the burden of mosquto-borne illness. While we still have much more worj to do, we have begun to have significant success. The rates for confirmed and suspected human WNV cases dropped to less than 1 per 100,000 in 2017. We have also started our surviellance activities and chemical rotation, and are looking to start resistence testing next year. The purchasing of equipment, hiring of staff, and departmental training will also be covered. We hope to share our experiences and share best practices along with learning from the feedback from our peers.

135 Creation of mosquito control districts in the United States: Key aspects of successful staffing, structure, and funding options
Michael Stephan Doyle (michael.doyle@dhhs.nc.gov)

The science and art of mosquito suppression in the United States has taken on many forms throughout its history. Many programs began in response to disease epidemics and evolved to handle multiple nuisance insects, others formed in response to massive mosquito nuisance issues, and were later forced to adapt to the sudden reemergence of diseases. The result is a wide kaleidoscope of organizational structures, funding options, and staffing strategies. This talk will provide an overview of how mosquito control districts in the United States can be created under current regulations, and then highlight several key aspects that make some successful.

136 Finding & hiring new employees
David Cooksey (DCooksey@mccallservice.com)

Finding passionate and professional people who are interested in pursuing a career in pest control can feel like looking for a needle in a haystack. Employers can increase their chance of success by having a focused hiring strategy. This includes well-thought-out job descriptions, marketing to prospective employees and thorough vetting through the hiring process. In this talk we will go through successful strategies for finding employees and important considerations for hiring.

137 Employee onboarding & training
Tom Jarzynka (tjarzynka@masseyservices.com)

Once an employee is hired, management is motivated to get him working as fast as possible, but only after ensuring he has the proper training, licensing and ability to do the job. In our industry, continuing education and quality assurance are essential to providing quality service. In this talk we will go over how a pest control company trains its new and existing employees and share tips and resources that anyone in vector control can use.

138 Q&A

139 Building collaborative projects with mosquito control and beekeepers
Kristen Healy (khealy@lsu.edu)

In 2013, we established a collaboritive research project among Louisiana State University, East Baton Rouge Mosquito Control, the USDA Honey bee research lab, and local beekeepers in Baton Rouge Louisiana. Our goal was to test our hypothesis, that "when mosquito control is done correctly, and according to label instructions, there should be minimal impact to honey bees." Our projects involved laboratory, semi-field, and field based studies with local beekeepers. Our work emphasized the importance of evaluating both toxicity and exposure, rather than just relying on lab based toxicity studies. Our results supported our hypothesis. Therefore, we encourage improved education and communication between mosquito control and beekeepers.

140 Educating beekeepers in the 21st century: Online and experiential learning from the UF/IFAS Honey Bee Lab
Mary Bammer (bammerma@ufl.edu)

The importance of bees to the global food supply is largely undisputed and has been well documented (Southwick & Southwick, 1992; Morse & Calderone, 2000). Although honey bees have been a staple in American agriculture for centuries, over the last decade the United States beekeeping industry has seen two significant changes. First, being a successful beekeeper has become more difficult; the movement of pests, pathogens, and diseases into and around the country has led to intensified management requirements for those who keep honey bee colonies (Hayes, 2015; Splevin, 2015). With these increased stressors have come high rates of annual colony losses across the United States (Seitz et al., 2016). The second major change in the beekeeping industry is a rise in participation; there were less than 18,000 beekeeping operations nationally in 2002 (U.S. Department of Agriculture, National Agricultural Statistics Service, 2004), compared to over 38,000 in 2012 (U.S. Department of Agriculture, National Agricultural Statistics Service, 2014). As the number of novice beekeepers continues to grow year after year, so too does demand for high quality, reliable, and accessible beekeeper training. To meet the growing educational needs of beekeepers in the 21st century, the UF/IFAS Honey Bee Research and Extension Laboratory (HBREL) is exploring new ways of reaching bigger audiences most effectively, including the revision of existing programs and the development of new ones. Details of the new online Florida Master Beekeeper Program, a collaboration with UF/IFAS Extension county offices, an online system for requesting antibiotics for honey bees, and in-person training opportunities at the brand new UF/IFAS HBREL facilities will be discussed.

141 Honey Bee and Mosquito Control Coexistence
William H Kern, Jr. (whk@ufl.edu)

While much of the concern about the effect of mosquito control activities on a beekeeper's hives is unjustified, we do use insecticides. Blaming the decline of honey bees, *Apis mellifera*, on pesticides is naive at best and scapegoating at worst. The honey bee declined is not a simple cause and effect. It involves pathogens, parasites, nutrition, in-breeding effects, and in some cases pesticide effects. There are some things that beekeepers can do to minimize the effect on their hives; beyond the precautions taken by mosquito control agencies or departments. Methods like hive screening, positioning, and supplying fresh water post-application will help reduce even more the possible harmful effects of adulticiding and larviciding activities. Placing hives as far from the roads used by mosquito control trucks as possible decreases the amount of possible drift reaching the hive entrances. Use of screening vegetation or fences also intercepts chemical drift. Hive covers during aerial applications create droplet shadows to protect bees bearding on the hive entrance. Supplying clean water close to the hives in the morning may discourage bees from collecting water that may have been contaminated by pesticide applications.

142 Pesticide, parasite, and pathogen interactions on pollinator health

Troy Anderson (tanderson44@unl.edu)

The honey bee plays an economically vital role in global agriculture as a pollinator of a wide variety of food and fiber crops that are needed to satisfy the health of humans and animals. The loss of honey bees is a major environment health challenge that demands attention from the scientific community.There are numerous environment stressors that negatively impact the health and survival of honey bees, although a growing consensus identifies the high levels of parasites and pathogens, especially arthropod-borne viruses, are among the most significant threats to the health of these pollinators. A common approach to arthropod-borne virus management is the use of synthetic neurotoxicants alone or in combination with organic acids and botanical oils to reduce ectoparasitic mite infestations. These conventional acaricides not only have adverse health effects on honey bees, but widespread acaricide resistance limits their use to reduce mite infestations and their transmission of viruses to honey bees. Here, I will discuss data that not only shows nutrition and immune deficiencies of honey bees exposed to conventional acaricides and the relationship of these deficiencies to altered gut microbes and pathogen infections, but will emphasize the need for safe and selective chemical interventions for mites. In addition, the data presented here will focus on a (i) comparative toxicology and functional genomics approach for the laboratory toxicity and field efficacy testing of conventional acaricides, (ii) a metabolic activity and target-site interaction analysis of conventional and experimental acaricides, and (iii) the laboratory toxicity and field efficacy of next generation acaricide modes of action and their applications as a guide for reducing arthropod-borne diseases to honey bees and improving the health and protection of these important pollinators.

143 Florida's participation in the National Honey Bee Survey

Brandi Simmons (Brandi.Simmons@FreshFromFlorida.com), David Westervelt

USDA-APHIS funds a national bee survey in an attempt to document which bee diseases/parasites/pests of honey bees are and are not present in the United States. This survey is sponsored by APHIS in collaboration with ARS and the University of Maryland (UMD) and has established the absence of exotic bee pests including, but not limited to, the parasitic mite *Tropilaelaps*, the Asian honey bee (*Apis cerana*) and Slow Paralysis Virus in the US. This survey will also evaluate bee wax from the sampled hives for the presence or exposure to pesticides. This data will be used to act as a reference to compare future pesticide analysis, permit preliminary identification of sub lethal pesticide exposure effect on colony health, and potential synergisms between pesticides and diseases. An emphasis of this survey is early detection of these exotic pests if they enter the United States. Early detection would be critical if these serious pests of honey bees are to be contained efficiently, as these exotics will likely cause extensive and sever damage if they become well established. To maximize the information gained from this survey effort, samples will be analyzed for other diseases and parasites known to be present in the United States. The resulting data from this effort will be combined with past year data acting as a baseline from which beekeepers and bee health professionals can identify emerging issues, identify risk factors and design bee health mitigation programs. Florida's apiary inspection team assist with sample collection for this survey to ensure the State of Florida is represented in the data.

144 Bee Friendly Mosquito Control

Matthew Powell (fieldsupervisor@grmcd.org)

What can mosquito control districts do to improve their reputations with, and foster good relations with, beekeepers operating within their treatment boundaries? Grand River Mosquito Control District (GRMCD) has established protocols that include the following policies. GRMCD doesn't begin fogging operations before dark, after honeybees have returned to their hives for the night. We maintain an updated, district-wide, No-Spray list which includes the names, addresses, and phone numbers of beekeepers. This info is gathered through membership in the Colorado Dept. of Agriculture supported website, coloradodriftwatch.org (DriftWatch or Field Watch); as well as an in-house call-in campaign advertised on our website, grmcd.org and through social media. We enter all No-Spray addresses on our adulticiding route maps, and turn off the fogger's pump while passing the address, and the addresses immediately adjoining either side. This is easily facilitated, accurately tracked, and recorded, by using the Monitor 4S control system installed on our foggers. We publish our fogging routes on our website, and offer to call any neighborhood homeowner's associations that have requested advance contact. I have even gone so far as to enroll in and complete two beekeeping courses offered by our local community college. I have been an invited guest speaker at the local beekeeper's association meetings that was well attended and well received and resulted in an hour-

long question and answer session about mosquito biology and how we do everything we can to be 'Bee Friendly'.

145 Learning to talk like a beekeeper: Mosquito control communications with the beekeeping community when confronted with reported honey bee colony losses
Daniel Killingsworth (dan.killingsworth@pest.com)

Interactions between mosquito control operations and beekeepers can be adversarial as vector management efforts are often viewed as a culprit for hive losses throughout the beekeeping season. The vast majority of honey bee health issues are due to *Varroa destructor* mite infestations and the viral diseases they transmit to the colony. Beekeeper mismanagement can also be a significant factor. The intent of this exercise is to highlight the necessity for mosquito control operators to communicate with beekeepers on a level that reveals if a beekeeper is following hive management practices necessary for maintaining healthy honey bees. Familiarity with beekeeping vocabulary, methods, and seasonal calendar management is instrumental in bridging the communication gap between mosquito control and beekeeping communities. Transparency when sharing information is essential to make this a viable undertaking. It is imperative that each mosquito control operation take proactive steps when handling beekeeper complaints to determine the factors that led to a particular honey bee hive loss incident. This should lead to a standard operating procedure for a mosquito control outfit to quickly ascertain any possible link with mosquito control activities and a reported loss of honey bee colonies.

Innovations and Discoveries in Mosquito Control

154 Use of technology and innovations to increase the efficacy of mosquito control and learn more about mosquito biology in Salt Lake City
Gregory White (greg.white@slcmad.org), Nadja Mayerle, Brad Sorensen, Andrew Dewsnup, Ary Faraji

Like invasive mosquito species, new technologies are constantly emerging. Some of these technologies are being utilized in the mosquito control field. At Salt Lake City Mosquito Abatement District new technologies and innovations were used to try an increase efficiency and efficacy. 3-D printing methods are being used to aid in mosquito surveillance, replace hard to find parts, and design new equipment. We have found that 3-D printing technology can reduce costs of for some items and one unexpected benefit was having many different staff members come up with ideas for useful items to be created with our 3-D printers. Additional trials were conducted looking the utility of new batteries for traps, creating a granular dispenser for a sUAV, and modifying resting boxes to increase the catch of resting mosquitoes for different studies. In addition, a study with the ultra-fast metagenomics analysis software, Taxonomer was conducted on mosquitoes from the Salt Lake City area. These studies show ways in which mosquito control can benefit from the adoption of new technologies.

155 Advances in developing real-time mosquito-borne arbovirus surveillance
Nathan Burkett-Cadena (nburkettcadena@ufl.edu)

Vector-borne diseases such as malaria pose imminent threats to the health and economy of the world. Mosquito control relies upon accurate estimates of the vector population to justify and implement timely vector-control responses and/or interrupt pathogen transmission. Current mosquito-borne disease surveillance programs typically rely on a process of field collection of mosquitoes *en masse*, separation of mosquito species into pools by trained entomologists, followed by detection and characterization of pathogens. The end-to-end process is very labor intensive, time consuming and requires enormous expenditures of person-power, travel and processing time to satisfactorily sample an area (e.g., district). Time lags and insufficient spatial coverage compromise the utility of trapping and surveillance for effective deployment of vector control. Advances in automated mosquito capture and arbovirus detection could provide critical tools for mosquito control to increase the number and regularity of sampling and early detection of arbovirus transmission, particularly in large or remote areas.

156 Mid-IR Spectroscopy and Chemometrics for Mosquito Identification and Characterization
Scott Huffman (shuffman@wcu.edu), Lamyae Sroute, Stephanie Richards, 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 and/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 and/or laboratory errors. Therefore, there is a need for rapid species identification and population characterization (e.g., parity and insecticide susceptibility) techniques that can be used on a scale that is ecologically, economically, and epidemiologically meaningful. Our current research aims are to develop methods of biochemical discrimination between different mosquito species using infrared spectroscopy. Infrared spectroscopy is a sensitive, information rich technique 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 (chemometrics) methods may be used to classify mosquitoes by species or physiologic status. To date, we have applied spectroscopy to identify multiple container-inhabiting *Aedes* species (e.g., *Ae. aegypti*, *Ae. albopictus*, *Ae. japonicus*, and *Ae. triseriatus*) and to assess chlorpyrifos susceptibility/resistance in *Ae. albopictus*. At present, our species identification success rate, when compared to identification by a trained entomologist, is approximately 95% (95% CI: 91.9%-97.7%, n=238). The analysis of the chlorpyrifos susceptibility/resistance status are underway. We posit that spectroscopic and chemometric methods have the potential to improve accuracy and decrease labor costs/time associated with measures of mosquito species identification and characterization.

157 Creation of a temporary positive pressure spray booth and utilizing a Malvern Spraytec laser to improve mosquito control applications

Mark Edwin Smith (mmcd_mes@mmcd.org)

As adulticide products go through the EPA's re-registration process, product label directives can change and become more restrictive on equipment to produce specific droplet size ranges. The Metropolitan Mosquito Control District (MMCD) saw an opportunity to improve its ability to accurately measure a wide range of droplets for our ULV and barrier applications. MMCD created a large indoor spray booth utilizing a Malvern Spraytec Laser to evaluate vehicle-mounted and handheld spray equipment. The laser provides a real-time measurement of a true droplet size without requiring impingement or further processing. This temporary positive pressure spray booth can be created with readily available materials.

158 Evaluating the utility of wide area larvicide spraying with VectoBac WDG for the control of urban-breeding Culex pipiens

Sarah Wheeler (swheeler@fightthebite.net), Peter DeChant, Bret Barner, Steve Ramos, Samer Elkachef, Marcia Reed

Wide area larvicide spraying (WALS™) in urban areas with VectoBac WDG has shown utility in controlling container breeding *Aedes*. A series of trials were designed and conducted by Sacramento Yolo Mosquito and Vector Control District (District) to determine whether the technique can also be implemented for the control of *Culex pipiens* in urbanized areas, the most important urban-breeding West Nile virus vector in our area. A series of trials were designed to 1) test different application equipment, 2) characterize the effective spread of the product under varying weather conditions, and 3) quantify the impact of applications on urban *Cx. pipiens* populations. Study methodology and results will be presented.

159 How we can use "Minecraft" to teach a whole new generation about the importance of mosquito control

Kristen Healy (khealy@lsu.edu), Andrew Garcia

As younger generations are becoming more tech-savvy, game based tools can be a great way to teach youth about important topics, such as mosquitoes, mosquito control, and mosquito-borne diseases. Minecraft Education is a fun and inexpensive tool that teachers can use to introduce topics in their classrooms. Lesson plans on the site include numerous topics in science, such as chemistry, physics, ecology, and biology. In the fall of 2018, we began developing several entomology based lesson plans for Minecraft Education. Our goal was to develop lessons that were interactive and fun, yet challenged students to criticially understand the importance and challenges of mosquito control.

146 Aedes aegypti insecticide resistance in Puerto Rico

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The Puerto Rico Vector Control Unit (PRVCU) was established through a cooperative agreement between the Centers for Disease Control and Prevention (CDC), and the Puerto Rico Science, Technology, and Research Trust, to monitor and control the mosquito *Aedes aegypti*, the vector on the Island for dengue, Zika, and chikungunya. As part of the PRVCU integrated vector management (IVM) strategy, insecticide resistance testing is conducted using the CDC Bottle Bioassay to monitor the status of insecticide resistance of wild populations of *Aedes aegypti* in Puerto Rico. Mosquito eggs are collected from ovitraps deployed in urban neighborhoods around the Island and reared in the laboratory for testing using 2-5 day old adult female mosquitoes. The PRVCU tests those pesticides for which a formulated, commercially available product is approved for use locally (permethrin, deltamethrin, chlorpyrifos, malathion, etofenprox, and phenothrin) and tests are carried out using technical grade chemical solutions made in acetone. Preliminary results have shown resistance towards all insecticides tested, including both pyrethroids and organophosphates. Due to the challenging situation of insecticide resistance in Puerto Rican *Aedes aegypti*, the PRVCU has pledged to continue regular testing to provide reliable data of the up-to-date status of *Aedes aegypti* insecticide resistance on the Island. This data will serve as guidance for stakeholders and municipalities of Puerto Rico, reinforcing the need of implementing integrated strategies for the control of *Aedes aegypti*.

147 Susceptibility status of immature and adult stages of Aedes aegypti against conventional and biorational insecticides in Mexico

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In México, the mosquito vector-borne diseases are of public health concern due to their impact on human health. The use of insecticides against immature and adult mosquitoes is one of the most common ways to control population density. However, the use of these compounds has resulted in the development of insecticide resistance. The first aim of this study was to estimate the susceptibility to six pyrethroids, two carbamates and two organophosphates against adult *Aedes aegypti* mosquitoes. The second aim was to assess the efficacy and two-months residual activity of two larvicides and three growth regulators (GRs). All insecticides are approved and under current use by Ministry of Health. Bottle insecticide susceptibility tests were performed on adult mosquitoes from 75 localities, covering 28 states. The efficacy and residual activity of the larval products were measured in in 1-liter or 200 L water storage containers (with and without 50% of water replacement). For larvicides and GRs, populations from 28 and 15 states (respectively) were examined. Results showed, the carbamate insecticides were the most effective group in terms of 30-min fallen adult mosquitoes (72-100%) and 24 h mortality (97-100%). High and widespread resistance was observed to pyrethroids type I and II and to a lesser extent to organophosphates. Insecticide susceptibility among states was highly variable. For larvicides, products showed the desired toxic effect in terms of mean acute mortality and residual activity. The efficacy of the products could depend on their presentation (granule or tablet). The GRs showed the desired toxic activity against larvae with an excellent residual effect. No differences between treatments with and without water renewal were found. Regular insecticide resistance monitoring data is now essential to schedule interventions and will confirm their sustainability. Biorational formulations are an acceptable alternative and important tool of an integrated vector control programme.

148 Preventing the colonization of Aedes (Stegomyia) aegypti in new regions: Puerto Nariño, Amazonas, Colombia

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Aedes aegypti is the main vector of dengue, chikungunya, Zika and yellow fever, amongst other arboviruses in the Americas. These arboviruses have been expanding to new regions, increasing the risk of human transmission due to the colonization of the vector to new areas. Prior to 2016, *Ae. aegypti* had not been reported in the town of Puerto Nariño, Amazonas, Colombia. Our subsequent survey of *Ae. aegypti* found low numbers in few houses, indicating a potential public health problem in a community of 2000 inhabitants

that live in Puerto Nariño. The aim of this research was to prevent the colonization of *Ae. aegypti* in this locality, using Integrated Management Strategy and Integrated Vector Management. Working with the community and local health institutions, we developed an immediate strategy to prevent vector colonization. 1. Evaluation of the colonization with ovitraps. 2. Elimination of breeding sites. 3. Insecticide spraying to kill adults. 4. Surveillance for 18 months. In the laboratory mtDNA (COI) sequencing and analysis was carried out. The control strategy implemented was successful. After 18 months of surveillance, *Ae. aegypti* was absent from the entire town. The mtDNA COI analysis revealed that *Ae. aegypti* of Puerto Nariño shared the same ´West African´ haplotype with specimens from Leticia (Amazonas) and Bello (Antioquia) Colombia, and Venezuela, USA, Vietnam and Thailand. This differs from the East African´ clade found in Brazil, Mexico, Tanzania, as well as, Bello (Antioquia) Colombia. Integrated vector control programs are effective strategies to control the colonization of diseases transmitted by mosquitoes. Community education on the vector and the risk of diseases that they transmit raises awareness of the potential health problem. Early alerts for vector invasion and active community and local institution partcipation, are good strategies to prevent the colonization of *Ae. aegypti* to new regions.

149 Heritability, frequency of kdr mutations and detoxifying enzymes, after deltamethrin selection in Aedes aegypti from Mexico

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Aedes aegypti (L.) is the main vector of dengue, Chikungunya, and Zika in Mexico. Despite the efforts to develop a vaccine for dengue, these have not been efficient. However, the elimination of breeding sites and chemical control remain the main strategies to reduce vector-human contact and interrupt transmission. Unfortunately, the use of insecticides favors the development of resistance, impacting cost-effectively control programs. In this study, six natural populations of *Ae. aegypti* were selected artificially in the laboratory with deltamethrin through five generations using the CDC bottle bioassay method. Realized heritability (h^2) of the resistance was determined and the frequency of mutations C1534F, V1016I, and V410L as well as enzymatic activity was determined in each generation of selection. Our results indicate an increase in the LC_{50} and KC_{50} parameters with respect to the basal generation (FS_5 Vs FS_0). Two populations from Merida and Hoctun, both from the state of Yucatan showed the highest values of h_2 >0.7 for the parameter LC_{50}. The highest value of h^2 for the parameter CK_{50} was obtained also in a population from the same state called Progreso. Enzymes activity varied significantly after five generations of selection, however without a significant increase in activity after five generations of selection.

150 Evaluation of insecticides susceptibility through modification of microbiome in Aedes aegypti.

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Aedes aegypti is the mosquito that transmits viral diseases such as Dengue, Chikungunya and Zika. The microbiota in insects is recognized for its role in the regulation of digestion processes, metabolism, egg production, development, and immune response. However, the physiological importance of these bacteria in the insecticides susceptibility has not been established to date. Therefore, the objective of the study was to evaluate the susceptibility of two insecticides (permethrin and deltamethrin) modifying its microbiome with antibiotics in *Ae. aegypti*. Adult mosquitoes were fed with solution of sucrose mixed with antibiotics, and then exposed to insecticides. DNA was extracted from the samples with the ZymoBIOMICS® DNA Microprep kit. To finally perform targeted sequencing of the bacterial 16S ribosomal RNA gene using the NGS Quick-16S ™ library preparation kit. The final library was sequenced in the Illumina® MiSeq ™ sequencer with a v3 reagent kit. Our results show in a phylum level *Proteobacteria* (92.4%) and *Bacteroidetes* (7.6%) as a natural resident in *Ae. aegypti*. When microbita was modified we observed an increase in the mortality when they were exposed to insecticides in those treatments. The most abundant species in these treatments were *P. agglomerans* (38.40%) and *Ps. azotoformans-fluorescens-synxantha* (14.20%) with permethrin, while *E. meningoseptica* (38.4%), *Ps. azotoformans-fluorescens-synxantha* (26.1%) when exposed to deltamethrin. These results demonstrate the importance of the microbiota in insecticide response. Our finding will give us a start for development of new vector control strategies.

151 Silencing of the Dsx gene in Aedes aegypti for its population control.

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The mosquito Ae. aegypti is the main vector of different viral diseases such as Dengue, Sika, Chikongunya and Mayaro. Nowadays there is no completely effective control method for mosquito control because they have different mechanisms of resistance to insecticides. In this work we present how a bio-molecule called DsiRNA can help control the populations of this mosquito.

152 A new high-resolution melting analysis for the detection and identification of Plasmodium in human and Anopheles vectors of malaria

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Among vector-borne diseases malaria is the leading cause of morbidity in the world, with more than 200 million cases per year and a large number of deaths. The techniques traditionally used for the detection of *Plasmodium* in humans and *Anopheles* mosquitoes include microscopy, IRMA, ELISA, antibody or molecular assays, and anopheline dissection. However, these techniques are limited by their requirement of skilled personnel, low sensitivity or long processing times. A PCR-based high-resolution melting (PCR-HRM) analysis was developed for the detection and identification of *P. falciparum, P. vivax* and *P. malariae* that infect humans and *Anopheles*. In 15 human samples PCR-HRM detected four samples positive for *P. vivax*, three for *P. falciparum* and two *for P. malariae*. These results concurred with two benchmarking assays using microscopy on blood smears or nested PCR. Additionally, PCR-HRM was able to detect natural infection in *An. darlingi* infected with *P. vivax* and *P. falciparum*, and *An. mattogrossentis* infected with *P. vivax* (new record). The PCR-HRM presented is the first single assay developed for the detection and identification of *P. vivax, P. falciparum* and/or *P. malariae* in human and *Anopheles*. This method improves on currently available assays as it is easy-to-use, rapid, sensitive and specific with a low risk of contamination.

153 Importance of the assessment of the feeding patterns and co-existence of Leishmania spp in Lutzomyia spp captured in an anthropogenic zone.

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Due to the co-existence of several species of the genus Lutzomyia in a focus of transmission of Leishmaniosis, we proposed to determine the infection rate and the feeding patterns of the sandflies population in a community considered as hyperendemic for American Cutaneous Leishmaniasis (ACL). The trial conducted intradomicile and peridomicile of 24 houses distributed randomly in the locality, for one year considering the fumigation interventions and collecting data before and after the sprayings. We considered the most abundant species in the site*: Lutzomyia trapidoi*, *Lutzomyia gomezi*, *Lutzomyia panamensis*, *Lutzomyia triramula* and *Lutzomyia dysponeta*, and detected the infection of *Leishmania* spp in females, using oligonucleotide of the region Internal transcribed spacer -1 (ITS-1). Positive samples suggest that *Leishmania panamensis*, *Leishmania naiffi* and other *Leishmania spp*. were the most common and confirming the co-circulation of several parasites. On the other hand, the analysis of the blood meal, using cytochrome b suggested feeding patterns that include domestic animals, showed changes in the alimentary patterns of these species and their intrinsic capacity to adapt to a new habitat. Our data provide scientific evidence on the current status of transmission of Leishmaniosis, with the aim of contributing to the establishment of integrated vector control measures that involve applications of traditional or novel techniques. In this way, implement strategic plans for sustainable intervention over time, and that effectively corresponds to the decrease in cases of Leishmaniosis in Panama.

Disease/Vector Studies II

160 Aedes, it's cold outside! Meet the northernmost overwintering population of aegypti in the continental U.S.

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Aedes aegypti is a major vector for dengue, Zika, chikungunya and yellow fever in the tropics; however, it has also maintained an intermittent presence in temperate regions. Its establishment and proliferation has been assumed to be limited by cold temperatures roughly southward of the average 10°C winter isotherm (~33°N latitude) in the U.S., which runs between South Carolina and southern California. Nevertheless, Ae. aegypti has been detected in Washington, DC, every year since 2011, a city that is significantly colder (average 3.5°C winter isotherm) and further north (~39°N latitude) than this species' normal or extreme range.

A single female Ae. aegypti was serendipitously collected in October 2011, from the Capitol Hill neighborhood of Washington, DC, after complaints of mosquitoes inside a basement apartment. A total of 115 Ae. aegypti were collected from nine subsequent larval surveys (2011 to 2014) of container habitats within ~200 m of the original location. Studies published in 2015 and 2018 identified the same two haplotype sequences from those individuals and found this population to be most similar to populations in Florida. This, and the lack of new alleles across years, supports the conclusion that this a resident population, maintained during winter months in subterranean habitat that facilitates winter survival. Mosquito surveillance data posted on DC's Department of Health website since 2016 confirm that Ae. aegypti is routinely collected from different areas in Washington, DC, during the mosquito season. Across the Potomac River in Fairfax County, VA, only one Ae. aegypti was collected between 2003 and 2014, in 2007. From 2015 to 2018, however, Ae. aegypti has been found at 18 additional locations. The influence of climate change and the ability of this species to adapt to breeding underground may expand the range of this medically important species in years to come.

161 Evaluation of the accuracy of species distribution models related to arthropod vectors of medical importance

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Species distribution models (SDM) are commonly used to predict and study the distribution of medically important arthropod vectors. However, with a wide range of SDMs available, it can be difficult to determine which method best suits one's genus of interest. Ideally, one would select the SDM which consistently provides the most accurate predictions, yet an optimal model is not clear based on previous comparison studies. We conducted a meta-analysis to determine which SDM was most consistently accurate based upon area under receiver operating curve (AUC) statistics from SDMs for different genera of arthropod vectors. Fourteen methods were applied to arthropod vectors, though model use was not uniform across genera. The most common SDMs included maximum entropy, general boosting models, and genetic algorithm for rule set production. SDM accuracy differed among genera and family classifications, where different methods were found to have significantly higher AUC values depending on group considered. Maximum entropy models only outperformed other SDMs in one genus, highlighting that the most common model may not be ideal for all taxa. Identification of the optimal model will allow management officials to better predict vector distribution and select adequate management options to prevent outbreaks of diseases. Due to potential bias of the literature and drawbacks of AUC, further comparisons with more than one accuracy statistic is required to determine the optimal SDM for arthropod vectors.

162 Implementing Loop-Mediated Isothermal Amplification (LAMP) Testing into Tangipahoa Mosquito Abatement District Lab Operations

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This year, the Tangipahoa Mosquito Abatement in Hammond, Louisiana has implemented loop-mediated isothermal amplification (LAMP) testing into their lab operations. Currently, mosquito samples are sent for testing at the Louisiana State University veterinary lab, and results are received 7-10 days after the mosquitoes are collected. The new procedure enables results within one day of collection, thus reducing wait times and allowing for earlier treatments of at-risk areas. This new process will not replace the use of the LSU vet lab, but will serve as supplement testing during the mosquito season. This presentation will discuss costs, equipment setup and use, challenges, and briefly summarize the testing process.

163 Jamestown Canyon virus revisited: are we neglecting an under recognized disease
Theodore Andreadis (theodore.andreadis@ct.gov), Philip Armstrong

Jamestown Canyon virus (JCV) is a mosquito-borne Orthobunyavirus in the California serogroup that appears to be enzootic throughout much of temperate North America. JCV can cause acute febrile illness, meningitis or meningoencephalitis, but reports of human infection in the United States are rare. However, recent findings involving increased case recognition, suggest that human infections in the United States may be largely under recognized. The primary reservoir and amplifying vertebrate hosts are unknown, but white-tailed deer, *Odocoileus virginianus* have been incriminated based on experimental infections and the prevalence of neutralizing antibodies in wild populations. JCV has been found in a diverse array of mosquito species, especially boreal *Aedes* and *Anopheles*, but the principal vectors vary widely based on geographic and seasonal distribution. In this presentation, the spatial and temporal patterns of virus activity in mosquitoes as a function of mosquito abundance, land use characteristics, and vertebrate host distribution and abundance will be examined based on mosquito and arbovirus surveillance conducted throughout Connecticut over a 21-yr period, 1997 through 2017. The phylogenetic relationships of JCV isolates circulating in this region will also be examined.

164 Environmental surveillance for emerging arboviral diseases in Harris County for 2016 to 2018
Maximea Erasmea Vigilant (max.vigilant@phs.hctx.net), Mustapha Debboun

Arboviral disease surveillance have been conducted within Harris County and the City of Houston with a degree of consistency for more than 50 years. Environmental surveillance activities are distributed geographically to protect approximately 5 million residents who live within the 1,778 square miles of Harris County and the City of Houston. With the continued threat of emerging vector-borne diseases, the Mosquito and Vector Control Division of Harris County Public Health has expanded its efforts to monitor the *Aedes* mosquito population i.e, *Aedes aegypti* (Linnaeus) and *Ae. albopictus* (Skuse) for Dengue (DENV), Chikungunya (CHIKV), and more recently Zika (ZIKV) viruses. This was accomplished by increasing the number of Biogent Sentinel (BG) traps, pooling and testing all *Ae.aegypti* and *Ae.albopictis* specimen collected from the field. More than 57,000 *Ae.aegypti* and 113,915 *Ae.albopictis* mosquitoes were collected from more than 13,000 trapping events. Approximately 80% of these specimens were pooled and submitted for virus testing. There were no positive isolates for the above mentioned diseases

165 It doesn't always block! Wolbachia effects on arbovirus infections in mosquitoes are variable
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The bacterial symbiont Wolbachia is known to reduce pathogen infection and transmission in vector arthropods, leading to field trials examining Wolbachia for vector-borne disease control. However, pathogen suppression is not universal; Wolbachia strains have been demonstrated to enhance rather than suppress pathogens in a variety of natural and artificially infected arthropod hosts. Here, we investigated the effects of multiple Wolbachia strains on multiple viral pathogens in multiple mosquito vectors and show that Wolbachia may suppress, enhance, or have no effect on virus infection. These data indicate that the suppressive effects of Wolbachia infection on arboviruses are not universal, but rather depend on the characteristics of the specific symbiont-vector-pathogen system in question. These results have important implications for the deployment of Wolbachia-infected mosquitoes into field populations for disease control.

166 40 Years of Sentinel Chicken Surveillance
Sherry Burroughs (s.burroughs@irmosquito2.org)

The Florida State Board of Health established the Sentinel Chicken Arboviral Surveillance Program for St. Louis encephalitis (SLE) and eastern equine encephalitis (EEE) viruses in 1978, following the 1977 central Florida SLE epidemic. Indian River Mosquito Control District (IRMCD) is one of the 11 Florida programs that has been monitoring sentinel chickens since the program's existence. Over the last 40 years some aspects of the program have changed, while others have remained the same. The presentation will overview the historic data, highlighting the active years of seroconversion, and how the IRMCD's program has adapted over the last 40 years.

167 Creating an inexpensive assay for the detection of West Nile Virus (and others) in mosquito pools, using the QuantStudio real-time PCR system
Chip Hancock (chancock@scgov.net)

This QuantStudio is a recently developed real-time PCR system that is on the rise in local and state mosquito virus surveillance programs. This is largely due to the commercially available, multiplex assay for

the detection of Zika/Dengue/Chickungunya in field collected mosquitoes. The ability of the machine to multiplex and the commercially available assay have led to adoption of the platform in at least three Florida mosquito control districts so far, as well as Florida Department of Health to subcontract their testing to a private laboratory that uses the technology. Sarasota County Mosquito Management had been conducting molecular testing for West Nile Virus in mosquito pools for several years, but built a real-time PCR laboratory in 2016 around the QuantStudio platform and technology. The system requires a specialized probe type that renders previously published primer/probe sets ineffective. Due to the lack of inexpensive, commercially available assays for the system, a specialized Taqman assay for the detection of West Nile Virus was produced in house. This is an overview of how that assay and others can be created for the QuantStudio series, including proof of detection from field collected mosquitoes within the county.

168 Transcriptional profile of lachesin in Aedes aegypti: developmental regulation and arbovirus infection

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Lachesin, a cell surface protein, is required for the proper morphogenesis of some insect tracheal systems. Lachesin is expressed on the surfaces of differentiating neuronal cells from the onset of neurogenesis in both the central and peripheral nervous systems. The protein Lachesin is required for the blood-brain barrier in *Drosophila*. Lachesin from *Aedes aegypti* (*AaeLac*) was differentially expressed in the RNA-seq of those infected with Zika virus (Zhao et al., 2018). To confirm whether *AaeLac* is a critical metabolic pathway in mosquitoes in response to Zika and Chikungunya viruses, we have examined *AaeLac* genes expressed in different developmental stages of *Ae. aegypti* including Key West and Orlando strains. The gene expression of *AaeLac* through developmental stages and infected with Zika and Chikungunya viruses was analyzed using qualitative real-time polymerase chain reaction (qPCR). This information may provide a better understanding on how *AaeLac* responds to different arboviruses with implications for the development of mosquito control strategies.

Tackling Ticks: Moving beyond mosquito control Symposium

169 The New Jersey Tick Blitz: Leveraging the expertise of the mosquito control community for baseline tick surveillance

Andrea Egizi (andrea.egizi@co.monmouth.nj.us), Jim Occi, Dana Price, Dina M. Fonseca

Incidence of tick-borne disease (TBD) in the northeastern states is increasing. New pathogens have been identified and vector distributions are expanding. Unfortunately, the information and expertise needed to assess risk, inform the public and act proactively is dramatically lacking in many places. We developed and tested a methodology for obtaining baseline tick surveillance data by training and mobilizing existing personnel within local agencies, using the New Jersey mosquito control community as an example. New Jersey has a strong mosquito control infrastructure comprised of agencies in all 21 counties that work collaboratively with each other and with the state Office of Mosquito Control Coordination and Rutgers University's Center for Vector Biology. However, there is no statewide tick surveillance in NJ. We (1) organized a training workshop open to representatives from each agency with information on tick biology, identification, and surveillance techniques, followed by (2) a 1-day "Tick Blitz" in which representatives from each agency simultaneously collected ticks in their respective counties using the same SOP, and (3) developed a surveillance website where tick ID and pathogen testing results are made available to participants and mapped across the state. We were able to secure the participation of nearly all NJ counties and were successful in obtaining a "first look" at current tick distributions, including the American dog tick *Dermacentor variabilis* never before surveyed in NJ. While a 1-day snapshot is far from optimal surveillance, a "Tick Blitz"-like strategy leveraging existing personnel and expertise may represent the only means to achieve minimal tick surveillance in many areas. By sharing our results, strategy and training materials we hope to raise awareness about the need for improved tick surveillance in the US as well as the capabilities of existing agencies to fill this role if provided additional resources.

170 Spotted fever Rickettsia present in ticks collected during the first New Jersey "Tick Blitz"

Jim Occi (james.occi@rutgers.edu)

We held the first state-wide Tick Blitz in New Jersey in May 2018. The Blitz was a two part-process: first, a workshop to train representatives of NJ's extensive network of mosquito control programs in tick biology, surveillance and identification and, second, a simultaneous state-wide survey of *Dermacentor variabilis* (the

American dog tick), a species that had not been surveyed in NJ. *D. variabilis* is the purported vector of *Rickettsia rickettsii* (the agent of Rocky Mountain spotted fever, RMSF), a highly pathogenic bacteria. Human cases of RMSF and related spotted fever illnesses have been on the rise across the mid-Atlantic states, including in NJ. In 2017 the NJ Department of Health reported 137 cases of "spotted fever rickettsiosis" (SFR). However, it is not clear if these cases are caused by *R. rickettsii* or a different Rickettsia species, nor which ticks are transmitting them. In an attempt to define the species of Rickettsia circulating in NJ ticks, we used a high-throughput qPCR approach to screen for SFR in *D. variabilis* with both general Rickettsia and species-specific assays targeting *R. rickettsii* and *R. parkeri*, another tick-borne human pathogen. Here we present the results of our SFR screening of NJ ticks collected during our New Jersey Tick Blitz.

171 NJ mosquito control professionals' experience with the Tick Blitz

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In May of 2018 the Rutgers Center for Vector Biology team tasked mosquito commissions from 21 New Jersey counties to survey the species of ticks in their respective territories as part of a state-wide Tick Blitz. With backgrounds that specialized in mosquito habitat, this new Tick Blitz allowed county mosquito control groups to expand their areas of surveillance from swamps and standing water into open fields and meadows. For some counties, tick observation and collection were a new concept. With help from the Rutgers Tick Blitz team through demonstration and discussion a standardized method for the one-day blitz was presented to all participants. What follows are the experiences of two mosquito inspectors from different counties as they detail the challenges, successes, and lessons learned from the 2018 Tick Blitz.

172 Ticks vs. Mosquitoes

Dina Madeira Fonseca (dina.fonseca@rutgers.edu)

Mosquito (Insecta: Diptera: Culicidae) surveillance and control has more than 100 years of history in the United States. While funding for organized local, state and federal programs has risen and fallen in response to mosquito-borne epidemics, scientific breakthroughs and economic downturns, mosquito surveillance and control is an *established trade*. At national and international meetings, such as those of the American Mosquito Control Association, seasoned experts, academics, and the industry share information and learn from each other's experiences and accumulated knowledge. In contrast, tick (Arachnida: Acarina: Ixodidae) surveillance and control, apart from the invasive cattle ticks in the southern US that are a livestock concern, is still primarily limited to grant-funded academics and federal research institutions such as the CDC. Incredibly, ticks are responsible for over 60% of all combined human vector-borne diseases in the US (including ticks, mosquitoes, mites and fleas, source: CDC). Tick-borne Lyme disease is by far the most common vector-borne disease in the US. I will compare tick and mosquito biology, life-history, ecology, research foci and quirks as well as obstacles to effective surveillance and control in an effort to facilitate the communication needed for a constructive flow of information and the development of effective programs and collaborations.

173 Status of Haemaphysalis longicornis in the U.S."

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In November 2017, *Haemaphysalis longicornis* (Asian longhorned tick) was confirmed on a sheep in Hunterdon County, New Jersey and for the first time outside of quarantine in the United States. This exotic tick is parthogenetic, feeds on a wide variety of vertebrates including livestock and humans, and has been found to vector numerous viral, rickettsial, bacterial, and protozoal pathogens in its established range in Australia, Asia, and New Zealand.This talk will discuss detections in the United States since November 2017.

174 Tick surveillance and control programs in the United States of America

Laura Harrington (lch27@cornell.edu), Emily Mader, Annie Geiger

Background: Northeast Regional Center for Excellence in Vector-Borne Diseases (NEVBD), in conjunction with Regional Centers of Excellence (CoE) across the USA, conducted a survey among public agencies to gain a greater understanding of tick surveillance and control programs operating at state, local, and municipal levels. **Methods:** NEVBD investigators drafted the initial survey instrument using Qualtrics, which underwent two iterations of beta testing, with testers selected from each of the five CoE catchment areas and a variety of state and local agencies. The survey was disseminated following a snowball sampling approach using key contacts in state and local public agencies, and was advertised through CoE social media accounts. The questionnaire opened July 12, 2018, and closed September 10, 2018. NEVBD

investigators at Cornell University conducted descriptive analyses and qualitative assessments of survey responses. **Results:** 131 respondents from 42 state and territorial jurisdictions completed the survey. Most respondents worked within a county/district jurisdiction (57%), followed by state (56%), and local/municipal jurisdictions (20%). Of the 82 respondents answering questions on tick surveillance programs, 93% indicated routine, regularly implemented active tick surveillance; 88% indicated irregular/*ad hoc* active tick surveillance; and 88% indicated that passive tick surveillance was conducted in their jurisdictions. The most highly targeted tick species within these programs included *Ixodes scapularis* (87%), *Amblyomma americanum* (84%), and *Dermacentor variabilis* (84%). The most common pathogens tested for were *Borrelia burgdorferi* (83%), *Anaplasma phagocytophilum* (57%), *Babesia microti* (56%), and *Borrelia miyamotoi* (56%). Only 17 respondents stated that their jurisdiction or program directly supports tick control efforts. Common barriers to operating tick surveillance and control programs included funding constraints, competing priorities for limited resources, and lack of trained personnel. **Conclusions:** Results from the survey will enable a deeper understanding of potential mechanisms for overcoming barriers to tick and tick-borne disease surveillance across the nation.

Latin American Symposium III

175 Re-introduction of indoor residual spraying as a tool to accelerate Malaria elimination in Escuintla, Guatemala

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Guatemala has committed to eliminate malaria by 2020. In 2017, the department of Escuintla reported 2,434 cases, accounting for 60% of the national case burden despite only containing 5% of the country´s population. Although malaria cases nationwide have declined nearly 50% in the last decade, caseload in Escuintla has remained constant. In 2011, long-lasting insecticidal nets replaced indoor residual spraying (IRS) in Escuintla. Prompted by stagnant case counts and a drive to accelerate to elimination, the malaria program initiated an IRS pilot to determine the operational feasibility of re-introducing this intervention. The first round of the pilot was conducted in December 2017 in Las Cruces, a locality in Escuintla reporting the highest number of cases in Guatemala that year, with a second spray round conducted in May 2018. The coverage achieved during these two rounds was 91% (number of rooms sprayed of visited sprayable rooms) and 84%, respectively. Electronic tools for data collection and decision-making were deployed, and operational, epidemiological, and entomological data were evaluated to determine feasibility of IRS scale-up. The results demonstrated that IRS is an operationally feasible and accepted intervention for malaria elimination in Escuintla based on timeline, acceptance, coverage, peak biting time, and impact. Epidemiological data show that the average weekly number of cases in Las Cruces was lower during the 2017-2018 high transmission season compared to the two previous seasons, while surrounding communities saw an average upward trend in cases during this time. Given human resource constraints, the feasibility of incorporating community volunteers as spray operators will be evaluated beginning in September 2018. Lessons learned will inform a scale-up of operations to commence in October 2018 in key malaria foci throughout the department, and may be relevant to other countries in the region as they advance to malaria elimination.

176 Spatial repellency and contact irritancy in Aedes aegypti to insecticides recommended for IRS and ITNs in Mexico

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Most studies on insecticides have focused on the toxicological effects on mosquito populations such as knockdown and killing; whereas less research has been done on the behavioral responses as a result of chemical exposure. Studies have shown that most chemical compounds influence insect behavior, often resulting in excitation and movement away from treated surfaces and "avoidance behavior". The present study aimed to evaluate the behavioral response of a field population of *Aedes aegypti* resistant to pyrethroid insecticides against 8 insecticides used in Mexico for Indoor Residual Spraying (IRS) and Insecticide-Treated Nets (ITN). The HITSS (High-Throughput Screening System) modular system was used to evaluate contact irritation and spatial repellency. The insecticides alpha-cypermethrin, deltamethrin,

lambda-cyhalothrin, bifenthrin, pirimiphos-methyl, bendiocarb, propoxur and, fipronil were tested at 4 doses: 0.025, 0.25, 25 and 250 nmol/ cm^2. In general, the number of mosquitoes escaped from the treatment chambers increased with respect to the increase in doses for all insecticides. A significant contact irritancy response was found ($p < 0.05$) for bifenthrin at 25 nm/cm^2, deltamethrin at 2.5, alpha-cypermethrin, lambda-cyhalothrin and propoxur at 0.025. Spatial repellency response was nearly uniform among: deltamethrin (9 to 12%), alpha-cypermethrin (7 to 14%), lambda-cyhalothrin (3-13%), propoxur (3-17%) and pirimiphos-methyl (8-17%).

177 Challenges and new technologies to control Dengue, Zika and Chikungunya in Brazil

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CHALLENGES AND NEW STRATEGIES IN THE OPERATIONAL SCENARIO FOR THE CONTROL OF Aedes aegypti IN BRAZIL RECURRING PROBLEMS • Limited and temporary impact of vector control actions (reactive actions generally based on the use of insecticides). • Urban areas still represent a major challenge for vector control. • Limited human, material and financial resources. • Vertical programs do not take into account the heterogeneity and diversity of Ae. aegypti and the transmission cycles at the local level. GOAL Provide a framework of reference and technical guidelines for the planning and implementation of surveillance actions, prevention and control of Ae. aegypti based on risk stratification to support the construction of possible operational scenarios at the local level. The operational scenarios serve as a reference for the selection of the most appropriate vector control tools and their most efficient use. PROPOSAL Guide for the implementation of interventions based on generic operational scenarios for the control of Aedes aegypti in Brazil. Content: 1. Introduction 2. Update on Aedes aegypti surveillance and control methods. 2.1. Bioecology of Ae. aegypti and its importance for surveillance and control purposes. 2.2. Entomological surveillance 2.3. Vector control. 3. Operational scenarios to address the surveillance and control of Ae. aegypti. 3.1. Strategies for surveillance, prevention and control. 3.2. Surveillance, prevention and control strategies according to operational scenarios. 4. Risk stratification in the scenarios. 4.1. Spatial stratification. 4.2. Temporality of interventions. UPDATE OF SURVEILLANCE METHODS AND CONTROL OF Aedes aegypti. • High prevalence of closed / abandoned / reluctant homes. • The risk unnoticed by residents of an eminently domestic species. • Low densities to trigger transmission and high reproductive capacity. • Presence of critical breeding sites. • Resistance to egg desiccation. • Resistance to major chemical groups of insecticides. • Lack of sufficient agents for routine actions in cities.

178 Operational evaluation of modified larvitraps versus ovitraps for the monitoring of Aedes aegypti populations in Tapachula, Chiapas

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Background. Monitoring *Aedes aegypti* populations is crucial in the context of epidemiological surveillance and to evaluate the impact of control measures. It is also important in the collection of specimens to monitor resistance to insecticides. We are reporting herein the performance of a larvitrap that allows to collect in a fast and effective way immature stages of *Aedes* spp. Objective. Evaluate a modified larvitrap for the rapid collection of *Ae. aegypti* versus the use of traditional ovitraps. Materials and methods. The larvitraps were built with half a tire, to which a valve was incorporated in the lower part to drain the contents in a 2 L collection container. Each larvitrap was placed paired with an ovitrap of 1 L capacity. A total of 20 larvitraps and 20 ovitraps were placed in the same number of houses in a neighborhood in the city of Tapachula. Results The larvitraps collected *Ae. aegypti*, *Ae. albopictus* and *Culex* spp. in proportions of 88.08%, 11.77% and 0.15%, respectively. While with ovitraps only *Ae aegypti* and *Ae. albopictus* in proportions of 85.01% and 14.99%, respectively, were collected. Adult productivity of *Ae. aegypti* obtained from larvitraps was of 9,014 individuals compared to 4,043 from ovitraps. The same proportion, but in smaller quantities was registered for *Ae. albopictus*, with 1,205 adult from larvitraps and 713 from ovitraps. The times required for the review and collect specimens by modified larvitraps and traditional ovitraps, were similar. However, when comparing the time required with the unmodified larvitrap, it was significantly greater than with the modified larvitrap. Conclusions The modified larvitrap is an effective, sensitive and safe method, despite its simple modification, surpassing the ovitrap. It can be used for both, epidemiological surveillance and to evaluate control measures, as well as for the monitoring of insecticide resistance in sentinel sites.

179 Entomological efficacy of aerial ultra-low volume insecticide applications against Aedes aegypti in Mexico

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A cluster-randomized controlled trial quantified the entomological efficacy of aerial ultra-low volume (AULV) applications of the organophosphate insecticide chloropyrifos against *Aedes aegypti* in Puerto Vallarta, México, during November-October 2017. The trial involved 16 large (1x1 km) clusters distributed 1:1 between treatment and control arms. The primary endpoint was the abundance of *Ae. aegypti* indoors (measured as number of total adults, females and blood-fed females) collected using standardized Prokopack collections. After four consecutive weekly cycles of AULV spraying,all adult *Ae. aegypti* infestation indices were significantly lower in the treatment arm compared to the control arm (odds ratios and incidence rate ratios all ≤0.28). Efficacy in reducing indoor *Ae. aegypti*abundance increased with each weekly application cycle from 30% to 73% (total adults), 33% to 76% (females) and 45.5% to 89%, (blood-fed females). All entomological indices remained significantly lower in the treatment compared to the control arm up to two weeks after the fourth spraying round. Performing AULV spraying can have significant and lasting entomological impact on *Ae. aegypti* as long as multiple (ideally four) spray cycles are implemented.

180 Fludora Co-Max®: A new space spray combination for mosquito resistance management programs.

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Mosquito resistance to conventional insecticides is becoming an increasing threat to the fight against vector borne diseases. We have developed a new product for space spray application combining two active ingredients with different modes of action. One of Active Ingredient is of a new chemistry class for space spray applications while the other one is a pyrethroid with special characteristics. It is based on a new proprietary formulation. The unique features of the active ingredients and efficacy results will be discussed.

181 Eficacia biológica de Fludora CoMax ® (Flupyradifurone 26.3 g IA/l + Transfluthrin 52.5 g IA/l) para el control de mosquitos adultos en rociado espacial domiciliario con niebla térmica aplicado con equipo portátil en México.

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Se evaluó eficacia biológica de Fludora CoMax® (Flupyradifurone 26.3 g IA/l + Transfluthrin 52.5 g IA/l) aplicado en niebla térmica con equipo portátil en el interior de viviendas a dosis de 0.4 g IA/ 1,000 m^3. Recomendación Global. Fludora CoMax® mezclado con agua se aplicó desde la puerta principal de acceso de la vivienda sin desplazarse al interior, se cubicaron previamente para obtener su volumen para obtener el tiempo de descarga del equipo en función del tamaño de la casa. Se cerraron puertas y ventanas que comunican con el exterior y se ubicaron jaulas con hembras de mosquitos *Aedes aegypti* en sala, comedor, pasillos y recamas dejando fluir la niebla a través de todo su interior saturándose libremente durante 30 minutos posteriores al tratamiento. Transcurrido este tiempo se reingresó a la casa ventilándola y se hizo lectura de mosquitos derribados y las 24 de mortalidad. Se logró el objetivo al obtener mortalidad de ≥ 98% de los mosquitos expuestos.

182 Biological effectiveness of FLUDORA CO MAX (Flupyradifurone EW 026.3 g / L + Transfluthrin 052.5 g / L) for the control of mosquito vectors of dengue, chikungunya and Zika virus in southern Mexico.

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During the present study, the effectiveness of the FLUDORA CO MAX formulation (Flupyradifurone EW 026.3 g / L + Transfluthrin 052.5 g / L) applied as a thermal fog against the mosquitoes *Aedes aegypti* and *Aedes albopictus* transmitters of the dengue, chikungunya and Zika viruses was evaluated . The study site was carried out in "La Primavera", a colony of Tapachula, Chiapas state, Mexico, endemic to these diseases. Four houses were selected, and cages were placed with 15 female mosquitoes of the aforementioned species (resistant and susceptible to pyrethroids), two to three days old, fed with a 10% glucose solution; the mosquitoes within cages were distributed in the living room, kitchen and bedroom. Subsequently, FLUDORA CO MAX (Flupyradifurone EW 026.3 g / L + Transfluthrin 052.5 g / L) was applied at a dose of 0.4g i.a / 1000m3 using a SwingFog® SN50 thermospray device. As a control, a house was selected in which we put

the cages with mosquitoes but the insecticide was not applied. At the end of the test (60 minutes of exposure) the mosquitoes were taken to Centro de Investigación en Salud Pública (CRISP) laboratory and transferred to recovery vessels and kept under observation for 24 hours post-treatment, for reading and recording of the mortality. The biological efficacy of FLUDORA CO MAX (Flupyradifurone EW 026.3 + Transfluthrin 052.5) on *Ae. albopictus* was 100% in the living room, kitchen and bedroom; 98.89%, 97.78% and 95.95% in the living room, kitchen and bedroom respectively for *Ae. aegypti* susceptible strain; and of 99.44%, 96.67% and 97.29% in the living room, kitchen and bedroom respectively for *Ae. aegypti* strain resistant. The mortality in the controls was equal to 0%.

Operations/Genetics

183 The impact of Hurricane Irma on population density of the Black Salt Marsh Mosquito, Aedes taeniorhynchus (Wiedemann), in Collier County Florida

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In 2017, the Southeastern United States and Caribbean endured an extremely active year for tropical storm and hurricane activity. On September 10th 2017, Hurricane Irma made a second landfall in Florida (FL), striking Collier County – including Naples and Marco Island FL. These areas affected by Hurricane Irma are abundant in saltmarsh and mangrove swamps, prime breeding sites for the black salt marsh mosquito, *Aedes taeniorhynchus* (Wiedermann). Using both human landing rate and Biogents BG-Counter trap data, here we report the year-to-year fluctuations in population density of *Ae. taeniorhynhcus* populations. In 2017, Collier County experienced a population explosion of *Ae. taeniorhynchus* mosquitoes, with daily landing rates reaching as high as 150 adult females landing within a 2 minute period. The following year a dramatic population crash of *Ae. taeniorhynchus* was observed, representing some of the lowest *Ae. taeniorhynchus* numbers ever recorded in Collier County. Analysis of human landing rate and trap data following major hurricane strikes, including Hurricane Irma (2017) and Hurricane Wilma (2005), have revealed severe reductions in *Ae. taeniorhynchus* populations. Because *Ae. taeniorhynchus* accounts for a large majority of adulticiding missions in the State of Florida, an enhanced understanding of the factors contributing to *Ae. taeniorhynchus* population dynamics may allow for improved operational planning and decision making.

184 Operating a new insectary from ground up

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There are several practices and protocols in place for rearing mosquitoes and starting up an insectary, but these protocols exist based on what has been claimed as ideal for particular mosquito species. In North Texas, weather patterns and climate conditions are extremely variable, thus making it quite difficult to obtain an exact preference for North Texas mosquitoes. Over the past year and a half, we have focused our efforts on collecting, rearing, and blood feeding wild-caught North Texas *Aedes aegypti*, *Aedes albopictus*, and *Culex quinquefasciatus* mosquitoes. Over this span of time, there have been certain factors that have provided optimal conditions for longevity in our mosquito populations compared to our initial start-up conditions. In this study, we will cover the variables that have provided a new template for what may be more favorable for mosquitoes in North Texas, including day/night cycle, temperature, humidity, best methods for blood feeding, and further aspects of mosquito rearing. We anticipate to compare a well-established colony to our wild-caught mosquitoes under the same conditions and discuss the results in a future study.

185 Lone-worker Safety in Mosquito Control

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The Lone-Worker Safety Program of Grand River Mosquito Control District is created and maintained to ensure the safety of each employee by making every possible effort to minimize any hazards or risks employees may encounter while performing their job-related tasks and assignments, which are regularly carried out while working alone. It is important to manage hazards and risks by providing all required and/or reasonable safety equipment; including personal protective equipment (PPE), personal GPS safety monitors to continually locate lone-workers in the field, cell phones, IPads with specific site and access information, reliable vehicles with GPS trackers, and thorough, job-specific safety training. Supervisors assess and classify all treatment sites within the District and provide annually-updated access consent information for each property, entering the status on the GIS program installed on each field technician's iPad. Grand River Mosquito Control District utilizes a unique Access Consent Program to help ensure employee safety. This

program involves acquiring a property owner or resident signature on a simple, one-page access consent form that grants permission for employees to enter, inspect, and treat mosquito breeding habitats located on said properties. Since its inception in April of 2016, this program has been very successful in meeting the goal of eliminating land-owner confrontations regarding trespassing complaints.

186 "Tip this House" - A multi organizational mosquito-borne disease outbreak preparedness exercise under Incident Command System

Susanne Kluh (skluh@glacvcd.org)

On June 9, 2018 volunteers from the Medical Reserve Corps and from various public health volunteer network partners, such as CERT and TSUCHI, in cooperation with and under the leadership of two Los Angeles County vector control agencies and county health department emergency preparedness and response devision staff, participated in a mosquito-borne disease outbreak preparedness exercise. Public health volunteers had been trained to assist with information dissemination to residents as well as with door to door yard inspection and sanitation efforts to act as a force multipliers during a potential outbreak. Since any vector-born disease emergency response will have to be a multi agency effort of undetermined size, it would best use the Incident Command System (ICS) to ensure all participants are operating within a common organizational structure. This presentation describes organization, execution and outcome of the preparedness exercise.

187 A summer of Eastern Equine Encephalitis - Volusia County Mosquito Control response to EEE

Miranda Tressler (mtressler@volusia.org), Suzanne Bartlett, Drake Alexander Falcon

An overview of the unusual summertime activity of Eastern Equine Encephalitis in Volusia County and our response efforts. The mosquito-borne illness was first active in our sentinel chicken flocks at the beginning of the summer and was later confirmed in an emu flock and multiple equines. This activity was a precursor to the first human case of EEE in Volusia in over 15 years. Volusia County Mosquito Control has been consistently responding to domestic viruses such as Zika and Chikungunya over the past few years but this summer was focused on EEE. During this time, we faced a variety of challenges such as the boundary of our taxing district, communication with citizens, and a change in our primary contact for the Volusia County Health Department. We utilized the various tools of our integrated mosquito management program and collaborated with other organizations such as the Florida Medical Entomology Lab and the Florida Department of Agriculture and Consumer Services to maximize our response efforts.

188 Comparison of two trap-types for effective West Nile virus surveillance in St. Tammany Parish, LA

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A year's worth of surveillance in 2017 indicated CO_2-baited no-light CDC traps (NLC traps) were superior to CDC Gravid traps as a *West Nile virus* (WNV) collection method. Considering Gravid traps are the gold standard for collection of *Culex quinquefasciatus* and the detection of WNV, in 2018 we expanded the study to directly compare the efficacy of Gravid and NLC traps. Throughout the 2017 mosquito season, STPMAD placed both CDC Gravid and NLC traps at each of the 90 routine WNV surveillance locations across the Parish on a biweekly basis. NLC traps collected 4x as many total *Cx. quinquefasciatus* ($t(58)=-4.84$, $P<0.001$), and a higher diversity of species (Shannon diversity: 2.93) than the Gravid trap (1.06). 2.4x more WNV-infected pools were collected in NLC traps, but this was not statistically significant. No WNV-infected pools of *Culex salinarius* were detected in the CDC Gravid trap, while NLC traps caught 3. In 2018, a Latin square was performed at 32 sites, with an individual CDC Gravid/NLC trap set and rotated the following night to account for site variability. Nets were returned to the lab, counted, identified to species, and parity assessed. Results were analyzed in Minitab using a general linear model ($\alpha=0.05$). Results indicated NLC traps caught significantly more total mosquitoes ($F=2.31$, $P=0.002$), more *Cx. quinquefasciatus* ($F=4.43$, $P<0.001$), more host-seeking ($F=4.12$, $P<0.001$) and gravid ($F=1.91$, $P=0.013$) *Cx. quinquefasciatus*. No significant difference was observed between the two trap types with regard to species diversity ($F=1.46$, $P=0.095$), blooded ($F=1.23$, $P=0.236$), or engorged ($F=1.47$, $P=0.093$) *Cx. quinquefasciatus*. Results from these two studies suggest that the CO_2-baited no-light CDC traps may eliminate the need for multiple trap types for effective WNV surveillance.

189 Direct Mail, Text Messages, and an Impossible Goal - Resolving 2,000 Unmaintained Swimming Pools in Three Months

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Through a new program, the San Gabriel Valley Mosquito and Vector Control District was able to reduce the amount of staff and time needed to address unmaintained swimming pools. The program reduces the amount of physical interaction between residents and District staff. It uses a combination of direct mail and text message confirmation to motivate residents to fix issues on their own. In June of 2017, the District received its first ever list of swimming pools collected by aerial surveillance. The list contained photos of 3,569 unmaintained swimming pools within the 246 square mile district. The District's eight vector control specialists addressed the pools in the traditional way, making cold visits to each property to determine appropriate action. Working through the list dominated time and resources during the most critical time of year. Ultimately, the specialists had to give up at the end of October with hundreds of properties left unchecked, and swimming pools left unresolved. While the District resolved over a thousand mosquito breeding sources that year, it did not come close to reaching the full potential of aerial surveillance. The District needed to figure out a way to process these swimming pools much faster, using significantly less resources. This presentation will discuss the chronic nature of unmaintained swimming pools and the danger they pose. It will briefly examine the unsuccessful and unsustainable methods used in the past to address swimming pools. Finally, it will introduce a new program developed by the District to prioritize data provided by aerial surveillance and ultimately ensure that the thousands of swimming pools identified annually do not become a habitat for mosquitoes. The District tested the program in 2018 and successfully resolved over 2,000 swimming pools in under three months.

190 Small but mighty: putting Richmond County Mosquito Control on the map

Annie Elizabeth Rich (annie.rich@dph.ga.gov), A. Fred Koehle, G. Allen Hillman

With a department of 16 seasonal and full-time workers, we at Richmond County Mosquito Control are leading the way in showing that smaller programs can have a large impact on their county and surrounding region. From pond, pool, and property inspection programs, mosquito surveillance, public education and outreach, service-call and barrier sprays, to planning and development of goat clearing, tire, and a tick programs, we are working hard to make the biggest impact possible for our size. Additionally, we are working with state entomologists and the CDC to implement the first mosquito resistance testing documented in the state of Georgia. Working with local public agencies and government to make the most of our resources, and making an effort to grow each year, our program is working hard to be an excellent example of efficiency in mosquito control.

191 Launching the Next Generation of Self-Limiting Mosquitoes – A First Look at Oxitec's 2nd Generation Mosquito

Simon Warner (MJooste@DNA.com), Michael Jooste

Oxitec has been working to develop new and novel mosquito control for over a decade and pioneered the use of a biological methods to suppress wild populations of dangerous mosquito species. Chief Science Officer, Simon Warner, shares first-look details on Oxitec's development and deployment of its 2ndGeneration of Friendly™ *Aedes aegypti* Mosquitoes. When deployed as part of an integrated vector control program, these 2nd Gen. mosquitoes are anticipated to dramatically reduce wild populations of this disease-transmitting mosquito species via multi-generational suppression, while still ensuring self-limiting mosquitoes do not persist in the environment. Warner will also discuss the potential for this second-generation technology to reverse insecticide resistance.

192 Simulating the Dynamics of Gene Drive in Mosquito Populations

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Gene drive is a gene editing technique that promotes the inheritance of a particular gene to increase its prevalence in a population. The potential impact of releasing genetically modified organisms in the wild raises substantial concerns in terms of tracking their prevalence and managing their effects. Few scientific studies have been done, and few analytical tools or models exist, to quantify the nature of gene drive propagating through a population and identify key variables that affect the propagation. We have developed a computational agent-based model (ABM) to study the population dynamics of gene drive for a case study of mosquito populations. An ABM represents the individual characteristics and behaviors of a population of heterogeneous agents; the interactions among agents, and their interactions with the environment. ABM connects micro-scale processes (here, genetic inheritance) to macroscopic processes (here, population

dynamics). By incorporating experimental data and theoretical modeling on gene drive from the available literature, the model is able to provide the best science-informed estimates for edited genes to propagate and be sustained throughout a population, across generations. Probabilities being incorporated in the model include: survival of the laboratory control embryo, embryo survival of the gene drive cassette injection, successful cut of the first allele, successfully insertion of the cassette, and successful entry into the germ line. The ABM framework being developed to model the dynamics of gene drive in mosquitoes is designed to account for behaviors ranging from resistance alleles that thwart gene edits to responses to interventions. The goal is to elucidate the consequences of gene editing on mosquito populations, identify key factors in the success or failure of editing techniques, and provide strategic insights for the introduction of genetic variants into the wild to help reduce the threat of mosquito-borne diseases.

Disease/Vector Studies III

193 National Malaria Control Program of Uganda's Plans to implement integrated vector management, and larval source management in particular, in response to increasing insecticide resistance and changing vector behavior in Uganda.

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Background Several Vector Borne Diseases (VBDs) impose a heavy burden on human populations in Uganda. Well-planned, well-targeted vector control can interrupt VBD transmission by reducing vector density, longevity and human-vector contact. Malaria transmitted by anopheline species is a primary concern. The main current vector control interventions target indoor, night-time biting: indoor residual spraying (IRS) and long-lasting insecticide treated nets (LLINs). NMCP has never used larval control, which is relatively rare in the African setting. **Current Context** The use of pesticides in agriculture, especially pyrethroids, has affected immature and adult malaria vectors in Uganda and selected for resistance. Various past studies in Uganda have confirmed the growing problem of pyrethroid and organo-chlorine resistance in *An. gambiae s.l.* and *An. funestus* (Mawejje et al. 2012). IRS and LLINs have also changed the profile of anopheline distribution and composition, with *An. arabiensis* gradually increasing in abundance, especially in Northern, Eastern and North-eastern Uganda. *Arabiensis* mosquitoes quickly adapt to counter IRS and LLINs through avoidance of treated surfaces and outside early evening/early morning biting behaviour. **Mitigation Plan** Uganda's National Malaria Control Program (NMCP) is building a plan to implement IVM to mitigate the high costs and community fatigue of repeated IRS and mass distribution of LLINs in the context of low effectiveness. NMCP is currently conducting malaria vector larval control trials in Nakasongola district and plans more trials in Karamoja region on several WHOPES-recommended formulations. NMCP wishes to adopt those larvicides that prove most effective, to address outdoor transmission and to reduce the pressure creating insecticide resistance. It's imagined that IVM can address several diseases concurrently, as a single vector can transmit several diseases. NMCP seeks ideas, input and partners in its switch to regular programmatic larvicide use, and seeks advice on surveillance and deployment of effective programmatic larval source management (LSM).

194 Field evaluation of three different traps collecting Aedes aegypti in four parishes of Jamaica

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The United States Agency for International Development (USAID)-funded Zika AIRS Project (ZAP) is working in the Caribbean region to support governments to implement vector control activities and conduct monitoring to reduce the spread of the Zika virus. ZAP Jamaica and the Mosquito Control and Research Unit (MCRU), designed a study to test three mosquito traps; BG-sentinel traps, Gravid Aedes traps (GAT) and Prokopack aspirators (PK). The goal was to determine trap performance in the field and efficacy of the traps to collect *Aedes aegypti* individuals, inside and around premises of selected sites. Three sentinel sites were selected in geographic areas where a larvicide campaign, VectoBac® WDG is applied to containers found at the house-hold level. A fourth sentinel site was selected as a control site. The sample per site included four houses (total N=16). In each house, BGs, GATs and PKs were deployed for a three-day collection period. Each house had two sampling periods/month. Results showed that 76% of specimens in and around the premises of the sites were *Ae. aegypti* and 47% were females of the same species. Overall, the number of females *Ae. aegypti* per trap per person was higher in the control site. The number of female *Ae. aegypti* per BG, per person, was $2.8x10^{-2}$ in the control vs. $6.3x10^{-3}$ for the intervention. The number of female *Ae. aegypti* per GAT, per person, was $1.04x10^{-2}$ for control vs. $1.6x10^{-3}$ in the intervention. Females *Ae. aegypti* per PK, per person, was $6x10^{-2}$ for the control vs $3x10^{-2}$ in the intervention. GATs collected only *Aedes*. Most

of the *Ae. aegypti* dissected from the BGs and the PKs were multiparous. This is the first time that adult mosquito collections have been conducted in Jamaica, demonstrating that BG and GAT traps are the most effective tools for mosquito surveillance.

195 Public Health Entomology in North Carolina: Reflections from a 3-year University-Government Collaboration

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Since 2014, there has been increasing need for state and local public health agencies to focus on vector surveillance and control. This was spurred by the emergence of chikungunya and Zika viruses, as well as a general increase in awareness of mosquito-borne disease. As part of this trend, the state of North Carolina, Department of Health and Human Services, began a collaboration with three academics at state Universities. In this paper, we report on the various projects executed through this collaboration: state-wide surveillance of container *Aedes*, behavioral studies of Aedes albopictus (Skuse), and insecticide resistance studies. We also will examine future projects and assess the impact of the State's investment.

196 An Examination of the Effects of Hurricanes on Culex nigripalpus Populations in Indian River County, Florida

Mark Kartzinel (m.kartzinel@irmosquito2.org), Sherry Burroughs, Don Shroyer

Indian River Mosquito Control District (IRMCD) has a long-established arbovirus surveillance program which historically has targeted transmission surveillance of St. Louis encephalitis, eastern equine encephalitis and West Nile viruses. IRMCD incorporates a sentinel chicken program (8 flocks), passive box traps (previously lard can traps), CDC light traps, and ground aspirator collections into the surveillance program. The primary focus of ground aspirator collections is surveying the population of *Culex nigripalpus* in four different states: green (newly emerged), non-bloodfed, bloodfed, and gravid. The passive box trap collections focus on obtaining non-bloodfed female *Cx. nigripalpus* specimens for age grading, which aids in estimating the effective vector population, considering that older mosquitoes will be more likely to vector pathogens. CDC light traps assist in establishing host seeking mosquito population trends. The data collected over the past 15 years at IRMCD demonstrates the trends in the populations of *Cx. nigripalpus* on hurricane years and the years leading up to and following the hurricanes. Hurricanes Frances and Jeanne in 2004, Hurricane Matthew in 2016, and Hurricane Irma in 2017 were the primary focus of this examination. IRMCD found no dramatic changes in the populations of *Cx. nigripalpus* from hurricane impacts in ground aspirator collections. However, the data demonstrates there is a decrease of seroconversions from the sentinel chicken flocks in Indian River County on hurricane years and the years following these storms.

197 Mosquito Surveillance Tools Based on Aptamer-Gold Nanoparticle Conjugates for Colorimetric Detection of Arboviruses

Alexander J. Bosak (Alexander.Bosak@ucf.edu), Nileshi Saraf, Bradley Eastmond, Jebidiah Light, Keenan Wiggins, Alicia Willenberg, Michael Kwan, Matthew Longo, Griffith Parks, Sudipta Seal, Barry W. Alto, Bradley Jay Willenberg

Arboviruses such as Zika (ZIKV), dengue and chikungunya threaten public health in the United States and impose costly tolls on populations globally. The ability to rapidly identify the presence of both arboviral pathogens as well as vector mosquito species in the field is paramount to effective mosquito surveillance and control. Established surveillance techniques rely upon laboratory-based modalities such as viral detection by qPCR and antibody detection by sentinel programs to assess arboviral incidence and threat levels. However, these methods can be time consuming, expensive, require specialized equipment and are often unavailable in many at-risk areas. We have been pioneering the development of diagnostic and surveillance sensor tools based on aptamer-gold nanoparticle (Apt-AuNP) technology to "color-code" the midguts of the primary vector *Aedes (Ae.)* aegypti based on infection status with ZIKV and other arboviruses. Taking advantage of colloidal nano gold optical properties and the stability and sensitivity of DNA-based aptamers, analytes (targets) such as ZIKV can be detected in real-time via a straightforward change in solution color from red to blue wavelengths when the target is present. To date, we have created multiple ZIKV Apt-AuNPs and assayed each against both recombinant ZIKV envelope protein as well as live, intact ZIKV. Recombinant ZIKV envelope protein levels as low as 40nM were clearly detectable visually through a shift in ZIKV Apt-AuNP solution color from red to purple. Detections (spectrophotometric) of live ZIKV in the range of 1.0×10^5 PFU were also achieved. Further, we have developed methodology and reagents and established that adult female *Ae. aegypti* mosquitoes can imbibe these ZIKV Apt-AuNPs in a sugar solution formulated specifically to support Apt-AuNP function. Together, the obtained results support the potential of these ZIKV Apt-AuNPs as new tools for use in mosquito surveillance to aid in targeted mosquito control.

198 Updates for the Aedes aegypti sterile insect technique program in Lee County, FL
Rachel Morreale (morreale@lcmcd.org), David Hoel, Thomas Wayne Gale

In 2017, Lee County Mosquito Control District founded a sterile insect technique program in cooperation with the International Atomic Energy Agency in order to control *Aedes aegypti*. The pilot study, conducted on Captiva Island, began with biweekly background population sampling in June 2017. Since the beginning of the program there have been many developments regarding facilities, technology, and surveillance information. As a part of the SIT program, LCMCD will be mass rearing locally collected *Ae. aegypti* in order to irradiate and release sterile males to control the population. A building has been remodeled in order to accommodate the mass rearing and irradiation process. Dosimetry and irradiation of male pupae will be conducted using a RadSource RS2400V X-ray machine. Community engagement with civic leaders and scientists has been an essential part of the program and reception has been mainly positive so far. Releases of sterile male *Ae. aegypti* are expected to begin in February 2019.

199 A Recent Rise in Murine Typhus Activity in Tarrant County, Texas
Nina Marie Dacko (ndacko@hotmail.com), Abigail L Cheney, Russell W Jones

Murine Typhus is a flea-borne disease that is commonly associated with rats and the oriental rat flea, *Xenopsylla cheopsis*, especially in heavily populated urban areas. There may also be a suburban cycle associated with small mammals and the cat flea, *Ctenocephalides felis*. It is either caused by one of two Rickettsial agents, *Rickettsia typhi* or *Rickettsia felis*. It is reportable in three states including California, Texas and Hawaii where it is endemic to certain regions of these states. In Texas, Typhus is endemic to the southern region of the state, but uncommon in the north. In 2017, the Tarrant County Public Health Division of Epidemiology had reported 26 human cases and have reported 14 cases thus far in 2018. This is a stark contrast to the preceding 10 years having a combined number of 17 cases. This presentation will review possible Typhus cycles and outline the knowns and unknowns about the ecology of Murine Typhus in Tarrant County. Are we the new endemic area?

200 Lack of microfilarial enhancement of West Nile virus infection in American robins and common grackles associated with concurrent microfilarial infection
Michael J Turell (mturell@erols.com), Jefferson Vaughan, Elizabeth Andrews, Juanita Hinson

Concurrent ingestion of microfilariae (MF) and arboviruses by mosquitoes has been shown to enhance mosquito transmission of virus compared to when virus is ingested alone. Shortly after being ingested, MF penetrate the mosquito's midgut and introduce virus into the mosquito's hemocoel, creating a disseminated viral infection much sooner than normal. Because both robins and grackles are known to have a high prevalence of MF infections, we compared infection and dissemination rates in *Culex pipiens* mosquitoes that fed on birds with and without MF infections that had been infected with West Nile virus (WNV). Surprisingly, at moderate WNV viremia rates, about 10^7 plaque-forming units (PFU)/ml of blood, there was no consistent difference in either infection or dissemination rates in mosquitoes that ingested the viremic blood from a bird with or without a microfilaremia. At very high viremias, $>10^{8.5}$ PFU/ml, mosquitoes feeding on a grackle with a microfilaremia had significantly higher infection and dissemination rates than those that fed on grackles without a microfilaremia. As shown for other MF-virus combinations, the amount of MF enhancement is dependent on the specific virus, MF, and mosquito species being tested. While the presence of a microfilaremia did not affect WNV infection, *Cx. pipiens* fed on WNV-infected robins had significantly higher infection rates than did *Cx. pipiens* fed on grackles with comparable viremias. These results suggest that the infection threshold of arboviruses may depend not only on the species combination of virus and vector, but also on host species. Estimates of reservoir competence based solely on the profile of host viremia following viral inoculation may lead to inaccuracies.

201 Evaluation of fungal recognition in the mosquito Aedes aegypti.
Jose Luis Ramirez (jose.ramirez@ars.usda.gov), Ephantus J. Muturi, Alejandro Rooney

Entomopathogenic fungi represent an environmentally friendly alternative to control mosquitoes. Although some advances have been made to understand how the fungi infects and colonizes the mosquito body, there is still a need for understanding how the mosquito responds to infection and what determines pathogenicity of a given entomopathogenic candidate. The ability of the mosquito to respond and survive an infection depends in part on its ability to detect early pathogen invasion. This study presents a comparative transcriptomic profile of fungal recognition molecules at the early stages of infection when the mosquito is infected with two different fungal entomopathogens.

Equipment/New Prod Trials

202 Contrasting state and in-house laboratory arbovirus testing of sentinel chicken and mosquito samples

Milton Sterling (sterling@lcmcd.org)

Mosquito-borne virus surveillance is an important component of an integrated mosquito management program. Information regarding virus activity in sentinel animals and mosquitoes, along with human mosquito borne virus cases can provide for public awareness and help plan mosquito abatement activities to prevent disease transmission. Common surveillance methods such as the sentinel chickens and adult mosquito trapping are monitoring tools available for use by health departments and mosquito control districts. Most samples collected by mosquito control districts are not tested in-house, but by the State Health Department, which reports results back to the districts. There are advantages and disadvantages associated with State-only and in-house laboratory arbovirus testing of sentinel chicken and mosquito samples. These aspects include but are not limited to; results from a certified lab, cost effectiveness, turnaround time for response, erroneous results, and the reliability on a single source for results.

203 Strategic Trap Selection and Placement for West Nile Virus Surveillance in San Gabriel Valley, California

Melissa Ann Doyle (mdoyle@sgvmosquito.org)

A robust mosquito surveillance program is essential to monitor for arboviruses, such as West Nile Virus, and to drive mosquito mitigation efforts. Strategic placement of the optimal trap greatly enhances the quantity and quality of the resulting data. Additionally, a periodic evaluation of trap selection and placement is essential to ensure that the collected data demonstrates an accurate representation of the extent of mosquito breeding and potential transmission of arboviruses in an area. San Gabriel Valley Mosquito and Vector Control District (SGVMVCD) routinely traps for and tests *Culex quinquefasciatus* for West Nile Virus. In 2018, SGVMVCD expanded the surveillance program by increasing the number of gravid traps used weekly and equally distributing the placement of the traps across the district. Also, two different gravid water infusions were evaluated against *Cx. quinquefasciatus*. These changes resulted in higher trap captures and valuable data that aided in driving targeted operations decisions.

204 Scientific approach and innovative engineering solution for mosquito control

Anastasiia Romanova (director.ukrainemosquito@gmail.com), Andriy Mushakov

The System is designed to reduce the population of insects in the open area by means of attracting, trapping and extermination. The Smart Eco-Friendly Mosquito Control System (SEMCS) can operate as a part of a single mechanism of any Smart ecosystem. The system of several installations, within the city, can create its own ecosystem, controlled remotely. Is equipped with LTE / GSM modules and capable of managing ecosystems of entire cities. For municipalities, the SEMCS can be completed with: WiFi system, environment security monitoring system, advertising screens. The SEMCS can be equipped with solar panels and batteries, to work in a completely autonomous non-volatile mode. The technical solution offered is aimed at increasing the properties of the device for luring insects due to complex interaction of all the attractants avaliable, as well as improving the operational qualities of the device.

205 Use of Solar Panels to Charge Batteries for Adult Mosquito Traps

Janet McAllister, Lee William Noel (lwyonoel@gmail.com), Milena Guajardo, Cassie Scott

Electricity is a requirement for powering the most commonly used traps to collect adult mosquitoes. However, electricity may not always be readily accessible in some areas of the world that need mosquito surveillance the most, especially after a natural disaster. In order to ensure proper collection efforts at all times, it is crucial to investigate methods to independently generate electricity in an efficient and consistent manner to charge batteries for use in adult mosquito traps. Systems were designed at the CDC in Fort Collins which use solar panels and charge controllers to constantly keep 6 volt or 12 volt batteries charged that are powering CDC light traps or BG-Sentinel 2 traps, respectively. These systems can also be manipulated to charge batteries at a separate location with higher security away from the traps in order to prevent theft of the solar panels. Using solar energy greatly reduces the shipping costs of multiple batteries, it decreases the number of batteries that need to be purchased, and it reduces the dependency on a local electrical source, all the while keeping the traps consistently running. Implementing a system such as this will save money, manpower, and energy in the long run as it is perfected to charge batteries more quickly and charge different types of batteries as well.

206 The Form and Function of Conducting Caged Trials
Derek Drews (ddrews@clarke.com), Kattie Morris, Andrea Levey, Laetitia Leroy, Yemi Bullen-McClain

What's the fundamental purpose of conducting caged trials when introducing a new mosquito control product to the market? Beyond demonstrating product efficacy and shaping the user experience, caged trials are a required and critical step in the product optimization and U.S. EPA registration process. Caged trials help product manufacturers successfully transition a product from the lab to the field, ultimately delivering improved operational performance to end users. This presentation will focus on the fundamental purpose of caged trials as a required effort in the product optimization process, and share best practices for successful caged trials, based on real field work with two recently-introduced ULV products.

207 Latest results using automation for sterile mosquitoes manufacturing
Hanan Lepek (hanan@senecio-robotics.com)

The Sterile Insect Technique is gaining evidence as a promising tool for suppressing local populations by releasing large numbers of sterile male mosquitoes. Join us to learn about the BioMosquito factory - a novel robotic system that will make a district size sterile mosquito campaign an affordable yet effective tool. In the lecture we will discuss the flow process and the different robotic stations, from automating the sex sorting process using artificial intelligence and deep learning to ensure male only release, through automatic packaging to the actual automatic release from ground van through drones to aircraft using the same platform without terrain or other physical limitations. As mosquitoes are fragile insects, a novel technique was developed and latest results will be shared, teaching how large-scale sterile insect technique can be cost effective. Automating the process, the new technology can process and manufacture multiple types of mosquitoes with minimal adjustments to the robotic machine. Join the lecture and stay up to date with the latest information about the most advanced automatic sterile insect technique solution.

208 A novel compound (KCA1) attracts host-seeking and ovipositing Aedes albopictus: Results from initial field evaluations
Megan Saunders (ms1@umd.edu), Paul T. Leisnham, Kamal Chauhan

Aedes mosquitoes are vectors of numerous disease-causing viruses, including West Nile, Zika, Dengue, and Chikungunya. Semiochemicals mediate host-seeking and oviposition behaviors of adult-female *Aedes* and are frequently used as attractants in their surveillance and control. USDA-ARS has recently developed easily deployable field-stable attractants (e.g., KCA1) that and have shown promise at attracting *Aedes* mosquitoes in laboratory trials. This paper reports on the first evaluation of the effectiveness of KCA1 in attracting host-seeking and ovipositing *Ae. albopictus* under field conditions. attraction trials were conducted in College Park, Maryland (USA) during the late-summer or 2017. Oviposition attraction was tested by comparing *Ae. albopictus* egg abundances in green vases baited with one of four concentrations of KCA1 solution (1%, 0.2%, 0.04%, 0.008%) versus control vases (distilled water only). Host-seeking attraction was tested by comparing catch abundances of *Ae. albopictus* between BG-Sentinel adult traps that were baited with a KCA1 lure (200-mg dose) versus control traps (no lure) in a before-after-control-intervention design. Vases containing 0.04% KCA1 solution had higher oviposition than control vases and vases with other concentrations. Adult traps baited with the KCA1 lure had higher catches of adult females than control traps. The results of this study indicate early promise for KCA1 as an attractant for *Ae. albopictus* for use in the field. Future research should conduct further tests of KCA1, especially with other *Aedes* species, under varying environmental conditions, and with toxicants for eventual use in area-wide control strategies.

209 A community wide trial of In2Care traps in Volusia County
Drake Alexander Falcon (dfalcon@volusia.org), Miranda Tressler, Hong Chen

The purpose of this project was to test the efficacy of the novel In2Care trap for future use as a tool for domestic disease response. An area highly populated with citizens and domestic mosquitoes was chosen to be the base for the trial. We took advantage of the grid system of roads to set up control and treatment areas in blocks around the community. The trial consisted of multiple phases - permissions, set up and data collection. The first phase included door-to-door visits to citizens to gain permission for setting the traps and accessing the yard on a routine basis. Next, mosquito control employees spent an entire day constructing the traps and placing them in the grid system according to the required spacing of the label and which citizens agreed to participate in the project. The final phase of the trial was observation and data collection. This included routine maintenace of the In2Care traps and monitoring larval and adult populations of domestic mosquitoes.

210 Novel In2Care Mosquito Trap Evaluation in Highly Urbanized Environment in Harris County and the City of Houston, TX

Martin Reyna Nava (mreyna@hcphes.org), Dagne Duguma, Elaine Chu, Greg Motl, Christopher Tarrand, Christopher Fredregill, Rebecca Riley, Mustapha Debboun

Autodissemination strategy is a novel approach that uses adult mosquitoes to transfer mosquitocidal products to their breeding habitats to control mosquito-borne diseases. We evaluated the In2Care Mosquito Trap against field *Aedes aegypti* and *Ae. albopictus* populations in Harris County and the City of Houston, TX using 80 In2Care Mosquito traps during a 3-month period in 2018. Trap efficacy was measured by the reduction in eggs and larvae counts using 20 oviposition traps (10 at each site); and on adult counts using 20 Biogents (BG) Sentinel traps in treated and untreated areas (10 at each site). Findings of evaluation project will be discussed.

Public Relations/AMCARF

211 Haiti Mosquito Control Association: The evolution of an educational program for the citizens of Hait

Morel Jules (morel.jules@irmosquito2.org)

After the devastating earthquake in January 2010 in Haiti that produced misery there, I traveled to my homeland to visit relatives who were severely impacted by this natural disaster. During that trip I also brought attention to the problems there caused by disease-transmitting mosquitoes during their recovery efforts. Since 2010, I have made several trips back to Haiti to work with civic leaders, students and citizens to educate them about mosquitoes and how to reduce their impact. This presentation will summarize these efforts over the past 8 years which included the creation of the Haiti Mosquito Control Association in 2014.

212 Approaches to communicating pesticide risks to the general public: Available resources from the National Pesticide Information Center

April Strid (strida@oregonstate.edu), Amy Hallman, Jeffrey Jenkins

Pesticide risk conversations can be difficult to navigate. The National Pesticide Information Center (NPIC) specializes in pesticide science and risk communication and can be a valuable resource for both trained professionals and their clientele. NPIC provides science-based information about mosquito biology, pesticide toxicity, and health information about specific active ingredients used in mosquito management including repellents, larvicides, adulticides, and synergists. NPIC compliments the work of vector control professionals, health departments, the Environmental Protection Agency (EPA), and others by translating science into accessible content. This talk will provide an overview of the resources available from NPIC and offer helpful strategies and web-based tools to address questions such as "Is it safe?" and "What happens to a pesticide in the environment?" Constructive dialogues involve listening to an individual's concerns, discussing ingredient toxicity and exposure routes, and understanding risk perception science. Community members benefit from access to objective, science-based information and discussions of ways to minimize potential exposure. The talk will highlight strategies for having productive conversations about pesticide risks with a wide range of audiences.

213 Utilization of community surveys for development, implementation, and evaluation of messaging campaigns

Ada Barros (adab@placermosquito.org), Joel Buettner

The literature available on the development, implementation, and evaluation of outreach messaging for vector-borne disease transmission prevention in the United States is fairly limited. Communications staff tasked with the development of outreach and education messages for vector control for individual local agencies come from varied backgrounds, such as public relations, education, and public health. As a result, the process of development and implementation of messaging around vector control can vary widely from agency to agency, borrowing from the different disciplines in which those communications staff have experience. Here, a process that incorporates both public relations tools and public health strategies will be presented. The strategy to conduct a community survey is used both in public relations and public health to inform the cycle of message development, implementation, and evaluation. Community surveys were implemented in 2009, 2012, 2015, and 2018. Results from those surveys were used to develop both broad and targeted messaging campaigns, as well as improve the outreach department as a whole. A discussion of the lessons learned using this specific process will be also be presented.

214 Boots on the Ground: A look into a Season with MMCD's Field Staff
Aubrey Marie Soukup (asoukup@mmcd.org)

The Metropolitan Mosquito Control District (MMCD) provides a variety of services to 2.7 million people living in an area covering 2,900 square miles in the seven county Minneapolis and St. Paul, Minnesota metropolitan area. With the majority of staff conducting the work needed in the field, a visual aid to the daily tasks can be a great tool to use in recruitment. This project took the "boots on the ground" phrase to a literal sense. It highlights the variety of tasks and experiences the field staff can encounter. Showcasing the atypical work environment and variety of situations that can occur in any given day could help in getting talented young professionals into mosquito control districts for their careers. This can also be used to recruit the many talented seasonal staff that are necessary to keep our organization running. From the beauty of the sun on the water, to the gruesome carcass of a deer, to the mundane tasks of training, every day is different when working at mosquito control.

215 A picture is worth a thousand words - leveraging GIS to engage, educate and execute
Broox Boze (Bboze@vdci.net), Matt Parker, David Young

Over the past decade, Colorado has reported one of the highest rates of West Nile virus infection in people (>5,362) and many of those cases are concentrated in Larimer County. While most municipalities recognize that the virus has become endemic to the area and understand the need for mosquito control, actions toward control of adult mosquitoes are still extremely controversial and one of the most debated topics in local government. Whether it involves topics of natural resources or social issues the responses we get are highly emotional and highly variable. In order to instill a sense of trust and acceptance around these controversial emergency applications Vector Disease Control International (VDCI) has worked very closely with the City of Fort Collins to convey timely data, be predictable in policy, and transparent in our operations. This presentation will focus on some of the outreach efforts we have developed to increase awareness of West Nile virus in the area. I will also highlight how we've used GIS to provide citizens with a clear picture of the data involved and when, where, how Ultra Low Volume applications for adult mosquito control take place.

216 Losing control – The rebranding of a modern mosquito management program
Andrea Roshaven (roshavena@hcflgov.net), Ron Montgomery, Donnie Hayes

Hillsborough County Mosquito Management Services, located in Tampa, Florida, was founded in 1950. The past 68 years have shown dramatic changes in both operational strategies and public outreach for mosquito control. This presentation will discuss the successes and challenges of changing public perceptions, including educational programs, strategic partnerships, media relations, social media, and public outreach efforts.

217 Adopting a New Public Engagement Paradigm for Novel Vector Control Interventions
Kevin Gorman (MJooste@DNA.com), Michael Jooste

As vector control solutions are increasingly becoming more scientific and technically complex, the importance of clear, consistent, and transparent communication is becoming all the more important. Oxitec has learned that engaging and empowering stakeholders early not only can help shape intervention methodologies, but also help inspire product development and guide how companies can transform their technologies into trusted solutions in today's vector control landscape. Kevin Gorman, head of Field Operations for Oxitec, reflects lessons learned from Oxitec's past and how he thinks about and manages stakeholders across a variety of complex landscapes, regulatory bodies, and cultures.

218 Assessing the arboviral landscape via shotgun metagenome sequencing of honey-soaked FTA cards
Dana Price (d.price@rutgers.edu), Brian Johnson, Andrea Egizi

Standard mosquito traps are poorly designed for molecular-based surveillance approaches (e.g., detection of RNA viruses) due to issues such as cross-contamination and poor nucleic acid preservation. Given these limitations, a strategy has been developed that utilizes honey-soaked nucleic acid preservation cards (Flinders Technology Associates; FTA) to capture viral RNA for remote arbovirus surveillance without the need for mosquito sorting, ID, or pooling. FTA cards are easy to collect and store without needing to maintain a cold chain, and have been successfully used to detect arbovirus in field populations of

mosquitoes via qPCR. To improve on this approach, we coupled the utility of both saliva and excreta-collecting FTA cards with powerful next-generation RNA and DNA shotgun metagenome sequencing to assess the breadth of information that can be gleaned from these cards, including species composition, microbiome content and arbovirus diversity in field mosquito populations. Here we discuss our experience, share preliminary results and comment on the future promise of passive FTA-based mosquito surveillance to provide much more than arbovirus data.

219 Field evaluation of arbovirus surveillance using honey cards
Kristy Burkhalter (ktb3@cdc.gov), Tim Garner, Jacob Hartle

The collection, species identification, processing and testing methods commonly performed for mosquito pool-based testing are time- and labor-intensive. "Honey card" surveillance has been developed as an alternative or supplement to pool-based testing, but there have been few systematic field evaluations of this method in routine arbovirus surveillance and mosquito control programs in the United States. In collaboration with Placer Mosquito and Vector Control District we conducted a field trial over the course of 14 weeks in the summer of 2018, directly comparing virus detection data from mosquitoes collected in traps and corresponding honey cards placed in the same traps. This project also focused on developing a streamlined protocol for the production and placement of the cards in traps, and the optimization of viral RNA recovery from the cards.

Social Media and Mosquito Control Symposium

220 Social Media 101
Michael Mut (mmut@miamidade.gov)

This presentation will cover the basics of four of the largest social media platforms: Facebook, Instagram, Twitter and YouTube. I will provide a brief summary of my experience in social media, a history of each platform, their size in terms of daily users, and relevant demographic information, as well as provide a primer on how to produce the types of content that work best on each. Furthermore, I will provide examples of how the Miami-Dade County Mosquito Control & Habitat Management Division uses each (I am the division's chief content creator, with the exception of YouTube) and also discuss the benefits of using each platform to communicate with residents. I will also illustrate how to get the Facebook, Twitter and Instagram platforms verified, and talk about the benefits of having each attain verification. I also hope to address any questions the audience may have, offer my contact information for networking purposes, and discuss social media with attendees afterwards. It is my hope that any attendee not familiar with any of the platforms will walk away with the knowledge they will need to launch and manage their own channels for their respective organizations.

221 Social Media and Mosquito Control
Justin Taylor (jtaylor@clarke.com)

Within the mosquito control industry, social media platforms like Facebook, Twitter, LinkedIn and others have become powerful tools for community education and relations, best practice and knowledge sharing, and brand and marketing initiatives. This session of the Social Media and Mosquito Control symposium will provide insights into what social media platforms the industry is using and why, and highlight best practices from mosquito abatement entities using these tools.

222 Using Social Media In and Out of the Classroom
Jillian Meek (jmeek@pascomosquito.org)

Education is often seen as an essential piece of Integrated Mosquito Management (IMM). As Pasco County, Florida has delved further into the education realm using a fifth-grade level program to reach community members we've also found a useful tool within that program—social media. Social media has not only become a part of our IMM, but also an element of our education programs. It has proven to be a useful tool in promoting the free programs and reaching teachers, schools and the school district as whole more thoroughly. As we reach more schools we are working with more students and have hopes that as a result we're reaching their families too. The aim of this presentation is to give a quick glimpse into how we, as a mosquito control district, are using social media to reach community members and promote our school programs, as well as a couple quick tips to make your posts fun, engaging, and useful.

223 Made you look! A starter guide to capturing attention using digital ads
Levy Sun (lsun@sgvmosquito.org)

As more people every year turn to multiple sources for information, catching people's attention becomes more difficult. Mosquito control programs must integrate digital advertising into outreach strategies to be more effective. By targeting key lifestyles of residents and interrupting their online search behaviors, mosquito control outreach can inject themselves into the daily lives of distracted citizens. The San Gabriel Valley Mosquito & Vector Control District (SGVMVCD) uses several tools that successfully captures attention. Over the course of several years, SGVMVCD has conducted multiple digital campaigns that has cost about a penny per person reached. The presenter will identify best practices for mosquito control programs to identify ways to improve their digital outreach strategies.

224 Using Social Media to Effectively Communicate Scientific Research in Mosquito Control
Natasha Marie Agramonte (nme@epi.ufl.edu)

Scientific research has several tried and true outlets for communication, such as publishing in scientific journals or presenting at national and international conferences, however scientists often struggle to communicate their work to the general public. Some organizations encourage outreach to local and state communities in the form of classroom visits, educator trainings, state fairs, and extension publications. While very helpful for establishing ties to the local community, these outreach efforts typically reach fairly small audiences. With the aid of social media, scientists can now reach much larger, international audiences easily. More importantly, social media platforms like Facebook and Twitter allow for a dialogue between scientists and non-scientists, which encourages nuance into the interpretation of research that is often lacking when science research is presented via news broadcasts or popular media. I document my own journey from science researcher uncomfortable in my interactions with the general public to communicating my research on Twitter, Reddit, and even on the Bill Nye show.

225 Prevent & Protect: Mosquito control messages for your community
Ricky Telg (rwtelg@ufl.edu), Phillip Stokes, Ashley McLeod

Mosquito control protects the public from disease outbreaks, reduces nuisance mosquitoes and protects Florida's economy. The purpose of this project was to provide public officials with easy-to-use toolkits to inform the public about the necessity of mosquito control in Florida. A Mosquito Control Toolkit and an Emergency Response Toolkit were created for local officials, mosquito control programs, health professionals and organizations to use on social media and distribute information to the public. Each toolkit has pre-made, easy-to-use social media posts and graphics. The University of Florida Institute of Food and Agricultural Sciences Center for Public Issues Education in Agriculture and Natural Resources tested the Mosquito Control Toolkit on its Facebook page and Twitter account from May 29, 2018 to June 28, 2018. The Mosquito Control Toolkit was released to the public on www.piecenter.com/mosquito on June 15, 2018. Sysomos, an online platform that explores social media insights, was used to collect data about mosquito control sentiments on social media outlets Facebook and Twitter. Facebook analytics also provided useful statistics about Prevent & Protect's performance on the PIE Center's Facebook page.

226 Audiences, analytics and ads: Beyond the basics of digital outreach
Levy Sun (lsun@sgvmosquito.org)

More than 85 percent of government agencies are active on social media. However, many government outreach programs, including in mosquito control, lack a cohesive digital strategy that focuses on the first step to behavior change: Conversions. Achieving this objective requires a deeper analysis of digital platforms such as social media accounts, digital ads, and website analytics. The San Gabriel Valley Mosquito & Vector Control District (SGVMVCD) uses audience data to create salient and impactful campaigns that yield an average of 3.16% clickthrough rate and spend less than a penny per person reached. SGVMVCD also combines audience data with online search trends and behavior, which provide direction to campaign goals. The presenter will identify tools to further enhance a mosquito control program's digital outreach strategy.

Aerial Control/Aviation/Education I

227 The influence of sprayer type and nozzle placement on spray deposition, uniformity and transport with remotely-piloted aerial spray systems

Jane Annelise Bonds (jasbonds@gmail.com), Andreas Herbst, Xionkui He, Zhichong Wang

Irrespective of previous resistance Remotely-Piloted Aerial Spray Systems (RASS) are currently in use in the USA. There is however, a paucity information about the distribution of that spray in swath and the potential for off target losses. The flow field around an aerial vehicle is one of the most important factors affecting spray distribution. The flow field and resultant spray deposition will vary as the operational parameters and the environmental inputs change. Experiments have been and are currently being conducted to measure the spray distribution under an array of different biotic and abiotic conditions. The abiotic inputs were forward speed and altitude whilst the biotic were atmospheric conditions. Although it is understood that nozzle type and placement is important at this stage we are working with commercial systems as they stand. Wind speed, direction temperature and humidity measures were taken as a record of meteorological inputs. The flow field and spray deposition were measured in swath via wireless air velocity sensors, Mylar cards and Water Sensitive Papers placed perpendicular to the line of travel. Downwind deposition and flux sensors were placed downwind as a measure of drift. This presentation will discuss the results of these experiments and implications for future research and sprayer optimization.

228 Efficacy of DeltaGard® against Aedes aegypti when applied using an Unmanned Aircraft System (UAS) in Manatee County, Florida.

Katie Williams (k.williams@manateemosquito.com), Mark Latham, Christopher Lesser, Jing Zhai

DeltaGard 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 and approved for registration and use in aerial applications, and the purpose of this study was to determine the efficacy of DeltaGard when applied via an Unmanned Aircraft System (UAS) Precision Vision 600P at a rate of 0.00089 lbs AI/acre and 0.00134 lbs AI/acre against lab-reared *Aedes aegypti*. Adult female mosquitoes were exposed in bioassay cages on a 3x3 grid at distances of 50, 150 and 250 ft downwind from the spray path. Three control sampling stations were placed upwind of the UAS path for each treatment. Each sampling station was equipped with rotating 1x3 inch Teflon-coated slides. Mosquito knockdown data was recorded one hour post-treatment and mortality data was assessed 12 hours post-treatment. The slides were read using DropVision (Leading Edge Associates, LLC). No significant differences were found between DeltaGard applied at 0.00089 lbs AI/acre and 0.00134 lbs AI/acre. At 12h, the average mortality for *Ae. aegypti* was 100% for both applications indicating that the aerial application of DeltaGard when applied using an UAS was effective.

229 First year UAV use and applications

Gary Hatch (hatchgaryl@gmail.com), Joel Shegrud

The Mosquito Abatement District-Davis submitted our application to the FAA to receive our COA for a public use aircraft. We received our COA and started lgranular larvae applications with a UAV.

230 Distribution of mosquito mortality indoors and outdoors at a simulated urban site following aerial application of naled

Frances V Golden (frances.golden@ars.usda.gov), Seth C Britch, Robert L Aldridge, Kenneth J Linthicum, Mark S Breidenbaugh, Jennifer L Remmers, Don Teig, Mark Latham, Peter H Connelly, Charles A Silcox

Aedes aegypti is an important disease vector, with increasing populations in urban areas in the United States. They are difficult to control because they live in and around homes and also exploit protective cryptic habitat that is hard to reach with pesticides sprayed from the ground. However, aerial application of pesticides could potentially cover a larger area than ground application, possibly reaching these protected habitats in and around homes. We conducted a study in a simulated urban environment at a US military training area by placing colony-reared sentinel *Ae. aegypti* in protected and unprotected locations both indoors and outdoors. We then applied naled (Dibrom) from a USAF C-130 using a modular aerial spray system, conducting trials with both single and multi-swath sprays. Spatial patterns of mortality suggest that multi-swath applications did not greatly increase efficacy in the target area in comparison to the spray of a single swath. Indoor sentinel mortality was generally lower than outdoor mortality, underscoring the difficulty of controlling this endophilic species even in well ventilated buildings.

231 The Art of Outreach
Heather Althea-Rae Hyland (hhyland@glacvcd.org)

The Art of Outreach Conducting outreach in this new tech savvy and YouTube driven planet, one must think outside the box. How do you cater to these new ideals of outreach education? No longer is a PowerPoint viable. These three words can help guide you: *Enrich- Find ways to make your point valuable to their lives, this will become important to them and they will want to learn more. *Engage- Use tools to get their attention (microscopes, bug boxes, live larvae to explore.) *Entertain- Make the program fun, lay off big science terms and the best tool to use: **Humor-** make them laugh by using cartoons or video games they can relate to. When I was in Kindergarten I remember eating fruit loops as I was gluing them to my artwork. Nowadays Kindergarten classes produce art on an iPad. Oh and no naps! I have learned so much in my 15 years of outreach with grades K-12. Teachers want so much more for agencies then a PowerPoint, even if you are with vector control. They want something more to show their class. Schools want S.T.E.A.M. related programs that are hands on, enjoyable and unique. It does not take a lot of money to keep a crowd of kids happy. To get a new program going a great way to start is to ask a school to be your "pilot" class. You can start off with a nice layout: -Objective -3 sub categories -2 activities that are hands on and STEAM related -Conclusion of program (what you really want them to walk away with) Develop a survey for students and teachers to gather what the valued, what they learned and how well the topic was absorbed. This will give you great ideas to walk away with to start future curriculum development.

232 Developing the 3rd Edition of Florida's White Paper on Mosquito Control
Douglas Carlson (doug.carlson@irmosquito2.org), Aaron Lloyd, Roxanne Connelly

During 2016-18, the Florida mosquito control community updated the 2nd Edition (2009) of the Florida White Paper on Mosquito Control, a document which was originally published in 1998. This 3rd Edition (2018) revised the White Paper's 13 chapters to include items which were not prominent in the industry a decade ago (*e.g.*, Zika, chikungunya, SIT, new chemicals). The contributions of 35+ mosquito control professionals to this 3rd Edition is continuing the tradition of Florida Mosquito Control providing a valuable reference document for the profession.

233 How effective are traditional methods of public education for reducing mosquito breeding – is the rubber meeting the road?
Thomas Noftsinger (tnoftsinger@stlouisco.com)

The Saint Louis County Vector Control program has utilized what might be considered "traditional" methods of public education to reduce the instances of mosquito breeding on private property: press releases, handing out brochures, manning booths at public events, speaking to school classes. As with any education, a pertinent question is how effective is the methodology, and are there ways to improve upon it? This year we enhanced our response to the most common requests from the public: when a resident placed a request with us to spray for mosquitos or check out a specific breeding site, we would expand beyond that focused request and survey the surrounding area for mosquito breeding. In the process of doing these surveys we discovered several trends, some indicating the public is well-informed, some that they are not, and even a couple where this "seasoned" vector control employee learned some new things. This presentation will share the data gathered and the lessons learned in the process of reducing mosquito breeding, and relate it to possible ways to improve public education.

235 Outreach Education by the Western Gulf Center of Excellence for Vector Borne Diseases
Sonja L Swiger (slswiger@ag.tamu.edu)

The Western Gulf Center for Vector-Borne Diseases (WGCVBD) outreach efforts serve as a catalyst to bridge partnerships among federal, state, and local agencies to improve response and manage emerging VBD. A Master Vector-borne Disease Management Certification Course was developed to educate and develop partnerships between representatives from city, county, and state public health agencies, public/private vector control and professional organizations, federal agencies (e.g. CDC, USDA, FDA, DoD and EPA), and academia. Outreach educational efforts were developed to focus on vector management, bite prevention, and the integration of expertise to improve the management of VBDs. The outreach efforts of the WGCVBD has been conducted for two years and have trained over 1000 individuals throughout Texas, Louisiana, Arkansas, and Mississippi.

Biology/Behavior I

236 The modern evolution of Aedes aegypti in Orange County, Florida
David M. Pelley (Dave.Pelley@ocfl.net)

The Modern Evolution of *Aedes aegypti* in Orange County, Florida By David M. Pelley **Background** *Aedes albopictus* arrived in Orange County, Florida in 1991 and the population of *Aedes aegypti* subsequently declined. In 2011, *aeg*. numbers began to rebound, and observations from the field show that *aeg*. in the county are morphologically larger than previously observed. **Methods** *Aeg*. and *alb*. larval collection data from Orange County was analyzed from 2008 through 2017, resulting in a total of 35,662 *aeg.* and *alb.* larvae recorded. Newly trapped adult *aeg.* mosquitoes were examined, measured, and compared to preserved specimens (yr 2009) from Orange County, as well as specimens from Dade County, and the Orlando Strain of laboratory mosquitoes. Collected *aeg.* adult females were plotted on a map to determine the population range. **Results** Larvae collection results: 2008: 250 *alb.* vs. 30 *aeg.* 2009: 72 *alb.* vs. 35 *aeg.* 2010: 163 *alb.* vs. 24 *aeg.* 2011: 1716 *alb.* vs. 1516 *aeg.* 2012: 1373 *alb.* vs. 1942 *aeg.* 2013: 925 *alb.* vs. 1601 *aeg.* 2014: 2582 *alb.* vs. 5973 *aeg.* 2015: 2504 *alb.* vs. 4432 *aeg.* 2016: 670 *alb*. vs. 2459 *aeg.* 2017: 1713 *alb.* vs. 5682 *aeg.* Female adult *aeg.* were trapped and examined. 523 *aeg*. wing lengths were measured and the average was found to be 3.87 mm. Comparative measurements of 50 *aeg.* from Miami Dade averaged 2.66mm, and 100 Orlando Strain wing lengths averaged 2.96 mm. Human population density heat maps overlap *aeg.* refuge sites displaying harborage that provided time for *aeg.* to adapt to invading *alb.* **Conclusions** The isolated *aeg.* population in Orange County was able to withstand the invasion of *alb.* by refuging in the densely populated urban areas of Orlando. Due to Foster's Rule, *aeg.* in Orange County have adapted to *alb.* by becoming morphologically much larger.

237 Utilizing new technology for mosquito surveillance: The BG Counter Trap - A Game Changer
Marcia Reed (mreed@fightthebite.net), Sarah S Wheeler, Deborah Dritz, Samer Elkashef

The Sacramento-Yolo Mosquito and Vector Control District (District) performs over 500,000 acres of Ultra Low Volume (ULV) mosquito adulticiding every year. Optimizing the efficacy of these applications is an important component of a good mosquito management program. This past season the District incorporated the BG Counter trap as part of our surveillance program. The BG Counter is a remote monitoring device which counts mosquito-sized insects entering it in real time which can be viewed via a web application. Our units use solar panels to power the trap and the only maintenance time is to change CO2 cylinders and change trap catch bags weekly. The BG Counter trap combined with a weather monitoring station is an invaluable tool when determining peak mosquito flight activity, which in turn allows for maximum exposure of adult mosquitoes to adulticide applications. The prime habitat evaluated during the 2018 mosquito season was the District's approximately 45,000 acres of rice routinely planted each summer. The BG Counter trap revealed interesting peaks of *Culex tarsalis* activity beyond the usual 15-30 minutes post sunset peak which has been traditionally recognized. Combining this new mosquito flight activity information with meteorological information can dictate and fine tune the timing of adult mosquito control operations.

238 Evaluations of oviposition cues against Aedes mosquitoes under different conditions in Thailand
Thanyalak Fansiri (ThanyalakF.fsn@afrims.org), Arissara Pongsiri, Chanyapat Nitatsukprasert, Patcharee Khongtak, Boonsong Jaichapor, Wachiraphan Chittham, Ampornpan Khaengluecha, Silas A Davidson, Alongkot Ponlawat

Aedes aegypti and *Ae. albopictus*, the important vectors of dengue, zika, chikungunya and yellow fever, are urban mosquitoes which live close to humans and lay their eggs in and around home. Since female mosquitoes locate oviposition sites by using olfactory, optical and tactile cues, gravid traps with incorporation of oviposition attractants and visual aspects should be applied to decrease their population densities. Varity of plant infusions, phytochemical compounds and water from different sources were tested against background colors for their attractiveness under different conditions. Lemon grass infusion and larval rearing water under black shade showed the most attractive properties ($P < 0.05$) versus the other oviposition media. Different gravid trap designs were combined with those selected attractants and tested for their physical attractive appearance. The promising results were obtained under semi-field conditions that significantly numbers of gravid females were trapped when they try to enter the trap and lay eggs ($P < 0.05$). Further experiments of attractants under field conditions in combination with commercially gravid traps should be performed. A cost effective attractant from local materials can be considered as a useful tool in *Aedes* surveillance and in monitoring the risk of disease transmission.

239 Mosquito population trends in the United States Virgin Islands, 2017-2018—what we know, what we don't know, and why we need to know

Krystal R. Seger (krystal.seger@doh.vi.gov), Brett R. Ellis

The United States Virgin Islands (USVI) is a United States territory located in the Caribbean Sea due east of Puerto Rico. USVI has experienced multiple mosquito-borne disease outbreaks within the last decade and two Category 5 hurricanes in September 2017. Despite being prone to mosquito-borne disease outbreaks and hurricanes, 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, *Ae. aegypti* surveillance began in two neighborhoods on the island of St. Croix and two neighborhoods on the island of St. Thomas. The surveillance neighborhoods were chosen because they experienced high human chikungunya infection rates during the 2014-2015 chikungunya virus outbreak. Thirty BG-Sentinel 2 traps were placed in each neighborhood. St. Thomas surveillance continued through June 2017. St. Croix surveillance is ongoing with six traps per neighborhood beginning in November 2017. Gaps in data remain because of the hurricanes and limited staff. Preliminary *Ae. aegypti* surveillance results suggest a population peak from April-May, but less than two years of incomplete data is not sufficient to establish a trend. Inadequate mosquito population trend information hindered the ability to conduct thorough outbreak and hurricane responses. Understanding mosquito population trends before mosquito-borne disease outbreaks and hurricanes in conjunction with community assessments is critical to effective control capacities and emergency responses in the U.S. Virgin Islands.

241 Evaluation of conspecific rearing water as attractant of gravid Aedes aegypti

Agne Janusauskaite (ajanus@pascomosquito.org), Dennis Moore, Aaron Lloyd

Recognizing what stimulates disease vectors to deposit their eggs, choosing one suitable nursery over another, is significantly useful information for any mosquito control operation. Now that once tropical diseases are conquering more temperate climates, exploration into the egg laying behavior of certain vectors is becoming more and more important. *Aedes aegypti* mosquitoes are responsible for transmitting many of the world's infectious diseases, including dengue, chikungunya, yellow fever and Zika. Their habit of skip-oviposition complicates accurate surveillance and egg collection in general. However, gravid females can be guided to oviposit in specific containers with the use of certain infusions. The objective of this study is to evaluate an alternative attractant of gravid *Ae. aegypti* and explore its operational practicality. A field assessment, investigating conspecific rearing water as a stimulant of *Ae. aegypti* oviposition, was completed in various residential areas of Pasco County, FL.

242 Spatial analysis of aggregation behavior in larval Aedes sierrensis in response to environmental stimuli

Cassandra Urquhart (cassie@lcvcd.org), Mary Beth Danforth, Jamesina J Scott

Larval clustering has been observed in the field for many mosquito species but the behavior is not well understood. The Western treehole mosquito, *Aedes sierrensis*, has been observed engaging in apparent aggregation behavior in both laboratory and field settings. This study aims to determine whether these observations indicate true aggregation behavior and if so, to determine the environmental stimulus that triggers it. Experiments were performed on third and fourth instar *Ae. sierrensis* larvae taken from the colony at the Marin-Sonoma Mosquito and Vector Control District (Cotati, CA). For each replicate, 100 larvae were placed into a glass aquarium and exposed to one of four possible treatments (shadow, inedible material, introduced pupae, and nothing as a control) for 40 minutes. A labeled grid was printed on the bottom of the aquarium so that larval density could be assessed. A GoPro Hero4 Black camera mounted above the terrarium recorded a still image every 60 seconds. There were 10 replicates for each treatment. Images were enhanced for clearer viewing, then the number of larvae per grid square, the location of the square within the grid, and the treatment conditions were recorded. Spatial analysis will determine level of aggregation and effects of treatments on the behavior. This study will provide greater understanding of larval behavior in *Ae. sierrensis* mosquitoes, which may be used to improve control methods for this species in the future.

244 Study of the behavior of Culex tarsalis in a rice field environment using a BG-Counter
Mario Boisvert (mariob@placermosquito.org), Joel Buettner

In 2017, the use of a BG-Counter at one specific location (Locust Road site) in a rice field showed that peaks of activity for *Culex tarsalis* were readily apparent from the BG-Counter data. *Culex tarsalis* showed consistent peaks of activity before midnight and in the early morning during July and August. We also observed that peaks in the morning and the evening maintained a consistent time interval before sunrise and after sunset. In 2018, we repeated the experiment at the Locust Road site, and three other locations with slightly different environments ranging from rice fields to other types of rural areas. The second year at the Locust Road site allowed us to compare abundance and activity data from 2017 and 2018. In 2017 there was a large area of organic rice fields next to the trap, and in 2018, there were no rice fields next to the trap. This difference is likely the reason we observed a major drop in the abundance of mosquitoes at the Locust Road site in 2018 compared to 2017. While the overall abundance dropped, daily peaks of activity remained the same over the three month period of observation for both years. In addition to the Locust Road site, the three other locations, even though in slightly different environments, showed similar peaks of mosquito activity relative to sunset throughout the three months of 2018. However, the three other locations did not show peaks of activity before sunrise. Confirmation of the peak of activity for *Culex tarsalis* (30 min after sunset) in rice fields in all four locations strongly suggest that this is the most effective time for mosquito adulticide applications at these locations during mid to late summer.

Challenges and Opportunities in Vector-borne Disease Management and Vector Control Symposium I

245 Arbovirus detection in mosquitoes: a review of options and opportunities
Kristy Burkhalter (ktb3@cdc.gov)

One facet of a well-developed arbovirus surveillance program consists of monitoring vector populations for pathogens. There are a number of testing options available that range from highly technical assays that enhance our ability to characterize virus isolates or facilitate novel pathogen discovery, to simpler tests intended to provide targeted and timely results in an operational setting. However, opportunities exist across the spectrum to improve detection methods, expand our repertoire of available tests, and enable agencies to implement assays that are tailored to accommodate their testing capabilities and surveillance program needs.

246 Genomic epidemiology of Zika virus and West Nile virus in the United States
Karthik Gangavarapu (gkarthik@scripps.edu), Nathan Grubaugh, Andrew Holbrook, Simon Dellicour, Saran Grewal, Ying Fang, Sarah Wheeler, Christopher Barker, Nikos Gurfield, Philippe Lemey, Marc Suchard, Kristian Andersen, Nate Matesson, Bram Vrancken, S. Lequime

Zika virus (ZIKV) is linked to severe congenital abnormalities and caused an unprecedented epidemic across the Americas, starting in 2015. Mosquito-borne ZIKV transmission was first reported in Florida, USA in July 2016. To gain insights into the timing, source, and likely routes of introduction into the USA, we tracked the spread of the virus by sequencing ZIKV genomes from infected patients and *Aedes* aegypti mosquitoes. Despite the fact that 224 locally acquired ZIKV cases were reported in the USA in 2016, the number of locally acquired cases have remarkably dropped to less than 10 in 2017 and to 0 in 2018. In contrast, since its introduction in 1999, West Nile virus (WNV) has become endemic in the USA and has since caused 45,000 confirmed human cases and 2,000 deaths. WNV causes localized outbreaks in the summer but the size and timing of these outbreaks is heterogeneous within and across different states. To investigate the drivers and dynamics of seasonal WNV outbreaks, we sequenced 600 genomes with high spatio-temporal sampling, from dead birds and *Culex* mosquitoes, across three longitudinally dispersed counties in California: Sacramento-Yolo, Kern and San Diego. We were able to quantitatively assess the contribution of environmental and ecological factors to the WNV transmission in California. The high spatio-temporal sampling allowed us to understand the overwintering dynamics of WNV in counties with varying climatic conditions. In both these contrasting cases of mosquito borne viruses, we show how genomic epidemiology can be used to investigate outbreaks and develop more effective mitigation and control strategies.

247 Simultaneous Detection of Chikungunya, Dengue and Zika Viruses in Mosquitoes Using RT-PCR
Taylor Lura (tlura@wvmvcd.org), Tianyun Su, Michelle Brown

Over the years, there has been endemics and epidemics of arthropod-borne diseases worldwide due to increased globalization and urbanization. As infections such as chikungunya, dengue and Zika become more widespread, it is vital that accurate and efficient detection tools become available to better assess the viral prevalence within mosquito populations. Here we describe a protocol for a triplex RT-PCR for simultaneous detection of chikungunya virus (CHIKV), dengue virus serotypes 1-4 (DENV1-4) and Zika virus (ZIKV) in mosquitoes. CHIKV, all four serotypes of DENV and ZIKV were all detected individually or in combination using this triplex. When tested individually, CHIKV was detected to 1.98 x 10^3 pfu/ml, DENV1 was detected to 1.90 x 10^4 pfu/ml, DENV2 to 1.60 x 10^4 pfu/ml, DENV3 to 4.00 x 10^2 pfu/ml, DENV4 to 7.90 x 10^2 pfu/ml, and ZIKV to 3.10 x 10^3 pfu/ml. Mixing DENV serotypes did not compromise the detectable levels of individual serotypes when tested the DENV1-4 mix alone. CHIKV, DENV1-4 mix or ZIKV tended to have lower detectable levels when tested in a full combination of six targets (CDZ mix) as compared with those when tested alone, particularly for DENV1-4 mix. This triplex appears to consistently detect all six viral targets, individually and in combination, and does not cross react with *Aedes aegypti* L. homogenate.

248 Regionalizing our view of mosquito and arbovirus surveillance data
Christopher M. Barker (cmbarker@ucdavis.edu), Jody K. Simpson, Mathew Leland, David Heft, Vicki L. Kramer, Greg White, Kim Cervantes, Scott Crans, Grayson Brown

Annual patterns of vector-borne pathogen transmission risk in the U.S. often vary at regional scales that span multiple states, presenting opportunities for earlier and broader awareness of emerging epidemics. However, such anomalies are often slow to reveal themselves through our existing reporting systems because data on surveillance of enzootic and epizootic cycles are irregularly reported to national databases, often weeks to months after the data were collected by local agencies. In this presentation, we describe broadly applicable mapping and reporting features of the CalSurv system, which is a front-end data management platform that is used daily by mosquito control agencies in multiple states. Integration of the visualization and reporting capabilities into CalSurv's unified back-end architecture allows for near-real-time updates of national and regional data and a broader view of standardized surveillance information to inform decision-makers ahead of epidemics.

Water Management Symposium I

285 Dewatering the Savannah Harbor dredge material containment areas.
T. Carlson (tacarlson@chathamcounty.org)

Chatham County Mosquito Control has been dewatering the Savannah Harbor dredge material containment areas (DMCAs) since 1972. Ditching techniques have changed over the years in order to provide more effective source reduction for these mosquito breeding sites. Currently long reach amphibious excavators are used to create fewer ditches that are wider and deeper than ditches created in the past.

286 Mandated trash capture devices: Impeding trash without impeding mosquito abatement.
J. Huston (joseph@mosquitoes.org),

Installation of trash capture devices (TCD) into catch basins was mandated and implemented by the San Francisco Bay Regional Water Quality Board (SFBRWQB) for San Francisco Bay Area Counties. CB may hold water throughout the year, and are intense breeding sources for mosquitoes that can transmit arboviruses to humans. SFBRWQB approved several TCD that complied with their mandate. However, impacts of the TCD design on mosquito control activities were not considered during the review and approval process. After noticing these devices in the field, Alameda County Mosquito Abatement District (ACMAD) reviewed the diagrams and specifications of TCD approved by SFBRWQCB, and identified TCD that would pose the least impediments to mosquito control activities. To convey the importance of TCD design on mosquito control, we prepared a flyer describing ACMAD's mission to protect public health through effective mosquito control, and indicated which of the SFBRWQB-approved TCD permitted inspection and treatment of CB, those that would require more research, and TCD that were unacceptable in terms of mosquito abatement activities. This flyer was disseminated by the Bay Area Storm-water Management Agencies Association (BASMAA) to their member cities in the San Francisco Bay Area. We participated in a BASMAA meeting that was attended by city representatives to discuss our concerns with TCD. Following the meeting, Fremont, one of our largest cities, contacted ACMAD to discuss the TCD they had installed were indicated on the flyer as unacceptable. Subsequently, a TCD manufacturer contacted ACMAD regarding one of their TCD indicated

as unacceptable. In both cases modifications were made to the TCD that permitted mosquito abatement activities. These interactions have helped reinforce our relationships and partnerships with local cities and agencies in our region, and have helped put mosquito control in the mind of government officials and contractors when devising and implementing storm water regulations.

287 A brief overview of current and past wetland impoundment and mosquito ditching projects in Lee County, Florida

E. W. Foley (foley@lcmcd.org)

Source reduction through impoundments and ditching serves as an important method of mosquito control throughout Florida, especially as a means of controlling Aedes taeniorhynchus. A predominant wetland impoundment at the J. N. "Ding" Darling National Wildlife Refuge on Sanibel Island, was originally constructed and managed by the Lee County Mosquito Control District as a means of mosquito control. Today, this impoundment is successfully operated by the US Fish and Wildlife Services and serves as a refugia for fish and wadding bird species. Large scale trenching programs in the 1950s and 1960s led to an extensive network of mosquito ditches throughout much of the coastal wetlands of Lee County. Nearly 60 years later, many of these same ditches still work as designed by shedding excess water from locations otherwise ideal larval habitats and also providing a source of natural predators such as mosquito fish. A 2017 joint project between the USFWS and LCMCD installed a mosquito ditch on refuge-managed lands in the Caloosahatchee River with the goal of improving mangrove health and reducing mosquito populations. The addition of a ditch allowed for increasing tidal flushing of low lying breeding sites and increased mosquito fish populations which reduced the need to larvicide, a solution that was mutually beneficial to both agencies. The success of this project has opened the door for future projects to come.

288 Opportunities with the advancement of tidal marsh restoration in the San Francisco Bay Area

E. Castillo (erika@mosquitoes.org)

The San Francisco Bay Area is a dynamic region where environmental stewardship is championed. It is not only home to the largest tidal wetland restoration project on the West Coast but also an unprecedented nine-county parcel tax which was approved with a 70% voter majority. Measure AA, the San Francisco Bay Clean Water, Pollution Prevention and Habitat Restoration Measure, will raise approximately $25 million annually, or $500 million over twenty years, for the restoration, enhancement, protection, and enjoyment of wetlands and wildlife habitat in the San Francisco Bay and along its shoreline, and associated flood management and public access infrastructure. As the Bay transitions from dumping grounds to a revitalized resource there are many opportunities to reaffirm the importance of water management that reduces mosquito breeding potential. New restoration design techniques are focused on creating an adaptive shoreline which is both resistant to rising sea levels and provides habitat by expanding the horizontal footprint of a levee creating a gradual vegetated slope to break the waves. With a new funding resource available wetland restoration will continue to progress in the Bay Area and the Alameda County Mosquito Abatement District is fostering partnerships to keep the public health perspective included.

289 Open Marsh Water Management (OMWM) in Delaware

W. H. Meredith (William.Meredith@state.de.us)

Open Marsh Water Management (OMWM) is a source reduction water management technique for saltmarsh mosquito control, involving installation of small, shallow ponds and narrow ditches in mosquito-producing areas of the high salt marsh, excavated with specialized heavy marsh equipment. OMWM usurps or adversely alters ovipositioning and larval-rearing sites for saltmarsh mosquitoes, and also allows better access to remaining larval sites by native larvivorous fishes along with creating reservoirs for these fish, and thereby substantially reduces mosquito production within OMWM-treated marshes. In turn, this can significantly reduce future needs for larviciding. All of this can be accomplished and maintained in environmentally-compatible manner with marsh structure and function. Delaware has been practicing OMWM since 1979, with an initial target to treat about 10% of our coastal wetlands with OMWM in areas where saltmarsh mosquito production is most severe, involving in many cases superimposing OMWM systems ontop of the old parallel-grid-ditch network. Now almost 40 years later, we've treated most problematic areas on state-owned or privately-owned lands that were initially targeted, with exception due to a federal policy matter of some large expanses of previously unaltered marsh at Bombay Hook NWR (although on the old parallel-grid-ditch marshes at Prime Hook NWR, we've done considerable OMWM work). Today, most of our OMWM work involves spot-treating smaller marsh areas that heretofore we've not been able to access or work, along with our also maintaining many areas now having older OMWM systems. In comparison to pre-OMWM times, the need to larvicide our coastal wetlands has significantly decreased. But a new challenge we're now facing concerning OMWM's use, stemming in part from some "preservationists" who really don't want to see any type of marsh alteration, is speculation that OMWM systems will exacerbate adverse impacts to coastal wetlands caused by relative sea-level rise.

290 Salt marsh mosquitoes in human altered environments and some novel water management solutions - three projects in The Norfolk County Mosquito Control District, MA

D. A. Lawson (dave.lawson@norfolkcountymosquito.org)

Many of the worst local outbreaks of mosquitoes in The Norfolk County Mosquito Control District (MA) have historically come from human altered environments that allow salt water to enter but not to exit. Though the geographic extent of these outbreaks may not be as expansive as large mosquito emergences from the Districts' river floodplains, the sheer number of Ocherotatus sollicitans affecting bordering neighborhoods is stunning considering the small sources of water they come from. There currently are three human altered environments that are actively producing prodigious amounts of Oc. sollicitans larvae during the summer season in the District. All three sites were originally salt marshes that were in turn filled in by various human activities in previous decades. At each site, something changed that has subsequently allowed tidal water to enter. The result has been the creation of degraded salt marsh environments that are prime habitat for larval mosquito development. The District attempts to control these larvae with bacterial larvicides, which has been costly in both larvicide and manpower. We have proposed water management projects to permanently address these problem sites so that larviciding will no longer be necessary. One site is the location of an already partially completed project (The Broad Meadows Middle School, Quincy, MA) and two other sites have proposed projects that will be executed in the near future. (Defunct U.S. Navy ammunition bunkers site, Quincy, MA, and The Neck Street Marsh, Weymouth, MA) These projects will reduce the reliance on larviciding and will greatly reduce the risk of large outbreaks of adult mosquitoes in the nearby neighborhoods.

291 On Site Sewage Facilities and Mosquito Breeding in Tarrant County, Texas

N. M. Dacko (ndacko@hotmail.com)

There are many different environments where mosquitoes may be able to breed. In rural Tarrant County, Texas mosquito control generally takes place on county-owned properties such as right-of-ways, roadside ditches, culverts and isolated pools of collected rainwater/stream water. Occasionally, homes and commercial properties are investigated because of citizen complaints; however, many mosquito breeding sources remain unreported. Private property presents many challenges for mosquito control because of the ability to gain access to the property and many breeding sights may be cryptic in nature. One of these potential breeding sites is On Site Sewage Facilities (OSSF). On Site Sewage Facilities are systems designed to treat, dispose of or recycle wastewater effluent from a property on which it was produced. It is nearly impossible to know which OSSF systems are breeding mosquitoes unless tank lids are removed to reveal the space above one of the multiple treatment tanks inside the system. This symposia presentation will review OSSF systems used in Tarrant County, Texas, discuss ways mosquitoes could possibly find a way to enter and breed in these systems and review the findings from a study conducted by the Centers for Disease Control and Prevention and Municipal Mosquito in late summer of 2018 in relation to mosquitoes breeding in these systems.

292 Continuous Deflective Separators and there implications for mosquito control.

M. A. Daniel (mdaniel@glacvcd.org)

Stormwater capture and reuse has garnered increasing attention in Los Angeles County as a means of defraying the need for importing water and long term sustainability. Stormwater capture devices are proliferating to facilitate the removal of pollutants, such as trash, and diverting stormwater into infiltration basins, underground storage facilities and flood control channels. Continuous Deflective Separation (CDS) units, also known as Hydrodynamic Separation units are used throughout Los Angeles County to achieve stormwater quality goals.These units are effective at removing trash during storm water events, however, they represent a significant source of mosquito breeding during the rest of the year. Non stormwater runoff accumulates in these units and can provide year round habitat for both Culex quinquefasciatus and Aedes aegypti. Hundreds of these units are in place and more will be installed in the years to come. We are establishing an Urban Water program to identify the location and condition of the CDS units as well as other stormwater capture devices. The goal is to work with manufacturers and agencies to eliminate water accumulation during the dry periods between stormwater events and prevent mosquito breeding.

293 An Overview of Water Management in New Jersey

V. Thompson (victoria.thompson@co.monmouth.nj.us)

In New Jersey, water management has long been recognized as a viable strategy for mosquito control by county mosquito control agencies. The goal of all water management projects is to create conditions inhospitable to mosquito larvae by either improving water flow, deepening water to support predaceous fish or removing excess surface water without loss of hydric soil conditions. This presentation will spotlight a variety of water management projects conducted by county agencies, review the unique permits developed

for the mosquito control community, introduce the State of Jersey's Equipment Program and demonstrate intra-county cooperation needed to implement projects in Monmouth County.

294 Managing Expectations – Using State-level Partnerships to Evaluate Mosquito Control and Wetland Management for Waterfowl

J. A. Henke (jhenke@cvmvcd.org), Brian W. Olson, Joel Buettner, Matthew C. Ball, Conlin Reis, William Walton

The management of seasonal wetlands for waterfowl and other wetland-dependent wildlife has the potential to produce mosquito abundance that surpasses mosquito abatement thresholds. To help minimize the impact of wetland management activities on public health and safety, the Mosquito and Vector Control Association of California set up a working group with the California Department of Fish and Wildlife to explore how to meet the needs of both agencies. Best management practices (BMPs) were developed by the Central Valley Joint Venture in coordination the California Department of Public Health and the Mosquito and Vector Control Association of California. In 2017, we evaluated the effect of two BMPs (discing and establishment of predator reservoirs) on the presence of mosquito larvae in wetlands managed by the California Department of Fish and Wildlife (CDFW) at two wildlife areas (Gray Lodge and Los Banos). Larval mosquito abundance in disced treatments at both study sites was significantly lower compared to traditional and optimal management strategies. Larval mosquito abundance in disced wetlands was significantly lower than in wetlands with reservoirs for mosquito predators at both wildlife areas in early summer, but immature mosquito abundance was comparable in both BMPs during July at Gray Lodge Wildlife Area. When financially feasible, discing has significant potential to both enhance wetland quality for waterfowl and decrease mosquito production in units managed for wintering waterfowl, but there may be times when wetland units utilizing these BMPs need to be treated for surpassing abatement thresholds. Further evaluation is needed to determine the overall cost-effectiveness and long-term applicability of these strategies.

295 Innovations in Water Management and Mosquito Source Reduction Analysis

M. Scholl (mscholl@fightthebite.net)

The Sacramento-Yolo Mosquito and Vector Control District actively pursues Mosquito Reducing Best Management Practices (BMPs) implementation on Federal, State, Local Government and privately owned properties. The District works to reduce mosquito control costs through a variety of methods including the use of UAS (drone) imagery for land surveying, cost share programs, use of heavy equipment, and water control devices. Using the District's UAS units, the District teamed up with the San Francisco Drone School, Suas news and Propeller Aerial to survey irrigated agricultural and wetland areas to find high and low areas for localized treatments as well as potential drainage options. District source reducing BMP projects are able to utilize emerging UAS and topographic modeling technologies as an accurate and time saving method for project analysis and design.

296 Integrated marsh management: A holistic approach to managing coastal wetlands for multiple objectives

R. Wolfe (roger.wolfe@ct.gov)

The Wetland Habitat and Mosquito Management (WHAMM) Program of the Connecticut Department of Energy and Environmental Protection's Wildlife Division, employs and promotes the practice of Integrated Marsh Management (IMM) for restoring and managing Connecticut's degraded coastal wetlands, while minimizing public health risks from mosquito-borne diseases. IMM is a holistic approach to wetland management utilizing a variety of techniques to achieve site-specific goals. IMM takes into consideration the many aspects of wetland restoration and management including tidal flow restoration, hydrologic modification and removal of dredged material to restore ecosystem functions, source reduction and biological control of saltmarsh mosquitoes (open marsh water management), control of invasive plants such as Phragmites through tidal flow restoration and selective herbicide use, and habitat enhancement for coastal wetland-dependent species. With roughly 6500 ha of coastal wetlands, our marshes are small compared to other coastal states, but because of the unique character of each location and site-specific objectives, IMM projects can be relatively simple, while others can be quite complex requiring input from many disciplines. Potential projects are reviewed by a multi-stake holder site review team and approved through a streamlined state and federal permitting process. This review process also identifies where proposed projects could dovetail past or current work, or potentially impact other projects or ongoing research. The success of any IMM project depends on diligent education and the formation of partnerships to share expertise, equipment and funding. Pre- and post-monitoring is important to evaluate success, document where follow up work may be needed, and identify further research opportunities. Various types of projects will be examined describing successes and pitfalls which will hopefully prompt constructive dialogue with other wetland managers and practitioners.

297 Managing impoundments along Florida's Indian River Lagoon: Controlling saltmarsh mosquitoes while enhancing the resource
D. Carlson (doug.carlson@irmosquito2.org)

From the mid-1950s to 1970, approx. 40,000 acres of salt marsh/mangrove swamp was impounded along Florida's Indian River Lagoon. Because saltmarsh mosquitoes oviposit on moist soil but not on standing water, building earthen dikes around known mosquito-producing marshes and flooding them during the summer months is an effective and economical method of controlling saltmarsh mosquitoes requiring a minimum of pesticide use. This presentation will provide an overview of impoundments along east-central Florida and will explain the process of managing these environmentally-sensitive areas both for mosquito control and natural resource enhancement over the past 60+ years.

298 Water management activities in Bristol County, Massachusetts
P. Matton (brismosqpc@comcast.net), Diana Brennan

Water management is a vital part of Bristol County Mosquito Control Project's integrated mosquito management plan. Our goal is to remove debris, sediment and vegetation from drainage ditches throughout our service area to improve water flow, thereby reducing standing water and larval habitat. This activity includes both hand and mechanized work in fresh and salt water. We use erosion control materials and re-seed to stabilize soils disturbed by our operations. The majority of these activities take place over the winter months; however, Bristol County does have a year-round program to address time and environmentally sensitive concerns. Locations are chosen on a variety of factors including proximity to areas where West Nile virus or Eastern Equine Encephalitis has been detected in mosquitoes. This presentation will highlight some of the work that has been conducted in the County.

Biology Behavior II/Larval Control

249 Ecological and spatiotemporal dynamics of mosquito populations in waste tires in New Orleans
Jennifer Breaux (jabreaux@nola.gov), Mohamed Sallam, Claudia Reigel

Many mosquito vector species preferentially colonize man-made containers such as buckets, cemetery vases, and tires. The New Orleans Mosquito, Termite and Rodent Control Board is conducting enhanced surveillance projects in order to better understand the ecology of mosquito populations in waste tires throughout the city. Waste tires are located systematically through grid searching of neighborhoods. Microhabitat environmental characteristics are measured at each site, and all aquatic invertebrates inhabiting the tires are taken to the laboratory for identification to the lowest possible taxonomic level. Detritus from tires is dried, sorted into categories, and weighed. We then combine the collected environmental and species data with available landscape, climate, socioeconomic, and demographic data to generate predictive models of mosquito spatiotemporal population dynamics in waste tires across the city of New Orleans. The goals of this enhanced surveillance project are a) to investigate whether waste tires represent a significant public health issue via production of mosquito vector populations; and b) to better understand how ecological and environmental factors at the micro- and macrohabitat scale influence mosquito colonization of tires. These predictive models will ultimately be field-validated and used to produce risk maps for areas of high vector abundances in tires and other container habitats. This will help to streamline and focus control efforts in priority areas, thereby reducing the risk of vector-borne disease outbreaks.

250 A season-long study of tank bromeliads as larval mosquito habitat in southern California
Aviva Goldmann (aviva.goldmann@ucr.edu), Melissa Ann Doyle, William Walton

Tank bromeliads are a mosquito breeding hazard because their leaf axils trap pools of water, forming phytotelmata. These plants, which are native to tropical areas, are used as houseplants or as irrigated garden plants in southern California. Local vector control workers regularly detect *Aedes* spp. and *Culex* spp. in untreated garden bromeliads, which indicates that these plants are a potential public health risk if not properly managed. To better understand the nature of this risk, we studied the species composition and seasonal abundance of larval mosquitoes found in sentinel bromeliads. Each sentinel bromeliad site was paired with a nearby BG trap site, allowing comparison of larval abundance and species composition in bromeliads with that of adult mosquitoes in the surrounding area. Sampling was conducted May through October, 2018, in the San Gabriel Valley of southern California.

251 New county records of Aedes aegypti and Aedes epactius in Colorado
John-Paul Mutebi (grv0@cdc.gov), Erik Ostrum

In August and September, 2017 we conducted mosquito surveillance in southeastern Colorado by using ovitraps and larval sampling. The aim was to determine if there were established populations of Aedes (Stegomyia) aegypti (L) and Aedes (Stegomyia) albopictus (Skuse) in the region. A single female Ae. aegypti was reared from eggs collected in La Junta CO, but Ae. albopictus was not detected. Three other species were reared from eggs and/or larvae; Aedes (Ochlerotatus) epactius Dyar & Knab, Culex (Culex) restuans Theobald, and Culex (Culex) pipiens L. Aedes aegypti and Ae. epactius were detected for the first time in Otero and Baca counties respectively and these are new county records for Colorado. Both species were detected in very low numbers suggesting extremely low population density or sporadic introductions into southern Colorado.

253 Field trial of VectoBac® WDG applied by truck-mounted ULV sprayer in the Florida Keys
Heidi L Murray (hmurray@keysmosquito.org)

Since 2011, the Florida Keys Mosquito Control District (FKMCD) has successfully used helicopter based aerial treatments of VectoBac® WDG in Key West in the treatment and control of *Aedes aegypti* larval populations. FKMCD recently conducted a study to determine the effectiveness of using a truck-mounted A1 Mist Sprayer Super Duty with a Micronair AU5000 atomiser to apply VectoBac WDG. Bioassay cups were placed in a residential area encompassing open, moderate, and heavy cover scenarios between 0-300 ft perpendicular to the spray line. An application rate of 8 oz/acre (0.5 lb/acre) was used. Bioassay cups were collected after application and returned to the laboratory where 100 ml of distilled water and 10 *Ae. aegypti* larvae were added. Laval mortality was monitored at 2, 4, and 24 h. Three separate runs were completed during the summer of 2018. Average larval mortality at 24 h was >90%. The field trial demonstrated sufficient efficacy to introduce this method of larviciding into operational use.

254 Evaluation of Residual Larvicides Treated Plant Saucers against Aedes albopictus Larvae in Semi and Field Conditions
Peter Jiang (jiangY1@cityofgainesville.org)

Previous studies indicated that plant saucers are the 2nd most productive container breeder *of Ae. albopictus* among the variety of containers in the urban environment. Conventional control method such as source reduction is not reliable as less than half of the homeowners actually empty their plant saucers regularly. The goal of this study was to assess the efficacy of plant saucers coated with residual larvicides (Lambda 9.7 CS, Talstar P Professional, and Mavrik Perimeter) at the max rates against *Ae. albopictus* larvae under the semi-field and field conditions. Two types of plant saucers (10" clay and plastic) were selected for testing in this study. After the treatments, plant saucers were air dry and then divided into two group: Group 1, plant saucers were kept in the open covered area (semi-field condition) and group 2 were exposed in the open field directly. Plant saucers subsequently were brought back to the laboratory for bioassay at 1, 3-day and weekly, intervals. 20 3rd instar larvae and 200 ml distilled water were added into each saucer. Mosquito mortality was checked 24-h and 48 h post-treatment. Both Lambda and Talstar yielded excellent control (>90%) of *Ae. albopictus* larvae for 8 weeks under the semi-field condition, and up to 7 weeks under the field condition, whereas, Mavrik only yielded 60% control (clay saucers) at the first week and 50% at the second week under both semi-field and field conditions but excellent control up for 3 weeks under the both semi-field condition and the field condition with plastic saucers. This is the first study proves that plant saucers treated with residual pesticides can play a significant role in controlling of container breeder *Ae. albopictus*.

255 Predation efficiency of carnivorous aquatic plants: a novel biocontrol method for container breeding mosquito vectors in the genus Aedes
Jannelle Couret (ncouret@uri.edu), Marco Notarangelo

Vector-plant interactions are an important aspect of vector ecology, though relatively unexamined. Predator aquatic plants offer a novel approach to larval mosquito control, one that does not impact non-target, beneficial pollinators. The direct and indirect impacts of plant carnivory on larval survival and development are not well understood. We explored the impacts of an aquatic carnivorous plant called the common bladderwort, *Utricularia vulgaris* on larval mosquitoes. Carnivorous plants in the genus *Utricularia* are distributed in a variety of freshwater environments worldwide, and use bladder-like traps to catch and consume invertebrates. We explored cultivation of *U. vulgaris* in small volume containers for use in larval control of container-breeding mosquito species. To our knowledge this is the first estimation of plant

predation of *Aedes aegypti* and *Aedes albopictus* mosquito vectors using the common bladderwort (*Utricularia vulgaris*). In controlled laboratory rearing experiments of *Ae. aegypti* and *Ae. albopictus*, we investigated the direct impacts of plant predation on larval mortality, finding near-complete elimination (99%) of larvae of both species within 3 days of introduction of the plant. Our findings also indicate complex indirect impacts of plant presence, when predation is prevented, on larval developmental traits including a plant-induced slowing of larval development time for *Ae. aegypti* and *Ae. albopictus*. There is a critical need for the development of effective and targeted biocontrol methods against mosquito arboviral vectors, particularly *Aedes* vectors. This work explores a novel biocontrol application and improves our understanding of plant-vector ecological interactions for larval *Aedes* mosquitoes.

256 Wide Area Larvicide Spraying (WALS™) of a simulated neighborhood in Los Angeles County using the Adapco Guardian® 190 G4 and the A1 Super Duty®

Tanya Posey (tposey@glacvcd.org), Susanne Kluh, Harold Morales, Peter DeChant, Stephanie Whitman, Steven Vetrone

In the early morning hours of June 28, 2018, the Tillman Water Reclamation Plant in Van Nuys, California, served as a simulated neighborhood for a Wide Area Larvicide Spraying (WALS™) of VectBac® WDG. In conjunction with Valent BioSciences, Coachella Valley Mosquito and Vector Control District, and Adapco, Greater Los Angeles County Vector Control District (GLACVCD) evaluated the Adapco Guardian® 190 G4 and the A1 Super Duty® by placing bioassay jars along the designated spray route. Ten "properties" within the boundaries of the water reclamation plant were selected and four jars were placed at each property in varying stages of cover (Open, Light, Heavy, and Covered). The jars were then returned to GLACVCD where the larval bioassays were conducted using *Culex quinquefasciatus* larvae and the results from both sprayers were compared.

257 Characterization of a broad-range yeast interfering RNA mosquito larvicide with a target site conserved in multiple disease vector mosquitoes

Keshava Mysore (kmysore@iu.edu), Chein-Wei Wang, Nicholas D Scheel, Jacob S Realey, David W. Severson, Na Wei, Molly Duman-Scheel

New mosquito control strategies are vitally needed to address established and emerging arthropod-borne infectious diseases. Although RNA interference (RNAi) has been applied for functional characterization of mosquito genes, this approach, which is attracting attention in the agricultural pest control community, is still a largely unexplored approach for control of disease vector mosquitoes. To facilitate the cost-effective production of interfering RNA and oral delivery of RNA pesticides to mosquitoes in the field, we recently engineered *Saccharomyces cerevisiae* (baker's yeast), a model organism that is genetically tractable and inexpensive to culture, to produce shRNA corresponding to select genes required for mosquito survival. One of the yeast interfering RNA larvicides constructed has a target site in *the Aedes aegypti synaptotagmin (Aae syt)* gene. Detailed characterization of this larvicide, which was developed through the genetic engineering of *Saccharomyces cerevisiae* to express a short hairpin RNA (shRNA) targeting *Aae syt*, demonstrated that the larvicide effectively silences this gene, generates defects at the larval neural synapse, and induces high rates of *A. aegypti* larval mortality both in laboratory and semi-field trials. Conservation of the interfering RNA target site in multiple mosquito species, but not humans or other non-target species, suggested that this larvicide may function as a broad-range mosquito larvicide. In support of this, the yeast interfering RNA larvicide was found to induce high rates of larval mortality in *Aedes albopictus, Anopheles gambiae*, and *Culex quinequefasciatus* mosquito larvae. The results of these studies suggest that this yeast interfering RNA larvicide may represent a new intervention that can be used to combat multiple mosquito vectors of human diseases.

Education II/GIS/GPS

258 Engaging citizen scientists in mosquito response using the iNaturalist social network, app and machine learning tools.

Durrell Kapan, Ph.D. (dkapan@calacademy.org)

Mosquito-borne diseases remain one of the greatest threats to global health worldwide. Despite countless efforts to control, suppress or eradicate mosquitoes by thousands of institutions worldwide, the scope of the mosquito problem continues to grow too large to be addressed solely by dedicated professionals. To fill this gap, a growing number of citizen science projects focused on mosquitoes have sprung up around the world. To test of the general utility of a citizen science platform known as iNaturalist (iNat) for motivating mosquito

citizen science and mosquito control directly by lay-persons, I started the "Mosquitoes in Hawai`i" project in 2015 prior to a widely publicized Dengue outbreak. This project has now grown to over 1000 observations collected by a group of dedicated volunteers who curate the data, promote mosquito awareness and personally respond to calls for vector control in their communities. I will explain how the growing database of curated mosquito images are used to train a ***machine learning algorithm allowing photographic identification of mosquitoes***. I will do a live demonstration the machine learning algorithm and show how this tool can help amplify the expertise vector professionals and help them engage their local communities. I will briefly summarize how our lab is using iNat data to model mosquito distributions. As the Hawai`i project has grown, so has the use of iNat to document mosquitoes in different regions and worldwide. I will conclude by focusing on how the iNaturalist efforts fit into global efforts to build mosquito citizen science tools and engage communities to tackle the problem of controlling and ultimately eliminating the threat of vector-borne disease worldwide.

259 Mosquito & vector control as special districts: opportunities and challenges
Ryan Clausnitzer (ryan@mosquitoes.org), Kyle Packham

According to the 2017 National Association of County and City Health Officials (NACCHO) Report: Mosquito Control Capabilities in the U.S., dedicated mosquito and vector control districts provide more competent mosquito control than local health departments and other city or local governmental agencies. Dedicated mosquito and vector control districts mean "special districts" with a board and staff focused exclusively on this issue. What makes this form of government so special? What threats do special districts face in our current political environment? And, how can special districts and other leaders promote their story and ensure the continued delivery of effective mosquito abatement and vector control? Fortunately, special district state associations, which exist in California, Florida, Colorado, Oregon, and Utah, dedicate themselves to the needs of special districts. They provide services such as lawmaking advocacy and professional development. These essential tools are needed in an era that values increased transparency and government accountability.

260 Integrated Vector Management with ArcGIS Enterprise - Puerto Rico Vector Control Unit
Cesar Piovanetti (cpiovanetti@prvectorcontrol.org)

The Puerto Rico Vector Control Unit (PRVCU) is an initiative of the private non-profit organization the Puerto Rico Science, Technology, and Research Trust. The PRVCU was established to leverage Puerto Rico's capacity to control the Aedes aegypti mosquito, the vector for the diseases zika, chikungunya, and dengue in Puerto Rico. The PRVCU focuses on strengthening the capacity for vector control in Puerto Rico as well as implementing vector surveillance, creating innovative information systems, carrying out vector control operations, and boosting community engagement through citizen mobilization and education programs. Technology plays a critical role in the daily operations of the PRVCU. From Weekly trap maintenance, to mosquito identifications and community outreach, ArcGIS Enterprise provided the necessary tools to design, develop and integrate GIS as a tool to make informed decisions for the organization. The integration of ArcGIS Enterprise, Workforce for ArcGIS, Survey123 and ArcGIS API for Python have provided the capabilities for task automation, map production for reports and real time visualization tools that are shared with key stakeholders in the mission of implementing a successful, integrated vector management (IVM) strategy at Puerto Rico Vector Control Unit. The PRVCU team is using Workforce for ArcGIS to plan and coordinate all vector control activities (deployment and maintenance of AGO surveillance of traps along with vector control). Workforce allows PRVCU to assign tasks to field workers and provides a solution for field workers to visualize their assignments on mobile devices. Once in location, Survey123 provides an easy to use experience for trap placement and data capture.

261 Use of GIS-based routing app for turbine truck larviciding operations
Michael Melendez (mmelendez@broward.org), Odette Reza-Brown, Adriana Toro

Broward County Mosquito Control staff developed a navigation app that replaced the use of paper-based maps to route turbine larviciding trucks. Based on a GIS platform, the app significantly reduces the time that technicians need to create maps for spray routes. What used to take hours to do by hand, now takes only minutes. The app runs on tablets (Ipads) that are mounted on the dashboards of the larviciding trucks. Much like a GPS system, drivers follow the predetermined routes shown on the tablet screens. Truck-mounted turbine larviciding is dependent on the wind direction, and the maps are north-oriented, helping drivers to ensure that the spray patterns follow the wind direction. Using 4G LTE data stream, the app transfers data that allows supervisors to view up-to-date information on the drivers' assignment progress, location of the trucks, and saves information that serves as a permanent record of the areas that were sprayed (or not sprayed). Larviciding takes place at night and the use of the app greatly increased the

safety and work efficiency of the technicians. Before the app two technicians were assigned per truck (one to drive and one to read the map). With the app, now only one technician per truck is needed, freeing additional technicians to drive the other spray trucks.

262 Use of real time monitoring to improve implementation of vector control and entomological surveillance in Guatemala

Miriam Vanessa Castillo (Vanessa_CastilloGutierrez@abtassoc.com), Carlos Enrique Cardenas

In response to the Zika epidemic in the Americas, the United States Agency for International Development (USAID) funded the Zika AIRS Project (ZAP) to support the emergency response in several Latin American countries, including Guatemala. Given the large volume of vector control and entomological data points collected on a daily basis (approx. 3,500 records per day), ZAP selected a data capturing system Open Data Kit (ODK), where data would be entered in the field using mobile phones. A web platform Tableau (a "business intelligence" application) uses the cloud-synchronized data to show programmatic progress and surveillance performance indicators using maps, graphs, and tables. Visual dashboard tools include user-defined filters to analyze data and visually identify challenges/problems, monitor field staff, and supervisor performance, and provide programmatic data to make immediate corrective and preventive decisions. A further advantage is that GPS enables mapping of untreated and treated locations and identify "hotspots" where more intensive attention and supervision is required. The system also enables entomological data (larvae and pupae indicators, egg density, types of mosquitos) to be overlapped with vector control data, which enables managers to look at indicators in combination, providing an instant and more complete assessment of the situation, versus a more vertical analysis of indicators. Compared with the "paper and pencil" data collection method, where there is often time lags, the real-time monitoring system is more sensitive, comprehensive in the way indicators can be layered, cost-effective, timely and easily utilized by field staff.

263 Impact of a relaxed residential do not spray policy on adulticiding operations

Daniel Bartlett (dbartlett@nwmadil.com), Justin Harbison, Patrick M Irwin

Adulticiding is a key operational component in integrated mosquito management. These operations can vary between districts, from the types of treatment (aerial, truck-mounted, backpack), to the restrictions placed on what areas of the district can be sprayed. However, there does not seem to be a consensus among mosquito abatement districts (MADs) on the policies that allow individual residents to be exempt from adult mosquito spraying. In addition, other factors such as protected nature and conservation areas and apiaries can impact the areas which can be sprayed. We examined the differing "do not spray" policies between Cook County MADs and examined spatially how a "do not spray" policy can affect adulticiding operations performed by truck-mounted ultra-low volume sprayers in the Northwest Mosquito Abatement District. The analysis looks at the impact of resident apiaries, forest preserve and nature preserve area restrictions, resident exempt requests and the impacts of those requests on surrounding residents. We also look at how the differences among townships in the district affect adulticiding capabilities. By reviewing a MAD "do not spray" policy spatially, the impacts on adulticiding operations can be quantified and begin a conversation between MADs on best practices for adulticiding operations and do not spray policies.

264 VectorBase: Population Biology (PopBio) and omics data for all vector species

Gloria Isabel Giraldo-Calderón (ggiraldo@nd.edu), Sarah Kelly, Samuel Rund, Robert MacCallum, George Christophides, Daniel Lawson, Mary Ann McDowell

VectorBase is a Bioinformatics Resource Center for Invertebrate Vectors of Human Pathogens, that hosts data and builds tools to facilitate research, monitor and control of vector-borne diseases. The population biology (PopBio) data includes insecticide resistance phenotypes and genotypes, population abundance, pathogen infection status, genomic variation and blood-meal identification, which can be freely accessed here www.vectorbase.org/popbio. PopBio data is geotagged and can be queried and browsed with a map-based interface that has autocomplete, summary statistics and graphs, share screen, spreadsheet-ready data download for any user query, among other features. PopBio data comes from scientific papers, vector control districts, ministries of health, public and private health agencies and international initiatives like the Worldwide Insecticide Resistance Network (WIN). PopBio allows the interrogation and visualization of worldwide populations for more than 300 species. We operate a continuous process of literature curation to add new data every two months. Since 2017, our collections have grown dramatically. As of August 2018, we have population count records from 100863 trap collections from 3493 trapping locations, representing over 22 million mosquitoes. Records we are currently processing will eclipse these numbers. We will also

present on our integration with Biogent's smart traps for automatic transfer of data from the field to our publicly available website. On the other hand, VectorBase omics data includes genomes, transcriptomes, and proteomes, all with their specific bioinformatic tools for analysis. VectorBase is under constant development, please send us your requests or feedback to info@vectorbase.org. VectorBase has been funded since the year 2004 by the National Institutes of Health (NIH) - National Institute of Allergy and Infectious Diseases (NIAID).

265 Real time Arbovirus mapping with ArcGIS.
Ron Montgomery (montgomeryr@HCFLGOV.net), Donnie Hayes

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 arbovirus surveillance unit.

266 Drone-based photography for finding cattail mosquito habitat
Nancy Read (nancread@mmcd.org), Joe Elling

Metropolitan Mosquito Control District has started testing how use of UAVs (drones) can make our operations more efficient and effective. Our cattail mosquito (*Coquillettidia perturbans*) surveillance and control program requires field inspectors to traverse rooted and floating cattail mats looking for open water holes where larvae are found. Locations of these holes, and even locations of the mats themselves, vary from year to year. We tested use of a DJI Phantom 4 collecting color imagery (visible spectrum) in both real time and later-processed ortho-corrected formats to see how this functionality could best fit our work flow. We also tested additional sensors and imagery processing indexes to assess their usefulness for locating current wet areas in both cattail and floodwater mosquito habitat. We compared equipment and training costs vs. potential savings to determine next steps. This talk presents results to date.

Challenges and Opportunities in Vector-borne Disease Management and Vector Control Symposium II

267 Validation of adulticides and adulticiding
Jing Zhai (jingzhai@eurofins.com)

The author will discuss history of adulticides used in vector control, challenges and opportunities in new product development and new adulticide application technology.

268 Mosquito larvicides and larviciding – Enhancement and optimization
Justin Harbison (jharbison@luc.edu)

As many mosquito control programs base much for their operations on routine larviciding, optimizing the effectiveness of this work is important. Using catch basins as a case study, lessons learned from recent larvicide cost-effectiveness studies in the Upper Midwest will be discussed.

269 Urban storm drains as significant mosquito breeding sources
Michelle Brown (mbrown@wvmvcd.org), Alfonso Melgoza, Robert Garner, Alfredo Mejia, Tianyun Su

Stormwater collection devices have been known to be potential breeding sites for mosquitoes for several years. This study examined three different types of stormwater collection devices: infiltration basins, media filters and hydrodynamic separators. Larval samples, when available, were taken each week and samples identified down to species. Larval samples were found in infiltration basins in the first part of the year and samples were found continuously in media filters and hydrodynamic separators, with counts as high as 295 mosquito larvae at a single site at a single inspection. The dominant species of mosquito found at all types of devices was *Culex quinquefasciatus*, (the Southern house mosquito). Unsurprisingly, the greatest diversity of species was found in infiltration basins and hydrodynamic separators contained only *Culex quinquefasciatus*. When comparing the rate at which District technicians found mosquito breeding upon inspection, stormwater collection device inspection teams were twice as likely to find mosquito breeding than all other technicians, including those inspecting District dairy and farmland, and flood control channels and basins. In the early parts of the year (February through April), the stormwater collection device teams

were three times more likely to find mosquito breeding than the other technicians. With 528 known sites (with each site generally containing 2 or more devices) within the 210 square mile District, the amount of mosquito breeding due to stormwater collection devices is significant and will require continued attention and cooperation with our District cities for maintenance of these devices.

270 Challenges in Evaluating Mosquito Control Strategies in the Urban Environment
F. Steve Mulligan (smulligan@mosquitobuzz.net)

The invasion and establishment of mosquitoes into new regions, the emergence/re-emergence and spread of mosquito-borne diseases and issues of susceptibility/resistance have challenged the development and implementation of new mosquito control products and innovative technologies and strategies. Such challenges are compounded when dealing with mosquito species such as *Aedes aegypti* which are closely associated with humans and the urban environment; and when introducing novel control methods, such as Debug Fresno with the release of male mosquitoes. Evaluations of mosquito control strategies in residential settings can be challenging, as it magnifies the interactions with residents and stakeholder groups and increases the need and importance of public outreach efforts. Further challenging are efforts to engage residents to take personal responsibility to protect themselves from mosquito bites and to prevent mosquito production through resident participation in sanitation. Such challenges will be discussed in the context of experiences of the Consolidated Mosquito Abatement District in research collaborations.

271 Challenges in vector-borne disease management and vector control
William K Reisen (wkreisen@gmail.com)

Relatively recent increases in the global human population size and the degree of urbanization have altered the earth's climate, expanded the distribution of vectors and pathogens into northern latitudes, lengthened transmission seasons, and increased dispersal through exploiting human travel and commerce. Concurrent with these changes and the historic dispersal of the *Culex pipiens* complex and *Aedes aegypti* from the Ethiopian region has been the urbanization of formerly rural arboviruses leading to global pandemics of dengue, West Nile, chikungunya and Zika viruses. Intervention methods that successfully limited cases of rural arboviruses such as St. Louis virus and may have contributed to the elimination of Western equine encephalitis virus, have been less successful in preventing urban/suburban problems, perhaps because of the unwillingness of an urban population to embrace the implementation of intervention strategies such as immunization, aerial adulticiding and the release of genetically altered mosquitoes.

Water Management Symposium II

292 Continuous Deflective Separators and there implications for mosquito control.
M. A. Daniel (mdaniel@glacvcd.org)

Stormwater capture and reuse has garnered increasing attention in Los Angeles County as a means of defraying the need for importing water and long term sustainability. Stormwater capture devices are proliferating to facilitate the removal of pollutants, such as trash, and diverting stormwater into infiltration basins, underground storage facilities and flood control channels. Continuous Deflective Separation (CDS) units, also known as Hydrodynamic Separation units are used throughout Los Angeles County to achieve stormwater quality goals.These units are effective at removing trash during storm water events, however, they represent a significant source of mosquito breeding during the rest of the year. Non stormwater runoff accumulates in these units and can provide year round habitat for both Culex quinquefasciatus and Aedes aegypti. Hundreds of these units are in place and more will be installed in the years to come. We are establishing an Urban Water program to identify the location and condition of the CDS units as well as other stormwater capture devices. The goal is to work with manufacturers and agencies to eliminate water accumulation during the dry periods between stormwater events and prevent mosquito breeding.

293 An Overview of Water Management in New Jersey
V. Thompson (victoria.thompson@co.monmouth.nj.us)
In New Jersey, water management has long been recognized as a viable strategy for mosquito control by county mosquito control agencies. The goal of all water management projects is to create conditions inhospitable to mosquito larvae by either improving water flow, deepening water to support predaceous fish or removing excess surface water without loss of hydric soil conditions. This presentation will spotlight a variety of water management projects conducted by county agencies, review the unique permits developed for the mosquito control community, introduce the State of Jersey's Equipment Program and demonstrate intra-county cooperation needed to implement projects in Monmouth County.

294 Managing Expectations – Using State-level Partnerships to Evaluate Mosquito Control and Wetland Management for Waterfowl

J. A. Henke (jhenke@cvmvcd.org), Brian W. Olson, Joel Buettner, Matthew C. Ball, Conlin Reis, William Walton

The management of seasonal wetlands for waterfowl and other wetland-dependent wildlife has the potential to produce mosquito abundance that surpasses mosquito abatement thresholds. To help minimize the impact of wetland management activities on public health and safety, the Mosquito and Vector Control Association of California set up a working group with the California Department of Fish and Wildlife to explore how to meet the needs of both agencies. Best management practices (BMPs) were developed by the Central Valley Joint Venture in coordination the California Department of Public Health and the Mosquito and Vector Control Association of California. In 2017, we evaluated the effect of two BMPs (discing and establishment of predator reservoirs) on the presence of mosquito larvae in wetlands managed by the California Department of Fish and Wildlife (CDFW) at two wildlife areas (Gray Lodge and Los Banos). Larval mosquito abundance in disced treatments at both study sites was significantly lower compared to traditional and optimal management strategies. Larval mosquito abundance in disced wetlands was significantly lower than in wetlands with reservoirs for mosquito predators at both wildlife areas in early summer, but immature mosquito abundance was comparable in both BMPs during July at Gray Lodge Wildlife Area. When financially feasible, discing has significant potential to both enhance wetland quality for waterfowl and decrease mosquito production in units managed for wintering waterfowl, but there may be times when wetland units utilizing these BMPs need to be treated for surpassing abatement thresholds. Further evaluation is needed to determine the overall cost-effectiveness and long-term applicability of these strategies.

295 Innovations in Water Management and Mosquito Source Reduction Analysis

M. Scholl (mscholl@fightthebite.net)

The Sacramento-Yolo Mosquito and Vector Control District actively pursues Mosquito Reducing Best Management Practices (BMPs) implementation on Federal, State, Local Government and privately owned properties. The District works to reduce mosquito control costs through a variety of methods including the use of UAS (drone) imagery for land surveying, cost share programs, use of heavy equipment, and water control devices. Using the District's UAS units, the District teamed up with the San Francisco Drone School, Suas news and Propeller Aerial to survey irrigated agricultural and wetland areas to find high and low areas for localized treatments as well as potential drainage options. District source reducing BMP projects are able to utilize emerging UAS and topographic modeling technologies as an accurate and time saving method for project analysis and design.

296 Integrated marsh management: A holistic approach to managing coastal wetlands for multiple objectives

R. Wolfe (roger.wolfe@ct.gov)

The Wetland Habitat and Mosquito Management (WHAMM) Program of the Connecticut Department of Energy and Environmental Protection's Wildlife Division, employs and promotes the practice of Integrated Marsh Management (IMM) for restoring and managing Connecticut's degraded coastal wetlands, while minimizing public health risks from mosquito-borne diseases. IMM is a holistic approach to wetland management utilizing a variety of techniques to achieve site-specific goals. IMM takes into consideration the many aspects of wetland restoration and management including tidal flow restoration, hydrologic modification and removal of dredged material to restore ecosystem functions, source reduction and biological control of saltmarsh mosquitoes (open marsh water management), control of invasive plants such as Phragmites through tidal flow restoration and selective herbicide use, and habitat enhancement for coastal wetland-dependent species. With roughly 6500 ha of coastal wetlands, our marshes are small compared to other coastal states, but because of the unique character of each location and site-specific objectives, IMM projects can be relatively simple, while others can be quite complex requiring input from many disciplines. Potential projects are reviewed by a multi-stake holder site review team and approved through a streamlined state and federal permitting process. This review process also identifies where proposed projects could dovetail past or current work, or potentially impact other projects or ongoing research. The success of any IMM project depends on diligent education and the formation of partnerships to share expertise, equipment and funding. Pre- and post-monitoring is important to evaluate success, document where follow up work may be needed, and identify further research opportunities. Various types of projects will be examined describing successes and pitfalls which will hopefully prompt constructive dialogue with other wetland managers and practitioners.

297 Managing impoundments along Florida's Indian River Lagoon: Controlling saltmarsh mosquitoes while enhancing the resource
D. Carlson (doug.carlson@irmosquito2.org)

From the mid-1950s to 1970, approx. 40,000 acres of salt marsh/mangrove swamp was impounded along Florida's Indian River Lagoon. Because saltmarsh mosquitoes oviposit on moist soil but not on standing water, building earthen dikes around known mosquito-producing marshes and flooding them during the summer months is an effective and economical method of controlling saltmarsh mosquitoes requiring a minimum of pesticide use. This presentation will provide an overview of impoundments along east-central Florida and will explain the process of managing these environmentally-sensitive areas both for mosquito control and natural resource enhancement over the past 60+ years.

298 Water management activities in Bristol County, Massachusetts
P. Matton (brismosqpc@comcast.net), Diana Brennan

Water management is a vital part of Bristol County Mosquito Control Project's integrated mosquito management plan. Our goal is to remove debris, sediment and vegetation from drainage ditches throughout our service area to improve water flow, thereby reducing standing water and larval habitat. This activity includes both hand and mechanized work in fresh and salt water. We use erosion control materials and re-seed to stabilize soils disturbed by our operations. The majority of these activities take place over the winter months; however, Bristol County does have a year-round program to address time and environmentally sensitive concerns. Locations are chosen on a variety of factors including proximity to areas where West Nile virus or Eastern Equine Encephalitis has been detected in mosquitoes. This presentation will highlight some of the work that has been conducted in the County.

Poster Session Abstracts
Adult Control

P-01 Evaluation of insecticide resistance in Aedes albopictus in North Carolina, 2017
Stephanie Richards (richardss@ecu.edu), Avian White, Brian Byrd, Michael Reiskind, Michael Doyle

Mosquitoes may develop resistance to insecticide active ingredients (AIs) found in formulated products. Hence, mosquito control programs should implement resistance management strategies by assessing resistance in targeted populations, rotating different classes of insecticides based on resistance testing, and/or increasing insecticide concentration (i.e., saturation) to overcome emerging resistance. The resistance/susceptibility status of mosquito populations should be monitored at least annually, in advance of a potential mosquito-borne epidemic and to avoid treatment failures or inefficiencies for nuisance mosquito control. Resistance testing is often done solely on AIs, but should include both AIs and formulated products at the concentrations mosquitoes encounter in the field. Here, we determined the resistance/susceptibility status for selected mosquito adulticides (AIs and formulated products) commonly used for adult mosquito control. We propagated adults from field-collected *Aedes albopictus* eggs obtained from seven regional populations in North Carolina during 2017 and compared them to a known insecticide susceptible strain. We used Centers for Disease Control and Prevention (CDC) bottle bioassays to assess the resistance/susceptibility status for eight AIs (i.e., bifenthrin, permethrin, sumethrin/prallethrin, deltamethrin, tau-fluvalinate, chlorpyrifos, malathion, and naled) and eight formulated products (TalStar®, Biomist 3+15®, Duet®, Suspend Polyzone®, Mavrik®, MosquitoMist®, Fyfanon®, and Dibrom®) that respectively contain the tested AIs. We used current CDC guidelines for *Aedes albopictus* to classify mosquitoes as susceptible (97-100% mortality at diagnostic time [DT]), developing resistance (90-96% mortality at DT), or resistant (< 90% mortality at DT). Significant differences were observed in mosquito susceptibility/resistance among and between AIs and formulated products.

P-02 Development of an attractive toxic sugar bait system using solid sucrose
Caleb Lee Corona (clcorona@iastate.edu), Joel R. Coats

Attractive Toxic Sugar Bait (ATSB) technologies have recently been developed to control mosquito populations by targeting the insect's physiological need to feed on a sugar source as a method to encourage the mosquito to ingest a toxic compound. The hydrophobicity of certain natural products has led to the development of a new assay to better screen these compounds using solid sucrose and an active ingredient against *Aedes aegypti* mosquitoes.

P-03 Florida Aedes aegypti and Aedes albopictus: A statewide survey of pyrethroid resistance and knockdown resistance (kdr) mutations

Sarah J. Bernard (sarah.bernard@ars.usda.gov), Alden S. Estep, Neil D. Sanscrainte, Christy Marie Waits, James J. Becnel

Container breeding Aedes mosquitoes are widely distributed in Florida and have recently been responsible for autochthonous transmission of dengue and Zika. Insecticide treatment, primarily with pyrethroids, is one common control measure implemented by local vector control districts but the distribution of resistance in Florida is not well described. In this study, twenty-one strains of *Aedes aegypti* and 5 strains of *Aedes albopictus* were collected from 9 counties in Florida and F1 eggs were reared for topical toxicology testing. Resistance ratios for strains were calculated by measuring the number of mosquitoes that died in topical adult bioassay as compared to the permethrin susceptible ORL1952 strain. These same *Aedes aegypti* populations, along with surveillance samples from approximately 40 other strains were genotyped using melt curve analysis with previously described allele-specific primers to determine the distribution of two common *kdr* mutations (1016I and 1534C). Variable levels of resistance and variable frequencies of *kdr* alleles were detected throughout Florida in these strains of *Ae. aegypti*. The frequency of double homozygotes (genotype: 1016II & 1534CC) correlated strongly with resistance ratios. In contrast, all tested *Ae. albopictus* were found to be susceptible to permethrin.

P-04 Evaluation of four pyrethroid-based insecticides for aerial applications targeting the Black Salt Marsh Mosquito, Aedes taeniorhynchus (Wiedemann), and the Yellow Fever Mosquito, Aedes aegypti (Linnaeus) in Collier County, FL

Rachel Bathsheba Bales (rbales@cmcd.org), Kaci McCoy, Caroline Weldon, Alexandria Watkins, Keira J Lucas

The black salt marsh mosquito, Aedes taeniorhynchus (Wiedemann), is a nuisance pest found in Florida's coastal counties. The majority of spring and early summer adulticiding efforts by Collier Mosquito Control District (CMCD), located in Southwest Florida (FL), are due to Ae. taeniorhynchus, which migrate on the wind as far as 20-60 miles from breeding sites within the Everglades National Park, Ten Thousand Islands National Wildlife Refuge and the Rookery Bay National Estuarine Research Reserve. In 2017, CMCD experienced a population explosion of Ae. taeniorhynchus with landing rate counts exceeding 100+ adult female mosquitoes within 2 minutes in coastal communities. In an effort to explore the usage of pyrethroid-based control materials for the control of Ae. taeniorhynchus, we evaluated four commercially available products: Anvil 10-10, Deltagard, Merus 2.0 (replaced with Merus 3.0) and Zenivex E20. The CDC Bottle Bioassay, as well as cage trials using ground and aerial applications, were utilized to evaluate each product against the Orlando 1952 Aedes aegypti laboratory strain, pyrethroid-resistant Puerto Rico Ae. aegypti laboratory strain (CDC Bottle Bioassay only), local field caught pyrethroid-resistant Ae. aegypti, and local field caught Ae. taeniorhynchus. During the 2018 mosquito season in Collier County FL, CMCD utilized two pyrethroid-based insecticides: Merus 2.0 (replaced by Merus 3.0

P-05 Evaluation of insecticide-treated house screening on entomological infestation and arbovirus infection of Aedes aegypti during a Zika transmission period in Merida, Mexico

Pablo Manrique-Saide (pablo_manrique2000@hotmail.com), Josue Herrera-Bojórquez, Anuar Medina-Barreiro, Emilio Trujilllo-Peña, Josue Villegas-Chim, Norma Pavía-Ruz, Nina Valadez-González, Hugo Delfín-Gonzaléz, Juan Chablé-Santos, Fabian Correa-Morales, Felipe Dzul-Manzanilla, Azael Che-Mendoza, Juan Arredondo-Jiménez, Adriana E Flores-Suarez, Gonzalo Vázquez-Prokopec

We evaluated in a cluster-randomized controlled trial, Insecticide-treated house screening (ITS), on *Aedes aegypti* entomological infestation, arbovirus infection and community acceptance during a Zika outbreak in Merida, Yucatan, South Mexico. Cross-sectional entomological surveys quantified indoor adult mosquito infestation at baseline (pre-intervention) and throughout two post-intervention (PI) surveys spaced at 6-month intervals corresponding to dry/rainy seasons over one year (2016-2017).The study included the detection of dengue (DENV), chikungunya (CHIKV) and Zika (ZIKV) viruses in female *Ae. aegypti* collected from the same sample of houses with the Trioplex Real time RT-PCR Assay. Household-surveys were applied to families randomly selected within intervention clusters to address the social reception of the intervention. At 6 months after the installation of ITS (rainy season), houses protected were >80% less infested with *Aedes* females than the houses of control clusters (OR females = 0.14, 95% CI = 0.08-0.26; OR blood fed = 0.18, 95% CI = 0.09-0.33). One year after intervention, significant differences were still observed between houses protected with ITS and non-protected controls (OR females= 0.21, 95% CI = 0.08-49; OR blood fed = 0.24, 95% CI = 0.09-0.58). The houses protected with ITS had significantly less females infected (OR females with ZIKV=0.17, 95% CI 0.08–0.32) at the 6 months PI survey, and these differences remained significant (OR females with ZIKV==0.24, 95% CI 0.09–0.60). Social acceptance process was a key factor to understand what drove the community to get involved in the intervention. Three main reasons

encouraged participation: the rationality-efficacy of the intervention on reducing of mosquito-human contact, the perception of people iof the high risk for *Aedes*-borne diseases transmission, and that enrolled participants convinced more families through sharing their positive experiences about ITS. All participants perceived an efficacy on mosquito reduction and definitively recommended the scaling-up of the intervention, because the multiple positive outcomes perceived.

P-06 Evaluation of EverGreen ULV 5-25 Ground at below label rate

Kim Y Hung (khung@cvmvcd.org), Melissa Snelling, Christopher Cavanaugh, Arturo Gutierrez, Greg Alvarado, Jennifer A. Henke

EverGreen ULV 5-25 (active ingredient: pyrethrins 5% and piperonyl butoxide 25%) is a product labeled for use at a rate of 0.0018 pounds of pyrethrins per acre to 0.0025 pounds per acre. There was an indication from the manufacturer that using the product at below label rate may be effective; consequently, we examined whether applying at a rate of 0.0015 lbs/acre would provide effective mosquito control at our district. We set up 9 pairs of sentinel cages with each pair having an adult susceptible *Culex quinquefasciatus* and a wild F1 cage. Wild mosquitoes were from La Quinta and Indio, CA because they have been found to be resistant to several pyrethroid insecticides. We placed impingers with Teflon slides next to 7 of the 9 sentinel cages in order to characterize the droplets arriving at the cages. Cages and a spinner were set up similarly 150 feet upwind of the spray area for the control. After truck ULV application using a Guardian sprayer, we brought the sentinel cages back to the lab and counted the mortality. We found good mortality at below label rate (0.0015 lbs/acre) in both the colony and wild mosquitoes. Unfortunately, we did not see the same mortality pattern at the higher rates possibly due to poor weather conditions during those applications. Droplet size did not show any variation among the treatment locations but droplet density showed a decrease at treatments 300 ft away from the spray origin. Since the mosquitoes did show mortality at the lowest rate, we shared this with the manufacturer for their consideration. We plan to use the lower approved label rate in our mosquito control applications.

P-07 Aedes aegypti insecticide resistance in Puerto Rico

Nicole Nazario (nnazario@prvectorcontrol.org), Angela Harris, Mark Concepcion, Reynaldo Morales, Marianyoly Ortiz, Luz A Crespo

The Puerto Rico Vector Control Unit (PRVCU) was established through a cooperative agreement between the Centers for Disease Control and Prevention (CDC), and the Puerto Rico Science, Technology, and Research Trust, to monitor and control the mosquito *Aedes aegypti*, the vector on the Island for dengue, Zika, and chikungunya. As part of the PRVCU integrated vector management (IVM) strategy, insecticide resistance testing is conducted using the CDC Bottle Bioassay to monitor the status of insecticide resistance of wild populations of *Aedes aegypti* in Puerto Rico. Mosquito eggs are collected from ovitraps deployed in urban neighborhoods around the Island and reared in the laboratory for testing using 2-5 day old adult female mosquitoes. The PRVCU tests those pesticides for which a formulated, commercially available product is approved for use locally (permethrin, deltamethrin, chlorpyrifos, malathion, etofenprox, and phenothrin) and tests are carried out using technical grade chemical solutions made in acetone. Preliminary results have shown resistance towards all insecticides tested, including both pyrethroids and organophosphates. Due to the challenging situation of insecticide resistance in Puerto Rican *Aedes aegypti*, the PRVCU has pledged to continue regular testing to provide reliable data of the up-to-date status of *Aedes aegypti* insecticide resistance on the Island. This data will serve as guidance for stakeholders and municipalities of Puerto Rico, reinforcing the need of implementing integrated strategies for the control of *Aedes aegypti*.

P-09 Cytochrome P450 mono-oxygenase and resistance phenotype in DDT and deltamethrin resistant Anopheles gambiae s.s. and Culex quinquefasciatus

Ifeoluwa Kayode Fagbohun (fagbohunife@gmail.com), Olubunmi Adetoro Otubanjo, Samson T Awolola, Tolulope Amos Oyeniyi, Emmanuel Taiwo Idowu, Taiye Shade Olusegun-Joseph

Pyrethroids and DDT insecticides are key insecticides in the control of malaria, yellow fever and lymphatic filariasis vector. Knockdown and metabolic resistance mechanisms have been proven to be important in determining the efficacy of insecticides. Here we report cytochrome P450 resistance mechanism and plausible effect on resistant phenotype in *Anopheles gambiae* and *Culex quinquefasciatus* exposed to pyrethroid and DDT. Two to three days old adult female mosquitoes were used for the insecticides exposure and PBO synergistic assay using WHO standard guideline, kits and test papers (DDT 4%, deltamethrin 0.05% and PBO 4%). PCR assays were used for the identification of the species and for characterization of the kdr allele. Resistance to DDT and deltamethrin was recorded with 24hours post exposure mortality of 18% and 17% in *An. gambiae* exposed to DDT and deltamethrin respectively, 1% and 5% in *Cx.*

quinquefasciatus exposed to DDT and deltamethrin respectively. Significant (P<0.01) level of susceptibility was recorded in mosquitoes pre-exposed PBO as KDT_{50} and 24hours exposure ranges from 37.6minutes to 663.4minutes and 27% to 80% respectively. Presence of knockdown resistance allele was recorded in *An. gambiae*, 22.5% for homozygote resistance and 7.5% for heterozygote while *Cx. quinquefasciatus* population showed no kdr allele despite the high level of resistance to DDT and deltamethrin. Findings from this study indicated that cytochrome P450 monooxygenase is highly implicated the resistance phenotype to DDT and pyrethroid expressed in *An. gambiae* and *Cx. quinquefasciatus* in the study area.

P-10 Field evaluation of natural essential oil misting and λ-cyhalothrin residual pesticide applications against medically important mosquitoes in Thailand

Arissara Pongsiri (arissarap.ca@afrims.org), Alongkot Ponlawat, Silas A Davidson, Seth Carroll Britch, Kenneth J Linthicum, Robert L Aldridge, Frances V Golden

Use of natural essential oils as repellents may be a viable alternative method for mosquito bite protection which may be safer to humans and the environment than using standard pesticides. However, repellent activities of these products are of possibly short duration and may not reduce mosquito populations for long periods. In the current study, a product containing a blend of essential plant oils (Essentria™ IC^3: 10% rosemary oil, 5% geraniol, and 2% peppermint oil) was tested for its repellent effect to enhance the known mosquito protective effect of a standard residual pesticide treated on two types of militarily relevant materials. Geotextile HESCO structures (2x2x2.5 m) and ultra-lightweight camouflage net structures (3x3x2 m) were constructed at Chanthaburi province, Thailand, and both treated with the residual pesticide formulation containing λ-cyhalothrin. We installed a misting system to automatically release the essential oil formulation on both structure types. Effectiveness of the combined residual and misting system to reduce mosquito population was evaluated using BG-sentinel traps and CDC light traps baited with dry ice to collect day- and night-biting mosquitoes, respectively. Traps were operated during the misting application for several consecutive days and nights, and then set up at week 2, 10, and 18 with no additional misting application to determine long lasting synergistic effect of the combined misting and residual. The results revealed that populations of night-biting mosquitoes were significantly decreased after misting. Moreover, the combination of essential plant oil misting and residual pesticide application effectively reduced mosquito densities. The effect of combined application lasted for at least two weeks. However, we did not detect the reduction of day biting mosquitoes in this study. We conclude that the combination of natural plant oil misting system and λ-cyhalothrin residual pesticide application is strongly recommended for night-biting mosquito control.

P-11 Pesticide resistance testing in Suffolk, Virginia targeting Aedes albopictus and Culex pipiens

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Since the commencement of the mosquito control program in Suffolk, VA pesticide resistance testing has never been conducted. During this time the majority of adulticides utilized in the city were either pyrethroids or pyrethroid based, making the likelihood of resistance high. It was a priority during the 2018 mosquito season to integrate pesticide resistance monitoring into the program to detect the susceptibility of mosquito populations to the current active ingredients in use. This presentation will highlight the preparations taken to fully implement an annual pesticide resistance testing protocol using the CDC Bottle Bioassay into a small mosquito control program. Our aim was to test *Aedes albopictus* and *Culex pipiens* against the active ingredients sumithrin, prallethrin, and permethrin. Our results showed that our *Cx. pipiens* population was resistant to all three active ingredients and *Ae. albopictus* was susceptible to all three active ingredients. These results are directly influencing our decision to replace our current adulticides with a new adulticide that both of these species are susceptible to.

Aerial Control/Aviation

P-12 Community acceptance and perceived efficacy on Aerial Ultra-Low Volume application of insecticide for the control of Aedes aegypti in Puerto Vallarta, Mexico

Josue Villegas-Chim (jovich.etnos@gmail.com), Pablo Manrique-Saide, Alma Medina Várguez, Francia Espinosa Lizama, Carolina Martínez Cruz, Anuar Medina-Barreiro, Norma Pavía-Ruz, Wilberth Bibiano-Marín, José Vadillo-Sanchez, Gonzalo Vázquez-Prokopec, Fabian Correa-Morales, Armando Elizondo-Quiroga

The efficacy of Aerial Ultra-Low-Volume (AULV) application of insecticide was evaluated in 2017 at Puerto Vallarta, Mexico. As part of the social research, we develop a study of the social perceptions of the resident population of the area selected for AULV. First, we conducted ahouse-to-house awareness campaignon*Ae. aegypti*and *Aedes*-borne diseases, including information on AULV. A household questionnaire was applied after the AULV application to collect information on the use of domestic insecticides, housing materials,

number of residents and individual response to the treatment (allergic reaction, satisfaction with control, etc.). Community acceptance during the enrollment was 100% and main reasons were because: concern about dengue/chikungunya/Zika infections (36.76%), expectations of other benefits in near future (12.39%), convincement on the efficacy of the intervention (11.97%), AULV was perceived as good strategy and additional to methods used by local government (11.76%), and free-cost of the intervention (4.87%). The perceived efficacy on AULV was significantly positive, and numerous comments were received indicating the excellent "pest" mosquito control obtained. A 98.44% of participant families reported significant reductions on indoor mosquitoes, from which 34.38% reported complete reduction, and 64.06% noticed smaller amounts of mosquitoes. A 99.22% of interviewed did not reported to suffer from *Aedes*-borne diseasesduring and after the intervention, although 49.22% continued using domestic prevention methods such as insecticide (79.37%), repellents (7.94%), and coils (6.35%), mostly explained as behavioral and as social routines. There were no complaints concerning the low-flying aircraft, or the odor of the insecticide, or any adverse effects.

P-13 Efficacy against Mosquitoes Following Aerial Applications of DeltaGard® Insecticide in Stanislaus County, California

Jing Zhai (jingzhai@eurofins.com), Neta Wicker, Bill Reynolds, Piper Kimball, Lloyd Douglass, Ming Hua Huang

Study on aerial applications of DeltaGard Insecticide against *Culex quinquefasciatus* was conducted in Stanislaus County, California in June 2018. A Cessna 188 fixed-wing airplane equipped with two Micronaire AU 5000 was used to apply DetaGard at application rates of 0.00089 and 0.00134 lbs deltamethrin/acre. Application parameters, droplet spectrum and efficacy will be discussed.

P-14 Optimization of Aerial Larvicide Applications in Placer County, CA: Comparison of a spray system equipped with 2 vs 4 Micronair AU5000 rotary atomizers.

Jacob Hartle (jakeh@placermosquito.org), Mario Boisvert, Jason Smith, Mary Sorensen

Placer Mosquito and Vector Control District observed that within a single swath width from a fixed wing aircraft equipped with 2 rotary atomizers, the droplet deposition contained extreme peaks and valleys, especially under the belly of the aircraft. This study looked to optimize these aerial applications of Vectobac 12AS® from a fixed wing aircraft equipped with 2 rotary atomizers compared to the same aircraft equipped with 4 rotary atomizers. The applications consisted of an Ag Tractor 402 aircraft, equipped with two Micronair AU5000 rotary atomizers mounted on each wing, with a product application rate of 8 fl.oz/acre. The data collected showed a disproportional amount of droplet deposition from the right side of the aircraft compared to the left side of the aircraft. It was decided to add 2 additional Micronair AU5000s, one more on each wing of the aircraft. The same application rate was applied but the additional atomizers lowered the flow rate for each atomizer and spread out the distribution points of the product over the wing span. For both setups, droplet depositions were collected during the calibration of the aircraft's spray system. To collect the droplet deposition, Kromekote® cards were placed in a straight line perpendicular to the aircraft flight path. For calibration of the spray system and the characterization of the product only 1 swath width's droplet deposition was collected for each pass. For the operational droplet collections, the Kromekote cards were placed in a perpendicular line long enough to collect several swath widths in a traditional back and forth aerial application. The cards were scanned into a software system that calculated droplet size and density. The applications with 4 rotary atomizers created a droplet deposition that was more uniform from both sides of the aircraft and across the entirety of the swath width.

P-15 Influence of water quality on predatory fish and Culex quinquefasciatus cohabitation

Nicholas DeLisi (ndelisi@stpmad.org), Lisa Rowley, Kevin Caillouet, Evan Davies

Roadside ditches that receive effluent from homeowner septic systems are common in suburban and rural areas of Louisiana and are highly attractive to ovipositing *Culex quinquefasciatus*. A local government program that aims to repair or remediate improperly functioning systems conducted a cross-sectional survey of the working status of individual septic systems. In conjunction with this survey, we conducted a correlational analysis of water quality and mosquitofish/*Cx. quinquefasciatus* presence. Water quality measurements (pH, dissolved oxygen (ODO), total dissolved solids (TDS), oxidative reduction potential (ORP)), the presence of mosquitoes/fish, flowing water, and whether the corresponding address passed a septic system inspection were observed and measured from ditches at 215 properties. The effect of covariates on predicting fish presence, and separately mosquito presence, were compared using binary logistic regression in Minitab. Properties with septic systems that passed a functional inspection produced

water with higher ODO (χ^2=17.1; P < 0.001), but mosquito/fish presence was unaffected. Ditches high in TDS, a marker of organic pollution, were less likely to contain fish (χ^2=17.5; P < 0.001), while ditches with flowing water had increased likelihood of fish presence (χ^2=6.1; P = 0.014). Increased ODO influenced fish abundance (χ^2=3.1; P = 0.079), and became significant when TDS was removed from analysis. Mosquitoes were encountered significantly (χ^2=14.3; P < 0.001) less frequently (8x) when fish were present. ORP was the only water parameter that significantly structured mosquito presence (χ^2=7.8; P = 0.005).

P-16 Enhanced attractiveness of Aedes aegypti to oviposition cups baited with a gravid infusion compared to cups baited with tap water

Katherine Ramirez (kramirez@mosquitobuzz.net), Jodi Holeman, Steve Mulligan

The artificial oviposition cup or "ovi-cup" is a surveillance tool for urban container producing *Aedes* species mosquitoes. An ovi-cup baited with water is sufficient for the detection of *Aedes aegypti* (CDC 2016) however, studies have shown an increase in egg deposition in ovi-cups baited with an organic infusion when compared to ovi-cups baited with plain water (Chadee et al. 1993; Polson et al. 2005; Reiter et al. 1991). Since the first detection of *Ae. aegypti*, in 2013, the District has baited ovi-cups with tap water. In 2017 the District started evaluating if ovi-cups baited with an organic infusion would enhance *Ae. aegypti* oviposition. That evaluation suggested the addition of gravid infusion to an ovi-cup significantly enhanced the attractiveness of the ovi-cups to *Ae. aegypti* when compare to tap water alone. Building on those results, the District continued to evaluate ovi-cups baited with an organic infusion to ovi-cups baited with tap water. The study site was one-square-mile urban residential broken into 20-grid sections. Within each section, one-site was randomly chosen for ovi-cup deployment. There were four ovi-cup configurations that were rotated each week to avoid site bias. The results and observations of this study are discussed.

P-17 Discovery of natural drimane sesquiterpene from Madagascan medicinal plants (Cinnamosma spp.) for mosquito vector control

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Chemical pesticides are often used to control populations of mosquito vectors. However, overuse of these chemicals can lead to resistance in mosquitoes. Moreover, several environmental and health concerns such as accumulation of harmful residues in the environment, and undesirable effects on non-target organisms, including beneficial insects and vertebrates, have been proven to be associated with repeated use of conventional chemical pesticides (e.g., pyrethroids, DDT). These problems highlight the need for discovering safe insecticides and repellents. Recently, compounds derived from botanical sources have received much attention as potentially environmentally-safe bioactive compounds against pestiferous insects. Notably, drimane sesquiterpenes, a class of plant secondary metabolites, are known to elicit antifeedant and toxic effects in insect pests. However, the activities of these compounds against mosquitoes have not been previously characterized. Here we demonstrate that the bark of a plant (*Cinnamosma spp.*), commonly used in Madagascar as a traditional remedy for a variety of human illnesses, is enriched with an electrophilic drimane sesquiterpene dialdehyde (cinnamodial) that is toxic, antifeedant, and repellent to the yellow fever mosquito *Aedes aegypti*, an important vector of emerging arboviral diseases in humans, such as chikungunya, dengue, and Zika fevers. In addition, we identify other drimane sesquiterpenes from the bark of *C. fragrans* that exhibit toxic and/or antifeedant/repellent activity against *Ae. aegypti* suggesting that the bark contains a 'cocktail' of compounds that are bioactive against mosquitoes. Our data indicate that drimane sesquiterpenes may serve as a valuable chemical platform for the development of next-generation, natural product-based insecticides and repellents for controlling mosquito vectors of emerging arboviruses.

P-18 Immuno-marking Aedes aegypti for use in mark-capture studies

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Mark-release-recapture (MRR) techniques are used to study insect biology, including estimating dispersal, survival, and population size. MRR necessitates that the insects being studied are first collected from the field or reared in the laboratory before being released. For insects *like Aedes aegypti*, a vector of dengue, chikungunya, and Zika viruses, it is unethical to release them in geographic areas that are endemic for human disease. In addition, the act of uniquely marking *Ae. aegypti* often causes unnecessary stress on the mosquito which may influence their behavior. Mark-capture methods avoid these concerns by passively marking wild mosquitoes in the field. We investigated the utility of orally marking *Ae. aegypti* with the serum from rabbit and chicken. Mosquitoes were provided a 10% sucrose meal that was spiked with sera from either rabbit or chicken.. The mosquitoes were evaluated over an 8-day period to determine protein retention in the mosquito. We discuss how marking mosquitoes with proteins can be used to noninvasively study *Ae. aegypti* biology and ecology in the field.

P-19 Evaluating Different Resting Sites for Targeting Bloodfed Mosquito Populations in Salt Lake City, Utah

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The Salt Lake City Mosquito Abatement District primarily uses carbon dioxide (CO_2)-baited traps to estimate mosquito abundances and conduct arbovirus surveillance. CO_2 baited traps target host-seeking female mosquitoes, and do not sample the full distribution of different sex and life-stages of mosquitoes in a population. Sampling mosquitoes from resting sites collects adult mosquitoes from a broader range of physiological states, including blood-engorged female mosquitoes. Sampling from blooded female mosquitoes in a population can help determine important vector-host interactions for different mosquito species in a region. We conducted a study to evaluate the efficacy of different resting site collecting techniques in targeting blood-engorged female mosquitoes. Six different methods were tested in the wetland habitat near the Great Salt Lake in Utah. Results showed resting site collections had a much higher incidence of bloodfed mosquitoes compared to CO_2-baited traps. Different mosquito species showed a preference to particular resting sites as well. In the following mosquito seasons, we will expand our resting mosquito sampling to the urban area of Salt Lake City, as well as further evaluate the attractiveness of different resting sites to blood-engorged female mosquitoes.

P-20 Vulnerable areas for potential invasion of Anopheles darlingi to the African continent

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Mosquitoes are successful invaders because of their ability to colonize environmental suitable areas. Ecological Niche Modeling is currently the most appropriate method to predict their distribution. This work aimed to define areas in the African continent that could potentially be occupied by *Anopheles darlingi* in case of an invasion. The potential distribution model was designed using maximum entropy algorithm and calibrated using as dispersion area (M) the natural ecoregions where the species has been registered. Published records of species presence data and WorldClim bioclimatic layers were used, and the model was projected to the African continent. The results suggested that *An. darlingi* could find suitable areas in Northern, Western, Central Africa and along the east coast of the continent. No suitable areas for the species were observed in the Ethiopian and Kenyan highlands and south of the continent. Nonetheless, it will be important to study the estivation capacity of this species, given that some suitable areas are arid savannas with periodically absent surface water bodies, which are necessary for the development of their larvae. Knowledge of suitable areas for *An. darlingi* provides the information to design measures to prevent a potential invasion and spread of the vector.

P-22 First record of Aedes japonicus in Florida

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The presence of *Aedes j. japonicus* in Florida is reported for the first time. Four adult females were collected by a Mosquito Magnet® X trap baited with pressurized CO_2 in Okaloosa County, Florida in August, 2012 and later identified as *Ae. japonicus* in 2014. Additional adult and larval specimens were collected during 2014-2017 from Bay, Leon, Okaloosa, Santa Rosa, or Walton Counties, Florida. Notes are provided on the location, general habitats, and mosquito associates that may be found with *Ae. japonicus* in northwestern Florida. The role of *Ae. japonicus* in arbovirus transmission within Florida is currently unknown and should be further explored.

P-23 Four years of larval mosquito surveillance in Iberia Parish, Louisiana

David Lynn Martin (dmartin@iberiagov.net), Tina Paredes

In the winter of 2014-2015, 10 roadside ditch sites were selected as permanent surveillance sites for mosquito larvae in Iberia Parish. In Jan of 2017, 2 sites were added. These sites are monitored weekly. Mosquito larvae are identified and counted, ammonia levels are checked, and pH is measured. 3 of the sites have been found to have persistent *Gambusia* populations. 2 of the sites have been dry on at least 50% of visits. All sites were selected based partly on their presumed suitability for *Culex quinquefasciatus*, and overall, this species did account for almost 97% of all the mosquito larvae collected. However, 95% of the larvae of this species have come from only 2 sites. Both are septic ditches that are rarely dry, with high ammonia concentrations. A third site also exhibits high ammonia concentrations, but *Gambusia* have been present on 55% of visits. A fourth site appears generally too toxic even for *Cx. quinquefasciatus* larvae.

These results suggest that the right combination of factors which result in a prime *Cx. quinquefasciatus* roadside breeding site (persistent water, high but not extreme ammonia levels, *Gambusia* seldom present) are uncommon in the parish. With proper engineering, roadside ditches can be made much less suitable for this species, and effective larval control might be achieved with highly targeted larviciding.

P-24 Preferences of breeding containers for Aedes mosquitos: a case study from Jamaica

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Zika, chikungunya, dengue and other arboviruses, all transmitted by *Aedes aegypti*, continue to be a threat to public health in Jamaica and the Latin America and Caribbean region. The United States Agency for International Development (USAID)-funded Zika AIRS Project (ZAP) is supporting governments in the region to conduct entomological monitoring and implement vector control activities to reduce the vector populations. ZAP is currently leading a wide-spread larviciding campaign, treating domestic water containers with a biolarvicide *Bacillus thurigiensis (bti)*. This study aimed to identify the most productive breeding containers for *Aedes aegypti* populations in four parishes where ZAP is implementing activities. Pupal surveys, recommended by WHO to monitor the population of the *Ae. aegypti*, were used to calculate pupae per container, and pupae per person values. Four intervention sites where larvicide is being applied and one control site where no larvicide is applied, were selected. Field teams visited 800 houses (n=200 per site), every ten days, for five consecutive months during 2018. Results showed that 75% of the pupae found were present in plastic water drums or barrels which generally store over 20 liters of water. The average number of pupae per container was 1.14 for intervention sites and 0.3 for control site (all containers). The number of pupae per barrel was 0.774 for intervention and 0.353 for control sites. The average number of pupae per person were calculated, with 0.8 pupae in intervention vs. 0.5 in the control sites. The main breading sites for *Aedes aegypti* are drum barrels that store large volumes of rain/clean water. Pupae indicators are new to the country and continuing to monitor these indexes will provide important information on the local mosquito density, which will help to inform and improve vector control program management.

P-25 Single Mosquito coinfection with West Nile Virus and Saint Louis Encephalitis

James Will (jameswill@mail.maricopa.gov), John Townsend, Kirk Smith, Dan Damian, Steven Young

For several years we have had concurrent outbreaks of West Nile virus and St. Louis encephalitis circulating in our bird and local mosquito populations in Maricopa County, Arizona. On July 24th, 1 *Culex tarsalis* mosquito was collected at a routine trapping site. In-house PCR testing revealed that the sample was positive for West Nile virus and St. Louis encephalitis virus. Samples of this collection were sent to CDC and several Universities for confirmation of the coinfection of a single *Cx. t* mosquito. We would like to discuss the findings of this occurrence.

P-26 Seasonal and geographic patterns in mosquito abundance along the TX/MX border

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While efforts to control mosquitoes along the Texas and Mexico border are routinely conducted in various town, cities, and municipalities, there is limited data on the seasonal patterns of mosquito abundance in these regions. Limited funding and resources in this region results in limited ability to engage in long term monitoring of mosquito populations or assessing any regional patterns of abundance. We initiated a multi-year collection effort to monitor both species composition and abundance of two primary vector species, *Aedes aegypti* and *Aedes albopictus*. Field specimens were collected using oviposition cups in seven cities along the border. Eggs were returned to the laboratory where they were hatched and the species identified. Here we present our preliminary efforts to identify and geographic or seasonal patterns of mosquito abundance. We discuss potential implications of these results for disease transmission as well as the planned expansion of these efforts to the entire TX/MX border region.

P-28 Shifting the boundaries of traditional arbovirus testing

Jackie Surls (jsurls@pro-lab.us), Fuqu Hu, Daniel Portillo

The adoption of nucleic acid amplification tests (NAAT) for on-site arbovirus detection is uncharted territory for many mosquito abatement districts (MADs). Traditionally, MADs employ the services of local universities, public health agencies, or contract labs for arbovirus detection using reverse transcriptase quantitative real-time PCR (RT-qPCR). Although effective, any delays in obtaining reliable results impacts critical decision-making for implementing control measures. Consequently, MADs have sought alternative or supplemental on-site tests such as rapid analyte measurement platform (RAMP) or more recently a rapid NAAT called

reverse transcriptase loop mediated isothermal amplification (RT-LAMP). RT-LAMP is a simple and sensitive diagnostic assay that provides a sample to answer within 30 minutes. Like qRT-PCR it requires similar mosquito pool processing (homogenization and nucleic acid extraction), thereby streamlining the process for on-site and off-site testing. To determine whether LAMP can be successfully implemented into routine testing for vector control districts, we trained and evaluated three laboratory sites with no existing on-site NAAT methods. Site 1 consisted of one lab manager and two seasonal technicians who possessed some lab experience. Site 2 consisted of one lab manager and three seasonal technicians with varied lab experience. Site 3 consisted of a lab director and one technician with no prior lab experience. Each site had a small to moderate sized room dedicated and equipped for mosquito identification/testing. We identified the following commonality across all sites, technicians were able to follow the sample processing and RT-LAMP procedures with little to no difficulty and more importantly, lab personnel who had no previous lab experience were equally capable of successfully performing the tests and interpreting the data as those with a molecular biology background and/or lab experience. Based on our observations, we concluded that a 3-day training workshop is required for successful adoption of the RT-LAMP system for arbovirus detection.

P-29 Detection of two new invasive mosquito species in the United States, Culex panocossa and Aedeomyia squamipennis, and implications of putative range expansion.

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Invasive mosquito species, such as *Aedes albopictus* and *Aedes aegypti* have played a hand in altering vector disease transmission worldwide, such as Zika, Dengue, and Yellow Fever. Here, we present two mosquito species recently detected in peninsular Florida. These two species, *Aedeomyia squamipennis* and *Culex panocossa*, represent two new species and one new genus of mosquitoes to the USA. Both were detected as larvae, pupae and adult males and females in field collections in Florida City, FL in October 2016. *Ad. squamipennis*, is a tropical mosquito of which the native range extends throughout the American tropics, from Mexico, to northern Argentina and several Caribbean islands. Larval habitats are heavily associated with aquatic vegetation including water lettuce (*Pistia stratiotes*). Adults of *Ad. squamipennis* are considered to be important vectors of Gamboa virus and avian malaria, as well as suspected vectors of *Venezuelan equine encephalitis virus* (VEEV). Likewise, *Culex panocossa* is a suspected vector of VEEV, is associated with *P. stratiotes*, and is known from Central America, northern South America, and the Greater Antilles. Since larvae of both *Ad. squamipennis*, and *Cx. panocossa* are heavily associated with *P. stratiotes*, their distributions are likely to proliferate into northern Florida and beyond, with northern latitudinal ranges limited by winter temperatures. In particular, the putative establishment of *Cx. panocossa* into urbanized areas could link the sylvatic transmission foci of Everglades virus (EVEV) subtype II in the VEEV complex of viruses, which is endemic to peninsular Florida.

P-31 Developing novel RT-PCR markers for detecting Dog Heartworm (Dirofilaria immitis) and other filarial worms

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The incidence of dog heartworm (*Dirofilaria immitis*) infection in the US is increasing and *D. immitis* is present in Placer County (northern California). To better understand the presence and animal health consequences associated with dog heartworm, Placer Mosquito and Vector Control District (PMVCD) developed molecular probes for identifying dog heartworm using Real-Time PCR (RT-PCR). Currently, there are a number of molecular probes used for detecting *D. immitis*, but some probes are unable to distinguish between *D. immitis* and other filarial worms. Further, we tested a *D. immitis*-specific probe available from the literature and found that the marker was unreliable. Our goal was to develop novel probes to detect *D. immitis* and other filarial worms. We developed two probes including a *D. immitis*-specific probe based on the mitochondrial cytochrome *C* (CO1) gene and a more general probe targeting the 5s RNA gene which is highly-conserved across a wide variety of filarial worms including *D. immitis*. Combined in a duplex PCR reaction, biological samples can be cheaply and efficiently tested for the presence of *D. immitis* and other filarial worms. Tree-hole mosquitoes (*Aedes sierrensis*) are the primary vectors of *D. immitis* in Placer County, and using the probes developed here, we tested 378 *A. sierrensis* pools and detected filarial worms in 68 of the 378 pools (~18%). However, only three pools (~0.8%) were positive for *D. immitis*. Our results reveal relatively low levels of *D. immitis* in wild mosquitoes collected by PMVCD, and demonstrates the importance of using markers specific for *D. immitis* to avoid overestimating the infection rate of *D. immitis* in wild mosquito populations.

P-32 Comparison of sample processing methods for nucleic acid extraction and detection of West Nile virus in mosquitoes

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Nucleic acid amplification-based tests (NAATs) are widely recognized as the gold standard for West Nile virus (WNV) detection in mosquitoes. For accurate WNV detection, the RNA must be extracted prior to performing NAAT. Most commercial RNA extraction kits utilize similar principles and methods for RNA extraction, thereby allowing the purified RNA for use in most NAATs. These kits often include additional protocol steps, designated as optional, to improve purity, yield, or analyte detection. Some of these workflow enhancements include a Proteinase K step, Dnase treatment step, or addition of beta-mercaptoethanol to the lysis solution. It is important to understand the purpose, value, and impact these enhancements have on WNV detection. In this study, we compared various sample processing methods with the abovementioned enhancement steps using a commercially available RNA extraction kit followed by loop mediated isothermal amplification for WNV detection. Comparison of the LAMP results indicates some variation among the workflow protocols with a potential to impact WNV detection. We discuss the potential factors that may influence LAMP performance and solutions to mitigate these effects.

P-33 Community communication: key in the implementation of a new integrated vector management program in Puerto Rico

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The mosquito *Aedes aegypti*, the vector for dengue, Zika, and chikungunya, is globally recognized as the most efficient vector due to its close association with humans and its domestic breeding habitats in and around houses. Therefore, community engagement and participation are key to reduce mosquito breeding sites and control mosquitoes. The Puerto Rico Vector Control Unit (PRVCU), is establishing an integrated vector management (IVM) strategy, combining vector surveillance and monitoring, vector control operations, and island-wide community mobilization programs. IVM must be communicated effectively at all levels to ensure its adoption, to foster collaboration and networking among partners, and to empower communities. The PRVCU has a community mobilization division within its organizational structure that is developing strategies to reduce the number of mosquito breeding sites thru community engagement, education, and partnerships. In each area where the PRVCU works, the first step is to establish good communication channels and trustworthy relationships with the community leaders, service organizations, churches, schools, and others. To achieve this, an exhaustive study characterizing each community is developed, including the following information: political leadership, demographic variables, stakeholders, characteristics of the communities, observations during community visits, and outcomes of meetings with community leaders to understand the barriers and needs to adopt specific actions. The PRVCU regularly carries out educational talks, booths, and community visits to increase public awareness and knowledge on the PRVCU program and on the biology and behavior of the *Ae. aegypti* mosquito. By August 2018, the PRVCU has participated in 75 presentations, 49 educational booths, 59 community visits, and 31 school presentations, as well as developed 2 comprehensive media campaigns about the reduction of breeding sites. Effective communication interactions with the general public creates awareness, drives behavioral change, and has been key for the establishment of the PRVCU as a new program.

P-34 Comparing the Effectiveness of a Twin Tube CDC Gravid Trap, a BG-GAT and a BG-Sentinel Trap in Capturing Female Aedes albopictus Mosquitoes

James Roberts (JROBERTS@C-UPHD.ORG), Jeff Blackford, Morgan Soderlund

Originating in Asia, *Aedes albopictus* mosquitoes have been transported globally, primarily through the used tire trade to tropical, subtropical and temperate climates of the world. The first established population of *Ae. albopictus* was discovered in the United States in Texas, in 1985. The Champaign-Urbana Public Health District found its first *Ae. albopictus* mosquito in a CDC gravid trap, in Champaign, Illinois in 2011. Because of the spread of *Ae. albopictus* in the U.S. and their potential for disease transmission, vector control agencies are purchasing and deploying specialized traps for surveillance. Currently the most commonly used adult traps for *Ae. albopictus* collection are BG-Sentinel traps and a variety of gravid *Aedes* traps. *Ae. albopictus* mosquitoes are not known to be efficiently captured by CDC gravid traps. With assistance from the Midwest Center of Excellence for Vector-Borne Disease, the Champaign-Urbana Public Health District compared the effectiveness of a twin tube CDC gravid trap, a BG-GAT, and a BG-Sentinel trap for capturing adult *Ae. albopictus* in the Champaign-Urbana area.

P-35 A comparison of granular larvicide application methods
Eleanor Kirkscey (eleanor@municipalmosquito.com), Erin Plaisance, Hadis Hosseinzadehnaseri

Granular larvicide products are utilized by mosquito control personnel throughout the United States. Although product labels provide guidelines regarding the amount of product to apply to any given area, the physical means of application is left to the discretion of the applicator. This small scale study was developed to assess and compare the efficacy of hand-application and pest control bulb dusters in the North Texas Region. The study concluded that both application methods were viable but the efficiency of the method was dependent on the scale and type of the application area. Bulb dusters were most suited for applications into bodies of water smaller than $100ft^2$ such as small puddles, culverts, and small artificial containers. Hand-application was the most efficient method for bodies of water larger than $100ft^2$ such as ponds and flooded fields. Due to the scale of the study, further research is needed to assess and compare the efficacy of these and other application methods. Future studies should include surveying a greater number of personnel, increased variation in application sites, and the addition of different application methods.

P-36 Dynamic Placement of BG Sentinel Traps for Aedes aegypti Surveillance
Christopher Cavanaugh (ccavanaugh@cvmvcd.org), Kim Y Hung

Aedes aegypti mosquitoes were first detected in the Coachella Valley in May 2016. In order to efficiently direct the District's control efforts against this new threat, an update to our surveillance program was needed. Previous urban surveillance methods involved setting gravid and CO_2 traps, along with oviposition cups, at roughly 30 static locations on a weekly basis. However, as the known area of *Ae. aegypti* activity expanded rapidly throughout the valley, a more dynamic trapping approach was needed To better ascertain the movement of these invasive mosquitoes, we developed a strategy of selecting new, temporary trap locations on a weekly basis, allowing us to quickly cover more ground. This method involves setting roughly 30 BioGent Sentinel traps in a high-density fashion (approximately 10 traps per square mile) within previously unexplored neighborhoods each week. We displayed the results using ArcGIS technology, allowing us to quickly and easily share this data among District staff. Overall, this project has played an integral role in the District's ability to effectively respond to this invasive mosquito.

P-37 Comparison of Truck Larviciding Equipment
Jennifer A. Henke (jhenke@cvmvcd.org)

Working across agencies, we examined the effective swath width of six pieces of equipment from five manufacturers. In late June, the Guardian 190 and two Buffalo Turbines were characterized under similar conditions. In early September, a TIFA, a MicroNair and a Curtis DynaFog LV-8 were similarly compared. From this, the effective swath widths were determined using a line of cups set perpendicular to the path of the spray vehicle (in line with the dominant wind direction). Using this information, we think that agencies can better optimize spray routes for the control of larval mosquitoes.

P-38 Efficacy of Expanded Polystyrene Beads (EPB) and Diesel oil for mosquitoes (Diptera: Culicidae) control in integrated vector control management (IVM) methods
Aliya Jabeen (jabeen05@yahoo.com)

The aim of this 1st time conducted study in Pakistan was to assess the efficacy of expanded polystyrene beads and diesel oil to control mosquitos' density. Expanded polystyrene beads and diesel oil was applied in mosquito larvae breeding sites and their effect on adult emergence reduction was evaluated over time. The % reduction in emergence of adult mosquitoes in expanded polystyrene beads treated sites ranged from 88.3% to 100%, whereas in Diesel oil treated sites were varied from 58.4% to 90.2%. So Expanded Polystyrene beads were found more effective and also durable than the diesel oil, whereas diesel oil remains effective for maximum 1 week and have to repeat application afterwards. Breeding sites treated with Expanded Polystyrene beads showed statistically significant ($p =< 0.04$) reduction in emergence of mosquitoes, whereas no significant reduction calculated in diesel oil applied sites. This analysis also reveals the superiority in effectiveness of expanded polystyrene beads over diesel oil. The use of this intervention as a component of integrated vector management (IVM) coupled with other supportive measures could help to control the menace of vector borne diseases.

P-39 Evaluation of bacterial larvicides and insect growth regulators employed for the control of Ae. aegypti from Yucatan Mexico

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The govermment´s Ministry of Health in México require the entomological evaluation of the efficacy of the entire vector control tools to be employed in the national and state programs through the country. Insecticides employed in Mexico are required to meet efficacy standards (Official Mexican Standard NOM-032-SSA2-2014 for Epidemiological Surveillance, Prevention and Control of Vector-Borne Disease) to be included in the recommended Product List Insecticides National Center for Epidemiological Surveillance and Disease Control (CENAPRECE). We evaluated the efficacy and recidual activity of bacterial larvicides and insect growth regulators against local populations of larvae of *Aedes aegypti* under standard bioassays and laboratory conditions during 2018. Eggs of wild populations of *Ae. aegypti* were collected from ovitraps placed in different localities at Yucatan (Merida, Valladolid and Tizimin). Adults obtained from the F0 generation were reared at insectary conditions and F1/F2 progenies were used for the larval bioassays. We also tested the efficacy with and without water renewal. Larval bioassays were carried out using several formulations (dust, granules, liquid, and tablets) according to CENAPRECE and WHO guidelines. All larvicides tested are products used to control immature stages of *Ae. aegypti* in Mexico. All the bacterial larvicides (acute mortality and persistence) and growth regulators (% emergence inhibition) showed satisfactory biological effectiveness, in accordance with NOM-032-SSAS-2014: acute mortality >98%; % inhibition emergence >90%.

P-40 Recent advances in wide area larvicide spraying (WALS™) technology are expanding the public health vector control tool box

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Wide area larvicide spraying (WALS™) began as a novel method for control of container mosquitoes and is now opening the doors to new approaches for mosquito control. From its begining more than 18 years ago, WALS focused on the use of *Bacillus thruinginesis israelensis* strain AM65-52 WDG formulation for *Aedes spp*. control in dengue, Zika virus and Chikungunya control. This method is used as an essential component for vector response throughout the world. WALS technology is continuing to develop in several ways including improvements in application technology and expansion to control more species of concern, including vectors of malaria and West Nile virus. WALS has already proven success with multiple types of application equipment from aerial systems, truck mounted systems and various types of hand held equipment. Successful WALS application requires aqueous spray drops be distributed across an intended target and then deposit into mosquito habitats in sufficient quantities to deliver a lethal dose to larvae. As technology and euipment continue to develop, the WALS method will continue to expand with it. The purpose of this paper is to describe recent advances and explore how this success can open the doors to new approaches for overall mosquito control.

P-41 Blow 'em out of the water: Cool new tool for larval control

Sean Amodt (sean@swmosquito.org)

We have tested for the benefits of using a battery operated leaf blower with an attached hopper for the dispersal of granular larvacide products into the water. We have found advantages such as cost, versatility and ease of use compared to other current equipment being used for granular larvaciding. We will discuss issues of calibration for the proper amount of product dispersal as well as best methods of use for this cool new tool.

P-42 Aquatain AMF: summary of trials and their implications for mosquito control

Graham George Strachan (graham@aquatain.com)

Aquatain AMF is a unique silicone-based liquid monolayer for mosquito control. It spreads strongly across the water surface, forming a very thin film. As silicones have a very low surface tension, mosquito larvae and pupae can't attach at the surface to breathe - causing them to drown. Trials by universities, health ministries and other independent organizations in 20 countries have confirmed its effectiveness on *culex, anopheles* and *aedes* mosquito genera for around 30 days – even in very difficult conditions where other mosquito control products have been ineffective. It has been approved for sale in more than 60 countries, with most exempting it from registration due to its entirely physical action. This paper gives a brief overview of the product and some variations which are in the pipeline, in addition to a more detailed description of the field and laboratory trials.

P-43 Bio-efficacy and persistence evaluation of a diflubenzuron larvicide formulation applied by air against rice-land mosquitoes in Greece

Alexandra Chaskopoulou (achaskopoulou@ars-ebcl.org), Michail Miaoulis, Achilleas Mastoras

Rice fields are ideal mosquito breeding sites for a number of nuisance and pathogen transmitting mosquitoes. Application of mosquito larvicides by air is one of the most commonly used approaches for managing these vector populations. Diflubenzuron, a chitin synthesis inhibitor, has been used extensively against mosquito larvae but rarely in a rice-field environment. The current study investigated the impact of a liquid formulation of diflubenzuron (Dudim 15SC, 15% active ingredient) applied by air against *Aedes caspius* (major Mediterranean nuisance species), *Culex pipiens* (WNV vector) and *Anopheles hyrcanus* (malaria vector) larvae in a rice-field ecosystem of North Greece. Treatments were conducted in June and replicated in July to account for variability in product deposition due to differences in the rice canopy length and density. One dose was tested per label instructions corresponding to 350 ml of product/hectare. Emergence inhibition and larval population densities were compared between treated and un-treated (organic) fields for up to two weeks post-application. Furthermore, the persistence of diflubenzuron under rice-field conditions was assessed for the duration of the trials through Gas Chromatography (GC) coupled with Electron Capture Detector (ECD). The larviciding effect of diflubenzuron and its degradation rate under field conditions will be discussed and recommendations will be provided for optimizing aerial larviciding operations in a rice-field ecosystem.

P-44 Blood-meal preferences and avian malaria detection in mosquitoes (Diptera: Culicidae) captured at different land use types within a neotropical montane cloud forest matrix

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Human activities modify environmental conditions, altering ecological interactions that can contribute to the increasing number of vector-borne pathogens affecting both human and wildlife populations. There is a dearth of knowledge about mosquitoes feeding preferences and their role as potential vectors of haemosporidian parasites, particularly in modified habitats. During 2013-2014 we sampled mosquitoes in five different land use types within a cloud forest matrix. From a total of 4107 adult mosquitoes, 90 were engorged. We extracted DNA from mosquito blood-meals, abdomens, and thoraxes, which belonged to seven different species. Seventeen specimens were positive for avian *Plasmodium* parasites. We were able to identify the blood-meal source of 10 mosquitoes, the identified vertebrate species were: *Homo sapiens* (Human), *Sturnira hondurensis* (Bat), and *Bos taurus* (Cow). Our results show that *Culex restuans* is positive for avian malaria and it is feeding on both humans and domestic animals at urban and peri-urban habitat types, where it is also an abundant species throughout the year. Furthermore, *Aedes quadrivittatus*, also positive for avian malaria, is feeding on humans in the well-preserved cloud forest, where this mosquito species is highly abundant. This study is the first in Mexico to provide reference data showing generalist mosquito feeding preferences and presence of avian Plasmodium at locations with different land use types.

P-45 Evaluation of a community's perception of spatial emanators with metofluthrin for reducing the mosquito population in households from Ticul, Yucatan, south Mexico

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In 2018 we conducted a field trial on the efficacy of a metofluthrin-treated emanator in Ticul, Yucatan, Mexico. Metofluthrin is a volatile pyrethroid that affects the survival and biting rates of mosquitoes. As part of our evaluation we recorded the community's perception of the product. We enrolled 200 households (100 treated and 100 controls). Main motives for acceptance were: the high number of mosquitoes in the home (17.45%), concern about mosquito-borne disease (MBD) in the community (11.41%), confirmed cases of MBD in families (10.74%), positive experiences with a previous project of our scientific team (10.74%). Three weeks after emanator placement, we assessed perceptions of efficacy. Most participants (85%) reported a significant reduction of mosquitoes inside homes. Almost all households (98%) were free of dengue, chikungunya or Zika symptoms (self-report) and 85% considered that the emanator could form a complementary tool for Government programs on vector control. Overall, 83% liked the product because it 1) drove away mosquitoes and flies, 2) doesn't smell, 3) is safe, and 4) looks good aesthetically. There were reservations (12%) about the installation process (high humidity resulted in emanators detaching from their sticking points). Many householders (66%) stopped using other commercial products against mosquitoes mainly because the efficacy of the emanator, while 34% continued to use other control methods 1) as and when they saw mosquitoes, 2) from habit, 3) to kill other insects and 4) when they left their homes. Most

(95%) thought that the trial should be scaled up to involve the rest of the community. These data demonstrate that a safe, unobtrusive emanator that does not smell, is easy to install, and effective in driving away mosquitoes is likely to be accepted by the community and could be adopted as another preventive measure against mosquito vectors of dengue, chikungunya and Zika virus.

P-46 Political will and community engagement for a Wolbachia-based strategy for the control of Aedes aegypti in Yucatan, Mexico

Josue Villegas-Chim (jovich.etnos@gmail.com), Pablo Manrique-Saide, Alma Medina Várguez, Francia Espinosa Lizama, Carolina Martínez Cruz, Anuar Medina-Barreiro, Abdiel Martín-Park, Norma Pavía-Ruz, Zhiyong Xi

The government of the Mexican state of Yucatan is promoting the integration of a *Wolbachia*-based strategy for population suppression of *Aedes aegypti* as part of the local activities performed by the Ministry oh Health. Research and implementation is done in close collaboration between government and academia. Key initial processes involved: i) networking with national/international entities, from the academic, governmental and social sectors, and ii) strategies for social inclusion and education to involve and promote the participation of the communities. Local Ministries of Health and Research & Innovation are actively engaged; an agreement of collaboration was approved on September 2017 and they have provided approval for the release of *Wolbachia*-infected male mosquitoes. Other government organizations have been informed and the research team has had continuous communication with them. Localities for the release of male *Aedes*have been selected in consensus with the local authorities. Local leaders and stakeholders have been engaged and the project has gained social support. House-to-house surveys in selected localities were applied to investigate knowledge on mosquito-borne diseases, social experience on the vector control program, and acceptance of the project. Participants acknowledged the importance of the mosquito and the importance of mosquito-borne diseases, 65% reporting infections with *Aedes*-borne diseases in their families. After consecutive outbreaks of chikungunya and Zika (2015-2016), behavioral changes included: use of topical repellents, insecticides, and other domestic preventive measures. There was a positive social experience associated to the performance of the local vector control program during the outbreaks. The intervention to be delivered in the community is an integrated intervention model and 100% of the people interviewed accepted the *Wolbachia*-based project, strongly motivated for the integrated benefits. These initial results show that political will with inter-sectorial collaboration are both key factors for the development of projects such as this, using a *Wolbachia*-based strategy.

P-47 Application of integrated mosquito management (IMM) with digital mosquito monitoring system in South Korea

Yeon Jae BAE (yjbae@korea.ac.kr), Waggyu Kim, Sangwoo Seok, Jisoo Kim, Dong Gun Kim, Hwang Goo Lee, Jae Seung Yu, Jae Geun Kim, Hyesuk Baek, Hoonbok Yi

To adopt a more effective and environmental-friendly mosquito control method in South Korea, we have applied integrated mosquito management (IMM) techniques to use the biological control, the physical control, and the least chemical control, and we selected Ansan city near Seoul city as a testbed area for the IMM control from 2016 to 2018. A digital mosquito monitoring system (DMS), the smart mosquito trap and counter device, was associated with the above IMM system in the field condition. Considerable decreases in the mosquito density were observed in the testbed area after IMM apply, and the differences of mosquito population were statistically significant between the year 2016 the following years of 2017 and 2018. High positive correlations were shown between mosquito density and major environmental factors such as monthly average temperatures and humidity. For the biological control, we used the larvae of a beetle predator (*Hydrochara affinis*), and the method was effective. However, its application was limited to small water bodies such as artificial containers and small pools. This is the first testbed study of IMM in South Korea and its apply would be safe for the natural habitats and more useful for the human residential areas. This research was supported by the Korea Ministry of Environment as "Public technology program based on Environmental Policy (2016000210003)."

P-48 A Trial Experiment for the Effective Reduction of Mosquito Population at Recreation Area in South Korea

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We conducted this trial experiment at an auto camping site in Ansan City of South Korea and our research purpose was to make effective mosquito population reduction at a recreation area. The area is a place where citizens can enjoy recreational activities and the area is also well-suited for mosquito habitat because there are abundant waterways and vegetation. A lot of citizens complained that there were too many mosquitoes. So, to prevent the mosquito bites for citizens, we designed this trial experiment. We used DMS

(Digital Mosquito Trap for Monitoring System) and MOS-HOLE PRO devices to control and monitor mosquito populations. MOS-HOLE PRO devices use carbon dioxide to attract mosquitoes. However, it doesn't have the function of counting mosquitoes. We have been monitoring the mosquito population by 5 DMSs inside the auto camping area. We also used 26 MOS-HOLE PRO traps around the auto camping site to ensure mosquito population reduction. We operated those MOS-HOLE PRO traps and DMS trap daily from July 1 to August 1. As a result, the mosquito population from 5 DMSs per day was significantly decreased. The mosquito population from MOS-HOLE PRO increased or decreased depending on the location, but the variation was not statistically significant. As a result, our study greatly reduced the number of mosquito inside the auto-camping site. During the study period, we conducted surveys on citizens. Citizens felt that mosquito bites were decreased. Our study could provide the strategy for effective mosquito population reduction and we might implement for recreation activities.

P-49 Insecticide resistance evaluation in Laramie, WY

Milena C Guajardo (mcbguajardo@gmail.com), Cassie Scott, Lee William Noel, Keith Wardlaw, Tyler Shevling, Steven Trowbridge, 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 the city of Laramie mosquito control and integrated pest management crew, adult mosquitoes were collected and brought to the Centers for Disease Control and Prevention in Fort Collins, CO. Adult mosquitoes were evaluated to determine resistance to malathion, naled, and/or permethrin by performing bottle bioassays on *Culex* and *Aedes* species mosquitoes. Resistance to one or more insecticides of interest was not found in mosquitoes from Laramie, WY. Insecticide resistance surveillance is essential to guide future management strategies in Laramie, WY.

P-50 Integrated vector control management after two hurricanes

Marianyoly Ortiz (mortiz@prvectorcontrol.org), Angela Harris, Julieanne Miranda-Bermúdez, Natasha DeLeon-Rodriguez, Nicole Nazario, Luz A Crespo

In September 2016, the Puerto Rico Vector Control Unit (PRVCU) was established through a cooperative agreement between the Centers for Disease Control and Prevention (CDC), and the Puerto Rico Science, Technology, and Research Trust, to monitor and control the mosquito *Aedes aegypti*, the vector in the Island for dengue, Zika, and chikungunya. PRVCU follows an integrated vector management (IVM) strategy, combining vector surveillance and monitoring, vector control operations, and island-wide community mobilization programs. During the first year, PRVCU focused on implementing a vector surveillance program, creating innovative information systems, and boosting community engagement through citizen mobilization and education. After hurricanes Irma and María, PRVCU launched a media campaign with three key messages about appropriate management of personal water reservoirs, water removal from hurricane debris, and personal protection. The community mobilization program started house to house interventions, distribution of educational material and repellents, and educational activities that impacted more than 90% of the municipalities on Island. Most recently, PRVCU started adult mosquito surveillance in the municipalities of San Juan, Bayamón, Caguas, Carolina and Ponce. Despite the decrease in confirmed arboviral disease cases in Puerto Rico, as reported by the local Department of Health, results indicate a high population of adult female *Ae. aegypti* in most of the areas under surveillance. Mosquito eggs have also been collected and tested for resistance to several commonly used EPA approved pesticides and initial results showed resistance to pyrethroids and organophosphates pesticides. These results support the need of an integrated approach to control the *Ae. aegypti* and the diseases it transmit.

P-51 Nootkatone: a new active ingredient for integrated management of disease vectors and other nuisance pests

Giovanni Salerno (giovannis@evolva.com), Owen Jones

Nootkatone is a naturally occurring sesquiterpene found in the bark of the Alaskan yellow cedar, in grapefruit, and other sources which has been widely used for a long time in the flavour and fragrance industry. Obtaining substantial quantities of nootkatone from nature is cost prohibitive and not sustainable. However, Evolva is now capable of producing this ingredient in metric ton quantities using its disruptive proprietary technology making the ingredient available at high purity via a more sustainable and cost competitive route. Extensive research carried out over the last decade has shown nootkatone to have repellent and insecticidal/acaricidal properties when tested against a wide range of important insect and acarine pests. It has been shown to be active in single digit percent concentrations against a wide range of

disease vectors belonging to all three *Aedes*, *Anopheles*and *Culex* genera of mosquitoes. It has also been shown to be active against mosquito strains that are resistant to the major families of insecticides used in vector control. Pioneering work done by the US Centersfor Disease Control (CDC) and other agencies and academic groups has demonstrated its activity against ticks including those that are vectors of Lyme disease. Given nootkatone's potential as a novel biorational tool for vector and nuisance pest management, Evolva has submitted registration applications to the EPA in November 2017 for its use in this sector. Nootkatone already had GRAS (generally regarded as safe) classification in the flavours and fragrance industry. Evolva has now generated a substantial dossier to meet the requirements for its registration by the EPA. This poster summarises our progress and successes to date in demonstrating the potential for this new active ingredient against human disease and nuisance pests.

P-52 A survey of mosquito species in ornamental bromeliads of Collier County, FL

Alexandria Watkins (awatkins5@bucs.fsw.edu), Rachel Bathsheba Bales, Keira J Lucas

Travel-related and local incidences of mosquito-borne diseases in the United States has increased in recent years. Several outbreaks of mosquito-borne viruses transmitted by *Aedes aegypti* mosquitoes, including Dengue virus and Zika virus, has threatened human populations in Florida (FL). *Ae. aegypti* is a highly invasive species adapted to urban environments – often breeding in natural and artificial containers and feeding on human hosts. The most effective methods to combat *Ae. aegypti* is the use of integrated pest management practices, which includes the identification and removal of potential breeding habitat. Bromeliads are popular ornamental plants, which contains a "tank" that can serve as a safe-haven for mosquito eggs and larvae. Recent studies in Miami-Dade County have revealed *Ae. aegypti* successfully utilize the tank-type bromeliads as breeding sites. In order to assess how *Ae. aegypti* and other disease vectors, such as *Aedes albopictus* and *Culex quinquefasciatus*, have expanded their breeding habitat to include ornamental bromeliads in Collier County FL, Collier Mosquito Control District (Naples, FL) conducted a survey of mosquito species in local bromeliads. Here we report the identification and biodiversity of mosquito species in ornamental bromeliads of Collier County FL.

P-53 Laboratory for Biological Control of Aedes aegypti with Wolbachia in Yucatan, Mexico

Pablo Manrique-Saide (pablo_manrique2000@hotmail.com), Fabian Correa-Morales, Zhiyong Xi, Abdiel Martín-Park, Yamili Contreras, Anuar Medina-Barreiro, Norma Pavía-Ruz, Josue Villegas-Chim

Currently, the Government of Yucatan promotes the use of the bacteria *Wolbachia* for biological control of the mosquito *Aedes aegypti*. In February 2016 the government signed an international collaboration agreement with the Michigan State University and the Autonomous University of Yucatan for the application of strategies based on *Wolbachia* for vector control of Zika, the dengue and chikungunya. This project, which started in 2018 with funds of CONACYT and USAID, includes: i) the design, construction and implementation of a Laboratory (including a mass rearing system) for the development of strategies based on in the bacteria *Wolbachia* for the biological control of *Ae. aegypti*, and ii) the implementation of a pilot test releasing male mosquitoes infected with *Wolbachia*for population suppression and to evaluate its effectiveness as part of IVM and to complement the local activities performed by the Ministry oh Health. The Laboratory and the mass rearing system is based in the model established at the Sun Yat-sen University-Michigan State University Joint Center of Vector Control for Tropical Diseases in China. This project represents a proposal of a multidisciplinary group led by UADY, with the participation of international collaborators and health organizations as an applied initiative for the prevention and control of *Aedes*-borne diseases.

P-54 Developing local capacity for Aedes aegypti surveillance using ovitraps in the Dominican Republic

Patricio Murgueytio (Patricio_Murgueytio@abtassoc.com), Ingrid Marbella Miranda, Juan David Dominguez, Gavino Guzman, Mauricio Otalora, Nelson Grisales, Angel Solis, Sara Brujan

In the aftermath of the Zika outbreak in the Dominican Republic in 2016, the Ministry of Health (MOH) recommended increasing use of ovitraps to complement quarterly *Aedes aegypti* larval/pupal surveys due to concerns about survey sensitivity to detect local variations in mosquito populations. The United States Agency for International Development (USAID)-funded Zika AIRS Project (ZAP) contributed to existing MOH ovitrap implementation activities through the development of local teams tasked with managing ovitraps in 6 provinces. ZAP aimed to strengthen technical capacity, test the effectiveness of hay infusion vs. plain water as attractant, and scale up ovitrap coverage. ZAP selected and trained 6 teams of 9 technicians (total N=54), who each deployed and monitored ovitrap pairs (one with hay infusion and other with plain water). In each of the 6 sentinel sites 50 households were selected. Oviposition papers were changed every 5 days,

for an 18 week period. Results demonstrated that trained technicians and supervisors gained knowledge and skills to successfully manage ovitraps. Hay infusion ovitraps reported 2-3 times more oviposition than plain water ovitraps, collecting 72% of all eggs. Additionally, egg density patterns suggested temporal and geographic variations related to population density, water storage practices, prevalence of breeding sites, and rainfall patterns. ZAP contributed 600 ovitraps and increased the total number of ovitraps used in the country to 1000. Ovitrap monitoring in the Dominican Republic proved to be a simple, useful method to assess mosquito egg density across different areas of the country. ZAP demonstrated that trained technicians can collect valid, reliable data that can be used by provincial health teams to monitor current and planned vector control interventions. Current activities involve training local volunteers to increase the sustainability of ovitrap monitoring in the country.

P-55 Social assessment on an integrated intervention for the prevention of Zika and other Aedes-borne-diseases in pregnant women and their families in Mexico

Josue Villegas-Chim (jovich.etnos@gmail.com), Pablo Manrique-Saide, Norma Pavía-Ruz, Francia Espinosa Lizama, Alma Medina Várguez, Carolina Martínez Cruz, Anuar Medina-Barreiro, Emilio Trujillo-Peña, Josue Herrera-Bojórquez, Nina Valadez-González, Silvina Contreras-Capetillo, Gonzalo Vázquez-Prokopec

An integrated intervention model for the prevention for Zika (ZIK) and other *Aedes*-borne diseases (ABD) in 200 pregnant women and their families was conducted in Merida, Mexico from 2017-2018. They were provided with: Insecticide-Treated-Screens (ITS) on doors and windows of their houses, a preventive kit (repellent and larvicide recommended by the Mexican Ministry of Health, educational brochure for the promotion of good practices to avoid the risk of mosquito bites and for the elimination and control of breeding-sites, thermometer for fever monitoring, a personal symptom monitoring card compatible with ZIK and Carnet for recording laboratory tests, condoms), access to a 01800-0-ZIKA call center to report cases with suspected symptoms and clinical follow-up. A study on social acceptance and perceived efficacy of the intervention was carried-out in 2018 on 30 pregnant women. Main acceptance reasons were: they were very worried of ZIK infecting their babies (41.86%); concerns about multiple *Aedes*-borne diseases circulation (20.93%), that they were pregnant at that time (18.60%), a relative's recommendation (13.95%); and that they had a relative infected with ZIK (4.65%). The majority of respondents (96.55%) reported that the vector reduction inside their homes was effective, mainly because ITS. Overall, 83.33% of participants reported the use of the topic repellent; either provided initially by the project or another commercial brand. Educative information on ZIK (symptoms, preventive measures, and transmission routes) was perceived as good; but 53% confirmed that Zika can be transmitted sexually and 43% disagreed. All recommended the scaling-up of the intervention because they considered Zika infection as a dangerous illness to mothers and newborn. These results show that pregnant women can be provided with free or low-cost integrated interventions with methods of known efficacy and educative strategies to enhance maternal-child health for Zika and other ABD.

P-56 Replacing RAMP with ELISA testing to diagnose West Nile virus positive mosquitoes

Anthony Patullo (apatullo@stlouisco.com)

The Saint Louis County Department of Public Health (DPH) Vector Control Program (VCP) works to optimize resources while providing high-quality public health services. To this end, Integrated Pest Management principles drive mosquito surveillance and control activities, including testing for the presence of West Nile virus (WNV). In 2017, the VCP tested 1,725 pools of female *Culex* spp. mosquitoes using RAMP testing, of which 21.6% tested positive for WNV. Despite being commonly used and relatively straightforward to implement, RAMP testing is expensive. In 2017, the VCP spent $30,960.65 on RAMP test kits, which translates to $31.00 per 1,000 county residents. In February 2017, VCP staff began investigating the possibility of conducting enzyme-linked immunosorbent assay (ELISA) testing to identify WNV positive mosquitoes. After first developing a formal proposal which was quickly championed by DPH leadership, the VCP purchased the necessary laboratory equipment to conduct ELISA testing, including a multi-tube vortexer, plate reader, and washer. Next, VCP staff successfully developed accurate and replicable laboratory protocols. Cost savings from replacing RAMP testing with ELISA testing are estimated to be $27,180 - $36,240/year, and the VCP expects to recoup the initial investment for the purchase of laboratory equipment and supplies in under two years. In addition to the economic benefits of ELISA testing, there is also potential for improving regional mosquito control efforts by providing testing to jurisdictions that cannot currently conduct mosquito surveillance because of the prohibitive cost. Despite these benefits, challenges remain. ELISA test results need to be validated (e.g., by PCR testing) to provide full confidence in our findings. Additionally, direct comparisons of results to years past (and to jurisdictions using RAMP testing)

will be difficult. Nonetheless, we believe this is a step forward in our goal to improve the well-being of Saint Louis County residents, while maximizing our limited resources.

P-57 Correlation between geography and the gut microbiota of Anopheles albimanus mosquitoes
Margarita M. Correa (margarita.correao@udea.edu.co), Yadira Galeano Castañeda, Paula Urrea, Stefani Piedrahita, Yeraldine Zuluaga, Francesco Beghini, Nicola Segata, David Serre

The *Anopheles* gut bacterial microbiota has great importance because of its role in mosquito physiology. In addition, recent studies have attempted to evaluate the potential of some of these bacteria for *Plasmodium* paratransgenic control. The gut microbiota of various Asian and African mosquito vectors has been described with reports of some candidate bacteria; however, a variety of factors influence microbiota structure and composition, eg. geographical origin. Thus, the aim of this work was to determine if the structure and composition of *Anopheles albimanus* gut bacterial microbiota varies according to geography. Mosquitoes were collected in localities of the Colombian Pacific (PAC) and Atlantic (ATL) coasts. DNA was extracted from mosquito guts and the 16S rRNA gene-V2 region was amplified and sequenced by Illumina Mi-Seq. Bacterial communities varied according to sampling location with predominance of the Enterobacteriaceae family in the ATL locality, Bacillaceae in PAC, and some genera were unique to each locality. The structure of the bacterial communities in PAC locality showed higher genera richness, while that of ATL showed a predominance of *Enterobacter* spp. The results demonstrate the importance of evaluating the gut microbiota of native Colombian malaria vectors, since some the bacterial genera found in *An. albimanus*, eg. *Serratia, Enterobacter* and *Acinetobacter*, are described to have paratransgenic potential.

P-58 Implementing unmanned aerial systems (UAS) and aerial photography programs in mosquito control operations to detect urban breeding sources
Jesse Erandio (jerandio@deltavcd.com), Mir Bear-Johnson

Delta Vector Control District (DVCD) has recently implemented an unmanned aerial system (UAS) program to optimize mosquito control efforts. Following elevated mosquito trap counts, aerial photography is used to locate potential urban sources, such as green swimming pools. Potential UAS operation sites must be assessed prior to flight, based on geographical and airspace requirements. Additionally, law enforcement and city management are also notified prior to any potential operations. The district has a Federal Aviation Administration (FAA) part 107 certified remote pilot that operates a Phantom 4 Pro quadcopter to take aerial photographs between 100 and 400 feet in order to identify the presence of green swimming pools. Current ongoing trials include measuring the field of view of the UAS at 100ft, 200ft, 300ft, and 400ft and translating the measurements onto a map based on the Public Land Survey System. These measurements are used to optimize operational capacity and create a structured flight path to assist photographic analyses. Implementation of a mosquito control UAS program allows the district to perform aerial surveillance quickly and inexpensively, enhancing the ability to respond to potential public health threats.

P-59 Repellency of carrot seed essential oil and its pure compounds against mosquitoes.
Abbas Ali (dr_aliabbas@hotmail.com), Mohamed M. Radwan, Amira Wanas, Ikhlas A. Khan

Essential oil of carrot seeds was analyzed by GC/FID and GC/MS. Out of 47 compounds, carotol was more than 75% w/w followed by muurolene (4.86%), (*Z*)-β-farnesene (2.9%) and diepicedrene (1.1%). Systematic bioassay-guided fractionation of the essential oil was performed to identify the active repellent compounds. In vitro K & D and A & K bioassays were used to determine the repellent activity of the essential oil and its pure compound, carotol. Further evaluation in in vivo cloth patch and direct skin application were also performed. Both the carrot seed essential oil and carotol showed biting deterrent activity similar to *N,N*-Diethyl-3-methylbenzamide (deet) against both *Aedes aegypti* (L.) and *Anopheles quadrimaculatus* Say while in in vivo cloth patch bioassay, minimum effective dose (MED) of deet was lower (12.5 µg/cm^2) than the essential oil and carotol (25 µg/cm^2) against *Ae. aegypti*. In in vivo bioassays the mixtures of deet with the essential oil or carotol significantly increased the residual activity which indicated synergism. Mosquito repellent activity of carrot seed essential oil and carotol is reported for the first time.

P-60 Aerial ULV control of caged Aedes aegypti with naled in open and sequestered areas
Cassie Scott (gni6@cdc.gov), Brendan Carter, Peter H Connelly, Ed Foster, Cynthia Harrison, Mark Latham, Sarah Michaels, Andrew Ruiz, Claudia Riegel

Aedes aegypti is the principal mosquito species that transmits chikungunya, dengue, and Zika virus. In recent years, multiple outbreaks involving these arboviruses have occurred. In emergency outbreak situations, aerial adulticiding effectively provides rapid reduction of adult mosquitoes over large areas and halts the transmission cycle. *Ae. aegypti* prefer cryptic habitats making adult control efforts challenging. We

assessed the efficacy of aerial ultra-low volume (ULV) applications of naled for control of *Ae. aegypti* in open and sequestered areas in New Orleans, LA. The study consisted of three test sites in the spray target zone comprised of four test stations and three field control stations not subjected to the spray drift. Each station contained an exposed cage, a secluded cage, and a slide spinner for spray droplet analysis. The field trial was conducted at an aircraft flight altitude of 91.4-121.9 m (300-400 ft). The ULV application of Dibrom® insecticide (87.4% naled) at a rate of 51.2 ml per hectare (0.7 oz per acre) was effective in killing caged *Ae. aegypti* in both the sequestered and open areas.

P-61 Effectiveness of a Community Clean-up Event for the Control of Aedes aegypti
Jennifer A. Henke (jhenke@cvmvcd.org), Haide Vela-Alvarez

In conducting a community clean-up and block party for the control of *Aedes aegypti*, we examined the impact of our campaign. Yards were inspected the week before and between four and six weeks following the event to determine whethere there was a change in the number of residences where mosquitoes were found and the number of potential locations for mosquitoes to be found. While there was a redution in the number of residences where mosquitoes were found (from 13 before the event to eight following the event), there was an increase in the number of potential locations for mosquitoes to be found. Due to this, we determined that we did have a positive impact at a lect number of locations, but a further tuning of our message is suggested to improve the reach of our impact in future events. Both positive and negative results will be discussed.

P-62 Look-alike Mosquito Species and Rare Finds
Heather Marie Ward (hward@vdci.net), Kelsey Renfro, Michael Weissmann

VDCI's Taxonomic Laboratory in Denver focuses on the identification of adult mosquitoes collected throughout the continental United States, Alaska, Hawaii, and Puerto Rico. With the vast diversity and wide range of samples processed, several species with overlapping geographical ranges have been noted to be morphologically similar and difficult to distinguish between. This poster aims to illustrate several of these species and their morphological similarities and key differences. The ability to correctly identify between the noted species is crucial especially when a species is a known vector, but its look-alike is not. Accurate identification enables public health officials to track potential disease and reduce testing costs by submitting samples with only the correct vector species. Selected species will include groups from the genera: *Aedes*(*Ochlerotatus*), *Anopheles, Culex, Orthopodmyia,* and *Psorophora*. Key groups of species to be presented include: *Ochlerotatus increpitus/Ochlerotatus excrucians/Ochlerotatus fitchii Ochlerotatus dorsalis/Ochlerotatus campestris/Ochlerotatusmelanimon Anopheles punctipennis/Anopheles pseudopunctipennis/Anopheles franciscanus Culex pipiens/Culex salinarius/Culex erythrothorax Culex bahamensis/Culex chidesteri/Culex coronator Psorophora ferox/Psorophora horrida/Psorophora mathesoni/Psorophora longipalpus* As well as identifying species that share similar characteristics and geographic ranges, we find uncommon and beautiful species. Photos, taxonomy, and species descriptions will be provided for several which include: *Ochlerotatus purpureipes Ochlerotatus papago Ochlerotatus mediovittatus Psorophora johnstonii Psorophora pygmea Wyeomyia mitchellii*

P-63 The effects of mosquito adulticide exposure on red swamp crawfish (Procambarus clarkii)
Timothy Daniel McNamara (tmcnamara@agcenter.lsu.edu), Gregory Lutz, Christopher Green, Kristen Healy

Anecdotal reports imply that ULV sprays negatively impact farmed crawfish. Mosquito control adulticides are not typically applied over agricultural land, however there is concern that exposure via drift might impact crawfish survival. However, no data exists regarding droplet deposition or the effects of common ULV treatments on crawfish. We are examining the acute and chronic effects of common ULV products on the red swamp crawfish (*Procambarus clarkii*) to inform future ULV use in areas with crawfish agriculture.

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2013	Henry Rupp (NJ)
2017	Sammie Dickson

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)
	William R. Horsfall (IL)
1973	Don M. Rees (UT)
	Thomas D. Mulhern (CA)
1974	Anthony W. A. Brown (WHO)
	Donald L. Collins (NY)
1975	Daniel M. Jobbins (NJ)
	Arthur W. Lindquist (USDA)
1976	Austin W. Morrill, Jr. (CA)
	Carroll N. Smith (USDA)
1978	James B. Kitzmiller (FL)
	William D. Murray (CA)
1979	Richard F. Peters (CA)
1980	William E. Bickley (MD)
	John N. Belkin (CA)
1981	Stanley J. Carpenter (CA)
	Roland E. Dorer (VA)
1982	Kenneth L. Knight (NC)
	William C. Reeves (CA)
1983	Harry D. Pratt (GA)
	John A. Mulrennan, Sr. (FL)
1984	George T. Carmichael (LA)
1985	Norman G. Gratz (WHO)
1986	James R. Caton (CA)
1987	Jay E. Graham (UT)
1988	Lewis T. Nielsen (UT)
1989	Andrew J. Spielman (MA)
1990	Glen C. Collett (UT)
1991	Harold C. Chapman (LA)
1992	D. Bruce Francy (CO)
1993	Gilbert L. Challet (CA)
1994	Ronald A. Ward (MD)
1995	T. Wayne Miller (FL)
1996	Marshall Laird (New
1997	Robert K. Washino (CA)
1998	John D. Edman (MA)
1999	Bruce F. Eldridge (CA)
2000	Judy A. Hansen (NJ)
2001	Gary G. Clark (USPHS)
2002	Lucas G. Terracina (LA)
2003	Robert J. Novak (IL)
2004	James D. Long (TX)
2005	James W. Robinson (FL)
2006	John L. Clark Jr. (IL)
2007	E. John Beidler (FL)
2008	David A. Dame (FL)
2009	Dan Ariaz (NV)
	Gary Breeden (VA)
2010	Mir S. Mulla (CA)
2011	Dave Brown (CA)
2012	Sammie L. Dickson (UT)
2013	Wayne Crans (NJ)
2014	Chester G. Moore (CO)
2015	Jorge Arias
2016	Graham White (FL)
2017	Randy Gaugler (NJ)
	Allan Inman (CA)
2018	Bill Meredith (DE)
	Roger Nasci (IL)

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 (NJ)		William H. Meredith (DE)
	Helen Sollers-Riedel (DC)	1985	John C. Kuschke (NJ)	2006	William J. Sames (WA)
1975	Lewis E. Fronk (UT)		James R. Caton (CA)	2007	Henry R. Rupp (NJ)
	Joseph G. McWilliams (USN)	1986	C. Lamar Meek (LA)	2008	Allan Inman (CA)
	Lewis J. Ogden (USPHS)	1987	John C. Combs (CA)		Manuel Lluberas (FL)
	Rajindar M. Pal (WHO)	1988	Chester G. Moore (CO)	2009	Joe Conlon (FL)
	Kenneth D. Quarterman (USPHS)		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 (KY)	2016	Rui-de Xue (FL)
1978	Richard C. Axtell (NC)	1996	Donald J. Sutherland (NJ)		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)	2018	Gary Goodman (CA)

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)
	Leslie E. Fronk (UT)
	Jesse B. Leslie (NJ)
1981	Linda G. Raiche (CA)
	Margaret S. Slater (NY)
1982	K. G. Nolan (NY)
	Charles F. Scheel (IL)
1983	Coyle E. Knowles (NY)
1984	Ray Treichler (DC)
1985	Lawrence T. Cowper
	Janice B. Wells (NY)
1986	T. Oscar Fultz (GA)
1987	Sharon A. Colvin (IL)
1988	Daniel D. Sprenger (TX)
1989	Fred C. Roberts (CA)
1990	Leonard E. Munsterman (IN)
1991	James D. Long (TX)
1992	Charlie D. Morris (FL)
1993	Robert J. Novak (IL)
1994	James W. Robinson (FL)
	Dan L. Ariaz (NV)
1995	Sally Kuzenski (LA)
1996	Carl R. Tanner (IL)
	Sammie L. Dickson (UT)
1997	Charles T. Palmisano (LA)
	George J. Wichterman (FL)
1998	Douglas B. Carlson (FL)
1999	Charles Beesley (CA)
	Donald R. Johnson (GA)
2000	Peter B. Ghormley (CA)
	David A. Brown (CA)
2001	Donald Menard (LA)
	Joel Margalit (Israel)
2002	Dennis Moore (FL)
	Henry R. Rupp (NJ)
2003	James R. McNelly (NJ)
	Robert Bonnett (MN)
2004	James R. Brown (FL)
2005	Mark Newberg (IL)
	Susan Maggy (CA)
2006	Teung Chin
2007	Karl Malamud-Roam (CA)
2008	Wiliam H. Meredeth (DE)
2009	Rep. Dennis Cardoza (CA)
2010	Gordon Patterson (FL)
	Gary Clark (FL)
	Yasmin Rubio-Palis
2011	Angela Beehler (WA)
	Roxanne Connelly (FL)
2012	Truc Dever (CA)
2013	Robert Peterson (MT)
2014	Salvador Rico (TX)
2015	Kristy Burkhalter (CO)
	Elizabeth Cline (CA)
2016	Angela Beehler (WA)
	John Biedler
2017	Peter Connelly (FL)
	Larry Smith (GA)
2018	Stephen Sickerman (FL)
	Isik Unlu (NJ)

JOHN N. BELKIN AWARD

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

1981	Botha de Meillon (PA)
1982	Lloyd E. Rozeboom (IL)
1983	Kenneth L. Knight (NC)
1984	Thomas J. Zavortink (CA)
1985	Stanley J. Carpenter (CA)
1986	Elizabeth P. Marks & John Reid (Australia)
1987	James B. Kitzmiller (FL)
1988	Allan R Stone (MD)
1989	Pedro Galindo (Panama)
1990	Peter F. Mattingly (UK)
1991	Jose P. Duret (Argentina)
1992	Bruce A. Harrison (NC)
1993	Edward L. Peyton (DC)
1994	Theodore H. G. Aitken (CT)
1995	Oswaldo P. Forattini (Brazil)
1996	A. Ralph Barr (CA)
	Michael W. Service (UK)
1997	Christine J. Dahl (Sweden)
1998	Ralph E. Harbach (UK)
1999	Yiau-Min Huang (DC)
2000	Lewis T. Nielsen (UT)
2001	John F. Reinert (FL)
2002	Richard F. Darsie (FL)
2003	Richard C. Wilkerson (MD)
2004	Kazua Tanaka (Japan)
2005	Ronald A. Ward (MD)
2006	William K. Reisen (CA)
2008	Maria-Anice Sallum (Brazil)
2010	Daniel Strickman (MD)
2011	Rampa Rattanarithikul, Ph.D. (Thailand)
2012	Maureen Coetzee, Ph. D. (South Africa)
2013	John F. Anderson (CT)
2014	Graham White (FL)
2015	Elena B. Vinogradova (Russia)
2016	
2017	George F. O'Meara (FL)
2018	Dr. L. Philip Lounibos (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. Knipling	Waldemar Klassen	Titan and Driving Force in Ecologically Selective Area-Wide Pest Management
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	
2018	Fred Knapp	Steve Presley	

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 (FL)	2015	Joe Strickhouser (NC)
2004	John L. Clarke, Jr. (IL)	2016	Terry Couch (FL)
2005	Ernest Danka (IL)	2017	Clark Wood (IL)
2006	Willie N. Cox (IL)		Malcom Williams (AR)
2007	Bob Bonnett (MN)	2018	Larry Smith (FL)

GRASSROOTS AWARD

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

2005	Omar S. Akbari	Reno Washoe Country, Nevada
	Christopher Trapp	Multnomah County Vector Control,
2006	John Phelps	Mercer County, New Jersey
2008	Chris Frame	Cape May County, New Jersey
2009	Jason Craig Hardman	Salt Lake City MAD, Utah
2010	Jessica Fales	Midland County MC, Michigan
	Gary Hillsdale	Metropolitan MCD, Minnesota
	Elizabeth Vice	Buttle County MVCD, California
2011	David Bruget	Kings MAD, California
	Russell Eck	Washoe County Health District, Nevada
	Phillip Henry	Butte County MVCD, California
	Levi Zahn	Williston VCD, North Dakota
2012	Mike Smith	Anastasia MCD, Florida
2013	Arturo Gutierrez	Coachella Valley MVCD, California
2013	Michael Martinez	Coachella Valley MVCD, California
2013	David Lopez	Greater Los Angeles County VCD, California
2013	Martin Serrano	Greater Los Angeles County VCD, California
2014	Dell Boyd	Butte County MVCD, California
	John McCready	Jackson County VCD, Oregon
	Gaby Perezchica-Harvey	Coachella Valley MVCD, California
	Geneva Ginn	Coachella Valley MVCD, California
2015	Kevin Hill	Pasco County MCD, California
	Richard Ortiz	Coachella Valley MVCD, California
	Terry Sanderson	Lake County MVCD, California
	Melissa Snelling	Coachella Valley, MVCD, Californa
2016	Patrick Morgan	Indian River MVCD, Florida
	Janet Nelson	Northwest MVCD, California
	Richard Weaver	Anastasia MVCD, Florida
2017	Hailey Bastian	Shasta MVCD, California
	Gregorio Alvarado	Coachella Valley MVCD, California
	Aaron Lumsden	Butte County MVCD, California
	Danny Ray Hood	Beach MVCD, Floriday
2018	Jessica Dieckmann	County of San Diego VCP, California
	James Wynn	Anastasia MVCD, Florida
	Stefan Sielsch	El Dorado County MVCD, California
	Kyle Yager	Hillsborough County MVCD, Floriday

STUDENT PAPER COMPETITION AWARDS

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

1989	Scott Willis	McNeese State U.
1990	Andrea Brown	Peru State Coll.
1991	John Paul Mutebi	Notre Dame U.
1992	Rosmarie Kelly	U. Massachusetts
1993	Merry L. Holliday-	U. California, Davis
1994	John E. Gimnig	U. California, Davis
	Alice Shaeffer*	U. Mainz, Germany
1995	Glen Scoles	Notre Dame U.
	Jittawadee Rochaeroen*	U. California, Riverside
1996	Esther Chow Schaeffer	U. Maryland
1997	Lynn Cooper	U. Maryland
1998	C. Roxanne Rutledge	Louisiana State U.
	Emmalee Kennedy*	U. Illinois
	Timothy Schaub*	U. Illinois
1999	Laura Harrington	U. Massachusetts
	Adam S. Jones*	U. Massachusetts
	Hillary Reno*	U. Illinois
2000	Jason L. Rasgon	U. California, Davis
	Hope Q. Liu*	Virginia Polytechnic
2001	No competition	
2002	Laura B. Goddard	U. California, Davis
	Sharon L. Minnick*	U. California, Davis
	Margaret Sherriffs*	Yale U.
2003	Sarah Yaremych	U. Illinois
	Laura Goddard*	U. California
	Jason L. Rasgon*	U. California, Davis
2004	Gregory M. Williams	U. Delaware
	Stephen Aspen*	Colorado State U.
	Christian Kaufmann*	U. Zurich
2005	Wesley Rubio	San Diego State U.
	Whitney Qualls*	Auburn University
	Rebecca Trout*	University of Kentucky
2006	Robert D. Anderson	University of Winnipeg
	Linda O'Connor**	University of Delaware
	Joshua R. Ogawa*	Oregon State University
	Matthew Eaton*	Concordia College
	Linda M. Styer*	U. California, Davis
2007	Jennifer Armistead	University of Florida
	Robert D. Anderson*	University of Delaware
	Thomas M. Mascari*	Louisiana State U.
2008	Jerome Schleier	Montana State University
	Christopher Barker*	U. California, Davis
	Lisa Reimer*	U. California, Davis
2009	Alexandra	University of Florida
	Stephanie Larick*	University of Florida
2010	Sarah Wheeler	University of California,
	Kimmy Mains*	University of Kentucky
	Holly Tuten*	Clemson University
2011	Logan Minter	University of Kentucky
	Kristen Meckel-	San Diego County Vector
2012	Jerome Schleier	Montana State University
	Elizabeth Andrews*	University of Kentucky
	Jennifer Gordon*	University of Kentucky
	Joseph Iberg*	University of Georgia
2013	Brian Johnson	Rutgers University
	Andrea Egizi	Rutgers University
	Brittany Nelms	U. California, Davis - CVEC
2014	James Ricci**	University of California
	Eva Bickner***	University of Florida
	Allison Gardner***	U of IL Urbana - Champaign
2015	Maria Carrasquilla**	University of Florida
	Casey Parker***	University of Florida
2016	Sydney Crawley***	University of Kentucky
	Lin Zhu***	University of Miami
	Cassandra Urquhart**	University of Tennessee
2017	Adena Why**	University of California
	Evlyn Pless **	
	Edmund Norris***	Iowa State University
2018	Annie Rich***	University of Georgia
	Katelyn Haydett***	
	Jay Brown*	
	Christopher Bibbs*	Anastasia Mosquito Control
	Shiloh Judd**	Louisiana State University

* $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	T. Wayne Gale
1964-1965	John A. Mulrennan,	1991-1992	Matthew Yates	2018-2019	William Walton
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		

* - Eastern Association of Mosquito Control Workers

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		

* - Eastern Association of Mosquito Control Workers

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	2016-2017	Bill Schankel	Excecutive Director
			2017- present	Heather Gosciniak	Executive Director

* - Eastern Association of Mosquito Control Workers

BUSINESS MANAGER

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

TECHNICAL ADVISOR

2000-present	Joseph M. Conlon

EDITORS OF *JOURNAL OF AMCA**

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