THE AMERICAN MOSQUITO CONTROL ASSOCIATION

2021 VIRTUAL ANNUAL MEETING
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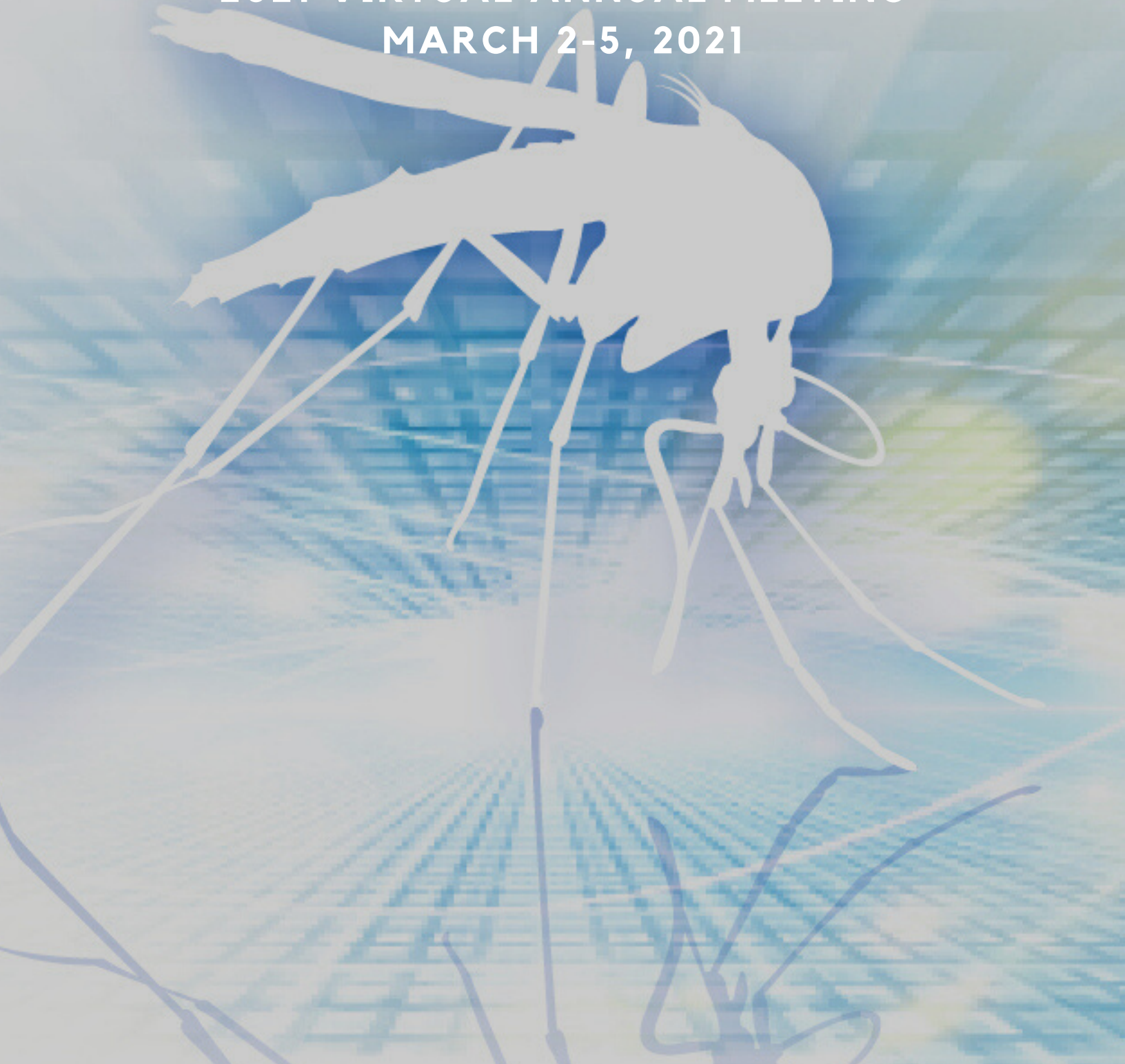

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Memorial Lecutre

42 Memorial Lecture Honoring Lewis T. Nielsen

Sammie Dickson (niphadopsis@icloud.com), Mark S. Blackmore

The 2021 AMCA Memorial Lecture honors Lewis T. Nielsen, PhD, 1920-2014 on the centennial of his birth. Dr. Nielsen was born August 6, 1920, in Salt Lake City, UT. Other than the four years he served in the US Army during WWII, Dr. Nielsen lived his entire life in Salt Lake City. He was the eldest of four children, with two sisters and a brother. His father, Knute Lester Nielsen, was injured during WWI and Dr. Nielsen credited his father's disability pension for supporting the family during the Great Depression and allowing 'Lew' to pursue his education rather than having to work to support the family.

Dr. Nielsen's lifelong love for the study of mosquito biology and systematics evolved serendipitously. After failing a junior high school algebra class, he was kept after school writing equations on a blackboard. At about this time a teacher by the name of Mr. Archibald took an interest in him and urged him to think seriously about his future, and to continue his education. It was at this early age that Dr. Nielsen began developing an interest in natural history. While earning a nearly straight A average in high school, he took botany and zoology which further fueled his interest in natural history.

Following high school graduation at the age of 17, he entered the University of Utah in fall 1937, which began a lifelong association with the "U." While working his way through college, he was assigned a position in the Zoology department pinning mosquitoes for Dr. Don Rees. That led to a summer job at the Salt Lake City Mosquito Abatement and ultimately his life's work with mosquitoes. His three degrees in Biology included a BS (1941,) MA (1947) "On the Biology of *Aedes dorsalis,"* and PhD (1955) "The Taxonomy, Biology and Control of the Rocky Mountain *Aedes* Mosquito Species." The intervals between degrees included a tour of duty in the US Army, 1942 – 1946, and the difficult task of teaching introductory Biology classes as an Instructor at the University while working on his doctorate. In 1956, Dr. Nielsen was promoted to Associate Professor and taught Entomology, Medical Entomology, Insect Morphology, Insect Sociality, Mosquito Systematics, and a general education course he developed called Insects and Man. In 1965, he became the Director of General Biology and was promoted to the rank of Professor in 1966. During his academic career, Dr. Nielsen had 29 students that received their Master of Science degrees and 10 students that received their PhD's. He published 82 scientific publications and was the lead author on 41 of those publications. At retirement in 1989, after 43 years teaching and research at the University of Utah, he received the honor of being named Professor Emeritus of Biology.

Dr. Nielsen played a major role in local mosquito research and control. No one knew more about the biology and taxonomy of Utah mosquitoes. His favorite mosquitoes were the snowmelt mosquitoes of the higher mountainous elevations. He twice served as the President of the Utah Mosquito Abatement Association (UMAA) (1958 and 1990), He was awarded the UMAA Don M. Rees Award in 1988 and the Meritorious Service Award in 2005. For more than 40 years, he organized the association's annual spring training workshop. From the inception of the UMAA in 1948 until his death he never missed an Annual Meeting of the UMAA.

Dr. Nielsen had a very close relationship with the American Mosquito Control Association (AMCA). He served as the AMCA President (1977), and received the Medal of Honor Award (1988), was made an Honorary Member (1994), and the John Belkin Award (2000). He was the Editor for AMCA's *Mosquito*

Systematics publication from 1979 – 1992, Co-editor 1992-1993 and Editor Emeritus 1993-1995. In 1997, Dr. Nielsen gave the Memorial Lecture entitled "In honor of Stanley Carpenter."
In his personal life, he had a love of the outdoors, including collecting mosquitoes, duck hunting; snow shoeing, fishing, and spending time at his cabin at Christmas Meadows in the Uinta Mountains. His love for music was immense, with his favorite composers being Mozart, Haydn and Beethoven. He was also a great fan of the Big Band music of the 30's and 40's. His vinyl record collection was in the thousands.

Mosquito Lightning Symposium

3 The weirdest of the weird mosquitoes of the world!

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

Mosquitoes are weird. From eggs to adults, larvae to pupae, anal papillae to modified siphons, host finding to host feeding, and from their general morphology to their biology. But they are also fascinating creatures that have captivated our attention and efforts for hundreds of years. I will highlight some weird facts about a mosquito species (or several) that most members of the audience will not be familiar with. It will perhaps be about a titillating *Coquillettidia* species, or some ladies from the *Aedes* species, or perhaps some trippy *Tripteroides*. You will have to be there to find out!

4 Do tigers hunt during the day? Diel Activity of the Asian tiger mosquito, Aedes albopictus (Diptera: Culicidae), in Urban and Suburban Habitats of North America

Isik Unlu (ioguzoglu@hotmail.com), Ary Faraji, Nicholas Indelicato, Jim McNelly

Aedes (*Stegomyia*) *albopictus* (Skuse) impacts human outdoor activity because of its aggressive biting behavior, and as a major vector of mosquito-borne diseases, it is also of public health importance. Although most mosquito species primarily feed at dawn and dusk, *Ae. albopictus* has been traditionally characterized as a diurnal or day-biting mosquito. With the global expansion and increased involvement of *Ae. albopictus* in mosquito-borne diseases, it is imperative to elucidate the diel activity of this species, particularly in newly invaded areas. Human sweep netting and carbon dioxide-baited rotator traps were used to evaluate the diel activity of *Ae. albopictus* in two study sites. Both trapping methods were used in New Jersey's Mercer County, USA (temperate urban), while only human sweep netting was used in Florida's Volusia County, USA (subtropical suburban). Human sweep netting was performed to determine adult mosquito activity at sunrise, solar noon, sunset, and lunar midnight. Because New Jersey is in a temperate area, diel activity was investigated during the early season (3-19 July), peak season (25 July-19 September), and late season (22 September- 22 October).
Aedes albopictus showed the highest activity during peak and late seasons at solar noon ($P < 0.05$). At sunrise and sunset during the peak season, *Ae. albopictus* activity was similar. Lunar midnight activity was significantly lower than sunrise and solar noon ($P < 0.05$) but was similar to that of sunset. In the late season, the highest activity was observed during solar noon while the least activity was observed during sunrise and lunar midnight ($P<0.05$). Rotator traps used in conjunction with the human sweep net technique exhibited similar results. Seasonal activity was not differentiated in Florida due to the consistent subtropical weather. The highest adult activity was observed at sunrise using human sweep netting but it was not significantly different from solar noon and sunset. The lowest adult activity was observed at lunar midnight; however, it was not significantly different from solar noon and sunset. These results provide evidence that the diel activity of *Ae. albopictus*, contrary to the common

perception of its diurnal activity, is much more varied. It also highlights the importance of behavioral studies of vector species which will not only help mosquito control professionals plan the timing of their control efforts but also provide empirical evidence against conventional wisdoms that may unjustly persist within public health stewards.

5 Mosquitoes pass through screens to enter traps

Jerome Hogsette (jerry.hogsette@usda.gov)

Remembering when people sat on screened porches after supper to cool off and let the meal digest (since there was no air conditioning), screen was there to keep out mosquitoes. But the human bodies on the porch still attracted mosquitoes to the screen, and if they could find even the smallest hole, mosquitoes would enter the porch. We wondered if plastic window screen wrapped around the clear plastic cylinder of a CDC trap would reduce its attraction. If it did not, could we replace the untreated screen with a pesticide-treated screen and kill the mosquitoes that were attracted. Pieces of treated and untreated screen were cut to fit the clear cylinders. Screens were long enough to push to the top of the trap lids and block the entryway into the traps. One screen-covered trap was hung on a shepherd's hook about 3 ft high in each of two 8 x 8-ft screen rooms. An unaltered CDC trap was hung in the same manner next to each screened trap. Hoses affixed to the tops of each trap supplies CO2 from gas cylinders. About 9:00 AM CO2 was turned on as were the screened traps in each cage. Then 300 female mosquitoes of 3 genera were released in each cage. About 5:00 PM, unscreened traps were activated. A test was terminated the next morning about 8:00 AM, catch containers removed and put in a freezer. The thought was to release equal numbers of mosquitoes in each cage, let the screened traps attract them for about 8 hrs, then capture a portion of the remaining mosquitoes in the unaltered traps. There should be fewer mosquitoes in the cage containing the trap with the treated screen if the treated screen was killing mosquitoes attracted to that trap. Results will be discussed in the presentation.

6 Aedes (Abraedes) papago: A poorly known Sonoran Desert mosquito of the US-Mexico borderlands

Lawrence Reeves (lereeves@ufl.edu)

In June 1969, a single specimen of an unusual mosquito species was collected in a remote canyon in the Coyote Mountains of southern Arizona, southwest of Tucson. Subsequent searches and collections of immature and adult mosquitoes in Mendoza Canyon, the site of the original collection, turned up no further specimens until eggs, taken from an oak tree hole, were reared out. *Aedes papago* and its monotypic subgenus *Abraedes* were described from this small series of specimens by Thomas Zavortink in 1970. Since then, collection records for this species have been scarce: John Burger collected three biting females in the desert south of Tucson, in the foothills of the Santa Rita Mountains, and a few specimens turned up in National Ecological Observatory Network collections from the same region. These later collections suggest that *Aedes papago* occurs in the lower and more arid habitats of the Sky Islands Region of Arizona rather than the higher mid-elevations where oaks are dominant.

7 Once-upon-a-time: Mosquitoes smell (parts) of you better at night

Sam Rund (srund@nd.edu)

Just like humans, mosquitoes have circadian rhythms. These rhythms range from gene expression on up to rhythms in behavior with everything in between - like the sense of smell. I'll explain

in 3 min what takes a nocturnal mosquito 24 hours to accomplish- as it tunes its olfactory system to detect certain parts of your body odor (the hydrophobic parts) better at night. We'll go on a rhythmic sun-down to sun-up journey from RNA to protein to electrophysiological responses to behavior and how a mosquito's daily rhythmic behavior is driven both by response to light and an internal circadian clock.

8 How I became a mosquito sexologist

Robert Hancock (rhancoc5@msudenver.edu)

In 1988, as an Ohio State University Masters student I received a grant to travel to the jungles of Panama to study the behavior of the exotic mosquitoes in the genus *Sabethes* that live there. Little did I know that it was a career-changing adventure. My brilliant mentor Dr. Woodbridge A. Foster only knew of these spectacular iridescent and ornamented jewels from Victorian-era color illustrations and museum specimens. We wanted them alive and thus designed an expedition to give us the best chances for finding them. We had so many questions about these remarkable arthropods. How do they behave? Where do they breed? What do they feed on? Our destination was Manuel Noriega's Panama and, with expected travel and logistical adversity, we made it to the jungle where we systematically pursued our elusive targets. Harrowing forest canopy work was not fruitful, but at ground level in tree-fall zones with rays of penetrating sunshine, we were delicately approached by a beautiful and blood-thirsty female. We now knew where to find them! Long field days ensued as we filled our field journals with bizarre accounts of nose-biting and aerial oviposition into tiny tree holes. And, on one special day, we caught glimpses of elaborate and beautiful mating rituals that were so exquisite they would ultimately steer my scientific career in the direction of mosquito sexology. Most importantly, we returned with living specimens and established laboratory colonies that, after 32 years, continue to be used to unravel the mysteries of *Sabethes*, most eccentric mosquitoes on earth. Today, Macrocinematography is my "Mosquito Lightning" and you will be the first audience in the world to be struck by it.

9 Come out, come out, wherever you are! Hunting for Ixodes ticks in the Sierra Nevada Foothills

Elizabeth Andrews (Elizabeth.andrews@cdph.ca.gov)

If you're looking for the nymphal stage of the western blacklegged tick in the Sierra Nevada foothills you'll find yourself out of luck if using standard flagging methods. These ticks don't typically quest along trails or in leaf litter and can be difficult to find in high numbers. Since the adult ticks are often abundant, the nymphs have to be somewhere, right? Join me on a journey to find the elusive *Ixodes pacificus* nymph. Warning: there's poison oak ahead!

10 How dogs saved South Texas from Zika virus

Gabriel Hamer (ghamer@tamu.edu)

Mosquito-borne viruses are emerging or re-emerging globally, afflicting millions of people around the world. *Aedes aegypti,* the yellow fever mosquito, is the principal vector of dengue, Zika, and chikungunya viruses and has well-established populations across tropical and subtropical urban areas of the Americas including the southern United States. While intense arboviral epidemics have occurred in Mexico and further south, local transmission in the United States has been minimal. Here we study *Ae. aegypti* and *Culex quinquefasciatus* host feeding patterns and vertebrate host availability in residential environments of South Texas to identify over and under host-utilization. Only 31% of *Ae. aegypti* blood meals were derived from humans while 50% were from dogs and 19% from other wild and domestic

animals. In *Cx. quinquefasciatus,* 67% of blood meals were derived from chicken, 22% came from dogs, 9% from various wild avian species, and 2% from other mammals including one human, one cat, and one pig. We developed a model for the reproductive number, R_0, for Zika virus (ZIKV) in South Texas relative to northern Mexico using human disease data from Tamaulipas, Mexico. We show that ZIKV R_0 in the LRGV could be greater than 1 if the risk of human exposure to *Ae. aegypti* bites in these communities is at least 60% that of Reynosa, Mexico. The high utilization of non-human vertebrates and low risk of human exposure in South Texas diminishes outbreak potential for *Ae. aegypti* and *Cx. quinquefasciatus* transmitted viruses.

11 Speed date to get hitched with impactful mosquito research of 2020

Banugopan Kesavaraju (Banugopan.Kesavaraju@valentbiosciences.com)

Every year greater than 1000 scientific articles are published on 1000 different subdisciplines in the field of biology. Although mosquito research occupies only a tiny sliver in the ocean of biology, the collective interest of members of AMCA revolves around this topic. Tune on to know about the peer reviewed mosquito related article that was published in one of the highest impact factor journals in 2020.

12 Chasing mosquitoes from Zanzibar to Papua New Guinea: following a trail blazed by Robert Desowitz

Jason Richardson (jason.richardson@ivcc.com)

IVCC is a unique Product Development Partnership (PDP) dedicated to the development of innovative vector control solutions. Established in 2005, our work has largely focused on replacing pyrethroids for indoor control of malaria vectors in Africa. With the successes on that front we have broadened our focus to address the urgent need to identify effective tools to prevent outdoor transmission to address populations not protected by bednets or indoor residual spraying. One of the potential solutions we are exploring is passive pyrethroid emanators. Working with manufacturing partners and control programs, we are supporting several field tests to evaluate the potential of this class of products to protect populations from mosquito-borne diseases. This presentation will summarize the projects we are supporting and planning.

13 The Chaos after the swarm

Whitney Qualls (wqualls@amcdfl.org)

The Texas Department of State Health Services (DSHS) has a limited role in vector control: 1) scientific consultation, 2) contingency contracts through emergency preparedness for disease outbreaks or severe weather events, and 3) laboratory mosquito speciation and arbovirus testing. During the emergency response to Hurricane Harvey, the DSHS organized the Vector Control Task Force to organize mosquito control for the hurricane impacted counties. Since Harvey, entities in Texas that do mosquito control have continued to request resources from the state to aid in post-flood nuisance mosquito control. The lightening round presentation will discuss the structure of Texas mosquito control and future directions.

14 The mosquito bucket list

Sean Amodt (sean@swmosquito.org)

What would a mosquito want to do in the last day of its life? This presentation will describe all of the exciting events on a mosquito's bucket list.

15 Almost There! Dr. William Maull: Window Screens and Malaria

Carl Doud (cdoud@co.midland.mi.us)

An article entitled "Window Screens as a Prophylactic of Malarial Poisoning" was published in *Michigan Medical News* September 10th, 1880 and is very interesting in hind sight. 1880 was the year that the *Plasmodium* parasite was first described from the blood of malaria patients, and this was a full seventeen years before the link of malaria and mosquitoes was discovered. The paper by Dr. Maull notes that among a malarious neighborhood in Illinois, two families were nevertheless malaria free. The only difference Dr. Maull noted between these families and others with malaria was that the homes of the two families had screened doors and windows. Conjecture regarding this observation was made within the framework of the prevailing theory at the time – that malaria was obtained from breathing gases arising from swamps and marshes. Dr. Maull was uniquely positioned by these observations to discover the link between mosquitoes and malarial infection years before it was to be found by others.

16 Utah is unique and so are our outbreaks

Jeffrey Eason (jeason@slco.org)

Utah is a state composed of rural, frontier, and urban communities. Each community type comes with associated potential health risks. When communicable disease outbreaks occur, the potential health risks associated with community type should be systematically assessed in the context of the etiology of concern. During this presentation attendees will follow an outbreak of *Escherichia coli* O157:H7 and gain an insider's perspective on how potential health risks associated with community type can impact outbreak response.

17 Is this working? An Applied-side approach to product assessment

Sarah Wheeler (swheeler@fightthebite.net), Ryan Wagner, Paula Matney, Marcia Reed

Vector control districts have choices when it comes to selecting mosquito control solutions. Cost and application parameters are key factors, but ultimately efficacy is paramount. Product efficacy can change over time due to insecticide resistance and changing environmental factors. Thus, Districts often need to evaluate the efficacy of a wide-range of products to ensure they are getting the intended result. Sacramento-Yolo Mosquito and Vector Control District employs a wide-range of assessment techniques used for this purpose. A quick survey of which technique is used for which product type will be presented along with procedural guidelines for avoiding common pitfalls.

18 What's that smell? Culex quinquefasciatus affinity for sewage-polluted water.

Kevin Caillouet (kcaillouet@stpmad.org), Nicholas DeLisi

Culex quinquefasciatus has a well-established attraction to the fecal odorant skatole. Open roadside ditches in St. Tammany Parish, LA are often contaminated with human sewage from decentralized septic systems and produce prodigious amounts of this West Nile virus vector. We tested the oviposition preference of *Cx. quinquefasciatus* females in a series of outdoor randomized block arrays to test the effect of: 1) sewage strength, 2) time since water fouling, 3) mosquitofish presence, 4) larvicide application, and 5) whether functioning septic systems reduced egg recruitment. Nearly six-times more egg rafts were oviposited in undiluted sewage effluent than in a 25% dilution of the same

effluent, though no statistically significant differences were found between 100% sewage and a 50% dilution. Egg recruitment significantly dropped off each night after sewage water was collected. Weak oviposition differences were documented in buckets containing mosquitofish at a 50% dilution, with no differences in 100% sewage effluent, though these experiments require further replication. No differences in oviposition were measured across *Bacillus thuringiensis israelensis* treated buckets, and no differences were found in effluent collected from houses whose septic systems recently passed or failed inspections. Female *Cx. quinquefasciatus* appear to have discriminating tastes for water polluted strongly by human sewage.

19 There ain't no party like a swarming party

Catalina Alfonso (catalfonso@gmail.com)

Swarms are important in the biological cycle of some mosquito species, as they are the main arena to mate. Males of the same species congregate, and females come in to the swarm to mate. But how is a swarm formed? How do males find each other? How do males locate a female and how do females choose the perfect male? Could we use some of the characteristics of swarming for vector control?

20 Breaking operational norms to meet the challenges of a rapidly evolving vector control industry

Jared Dever (jdever@sgvmosquito.org)

How do we continue to effectively provide our services for a society being cultured to favor nonverbal personal and professional communication, demand instant gratification of material needs and wants, and pursue harmonious coexistence in complex environments without chemical or physical interventions? Compounding the challenge of these shifts in societal norms is the spread of invasive vector species that require a deeper level of interpersonal communication and education, greater reliance on personal behavior change, and broad acceptance of strategic chemical interventions to protect public health. The San Gabriel Valley Mosquito and Vector Control District has spent the past two and half years deconstructing the traditional vector abatement and service provision models in order to build an improved model of service and control that compliments the expectations of modern urban society. This lighting round presentation will highlight the most transformative components of our new service paradigm and prove why the statement “It’s always been done that way.” is the hallmark of inefficient organizations.

21 What is the value of mosquito pool testing for CHIK, DEN, and ZIKA viruses in CONUS?

Roxanne C. Connelly (csz5@cdc.gov)

To assess the value of mosquito pool testing for chikungunya, dengue, and Zika viruses in *Aedes aegypti* and *Aedes albopictus* in the continental United States, test results from jurisdictions with and without imported or local human cases during 2014 – 2018 were evaluated. A summary of the number of pools tested and percent positive, by species, jurisdiction, and year, will be presented along with number of imported or locally-acquired human cases in the jurisdiction in the context of lessons learned.

22 Killing mosquitoes like Rambo, with 40mm Larvicide Grenades

Gregory Williams (gwilliams@hudsonregionalhealth.org)

Ary promised me a prize in Orlando and didn't deliver, so I'm back again. In 2019, we literally blew up the Mosquito Lightning Symposium with our giant pneumatic air cannon that launched mosquito mortars filled with various larvicides over 150 meters. While the cannon worked well, it wasn't exactly portable. This year we return with a new and improved model. Marvel as we draw First Blood from mosquitoes with a hand-held grenade launcher. We used an off the shelf 40mm airsoft grenade launcher to shoot 3D printed soluble projectiles filled with larvicides. The grenades are individually powered by carbon dioxide so there is no need for a compressor and reloading takes seconds. In the best three minutes you will spend at AMCA, we will present ballistic data for several grenade shapes and payloads, test your motion sickness with in-grenade video clips, and take cheap shots at our moderator. Not to be missed.

7th Annual AMCA Arthropod Vector Highlights Symposium

23 Highlights of mosquito biology, 2019

Rebecca Heinig (rheinig@cmcd.org)

Mosquitoes continue to be a hot topic in the research world, with new papers being published at a rate of over 50 per week. This presentation will highlight some of 2019's most impactful, interesting, and just plain weird findings from the realm of mosquito biology with an emphasis on their relevance to mosquito researchers and control professionals.

24 Highlights of mosquito biology, 2020

Rebecca Heinig (rheinig@cmcd.org)

This presentation will highlight some of 2020's most notable papers in mosquito biology, emphasizing their relevance to mosquito researchers and control professionals.

25 Highlights of Vector Control

Gissella Vasquez (gissella.m.vasquez.ln@mail.mil)

This presentation will highlight the latest advancements in vector control based on studies published in 2019, with sample papers selected for additional discussion. The goal is to review the year's highlights in vector surveillance and control approaches including innovations and promising findings on the use of mosquito larviciding and adulticiding, oral insecticides, botanical insecticides, anti-parasitic drugs, biological control, transgenic and sterile insect technique, and *Wolbachia*-based control. Topics will be broadly reviewed and aspects most relevant to vector control as for example the impact of insecticide resistance and vector-borne disease epidemiology, will be emphasized. Ground breaking research will be discussed in depth and major contributions will be noted. This review will provide insight into the latest vector control research topics and key engagements, and how these findings can help deal with current challenges in vector control operations.

26 Highlights of mosquito control and research in Africa 2019-2020

Silas Majambere (silas.majambere@pamca.org)

Mosquito borne diseases continue to burden the continent of Africa, with malaria on its own claiming close to half a million lives every year. Other diseases such as dengue fever are on the rise and likely to expand further with growing urbanization.
Unlike other parts of the world, mosquito control and R&D in Africa has long been biased towards "indoor control" mainly because it has been developed around the control of Anopheles vectors of malaria that predominantly bite and rest indoors. The two main mosquito control tools in Africa are bed nets and indoor spraying of residual insecticides. Since 2000, over one billion mosquito nets have been distributed in Africa.
However these methods of control are threatened with the development of insecticide resistance and behaviour change in mosquito vectors.
This review will summarize the latest developments in mosquito control and research in Africa in 2019-2020, focusing on the new chemistries being developed for bed nets and indoor residual spraying, but also the growing interest in additional mosquito control strategies including reviving larval source management and environmental management, house modifications, and innovative strategies for outdoor mosquito control.

Mosquito Control in the Beehive State Symposium

27 The Genesis of Mosquito Control in New Zion

Gordon Patterson (patterso@fit.edu)

The history of the Beehive State's war against the mosquito menace is rich and varied. From the malarial swamps in Nauvoo to the salt marshes of the Great Salt Lake, mosquitoes have played an important role in Utah's development. In 2023, Utah will celebrate the centenary of the passage of legislation allowing the formation of mosquito abatement districts. Substantial challenges face mosquito control in the 21st century. The threats posed by invasive species, emerging pathogens, increased urbanization, and declining revenues make clear that the road ahead will not be easy. The quality that defines the organized mosquito control movement in Utah is collegiality. For one hundred years, men and women have worked in Utah to protect the public from pest and disease-bearing mosquitoes. Their commitment has made a substantial contribution to innumerable lives.

28 Ties That Bind: UMAA & AMCA

Sammie Dickson (niphadopsis@icloud.com)

From the inception of the Utah Mosquito Abatement Association (UMAA) in 1948, until the present, there has been a strong connection between it and the American Mosquito Control Association. The UMAA is an unlikely association to play such a important role in the AMCA. It is not considered a large organization and is located away from either coast where most of the large mosquito control organizations have been established. The strength of the UMAA came from a single source that influenced many others through several generations. Dr. Don M. Rees, a Professor in the Zoology Department, at the University of Utah, was that source. After attending meetings of the Eastern Mosquito Control Workers, Dr. Rees recognized the importance of organized mosquito control. He was the guiding force for the formation of the UMAA. Dr. Rees was also one of the organizers of the AMCA. He served on its Executive Committee in 1947-48 and was Chairman of the Interim National Board in 1949 when AMCA organized its constitution and bylaws. Just three years after its formation, the UMAA

had one of its own, Don M. Rees PhD, serve as the 11th President of the AMCA. Dr. Rees was the first of six UMAA members that have served as AMCA President, as well as one Treasurer.
UMAA members have been recognized for their contributions on numerous occasions: two memorial lecturers, two memorial honorees, one John Belkin awardee, two Presidential citations, four Medal of Honor recipients, three Honorary Members and one Grassroots recipient.
The UMAA has hosted four AMCA Annual Meetings, and if the Covid19 virus abates, it will host its fifth in 2021.

29 The U of U's AMCA Legacy: Rees and Nielsen

Robert Novak (rnovak@usf.edu)

My contribution to the symposium on University of Utah and mosquito control will revolve around my experiences as a new graduate student working on my MS degree in Biology with Professor Nielsen. I came to the University of Utah from Southern Colorado State College working as an undergraduate in biology with Dr Jay Linam, a PhD student of Dr Nielsen on snow pool mosquitoes in Colorado. Dr Sammy Dickson followed the same course with Dr Linam a few years later at SCSC. My undergraduate work with Jay produced 2 mosquito publications, so pursuing my graduate studies at Utah was a natural next step. When i began at the university I was lucky not only to work for Dr Neilsen but was able to learn from several entomological and parasitological experts in the field of mosquito biology/medical entomology. A list of the faculty members included: Dr Rees, medical entomology, Dr Edmund, aquatic entomology/mayflies, Dr Gaufin, stone flies and Dr Grundman parasitology. I was a teaching assistant for Drs Edmunds and Grundman and general biology lab for Dr Neilsen during my tenure at the U. These faculty members and their research and teaching provided a strong and balanced scholastic atmosphere to a brand new MS student.

My fellow graduate students at this time also provided a huge source of learning and important information and techniques as well as how to pose a hypothesis for major problems in mosquito taxonomy. and biology. All of Dr Nielsen students at this time were working on their PhD's. The Nielsen lb at this tie included: Drs. Hal Arnell, Steve Romney, Betina Rosay, Mel Boreham, Bill Burgoyne and Clark Gardner. All made significant contributions to the field of mosquito biology and control in their current and future careers. Our lab also had a very close relationship with Dr Rees lab and his PhD students, Bruce Knudsen and Dave Bown as well as Phil Lawyer, who was working on his MS and ultimately received his PhD there. Knudsen and Bown established productive careers with PAHO and WHO as did Phil Lawyer in the US Army.

This presentation will include a brief synopsis of the research and field trips going on at the time I was at the university and how it influenced my future career. I will also discuss Dr Nielsens work on snow pool mosquitoes, he was the worlds expert on this group and how my career flourished after graduating with my MS from Utah. I will also discuss Dr Nielsen annual long-term field collecting trips which I participated in for 2 years and my work with Drs Carpenter, retired US Army Canal Zone and Prof. John Belkin at UCLA and Glen Collett Director of the Salt Lake City MAD.

30 When World War II found Brigham City

Tyson Packer (tysonpacker@mail.weber.edu)

With the United States entering the second World War, a location for an inland military hospital was selected in Brigham City, Utah, along the Wasatch Front. The hospital was used for many purposes, but its main focus was on amputee recovery and neuropsychological treatment. Box Elder County, in which Brigham City is the county seat, had long struggled with mosquitoes in endless abundance. The possibility of a malaria outbreak spread by the long-established Anopheles mosquito of the area became a reality when service men and woman returned from the Pacific Theater carrying the dreaded disease. The unique landscape and wetland habitat of Box Elder county lends itself to ample mosquito production. Sixty percent of the Great Salt Lake is within the borders of the county, implying that many waterways flow into the basin and eventually find their way to the massive lake, but not before a large share of water is used for flood irrigation and the filling of waterfowl management areas. A staggering 550,000 acres of wetland habitat is the result, in large part, of these flooding practices. The threat of malaria and the overwhelming mosquito population that the county residents had long battled became a large enough concern that the Box Elder Mosquito Abatement was created in 1944 to combat these two issues. This paper explores the process and history of the creation of the district, its unique origin, and the impacts it has had in the region.

31 The History of West Nile in Utah

Gary Hatch (ghatch@davismosquito.org)

Utah has a long history of vector borne diseases. Prior to West Nile virus (WNV) entering Utah there have been sporadic outbreaks of primarily Western Equine Encephalitis (WEE). Utah has been conducting various forms of vector borne encephalitis surveillance for many years. In Utah as with many states in the United State WNV ushered in a new era of surveillance and mosquito control. In 2001 the surveillance program changed to start to include WNV surveillance. By 2003 full integration of WNV surveillance had occurred in all active mosquito control programs. Surveillance for WNV activity brought together many more agencies because of its impacts on human, mosquito, wild bird, horse, and sentinel chicken populations. In 2013 a significant WNV events occurred involving Eared Grebes and Bald Eagles.

32 Discovery of Cache Valley Virus in Utah

Greg White (greg@slcmad.org)

Cache Valley Virus (CVV) was first discovered by two scientists from the U.S. Centers for Disease Control in 1956. The virus was found in *Culiseta inornata* mosquitoes in Cache Valley Utah, near the city of Wellsville. The report of this discovery was made in 1959 in the journal Science. CVV belongs to the Bunyamwera serogroup of the *Orthobunyavirus* genus. Since the initial discovery of CVV it has been found in North, Central and South America. CVV infections have been most extensively studied in small ruminates in the USA and Canada, although there have been a few reported cases and deaths in humans. This presentation will go into the discovery of CVV and what impacts this virus has on people and animals and how it is transmitted by mosquitoes.

Adult Control I

33 Evaluation of lambda-cyhalothrin barrier sprays for mosquito control in southwestern Virginia

Benjamin McMillan (benm93@vt.edu), Nicola Gallagher, Sally Paulson

Mosquitoes function as important vectors of disease and as nuisance organisms across the globe. In the United States, mosquito control has become a major service provided by pest control companies, which increases the importance of limiting the amount of chemical product that is released into the environment. This study evaluated the residual effectiveness of a lambda-cyhalothrin barrier spray treatment when applied to suburban yards in Roanoke, Virginia. This evaluation took place from July 26th through October 3rd, 2018. Two BG-Sentinel traps baited with BG Lures were deployed weekly at each participating location for roughly 24 hours to determine the population of host-seeking mosquitoes present. Homeowner opinions of treatment efficacy were obtained using questionnaires at the beginning, middle, and end of the study. Properties treated with lambda-cyhalothrin experienced significantly lower mosquito catch numbers than the control properties, but both had similar population trends. This finding was supported by the survey responses from the participating homeowners, who were unaware of which treatment group they had been assigned. This result indicates that a lambda-cyhalothrin barrier spray treatment applied at the recommended label rate should reduce the pressure from the local population of adult mosquitoes. This study suggests that such a reduction would persist for 8 weeks, regardless of population trends of mosquitoes in the area, and despite the harsh conditions from the environment. As part of an integrated pest management approach, barrier sprays can be used to reduce exposure to the local mosquito population by deterring mosquitoes from resting on treated substrates nearby.

34 Genetic isolation and toxicological evaluation of the L1014F kdr mutation in field collected *Culex quinquefasciatus* from Louisiana

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Numerous publications have revealed a strong correlation between specific knock-down resistance (*kdr*) gene mutations and pyrethroid resistance intensity in *Aedes aegypti*, prompting a similar evaluation of the role of *kdr* in *Culex quinquefasciatus*, an important vector of Saint Louis encephalitis virus, West Nile virus and Eastern equine encephalitis virus. Previous studies have shown the non-synonymous L1014F mutation is present in moderately resistant field strains and increased in frequency when strains were pressured with permethrin, but direct quantification of the effect of this 1014 *kdr* mutations has not been conducted with respect to the overall intensity of resistance. Egg rafts were collected from St. Tammany Parish, LA, and pupal exuviae of individually emerged adults were screened by a novel tri-allelic melt curve analysis assay for the L1014F and 1014S *kdr* mutations. Homozygous L/L and F/F strains were created over several generations by mating males and virgin females of each genotype. Toxicologic, genetic and enzymatic assays were conducted to characterize the contributions of various resistance mechanisms on the overall phenotype in the L/L, F/F, and heterozygous L/F strains compared to the susceptible laboratory *Cx. quinquefasciatus* strain. Centers for Disease Control bottle bioassays and direct topical application showed higher pyrethroid resistance as the number of F alleles increased. Notably, the no *kdr* mutation L/L strain had an LD_{50} 15-fold higher than the no *kdr* lab strain indicating other, non-*kdr* factors were involved. We conducted standard biochemical assays to examine whether enzymatic mechanisms accounted for this difference. We also conducted a full-length sodium channel coding transcript evaluation to determine the possible presence of other mutations and polymorphic sites as these have been noted in previous studies. This study indicates that the basis of pyrethroid resistance in *Cx. quinquefasciatus* is considerably different than in *Ae. aegypti*.

35 A new study for IR3535 insect repellent against mosquito borne yellow fever vectors

Howard Epstein (howard.epstein@emdgroup.com), Silvana Nakayama

According to the Centers for Disease Control and Prevention (CDC) the yellow fever virus is found in tropical and subtropical regions of Africa and South America. The virus is spread by infected mosquito bite. While yellow fever is rare in the United States, during 1793 as a result of trade between the United States and Europe, yellow fever spread to Philadelphia killing 10% of the population. During 1878 yellow fever infected and killed a significant number of residents of Memphis Tennessee, destroying the city. Spread of disease was attributed to an unusually warm winter and spring in 1878 that enabled Aedes aegypti mosquitoes to flourish in the Mississippi Valley. Beyond the weather, inadequate urban drainage, combined with a non-immunized population led to the tragedy. Currently there is a preventative vaccine, but no cure for yellow fever. The CDC advises use of insect repellent to reduce the risk of contracting the disease. During 2016 a yellow fever outbreak was reported in various regions of Brazil including Rio de Janeiro and other countries in South America. Human infection was associated with the mosquito Haemagogus leucocelaenus. We conducted an arm-in-cage mosquito repellent study comparing IR3535 a nature-inspired EPA registered biopesticide to DEET and found that IR3535 provided 10 hours protection against Hg. leucocelaenus. Arm-in-cage repellency studies were also conducted for Ae. aegypti and other mosquito species. Ten hours repellency was achieved for Ae. aegypti as well. These studies are significant given the possibility that yellow fever could potentially return to North America because of global warming, increased travel from infected regions and virtually no immunization against yellow fever United States. The test protocol and results compared to DEET as a control will be presented.

36 Frequency of kdr alleles in Aedes aegypti populations from coastal and high jungle areas in Peru

Fanny Castro (fannycastrollanos@gmail.com), Carmen Flores-Mendoza, KARIN S. ESCOBEDO, Marisa Lozano, Victor O. Zorrilla, Liz Espada, Victor Lopez-Sifuentes, Michael Laurin Fisher, Gissella Vasquez, Alden Vasquez

The use of chemical insecticides for *Aedes aegypti* control has led to the development of resistance. Pyrethroid resistance has been associated with the co-occurrence of two knockdown resistance (*kdr*) mutations (V1016I and F1534C) of the voltage gated sodium channel (VGSC) gene. We characterized and quantified *kdr* mutations in Peruvian *Ae. aegypti*, vector of dengue, Zika and Chikungunya viruses, collected during 2017-2019 from coastal communities in Arequipa, Piura and Tumbes (10) and high jungle communities in Amazonas and San Martin (3). Mosquitoes were genotyped using standard melt curve analysis for 1016 and 1534 SNPs; ORL1952 and Puerto Rico strains were used as susceptible and resistant strains, respectively. Genotype frequencies were calculated. Amazonas, Piura and Tumbes populations were fixed or nearly fixed (≥ 95%) for 1534CC, unlike Arequipa and San Martin where 1534FF mosquitoes were found (50-100%). Moderate levels of 1016II were found in populations from Tumbes (31-74%) and Piura (20-39%); very low or no 1016II were found in Arequipa (17%), Amazonas (6%) and San Martin (0-8%). Seven genotypes were observed (IICC, IIFC, VICC, VIFC, VVCC, VVFC, VVFF) with resistant genotypes (IICC, VICC), indicative of higher resistance (20X-60X) recorded in Tumbes and Piura, and less resistant genotypes (VVCC, VVFC, VVFF) indicative of lower resistance (4X) in Arequipa, Amazonas and San Martin. Only the wildtype (VVFF) was found in one San Martin population. Results suggest that pyrethroid resistance genetic markers are widely present in Peruvian *Ae. aegypti*, yet resistance levels vary across regions with a higher frequency of *kdr* mutations in mosquitoes from Tumbes and Piura, high dengue transmission areas. This may explain why pyrethroid insecticides are not being effective against *Ae. aegypti* in coastal areas in northern Peru. Further

sampling and analysis is needed to confirm these results. This study provides insights into pyrethroid resistance mechanisms and may guide mosquito control operations.

37 Efficacy of a new mode of action compound Imergard™ Wettable Powder (WP) compared to Actellic® 300 Capsule Suspension (CS) indoor residual spray (IRS) in a community randomized entomological trial.

Carly Marshall (carly.marshall@hotmail.com), Olukayode Odufuwa, David Kaftan, Jason Moore, Adam Saddler, David Stewart, Amanda Ross, Sarah Moore

Indoor residual spray (IRS) is a powerful tool to control malaria, but the emergence and spread of pyrethroid resistance has led to increasing reliance on more expensive non-pyrethroid alternatives and threatens to derail the substantial gains in the fight against the mosquitoes that transmit malaria. If IRS is to remain an important element in an integrated vector control approach, alternative insecticides, particularly ones with a novel mode of action (MOA) and that are cost effective, are essential.

Imergard™ Wettable Powder (WP) is one such insecticide that exhibits a novel MOA that mechanically disrupts the cuticle leading to desiccation. This MOA is unique among the products on the market today and is likely to deter the development of resistance when it is used in combination or rotation with other products. Additionally, Imergard™ WP is non-toxic to humans, non-target organisms and the environment.

We conducted a community randomised entomological non-inferiority trial of Imergard™ WP in comparison to Actellic® 300 Capsule suspension (CS) (the gold standard IRS in Tanzania at the time) against wild populations of *Anopeheles* (*An.*) *arabiensis* and *An. funestus* sensu stricto (s.s.) in Southern Tanzania. The trial was powered to detect a 30 % difference between treatment arms in the primary outcome of sporozoite rate. Secondary outcomes were residual efficacy of the insecticide up to 13 months, entomological inoculation rate (EIR) and vector density.

The trial was conducted at an acceptable quality with no imbalance between treatment arms, although spray coverage in the trial was 65% after two rounds of spraying due to community distrust of IRS. Imergard™ WP applied at 8.28g ai/m^2 has equal residual efficacy as Actellic® 300CS applied at 1.28g ai/m^2. Residual efficacy ($\geq 80\%$ mortality at 72 hours) was 11 months in both arms. The overall sporozoite rate was 38% higher in the Imergard™ WP arm, although not significantly different (Actellic® 300CS SR 0.00290 vs Imergard™ WP SR 0.00471; Odds Ratio 2.01 (95% CI 0.79-5.20); p=0.146). The annual EIR (infectious bites per person per year) of *An. funestus* and *An. arabiensis* was 25.11 and 4.24 respectively in the Imergard™ WP treatment arm and 7.93 and 1.84 respectively in the Actellic® 300CS treatment arm.

The average number of *An. funestus* per household per night in each CDC light trap was 10.20 (95%CI: 9.8-10.6) in the Imergard™ WP treatment arm, and 4.80 (95%CI: 4.6-5.0) in the Actellic® 300CS treatment arm. The average number of *An. arabiensis* per household per night in each CDC light trap was 2.79 (95%CI: 2.6-3.0) in the Imergard™ WP treatment arm, and 2.36 (95% CI: 2.2-2.5) in the Actellic® 300CS treatment arm. The number of mosquitoes collected by CDC light trap was higher in the Imergard™ WP treatment arm.

This trial provides entomological evidence that Imergard™ WP is not non-inferior to Actellic® 300CS in the primary outcome of sporozoite rate, but has an equal residual efficacy measured at 11 months. The long residual effect of Imergard™ WP means it would be possible to provide all-year-round protection with just one spray round a year. In areas where pyrethroid resistant *An. funestus* are the primary vector species, Imergard™ WP could be a valuable addition to national IRS programs to use in combination with other IRS for resistance management.

38 Transfluthrin emanators in military tents protect against mosquitoes in a wooded temperate Florida habitat

Barbara Bayer (barbara.bayer@usda.gov), Seth Britch, Robert Aldridge, Frances Golden, Bianca Moreno, Rachel Shepherd, Benjamin McMillan, Jedidiah Kline, Jeffrey Stancil, Jeff Stancil, Kenneth Linthicum

Mosquitoes are a severe nuisance and can serve as vectors of important human pathogens, including malaria and a variety of deadly arboviruses. Particularly at risk are military personnel who are often exposed to mosquitoes with little protection and are immunologically naïve to diseases transmitted by mosquitoes. Transfluthrin is a synthetic-pyrethroid that is a powerful spatial repellent that can both kill and repel mosquitoes without contact. We wanted to see if we could provide passive protection from mosquitoes entering small 2-man military tents using transfluthrin impregnated emanators. In this field study conducted at the Florida Army National Guard Camp Blanding Joint Training Center in northern Florida transfluthrin emanators were placed inside half of the tents while the remainder of the tents lacked the emanators. Over a 15-month period we observed differences in mosquito numbers, species and mortality between tents with and without emanators as measured with CDC light traps baited with dry ice. Here we discuss how the transfluthrin emanators impacted mosquitoes collected in the tents.

39 Trapping for Control

CARTER SYNHORST (supervisor@grmcd.org)

GRMCD treats a very large wildlife area near the City of Fruita, CO. This wildlife area is managed by the Bureau of Reclamation, and they have banned every form of control except BTI granules. This works well in some areas, but since this area is full of flood irrigated hay fields, it is nearly impossible to treat it effectively. We have caught nearly 50,000 mosquitoes in one trap, in one night at this area. So, in an attempt to gain better control of this problem area, we decided to set seven additional EVS traps all summer to catch as many mosquitoes as possible. We were curious to find out if trapping could help us in our control efforts. We were very successful overall, and the number of mosquitoes captured in our regular trap was greatly reduced compared to previous years.

41 Current status of organophosphate resistance in Aedes taeniorhynchus and Culex nigripalpus mosquitoes in Lee County, Florida.

Kara Tyler-Julian (tyler-julian@lcmcd.org), David Hoel, AARON LLOYD

In Lee County, Florida, two vector species of primary concern and targeted by the Lee County Mosquito Control District include *Aedes taeniorhynchus* and *Culex nigripalpus*. Adulticides are an integral component of an integrated mosquito management system used to manage these species, and resistance to adulticide products is a constant threat to these efforts. In 1965, malathion resistance was first confirmed in *Ae. taeniorhynchus* in coastal areas of Lee county after 8 years of use. In recent years, adulticiding operations in these coastal areas have consisted mainly of a rotation between naled and permethrin-based adulticides, with malathion treatments reserved mostly for inland areas. In an effort to guide adulticiding decisions, CDC bottle bioassays are routinely conducted on different mosquito species throughout the county. Recent CDC bottle bioassay results indicate evidence of resistance to the organophosphates malathion and naled, despite reduced use of malathion in recent years. In the summer of 2020, 92% of bottle bioassays conducted with malathion on *Cx. nigripalpus* resulted in a

resistant outcome with resistance reaching 89% in some populations. In many cases more than 2 h was required to reach 100% mortality (CDC bottle bioassays have a diagnostic dose time of 45 min). Bioassays with naled also showed evidence of resistance, with 100% of *Cx. nigripalpus* populations tested showing evidence of resistance, many taking more than 2 h to reach full mortality. More than 90% of *Ae. taeniorhynchus* populations tested showed evidence of resistance to malathion and 80% displayed evidence of resistance to naled. The geographic distribution and strength of resistance to these two active ingredients will be discussed.

Action Based Thresholds Symposium

44 To spray or not to spray, that is the question

Michael Turell (mturell@erols.com)

Diseases caused by arboviruses such as chikungunya, dengue, eastern equine encephalitis, West Nile, and Zika viruses are now occurring in the Americas. In addition, there are about 1,500 imported cases of malaria reported each year in the U.S. These diseases can be severe, and possibly fatal. Recognition of the disease in humans as a requirement for mosquito control before initiating control is too late. We need to initiate control before actual disease is recognized, but what indicators should we consider? This presentation will discuss various surveillance techniques including which mosquito species are present in the area, mosquito population size, serosurveillance (e.g., sentinel chicken flocks), environmental factors (e.g., rainfall and temperature), detection of virus from field-collected mosquitoes, and presence of disease in domestic or wild animals combined with what is known about potential vectors to determine where and when preventive mosquito control is needed.

45 Minimum thresholds used to determine mosquito adulticide applications in the state of Florida

Marah Clark (marah.clark@fdacs.gov)

Prior to 1987, thresholds for pesticide applications for the purpose of controlling adult mosquitoes in Florida were determined in Chapter 10D-54 of the Florida Administrative Code (F.A.C). The rule defined specific criteria for determining need for adult mosquito control applications and was oversight was originally provided by the Florida Department of Health. In 1987, it was moved to the Florida Department of Agriculture and Consumer Services and became a part of Chapter 5E-13 F.A.C "Mosquito Control Administration" and has been modified very little since its inception. Any pesticide applications targeting adult mosquitoes conducted by mosquito control programs (MCPs) must have documentation of increased mosquito activity. The primary baseline criteria used by Florida's MCPs utilizes data collected from light trap surveillance, however standard surveillance methods such as landing rate counts are also acceptable. More stringent thresholds than those outlined specifically in 5E-13.036 can be created by individual MCPs. Currently, the F.A.C. only defines applications made in response to an increase of adult mosquitoes and does not address preventative adulticide mechanisms such as barrier treatments and does not have separate thresholds for in response to disease vector mosquitoes compared to pestiferous mosquitoes.

46 Does the squeaky wheel deserve the attention?

Steve Mulligan (smulligan@mosquitobuzz.net), Jodi Holeman

Mosquito abatement and vector control districts often are faced with simultaneous events, challenges or threats that require action. Such challenges may appear mutually exclusive with divergent approaches. Decisions to address them may require temporary responses or longer-term solutions. Responses to co-occurrent events may need to be addressed in either a concerted or divided manner, and responses are also contingent on available resources. This presentation will review processes involved in deciding control responses to resident requests for service for nuisance mosquitoes (*Aedes aegypti*) versus response to threat of mosquito-borne disease (West Nile virus and St. Louis encephalitis).

47 Comprehensive mosquito surveillance through visualizing multiple types of data in the San Gabriel Valley, California

Melissa Doyle (mdoyle@sgvmosquito.org), Jared Dever, Jason Farned, Levy Sun

An integrated vector management approach in an urban environment is a complex task due to the variety of mosquito habitats created to accommodate large human populations. These structures include over 3,000 unmaintained swimming pools, 800 miles of underground storm water conveyance structures, 8,300 manhole covers and 23,312 catch basins. In the San Gabriel Valley, traditionally, mosquito surveillance relied solely upon adult mosquito trap catch data as a means to surveil mosquito populations. However, in an urban environment it is also necessary to understand the fluctuations of mosquito populations in reaction to man-made structures and environmental events. Integrating multiple sources of data and creating clear lines of communication across the departments has allowed for greater precision in targeting areas for treatment, especially in response operations to evidence of arboviral activity.

48 Aerial adulticiding planning and evaluation at Manatee County MCD

Mark Latham (manateemcd@aol.com), Christopher Lesser

Manatee County MCD operates a fully integrated program that utilizes comprehensive surveillance data to ensure appropriate, targeted and effective mosquito control applications. Large scale larviciding is generally limited to areas with high larval densities in concentrated and defined habitats, usually in the proximity of human population centers (urban and suburban areas), and primarily against *Aedes taeniorhynchus* and *Psorophora columbiae*, secondarily against *Culex nigripalpus*.

For wide-area adulticiding, the primary surveillance tools are 58 CO_2-baited CDC light traps and, for *Aedes taeniorhynchus*, routine daily landing-rate counts. There is no single “threshold number” in the traps that triggers an adulticide application, since different mosquito species are attracted/captured with widely varying efficiencies. Different mosquito species also vary widely in the degree to which they cause nuisance, or create the potential for vector-borne disease transmission. And finally, even within the same species, trap catches are highly influenced by their placement (proximity to habitats, light sources), moon phase and local meteorological conditions. When considering wide-area adulticiding, MCMCD staff weigh a number of factors including public service requests, trap collections in comparison to the historical average for that specific trap site, species makeup of the trap, arbovirus activity in sentinel chicken flocks, and potential human/mosquito interactions (proximity to public sports facilities and outdoor public events). Evaluation of efficacy is conducted by comparing pre-spray and post-spray collections on a per-trap basis for traps in the spray zones, then correcting for natural variation using one or more unsprayed traps as controls and applying Mulla’s Formula. Care must be taken in the timing

and evaluation of wide-area sprays, since rainfall patterns may cause asynchronous mosquito hatch within a species, and widely different development times across different species.

49 What evidance thrsholds are Anastasia Mosquito Control Distict used for operation control of mosquitoes?

Rui-De Xue (xueamcd@gmail.com)

Anastasia Mosquito Control District (AMCD), St. Augustine, FL makes the action decision for operation control based on the following evidences and thresholds: presences of any suspected human and animal cases for any mosquito-borne diseases, positive sentinel chickens and mosquito pools for any arbovirus, such as WNV, SLE, EEE, Dengue, Zika, and Chik-V. Collected more than 25 adult female mosquitoes of vector species per CDC trap/night and more than 2 adult mosquitoes/BG sentinel trap per day, positive adult mosquitoes landing on human volunteer per minute, and special cases such as hurricane, flooding, mass rally events, wedding, and special requests during mosquito pick seasons. All control decision and action by ground and aerial applications are based on case-by-case and weather condition.

Social Media and Mosquito Control Symposim

50 Social Media and Mosquito Control - Social Media 202: the Basics of Content Creation on Facebook, Twitter, and Instagram

Michael Mut (mmut@miamidade.gov)

This presentation will cover the basics of content creation for three platforms: Facebook, Twitter, and Instagram, including a step by step how-to tutorial for each. I will discuss best practices for each site, including hashtags, using images, calls to action, and hyperlinks. We will also dive into the concept of content scheduling, how to best utilize it, and will run through the basics of using Hootsuite's free software version. In addition, 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 further discuss the benefits of using each platform to communicate with residents. 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 novice and users with intermediary knowledge of social media use will walk away with the knowledge they will need to launch and manage their own channels for their respective organizations.

51 Mosquito control is fun!

Jillian Meek (jmeek@pascomosquito.org)

Mosquito Control is fun! Wait, what? Yes, I said it, mosquito control is FUN! For those of us working in this field we may enjoy our jobs and can find the fun in it, but this is not the case for the citizens in our areas. For them they think of pesky mosquitoes biting them, or the buzzing ULV trucks coming through the neighborhood. It is important not only get the buy-in from your citizens, but also make it fun for everyone at the same time. This presentation will give examples of sharing information in a way that allows citizens to understand and get engaged with their district through social media, all while encouraging them to take part in the action themselves. The presentation will also share ways to tie mosquito control to popular events, pop culture, and more; so, come join in on the fun!

52 Negative or inflammatory comments on social media: best practices to address them

Miranda Schield (mschield@clarke.com)

Social media channels like Facebook and Twitter are an impactful way for mosquito abatement entities to amplify their resident communications efforts. Even though approximately two-thirds of American adults use social media for news and information (Pew Research Institute), some agencies continue to be uncertain about how to have a dialogue with their constituents on these channels, particularly when faced with negative comments or inflammatory questions about mosquito control products and application methods. Based on real-world situations, this session will explore best practices for building trust and diffusing intense resident interactions online.

53 Video content: Information that will leave a mark

Phillip Stokes (p.stokes@ufl.edu), Ricky Telg, Ashley McLeod-Morin

Communicating the science of mosquitoes and mosquito control to the general public can be challenging as the public does not engage in these topics with any regularity. Social media provides a platform for individuals to be exposed to this information without actively searching for it, and furthermore the use of video can help engage viewers in the content being presented. The University of Florida Institute of Food and Agricultural Sciences Center for Public Issues Education in Agriculture and Natural Resources (UF/IFAS PIE Center) developed easy-to-use resources for public officials to inform the public about the importance of mosquito control in Florida. Four videos were created with a video production company on the following topics: mosquito biology, mosquito-borne illnesses, personal responsibility, and application methods. The video topics were selected based on public opinion research conducted by the UF/IFAS PIE Center. This presentation will provide insight into the type of content the general public is most interested in and concerned about as it relates to mosquitoes and mosquito control. Recommendations will be given based on the public opinion research conducted, as well as lessons learned from the production process of the four videos through a case study approach.

54 The Instagram Magic Touch

Pablo Cabrera (pcabrera@sgvmosquito.org)

Instagram continues to be one of the largest and most visited social media platforms. According to Instagram, as of July 2020, the platform reported 1 billion users worldwide, making it the second-ranked traditional social network in terms of active users. When looking at all social platforms, Instagram ranks fifth – behind Facebook, YouTube, Whatsapp, FB Messenger, and WeChat. It is becoming even more important for public health agencies to be present on Instagram because of the opportunity to reach new audiences and motivate people to take small, but concrete actions. It is also proven that social media platforms like Instagram allow for targeted, inexpensive, small-scale projects, as well as large, well-funded, mass-reach marketing campaigns (Freeman, 2015). This is extremely valuable, as vector control programs traditionally have very small marketing budgets and must rely on inexpensive campaigns. It's important to keep in mind that on Instagram it's not a matter of just posting, strategy and creativity is an important factor to maintain for the best messaging.

The San Gabriel Valley Mosquito and Vector Control District has only been present on Instagram since January 2019, but has already received a verified account, produced small scale campaigns like "Tip, Toss, Protect" in multimedia content. A viral campaign "#tipNtoss Challenge" that had 18 participants nationwide, and an Instagram Live series featuring vector control partners that consisted of 4 live

videos, 471 views, and 93 post engagements. COVID-19 has dramatically changed the way we do outreach, it has only emphasized the importance of social media strategies and maintaining communication with the public on public health issues. With a consistent level of communication and creative strategy, the public becomes more engaged, educated, and trustworthy of where the information is coming from. This led to a lasting effect and help prevent misinformation.

Adult Control II

55 Pyrethroid resistance in Culex tarsalis in several Northern Californian counties

Tara Thiemann (tthiemann@pacific.edu), Bonnie Ryan, Sumiko De La Vega

Culex tarsalis is one of the most abundant vectors of encephalitis viruses in California. Pyrethroid insecticides play a significant role in the reduction of mosquito populations and thus the transmission of vector-borne pathogens, but the effectiveness of vector control is threatened by increasing insecticide resistance. The goal of the current study was to determine the prevalence of pyrethroid resistance and characterize resistance mechanisms in several *Cx. tarsalis* populations. Bottle bioassays were conducted for 17 populations across Lake, Placer, San Joaquin, Sacramento, and Yolo Counties in summer 2018. Mortality ranged from 8.6 to 96.2% after 2 hours of exposure to permethrin. In all but one population, mortality rose to over 90% when mosquitoes were exposed simultaneously to both permethrin and piperonyl butoxide (PBO), suggesting that oxidases play a role in resistance. Results from enzymes assays also support this idea, as oxidase levels were higher in some field populations than in the susceptible *Cx. tarsalis* colony. The genetic mutation, *knockdown resistance (kdr)*, was also prevalent in all wild populations tested. In fact, the susceptible "leucine" allele was the least common allele detected in this study. Data analysis is ongoing, but it appears that both a target-site genetic mutation and increased enzyme levels are contributing to *Cx. tarsalis* pyrethroid resistance.

56 High, Medium, Low: Using a Standardized County-Wide Grid Surveillance System to Prioritize Operational Areas for West Nile Virus Control in Orange County, CA

Laura Krueger (lkrueger@ocvector.org), Tim Morgan, Kiet Nguyen, Amber Semrow, Sokanary Sun, Robert Cummings

Following the West Nile Virus (WNV) epidemic of 2014 that resulted in 278 human cases with exposure in Orange County, California, the Orange County Mosquito and Vector Control District (the District) spent the next five seasons optimizing and enhancing the District's WNV Response Plan and adult mosquito control activities. In 2019, the District developed action thresholds based on 15 years of WNV infection data in mosquitoes (Vector Index, VI) and GIS analysis, and a standardized county-wide grid surveillance system (7.24 km^2) to detect increasing WNV infection rates in mosquitoes and dead birds. The use of a surveillance grid allows the District to prioritize operational areas for WNV control in Orange County, CA. This presentation summarizes the development of the county-wide standardized surveillance grid, IVM action thresholds, and operational deployment and efficacy of the response in 2019. Analysis of 4 treatment blocks (pre and post spray WNV infection rates as compared to control areas without treatment using the Henderson-Tilton equation) shows a significant reduction in the West Nile Virus infection rates, as measured by the VI, in *Culex quinquefasciatus* (Say) the week after pesticide treatment within spray blocks.

57 In vivo laboratory and operational quantification of kdr mutations in Aedes aegypti

Alden Estep (Alden.Estep@usda.gov), Neil Sanscrainte, Waits Christy, Keira Lucas, Wilfong Erin

Aedes aegypti is a primary arboviral vector and has significant resistance to pyrethroids in the Americas. In 2009 it was proposed that assessment of knockdown resistance (*kdr*) genotypes could be a useful surrogate for estimating resistance rather than laborious insecticide bioassays, but this has never been rigorously evaluated *in vivo*. This study was conducted to validate the use of *kdr* genotypes for pyrethroid resistance estimation and relate this to real-world operational field performance. We used a novel testing method based on previous melt curve assays to isolate *kdr* mutations from a moderately resistant Florida, USA field strain. Mass cross mating between virgin males and females genotyped for the V1016I and F1534C mutations allowed us to create strains of the six extant *kdr* combinations found in the wild Florida population. Resistance profiles and underlying mechanisms for these lines, along with the susceptible and resistant control strains, were characterized by a variety of methods including direct topical application to allow determination of resistance ratios (RR). These laboratory tests determined that the lines varied greatly in RR to model type I and Type II pyrethroids based primarily on the number of IC alleles present. We also show that a recently described V410L mutation is present in US strains but found it did not increase RR *in vivo* above that of the IC alleles alone. Activity assays for cytochrome P450s, esterases and GSTs indicates that enzymatic activity does not account for a significant portion of the resistance phenotype thereby confirming that assessment of *kdr* is useful for estimating resistance levels in *Ae. aegypti*. Evaluation of these same strains in standard operational interventions showed complete failure of the permethrin-treated US military fabric to provide bite protection and failure of field sprays in cage trials to produce acceptable mortality in lines with high levels of *kdr*.

58 Select plant alkaloids synergize the toxicity and neural block of natural pyrethrins in Aedes aegypti

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With ever growing numbers of mosquito populations becoming resistant to a wide variety of insecticides, new insecticidal technologies are needed. However, the lack of new insecticidal chemical classes to control mosquito populations presents a significant hurdle in the continual control of mosquito populations. As such, the development of novel synergists may be a viable alternative approach. We explored the potential of two plant-derived, sodium channel-directed alkaloids, veratrine and aconitine, as both insecticides and synergists of natural pyrethrins (NP) on *Aedes aegypti* adults and larvae. Aconitine was more toxic than veratrine, with an LD_{50} of 165 ng/mg compared to 300 ng/mg on the pyrethroid-susceptible Orlando strain, but significant resistance was observed for aconitine on the pyrethroid-resistant Puerto Rico strain (RR = 14.5). When applied in mixtures with piperonyl butoxide (PBO) and natural pyrethrins, large synergism values were obtained. Aconitine + PBO synergized natural pyrethrins 21.8-fold, whereas veratrine + PBO synergized natural pyrethrins 5.3-fold on the Orlando strain. Less synergism of natural pyrethrins was observed on the resistant Puerto Rico strain, with acontine + PBO synergizing natural pyrethrins only 4.1-fold and veratrine + PBO synergizing natural pyrethrins 9.5-fold. When alkaloids were applied alone on the mosquito larval central nervous system (CNS), aconitine was less active on the pyrethroid-resistant strain (block at 10 μM) than on the pyrethroid-susceptible strain (block at 100 μM). However, the opposite was true for veratrine, as the pyrethroid-resistant CNS was at least three times more sensitive to this compound. The nerve blocking effect of NP was significantly synergized by both compounds on the pyrethroid-susceptible strain (approximately 10-fold synergism), however only veratrine synergized NP block on the pyrethroid-susceptible strain (10-fold synergism).

These results demonstrate that pyrethroid-resistance in the Puerto Rico strain also produces resistance to aconitine, presumably by altering aconitine binding at the sodium channel. These results highlight the potential of site II sodium channel activators to synergize natural pyrethroids and may represent future additives to insecticide formulations. Moreover, differences in the ability of each compound to synergize NP on the pyrethroid-susceptible and pyrethroid-resistant strains may highlight physicochemical properties that are necessary for synergizing natural pyrethrins at pyrethroid-insensitive sodium channels.

59 Field evidence of displacement of Aedes albopictus by Ae. aegypti in downtown Gainesville, Florida

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Prior to the introduction of Ae. albopictus to Jacksonville, Florida in 1986, Ae. aegypti was the primary container mosquito species in the State, including the city of Gainesville. Interestingly, the invasion of Ae. albopictus into Florida coincided with dramatic population declines of Ae. aegypti, resulting in Ae. albopictus becoming the dominant container mosquito species in much of the State. Similar to other regions of Florida, the Ae. aegypti population in Gainesville declined rapidly after the introduction of Ae. albopictus in 1989; no Ae. aegypti were detected after the year 1993. Ae. aegypti re-emerged in Gainesville after 26-year absence, when six larvae were collected from the downtown area (Pleasant Street neighborhood) in late 2019. Subsequent surveys confirmed that Ae. albopictus was completely displaced by Ae. aegypti in the Pleasant Street community; whereas, Ae. albopictus and Ae. aegypti co-existed directly of outside this community. Field evidence clearly showed that Ae. aegypti is re-surging in the downtown area of Gainesville, potentially spreading and replacing Ae. albopictus in the future.

60 Evaluation of radiation doses on a Texas strain of Aedes aegypti for use in a SIT program

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There are many approaches to controlling *Aedes aegypti* mosquitoes. Public outreach, asking the public to diligently remove standing water around their home, and the use of pesticides, both adulticide and larvicide, are the most common approaches. Since each of these methods have its limitations the development of new options enhances the chances of success. Sterilize Insect Technique (SIT), the release of sterilize male mosquitoes, is an approach that is being used by mosquito control personnel to assist in the control of *Ae aegypti* mosquitoes, in targeted locations. In this preliminary study, we colonized a strain of *Ae aegypti* from Harlingen, Texas and evaluated the impact of seven (7) doses of gamma radiation on both male and female pupae. Here we report the impact of radiation doses on adult eclosion, blood feeding, survivorship over a two-week period and the number of eggs laid by females and percent egg hatch.

61 Toxicity of Different Groups of Insecticides and Determination of Resistance in Aedes albopictus from Different Habitats

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Huge amount of insecticides are used for the control of agricultural pests and house hold pests like mosquitoes with over and under doses in Punjab, Pakistan. Moreover, after dengue epidemics during 2010, insecticides in huge amount with high doses were sprayed in major cities of the Punjab to control mosquito. This also resulted in insecticidal resistance in mosquitoes. So, the present study was

undertaken. Mosquitocidal assays were evaluated against larvae and adults after 24 h. Larvicidal LC_{50} of temephos ranged 0.0075 to 0.422 µg gm^{-1}. In case of adulticides, three groups of insecticides used on papers to twelve different populations collected from populated, agricultural and industrial areas of Lahore (LHR), Rawalpindi (RWP), Sialkot (SKT) and Faisalabad (FSD). Among insecticide group, synthetic pyrethroids were recorded as highly potent and extremely toxic at lowest concentration followed by Organophosphates (OP's) and carbamates. However, Synthetic pyrethroid group included Deltamethrin, recorded as highly potent (0.483 – 9.245 µg gm^{-1}) followed by cypermethrin (1.831 – 32.189 µg gm^{-1}) and permethrin (5.05 – 100.453 µg gm^{-1}). OP's group comprised of Pirimphosmethyl found highly toxic (12.123 – 311.712 µg gm^{-1}) followed by Malathion (20.961 – 612.525 µg gm^{-1}) and Fenitrothion (36.12 – 601.413 µg gm^{-1}). Carbamate group included Bendiocarb (70.08 – 6154.79 µg gm^{-1}). The Chi square value showed no heterogeneity in all experiments. The results also indicated that LHR population was highly resistant followed by RWP, SKT and FSD population, moreover, mosquito populations from agricultural areas were more resistant than populated and industrial areas. Biochemical analysis showed the elevated activity of enzymes (esterases, mixed function oxidases, gluthione S transferase and acetyl-cholinesterase) in resistant populations. It was concluded that injudicious application of chemicals in an area, initiated risks of resistance, reappearance and resurgence of certain mosquitoes. Further, research must be needed to identify health, environmental risks and devise an effective program by using selective and specific insecticides.

62 Oxidase, Esterase, and KDR-Associated Pyrethroid Resistance in Culex quinquefasciatus Field Collections of Collier County, Florida

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In several insect species, resistance to pyrethroids and DDT (dichlorodiphenyltrichloroethane) is linked to point mutations in the voltage-gated sodium channel (VGSC) gene. Pyrethroid-based insecticides prolong the opening of sodium channels, causing paralysis known as a "knockdown" effect before mortality occurs. Point mutations in the VGSC gene result in decreased pyrethroid binding and reduced sensitivity to the insecticide—this resistance mechanism is known as knockdown resistance (kdr) as insects do not die but recover from paralysis with time. In Culex mosquito species loss of target site sensitivity to pyrethroids is linked to a number of substitutions, one of which is leucine (L) to phenylalanine (F) at residue 1014 (L1014F) in the VGSC gene. Here we report the identification of kdr-associated pyrethroid resistance and developing resistance in Cx. quinquefasciatus field collections from Collier County, FL. Evaluation of position 1014 of the VGSC in Cx. quinquefasciatus collections from 7 locations in Collier County, FL, revealed a wide range of genotypes from one part of the district to the other. Centers for Disease Control and Prevention bottle bioassay, linear regression analysis, and cage trial evaluations suggest that the L1014F mutation plays a role, at least in part, to the pyrethroid resistance status of Cx. quinquefasciatus collected in Collier County, FL. Furthermore, we identified resistance attributed to both oxidase and esterase activity, indicating that multiple mechanisms are responsible for pyrethroid resistance in Collier County Cx. quinquefasciatus.

63 Target site kdr mutations in the voltage-gated sodium channel gene in pyrethroid-resistant Aedes aegypti from Jazan, Saudi Arabia

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In Saudi Arabia, many outbreaks and cases of dengue fever have been reported since 1994. Pyrethroid insecticides have been used intensively in the country since 1999. This constant use has

likely provided intense selection pressure for the development of target site mutations in the voltage-gated sodium channel (VGSC) gene in *Aedes aegypti* that result in knockdown-resistance (*kdr*) against pyrethroids. *Aedes aegypti* in Jazan was assayed for the presence of known *kdr* mutations in domains IIS6 and IIIS6 of the VGSC gene using PCR amplification and sequencing.

Haplotype and nucleotide diversity of VGSC regions was lower in Saudi Arabia than Africa, the Americas and Southeast Asia, consistent with a relatively recent spread of *Ae. aegypti* into the country. The presence of three *kdr* mutations S989P, V1016G (IIS6) and F1534C (IIIS6) were detected for the first time in the Jazan region but have been reported elsewhere in Saudi Arabia (Jeddah and Makkah) previously. The S989P mutation was in perfect linkage with V1016G. Haplotype inference indicated that S989P+V1016G was on a different haplotypic background from F1534C. Mutations S989P+V1016G were present at a frequency of 0.30 and F1534C at 0.71. Of the six genotypes present, the majority (45%) were homozygous for F1534C. From the presence of SS+VV /FC genotypes in Jazan, we inferred the presence of haplotypes containing no *kdr* mutations, i.e. S+V /F. The presence of such haplotypes indicates that appropriate insecticide resistance management strategies have the potential to restore insecticide susceptibility to this population to prolong the effective use of pyrethroid insecticides.

Poster Session

64 A model-based tool to evaluate spatially explicit mosquito-borne risk in the US Southern High Plains

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The complex ecology of mosquitoes makes predicting and controlling their populations at landscape scales challenging. Their juvenile and adult phases mosquitoes utilize distinctly disparate habitats, are susceptible to different pressures, and are controlled in different ways. Mosquito populations also respond dynamically to changes in weather and habitat availability. Spatially explicit, mechanistic population models are a tool that can help mosquito control authorities by providing predictions of the responses of mosquito populations to changes in habitat, weather, and treatment conditions. By combining mosquito population predictions with information on the distribution of human population in space, measures of spatially varying risk can be made that explicitly consider different conditional scenarios. Using the individual-based modelling platform NetLogo, we developed such a model for *Culex tarsalis,* the Western Encephalitis mosquito. This simulation-based model accounts for the ecology of both aquatic and adult life phases, and allows for the evaluation of how habitat, temperature and treatment conditions affect populations and specified measures of risk. Using Lubbock County, TX, as a representative model landscape, we demonstrate that this flexible type of model is a potentially useful planning and risk-management tool for mosquito control.

65 Adapting a new education strategy in the age of COVID-19: MQA

Francis Fernando (ffernando@glacvcd.org), Greg Mercado, Mary-Joy Coburn

In this unprecedented time, the emergence of COVID-19 has forced educators to abruptly change how they plan and implement their respective curricula. For years, the education program at the Greater Los Angeles County Vector Control District (GLACVCD) has been predicated on an immersive interactive experience using the district's mobile education unit, the Mosquito SWAT Lab. This presentation will discuss one approach to accommodate distance learning using a multimedia

experience in a new video series called Mosquito Questions Answered (MQA). By deriving key components of Mosquito SWAT Lab's curriculum and mosquito questions submitted by students and members of the public, MQA seeks to provide concise information produced in a fun and easy to understand way. Each MQA episode is designed to include language, comedy, and popular media trends that can appropriately resonate to elementary and middle school populations. MQA has increased social media activity and interaction, diversified the content used in current virtual programs, and provides a sustainable approach not only restricted to distance learning but to provide extracurricular content that can be used outside of the academic school year.

66 Aedes aegypti in 2020: Potential source preference

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Aedes aegypti (L.) ecology and container preference varies widely based on local environment, human behavior, and container availability. Understanding the regional differences within individual districts can help with choosing the most cost-effective control options and refining outreach efforts. This poster discusses the primary *Ae. aegypti* larval habitats and their contribution to the overall mosquito abundance within the District boundaries using data collected during property inspections. In 2020, Delta Vector Control District identified potential larval breeding sources and recorded the presence, or absence, of mosquito larvae during property inspections. Larval samples were taken from various source types and identified to species. Results showed that potted plant trays contributed the most to overall *Ae. aegypti* production at 23.5%, while yard drains and fountains contributed 12.8% and 11.7% respectively. Although often cited as a common source, tires contributed only 0.3% to the overall *Ae. aegypti* larval production within the District. Focusing public education and outreach efforts on controlling the most productive household containers is likely to be more cost-effective than broad messages, especially if they incorporate a concrete call-to-action for residents. More effective homeowner engagement and control of key container sources can greatly reduce the costs of control efforts by Districts.

67 Blood meal analysis and virus detection in mosquitoes collected from U.S. Air Force installations, 2018 - 2019

Leah Colton (leah.colton@us.af.mil), Aubri Pritchett, Faye Geary

Over 400 blood fed mosquitoes captured in surveillance traps from 49 Air Force installations around the world were analyzed for blood meal host identity and presence of arbovirus. Mosquitoes, which were initially stored at room temperature (RT), sometimes for weeks and months, were scored for quantity of blood ingested, from trace to fully engorged, and abdomens were processed separately from the rest of the mosquito. Primers targeting vertebrate mitochondrial cytochrome c oxidase subunit 1 were used to PCR amplify blood meal DNA, followed by amplicon sequencing to determine host identity. RNA was extracted from mosquito thoraces and heads and subjected to arbovirus testing. Results indicate whether the lab's routine samples (RT stored mosquitoes; no preservative methods) can be used for host meal identity and arbovirus infection status analyses, and whether meaningful information can be generated for local area risk assessments. Results will be stratified for analysis by blood meal quantity and duration of RT sample storage, which will help us understand the limitations of Air Force mosquito surveillance samples in providing actionable information about local epidemiologic and ecological conditions.

68 Cemetery vector control: key in the implementation of larviciding in cemeteries breathing sites.

Jose C Sanchez (jsanchez@prvectorcontrol.org), Grayson Brown, Marianyoly Ortiz-Ortiz, Nicole Nazario, Luz Crespo

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 increase Puerto Rico's ability to control *Aedes aegypti*, 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 by implementing vector surveillance, creating innovative information systems, carrying out vector control operations, and boosting community engagement through citizen mobilization and education programs. The PRVCU has a Field Team division within its organizational structure that is developing strategies to reduce the number of mosquito breeding sites. With the implementation of surveillance in different areas of Puerto Rico we can gather the mosquito populated areas around the island. During this surveillance we encounter a large number of *Aedes aegypti* in thosr traps placed inside cemeteries. Given these breeding sites, we started applying larvicides within the cemeteries on a weekly basis using Vectobac WDG applied with backpack sprayers. We lowered the mosquito populations inside the cemeteries that are near urban areas and can affect nearby communities. Our results will serve as guidance for stakeholders and municipalities of Puerto Rico, reinforcing the need of implementing integrated strategies for the control of *Aedes aegypti* especially in cemeteries.

69 Characterization and efficacy of VectoBac® WDG against Aedes aegypti utilizing Unmanned Aerial Systems

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Application of Bacillus thuringiensis israelensis (Bti)-based liquid larvicide for the control of container inhabiting mosquito species, such as Aedes aegypti, is typically performed through the use of ground sprayers, truck-mounted mist systems or fixed and rotary-wing aerial applications. Recently, Unmanned Aerial Systems (UAS) have provided a new avenue for control material applications. Here we report the characterization and efficacy of WALS™ applications of Vectobac® WDG (Bti strain AM65-52; Valent Biosciences) using UAS technology. Collier Mosquito Control District's (CMCD) PrecisionVision 13 UAS (Leading Edge) was outfitted with the PrecisionVision Liquid Application System (Leading Edge) using four flat-fan TeeJet nozzles capable of producing fine/extra fine droplets for WALS™ applications of Vectobac® WDG at a rate of 0.5 pounds per acre. While average droplet size was slightly larger than desired for WALS™ applications, we have achieved nearly 100% efficacy within a 30-40 foot swath. Furthermore, field testing has signified proper delivery of the control material to containers and other cryptic habitats at the desired application rate within the treatment block, resulting in the reduction of container inhabiting mosquito larvae.

70 Comparative analysis of Black widow Toxins to Evaluate biomosquitocide Potential

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Pesticides employed mosquitoes control have faced scrutiny regarding their safety and potentially limited life-span due to populations evolving resistance. From this perspective, new approaches are useful. One of the newer possibilities being explored is the use of toxins from spider venom. In particular, venoms of the widow spiders are of interest due to their taxa-specific toxin classes.

In this study, we used homology-based cloning methods to resolve and analyze the insect-specific toxin sequences, α-latroinsectotoxin (LMα-LIT) and δ-latroinsectotoxin (LMδ-LIT) from the southern black widow, *Latrodectus mactans*. We also analyzed expression of these toxins across tissues and life stages. Latrotoxin sequences were compared to homologs from 15 other widow species, as well as to α-latrotoxin (α-LTX), latrocrustotoxin, and theritoxin. Amino acid and domain composition between taxa-specific classes indicate many fewer ankyrin repeats in insect-specific toxins and a much narrowed spread throughout the protein while the crustotoxin and latrotoxins were very similar in domain architecture. Interestingly, sequence comparisons, overlaid with previously published phylogenetic analysis of widow species, show that conservation over time is restricted to narrow regions of the protein. Sequence analysis in combination with spatiotemporal gene expression analysis suggests that the insectotoxins and the latrotoxin are not toxic to the spider. This, in combination with the expression of putative crustacean-specific toxins, suggests that the insectotoxins follow strict insect-specific activity that excludes all other arthropods. Sequence resolution is the first step toward recombinant expression for functional assays that is in progress. Moreover, determination of amino acid sequences that display stringency in the taxa against which they are active contribute toward the goal of discovering or engineering an ideal mosquitocide.

71 Comparative field evaluation of different trap types, attractants, and light colors for collecting Phlebotomine sand flies (Diptera: Psychodidae) in Thailand

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Phlebotomine sand flies are the medically important blood-feeding insects that transmit protozoan parasites *Leishmania* (Kinetoplastida: Trypanosomatidae) causing leishmaniasis. Leishmaniasis is ranked to the ninth place of all human infectious diseases and considered as a public health importance in the tropics, subtropics and southern Europe. Objectives of this study were to evaluate the efficacy of different trap types [CDC-LT (single ring and double ring collection bags), BGS trap and EVS trap], different light colors [green LED (520-560 nm), red LED (635-700 nm), UV LED (300-400 nm), and incandescent light (standard)] and different attractants (BG-Lure and CO2) for collecting sand flies under field conditions. Experiments were conducted in rubber tree plantation in eastern Thailand, Chanthaburi province, rotated according to a Latin square design. A total of 2,795 sand flies including 1,551 females and 1,244 males were collected from a total of 192 trap nights in April 2019. Results showed significantly higher number of sand flies were trapped by CDC-LT compared to BGS and EVS traps (*P = 0.000*). CDC-LT augmented with UV LED significantly attracted more sand flies than red LED, but were not different to green LED and incandescent light (*P = 0.017; P = 0.807; P = 1.000*, respectively). CO2 and BG-Lure showed no significant differences in capture of the sand fly compared to control (*P = 0.699*). Additions of attractant and light color showed no significant difference in sand fly sex ratio in each experiment. According to the result, this study showed that CDC-LT equipped with either incandescent light or UV LED without attractants can be an effective sand fly sampling tool for using in the surveillance program in Thailand.

72 Continued surveillance for insecticide resistance in mosquitoes along the Texas/Mexico Border

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The primary control effort for mosquito-borne diseases is using insecticides to kill mosquitoes. It is critical to assess if mosquito populations are becoming more resistant to commonly used insecticides as they would reduce their efficacy and limit the efficacy of disease control efforts. Starting in 2018, we initiated an ambitious, long term project to monitor insecticide resistance in cities along the Texas/Mexico border. We collected *Aedes mosquito* eggs from between 5 and 9 cities along the border every week. We partnered with local city authorities, including vector control and environmental health officers, to identify up to 4 field collection sites in each participating city, using multiple oviposition cups at each site. Collected eggs were hatch in the lab, identified to species as adults, and then tested for insecticide resistance using the CDC Bottle Bioassay to commonly used insecticides: Permethrin, Deltamethrin, and Sumethrin. Our efforts in 2020 were disrupted in March by the SARS-COV2 pandemic, but we have resumed collection and testing efforts as of September 2020. Here we present some of the key findings related to both geographic and temporal resistance to insecticides in the common disease vectors in South Texas through 2020.

73 Development and validation of in-house arbovirus detection capacity for screening of West Nile virus antibodies during a pandemic

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The Florida Department of Health (FDOH) offers free services to mosquito control districts/programs that includes serological testing of sentinel chickens and arboviral screening of mosquito pools. In light of the COVID-19 pandemic, the FDOH shifted resources devoted towards these services to the state-wide testing of SARS-CoV-2 samples. This prevented many Florida mosquito control districts/programs from obtaining critical information needed to help guide their abatement efforts. In an effort to continue the sentinel chicken services in our county during the pandemic, Anastasia Mosquito Control District (AMCD) established an in-house sentinel chicken and mosquito arbovirus testing program. AMCD started weekly screening of 54 sentinel chickens in June, with screening ongoing. Once the FDOH was able to return to providing these services, AMCD has been able to confirm our sentinel chicken results based on the state lab's testing procedures. To date, all sentinel chicken samples (> 620) tested in-house have been congruent with the state lab results. In-house testing provides results at a much faster rate (same day verses about 3-5 days from the state lab). However, the downside to in-house testing is we are limited to only screening for WNV while the state lab is able to screen for exposure to more arboviruses.

74 Establishment of a multi-county vector surveillance collaborative using Hurricane Recovery Crisis Cooperative Agreement grant funding

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The Brazos County Health District (BCHD) established vector surveillance and disaster response vector control capabilities in underserved, rural communities within the Brazos Valley which lack the population size and funding necessary to sustain local health departments that include these services. This had not previously been attempted due to the difficulties of overcoming jurisdictional boundaries of county and local health departments, as well as limited funding source availability to agency collaboratives for regional responses. An opportunity was identified by BCHD following Hurricane Harvey to apply for one-time grant funding on behalf of eligible rural counties included in a declared disaster area who would not otherwise have participated in the grant opportunity due to the lack of an

existing vector program and staff to write a grant request. With permission from the Texas Department of State Health Services (DSHS), BCHD submitted an application and was approved for the Hurricane Recovery Crisis Cooperative Agreement (CoAg) grant funding with intent to use the funds to purchase and distribute vector surveillance equipment and larvicide briquettes to eligible adjacent rural counties who opted in as members of a Brazos Valley Vector Collaborative. County judges and emergency response directors of five adjacent counties were recruited to the collaborative with the agreement of each designating a county employee to conduct periodic adult mosquito surveillance and transport the samples to BCHD for inclusion with BCHD's submissions to Texas DSHS for arbovirus testing. Supplies purchased for distribution to members of the Brazos Valley Vector Collaborative include larvicide briquettes to be deployed in a disaster event where risk of vector borne disease or nuisance mosquitoes inhibiting disaster response might occur, as well as gravid and BG sentinel traps with rechargeable batteries, both of which require no ongoing expenditures for program sustainability purposes.

75 Evidence of West Nile virus and Saint Louis encephalitis virus in pools of mosquitoes testing negative for both viruses using real-time PCR

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Vector-borne diseases have been on the rise during the past fifteen years in the United States. Regular surveillance of such diseases is critical for maintaining the public health of a region. Screening of mosquito pools for arboviruses using polymerase chain reaction assay (PCR) is a commonly used practice. As part of an ongoing surveillance program in northwest Texas, Flavivirus-positive but West Nile virus (WNV) and Saint Louis encephalitis virus (SLEV) PCR-negative mosquito pools increased drastically in 2018 (2009-2017 average = 16.3%; 2018 = 69.0%). In an effort to determine the genetic structure of these Flavivirus-positive, WNV/SLEV-negative mosquito pools (n = 20), cDNA PCR product was sent to the Los Alamos National Laboratory for Next Generation Sequencing. Analysis of amplicon products matched 95% (19/20) of our samples to WNV and/or SLEV in various databases. Though further analysis is required, our findings demonstrate the need for continued evaluation of currently accepted surveillance tools. The primers and probes employed in this study have been utilized by various studies over the years. The potential of these primers to no longer capture all WNV or SLEV positive samples is alarming and may have a negative effect on vector surveillance operations that currently utilize these primer sets.

76 Examination of non-target effects of autodissemination approaches in lab and semi-field conditions

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Autodissemination approaches are based on the delivery of lethal doses of insect growth inhibitors to mosquito cryptic breeding locations using the natural behavior of insects. However, little is known about the potential for non-target effects of autodissemination approaches. While direct targeting of cryptic locations seems like a significant advantage over large scale applications of insecticides, autodissemination approaches could be harmful to non-target organisms by delivering these highly potent long lasting growth inhibitors to the exact places that other beneficial insects visit, such as locations where many anthophilous insects seek nectar sources. Here we have examined for non-target effects of autodissemination approaches by dusting male *Aedes albopictus* mosquitoes with pyriproxyfen (PPF) and exposing males to PPF using autodissemination stations. Transfer of PPF to

artificial and/or natural nectar sources, con-specific females, and anthophilous pollinator species from PPF exposed *Aedes albopictus* was observed in laboratory and semi-field cages. We discuss the potential for PPF contaminated *Aedes albopictus* mosquitoes to deliver lethal doses of PPF to artificial and natural nectar sources and the potential risk of impacting important pollinator species.

77 First report of Anopheles benarrochi B in the Achuar Indigenous territory, a malaria-endemic area in the southern Amazonian Ecuador

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Malaria transmission has declined in Ecuador in the last decade, yet, malaria is reemerging in the southern Amazonian region close to the border with Peru. In 2019, a total of 2,081 malaria cases were reported country-wide with more than half reported from residual transmission sites in Morona Santiago 790 (38%) and Pastaza 512 (25%) provinces in the southern Amazon, however, information regarding malaria vector species present in these provinces is very limited. Thus, we conducted anopheline mosquito collections in Napurak, Sharamentza and Wachirpas, Achuar Indian communities located along the Pastaza River between July and December 2019.

Mosquitoes were collected using protected human landing catches (1800-2400 h) and CDC light traps (1800-0600 h). Specimens were identified morphologically, and a subset selected for species molecular confirmation through COI barcoding. Mosquito DNA was extracted using a QIAgen DNeasy® Tissue kit and COI barcodes amplified using universal primers. DNA was sequenced in a Seq-Studio Genetic Analyzer and sequences compared and submitted to the Barcode of the Life Database (BOLD; www.boldsystems.org). Fifty-One anopheline mosquitoes were collected; 30 specimens (11 from Napurak, 18 from Sharamentza, 1 from Wachirpas) were morphologically identified and DNA barcoded. Morphological identification indicated the presence of *Anopheles benarrochi* (3), *An. oswaldoi* (1), *An. rangeli* (1) and *An. (Nys.) sp*. (6) in Napurak; *An. oswaldoi* (8), *An. strodei* (4), and *An. (Nys.) sp.* (6) in Sharamentza; and An*. (Nys.) sp.* (1) in Wachirpas. However, DNA barcoding revealed that all of these specimens were morphological variants of *An. benarrochi* B. Our preliminary results suggest that *An. benarrochi* B is a predominant species potentially involved in malaria transmission in this region of Ecuador. We also found that species identification based exclusively on morphological characters could be misleading for Amazonian anophelines, therefore, COI barcoding has proven useful for species confirmation in these remote malaria endemic communities.

78 Geospatial risk identification system (GRIdS): developing a risk-based West Nile virus response grid system

Kiet Nguyen (knguyen@ocvector.org), Amber Semrow, Tim Morgan, Laura Krueger, Robert Cummings

Following Orange County's (CA) worst West Nile virus (WNV) epidemic in 2014, Orange County Mosquito and Vector Control District (OCMVCD) has taken steps to increase early detection of WNV activity and decrease control response time. In 2019, OCMVCD implemented a Geospatial Risk Identification System (GRIdS) derived from 15 years (2004 – 2018) of location data of WNV human cases and virus-positive dead birds. OCMVCD used this information to construct a hot-spot analysis to identify spatially three County regions based on WNV risk: high, medium, and low, with the goal of distributing

surveillance resources more efficiently. Each area was divided into blocks (one gravid trap per block) with dimensions set to accommodate OCMVCD's ground based adulticiding resources. Each block was further divided into smaller cells to delineate sections for additional weekly mosquito sampling that was activated upon an initial WNV detection. The area with the highest density of WNV activity, based on human cases and dead birds, was assigned a tighter surveillance grid compared to the medium and low risk areas. Within each risk area, the blocks established a standard unit for calculating infection rates based on routine and extended trapping efforts. During 2019 - 2020, the grid system proved to enhance the communication of risk to constituents and stakeholders at a neighborhood level. The grid system and surveillance plan further strengthened inter- and intra-agency communication, allowing for a more rapid mosquito control response.

79 Harnessing the Power of the Science Classroom for Outreach Education

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The Lee County Mosquito Education (LCME) program is a cooperative effort, spanning over thirty years between the Environmental Education Department of the Lee County School District (LCSD) and the Lee County Mosquito Control District (LCMCD). The mission of the LCME program is to enhance the scientific and environmental literacy of the younger citizens of Lee County and to augment their lifetime understanding of the science related to mosquito control. The goal is to make sure that the public knows who the LCMCD is, what it does and why it is so important. LCMCD recognized very early on that in order to be successful combating mosquito vectored diseases they would need a strong environmentally based education program integrated into the community. During the 2019-2020 school year, the program reached over 19,000 students and was conducted in over 700 classrooms at over 120 schools.Our classroom programs are conducted in collaboration with classroom teachers and are designed for grades kindergarten, 5, 7, high school chemistry and biology classes to support Florida's Sunshine State Standards in a variety of areas. These hands-on learning experiences are being offered county-wide to public, charter and private schools. Students learn to identify different kinds of mosquitoes, their habitats and life cycles, and are familiarized with the techniques currently being used to control mosquitoes. Our poster presentation will show how individual organizations can set up similar partnerships with their local school system and simultaneously become recognized in your community as a leading innovator in science, technology, engineering and mathematics.

80 Knowledge, Attitudes and Practices on dengue and dengue control and the factors associated with the Utilization of the Dengue School Card

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Dengue affects 390 million people worldwide. It is hyper-endemic in Sri Lanka, with ≈30% of affected patients being of school-going age. Schoolchildren are good behavioural change agents and many interventions are conducted to improve their knowledge, attitudes and practices on dengue, to empower them for sustainable dengue prevention and control.

The objective of the study was to describe the knowledge, attitudes and practices on dengue and its control, and to describe the factors associated with the utilization of Dengue School Card (DSC) among grade-9 government-school students in a selected zone in the Kalutara District, Sri-Lanka.

A descriptive cross-sectional study was conducted among 782 grade-9 students in the selected zone using a multi-stage cluster-sampling technique. A pretested self-administered questionnaire was used to collect

information on the knowledge, attitudes and practices on dengue and dengue control, and the factors associated with the utilization of DSC. The analysis was done using frequencies and the Chi-square test.
Majority (85.7%; 95%CI= 83.1-88.1, n=670) of the schoolchildren demonstrated adequate knowledge on dengue and its control. The overall attitude and reported practice on dengue control were also good among the participants i.e. 85.7%(95%CI=83.2-88.0, n=670 and 86.2% (95%CI=83.6-88.5, n=674) respectively.
There is a statistically significant association between the utilization of the DSC and being a student of Type-2 school(p=0.003), the level of knowledge(p<0.001) and reported current practice on dengue and dengue control(p=0.003).
Grade-9 government school children in Horana Educational Zone had adequate-knowledge on dengue and dengue control, good-attitude towards dengue control, and good-reported practices on prevention and control of dengue. The Utilization of the DSC was associated with being a student of a Type-2 school, good levels of knowledge and reported practice on dengue control.
Continuous improvement of knowledge, practice and adaptation of good practices would lead to the better behavioural outcome on prevention and control of dengue.

81 Logistics of a 2,000 trap mosquito surveillance program

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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 principal vector for dengue, Zika, and chikungunya in Puerto Rico. The PRVCU has established a long term and large scale surveillance system using the Autocidal Gravid Ovitrap (AGO) in Puerto Rico across six municipalities distributed over 73 surveillance zones. In less than two years, the PRVCU has deployed 2,000 AGO, which aims to monitor the prevalence of mosquito density of *Aedes aegypti* and the detection of active arboviral transmission in the Island. Like an industrialized process, the PRVCU has developed an efficient, quick, and easy method to handle a large number of traps every week, separating the most time-consuming parts: trap servicing, mosquito ID, and mosquito pooling for arboviral testing. This system has allowed the PRVCU to collect an average of 15,000 *Aedes aegypti* females/week and conduct arboviral testing for 1,000 pools/week. Historical data has shown a high density of *Aedes aegypti* population in Puerto Rico all year round with seasonal peaks during rainy seasons. Having a unique mosquito surveillance system like this has been vital to demonstrate the importance of mosquito control programs in arbovirus endemic countries to stakeholders and public health agencies.

82 Morphological variances of Aedes aegypti mosquito populations in northern Tulare County

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The yellow fever mosquito, *Aedes aegypti* (L.), is commonly identified by its contrasting black and white coloration and the distinct lyre on its thorax. In 2019, Delta Vector Control District identified a mosquito specimen that closely resembles an *Ae. aegypti* with an almost entirely pale yellow-scaled terga. Previous findings have shown different morphological forms of *Ae. aegypti* across tropical and subtropical regions based on the density of scales on the terga. This poster presentation

discusses the morphological variations of *Ae. aegypti* that have recently been identified in northern Tulare County. Both variant and standard *Ae. aegypti* mosquitoes were mailed to San Mateo County Mosquito and Vector Control District for genetic analysis using a cytochrome c oxidase subunit I (COI) barcoding polymerase chain reaction. The sequence of the COI gene was compared to other *Ae. aegypti* sequences available in the GenBank using the Basic Local Alignment Search Tool (BLAST) under default parameters. Additionally, one variant of *Ae. aegypti* was sent to Dr. Leopoldo Rueda, a taxonomist from the Smithsonian Biosystematics Unit, for species confirmation and physical identification. BG-Sentinel traps were set where variant *Ae. aegypti* were previously found to collect more adult specimens for photographing morphological differences. Ovicups were also placed in these areas to collect mosquito eggs for rearing. Sequencing results of the COI gene for the variant *Ae. aegypti* species showed >99% matching identity to *Ae. aegypti*. Furthermore, Dr. Rueda confirmed the dried specimen as an *Ae. aegypti*. It is important to be aware that *Ae. aegypti* with pale yellow-scaled terga exists in northern Tulare County. Genetic and physiological analyses of the variant *Ae. aegypti* are required to further understand its biology and potential ramifications for pesticide resistance and mosquito-borne disease transmission.

83 Mosquito surveillance in the lower Rio Grande Valley, 2019-2020

Valerie Hernandez (valerie.hernandez01@utrgv.edu), Christopher Vitek

Mosquito surveillance is a critical component of an effective early-warning system for many mosquito-borne diseases due to the lack of sentinels or other systems prior to an increase in human cases. Our efforts to assist surveillance for prominent mosquito-borne diseases in South Texas have been active for the past four years. Working with local partners including local health departments, city animal and vector control officers, and county health offices, we receive mosquito samples they have collected. The mosquitos are identified to species and then tested for disease. While the 2020 season was disrupted in March 2020 with SARS-COV2 concerns, surveillance activities have resumed in September 2020. During 2019 and 2020, we received a total of 76,774 mosquitoes from local partners and identified a total of 28 species. In comparison to Hidalgo County, Cameron County had a higher amount of mosquito collection. During periods of high precipitation and flooding, the amount of *Psorophora* species increased. Throughout the year the most prevalent mosquito species collected in South Texas were *Culex quinquefasciatus*, *Aedes aegypti*, and *Aedes albopictus. Culex* species and certain *Aedes* species (*Ae. aegypti* and *Ae. albopictus*) were tested for relevant diseases (West Nile virus and dengue/chikungunya/Zika virus respectively). To date, all mosquitoes tested have been negative. While the disruption in 2020 has limited our ability to identify long term patterns in mosquitoes, we discuss some of the patterns that have been determined to date.

84 Mosquitoes of the United States Virgin Islands: surveys reveal new records and species

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The paucity of recent studies documenting the Culicidae fauna in the United States Virgin Islands (USVI) limits the ability of public health officials to prepare for and address emerging mosquito-borne diseases. Natural disasters (e.g. Hurricane Irma and Maria) and outbreaks of dengue, chikungunya, and Zika viruses within the USVI clearly underscore the need for robust integrated mosquito surveillance and management efforts. Recently completed mosquito surveys and ongoing surveillance activities within the islands have improved the accuracy of the valid species records for the islands. Here, we describe our

findings drawn largely from larval surveys conducted in 2019. Specifically, we 1) reconcile historical mosquito inventory records from the literature for the USVI, 2) report known valid species collected during the past 3 years, 3) report the first records of *Mansonia dyari* (Belkin, Heinemann & Page) on the island of St. Croix, 4) report the first records of an undescribed *Wyeomyia* species on the island of St. John, and 5) describe annual phenological trends for adult *Aedes aegypti* mosquitoes collected by BG-Sentinel traps.

85 Potential role of Integrated Aedes aegypti Monitoring (MI-Aedes) technology in improving targeted dengue vector control in Juazeiro do Norte, Brazil's largest religious pilgrimage destination: a case study

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INTRODUCTION: Dengue is an arboviral disease transmitted by Aedes aegypti and a growing public health threat to more than 1 billion people. Integrated Ae. aegypti Monitoring (MI-Aedes) technology uses a commercially available adult oviposition sticky trap (MosquiTRAP) to capture Ae. aegypti females in large scale, generating weekly real-time entomological indices, allowing dengue risk analysis and targeting of vector control. 570 georeferenced MosquiTRAPs were installed in Juazeiro do Norte, the largest religious pilgrimage destination in Brazil. During weekly MosquiTRAP inspections, catched mosquitoes were identified and data sent to MI-Aedes' on-line database via an app. Then, health managers directed vector control activities to areas of greatest risk.
OBJECTIVE: To compare dengue incidence before and after MI-Aedes implementation in Juazeiro do Norte and between neighboring municipalities, describing the potential impact of implementing a large-scale tool for adult Ae. aegypti management.
METHODOLOGY: Following MI-Aedes implementation in Juazeiro do Norte, from September 2019 to September 2020, entomological data and vector control activities were recorded. Data on the incidence of dengue cases in Juazeiro do Norte and six neighboring cities were collected from State Health Department reports. A multidisciplinary approach was used to explain dengue incidence in Juazeiro do Norte compared to previous years and to other municipalities.
RESULTS: MI-Aedes provided real-time georeferenced adult indexes, better directing vector control to areas with higher entomological risk. Epidemiological analyses showed a significant drop in dengue cases in Juazeiro do Norte in 2020, compared to historical baseline and other cities.
CONCLUSIONS: We have found evidence that suggests a role of MI-Aedes in improving targeted Ae. aegypti control, thus, reducing risk of dengue transmission in Juazeiro do Norte. Further studies could evaluate the individual contribution of directed control activities in reducing Ae. aegypti density and dengue cases.

86 Public acceptance of a large-scale deployment of a Wolbachia strategy in Ponce, Puerto Rico

Rafael Saavedra (rsaavedra@prvectorcontrol.org), Julieanne Miranda-Bermúdez, Marianyoly Ortiz-Ortiz, Grayson Brown

Insecticide resistance of the *Aedes aegypti* mosquito to commonly used chemicals in Puerto Rico has driven the evaluation of alternate vector control methods (VCM). Adopting a new VCM might be compromised if there is no community acceptance, and residents could perceive the interventions as unsafe or ineffective. It is vital to consider people's approval for a health intervention; however, defining acceptability is not straightforward; the published literature offers little guidance on defining it.

Quantitative and qualitative research has evaluated people acceptability to various VCM, including *Wolbachia's* use as a replacement technique. Still, to our knowledge, there is no published study about the acceptability of releasing male mosquitoes infected with *Wolbachia* for population suppression. Therefore, before implementing a *Wolbachia* population suppression strategy in Puerto Rico, and collaboration with the Communities Organized for the Prevention of Arboviruses (COPA) project, we conducted a quantitative survey to measure public acceptance of this technique. An ArcGIS Survey 1,2,3 was used to collect data from face-face interviews to a non-probabilistic sample of residents living in the 12 zones selected for the COPA project. A total of 2,756 face-face interviews were conducted. Of the respondents, 1,349 (48.95%) have heard of the male's mosquitoes with *Wolbachia* previously, and 353 (12.81%) have questions. A total of 2,328 (84.47%) residents supported the release of male mosquitoes with *Wolbachia* in their communities, 306 (11.10%) were neutral/not responded, and 122 (4.43%) opposed. Given the significant support for the project and the low opposition, the *Wolbachia* population suppression was considered an accepted method to control the *Ae. aegypti* population in the zones of the COPA project.

87 Reducing continued Aedes aegypti production among residents with a history of breeding

Crystal Grippin (clgrippin@deltavcd.com), Javier Valdivias, Jesse Erandio, Mark Nakata, Mir Bear-Johnson, Mustapha Debboun

Analysis of property inspection data from 2017 to 2019 showed that among properties with a history of *Aedes aegypti* (L.) mosquito production, 33% continued to produce mosquitoes in a subsequent year. These properties represent an increased risk of re-infesting the surrounding areas and contributing to the continued spread of *Ae. aegypti*. This study examined the effectiveness of a pre-mosquito season door hanger in reducing continued *Ae. aegypti* production among residents with a history of mosquito production. Properties that had *Ae. aegypti* larval sources in 2019 were assigned to a control or intervention group using a randomized block design. The intervention group received a color door hanger in May 2020 that reminded residents to empty water holding containers weekly and scrub them with bleach to remove any oviposited eggs. Properties in both groups were later inspected for breeding larval habitats when a service request was received or when at least 10 female *Ae. aegypti* were caught in a single trap night in the area. There was no significant difference between intervention and control groups in this study. Developing an effective method to reduce continued *Ae. aegypti* across multiple mosquito seasons has the potential to reduce overall control costs and slow the spread of this invasive species.

88 Resistance to bendiocarb and malathion, and the Gly12Ser mutation in the ace1 gene of Aedes aegypti from Tapachula

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The use of organophosphates and carbamates has increased in Mexico due to resistance to pyrethroids in *Aedes aegypti*, so it is necessary to monitor the emergence of resistance mechanisms to these insecticides. The susceptibility to bendiocarb and malathion (CDC) was determined in mosquitoes from four neighborhoods in Tapachula, Chiapas. Resistance ratio (RR) was calculated by comparing the LC_{50} of wild mosquitoes with those of a susceptible strain. Overexpression of enzymes that could metabolize these insecticides, as well as the detection of insecticide insensitive acetylcholinesterase (iAChE) were assessed by WHO biochemical tests; while the presence of the Gly12Ser mutation in the *ace-*

1 gene encoding acetylcholinesterase was determined by rtPCR. Three colonies of *Ae. aegypti* (Bonanza, Paraíso and Benito Juárez) showed a RR greater than 10 for bendiocarb, while in those from Palmeiras was 2.91. However, the Palmeiras's mosquitoes scored the highest RR (3.68) and the highest resistance for malathion. Esterases, monooxygenases, and glutathione S-transferases enzymes were overexpressed in mosquitoes from the four neighborhoods, while iAChE presented heterogeneous levels. The Gly12Ser mutation was found in all mosquito homogenates that had or did not have propoxur-insensitive AChE, as well as in dead and alive mosquitoes exposed to bendiocarb. Therefore, the presence of the Gly12Ser mutation in ace-1 of *Ae. aegypti*, could not be considered as a mechanism of resistance to carbamates and organophosphates in the collected mosquitoes from Tapachula. However, insensitivity of AChE to propoxur was detected by biochemical assays, suggesting that a mutation in the *ace1*, not identified yet, is present. Therefore, even though low levels of resistance to bendiocarb or malathion have been recorded in these colonies of mosquitoes, the monitoring of iAChE in those mosquito populations is mandatory.

89 Sterile insect technique - RS 2400Q

Brent Phelan (bphelan@radsource.com)

The sterile insect technique is a no-chemical, environmentally-friendly pest control method that has been around for over 70 years (developed during WWII). It is a way to suppress or eliminate pest insects without relying completely on chemical sprays. SIT practitioners use radiation to sterilize male insects and then release them in large quantities over a defined area to mate with wild females. The (mated) wild females subsequently lay eggs which don't hatch, leading to a decline in the target population. SIT can function on its own as a pest control method, or be used in conjunction with existing control methods. Traditional SIT programs have utilized gamma radiation as their radiation source during the sterilization process, but working with nuclear isotopes can be a dangerous, expensive, and complicated process. Due to the high costs and dangers of working with gamma systems, the SIT method has only been an option for facilities with high resources. However recent studies have shown that x-rays are a suitable replacement for gamma systems, making the sterilization process easier and safer to conduct, and less expensive to procure. Due to the recent advances in x-ray technology, the SIT method is now available to a larger audience of pest control professionals and will be critical in the fight to prevent insecticide resistance of invasive pests. SIT can be a standalone control method, or work in conjunction with other pest control methods such as Wolbachia. Rad Source Technologies is the leader is the field of x-ray technology for sterilization purposes. The RS 2400Q is the premier sterile insect irradiator in the world providing superior dose uniformity, capacity, and dose rate. The future of environmentally-friendly mosquito control is in x-ray-based SIT and nobody can do it better than Rad Source!

90 Tick- and Flea-borne disease surveillance in South Texas, 2018-2020

Christopher Vitek (christopher.vitek@utrgv.edu), Valerie Hernandez, Conseluo Aguilar, Mariana Aguilar, Liserena Madrigal, Teresa Feria-Arroro

The prevalence of tick- and flea-borne diseases in South Texas is uncertain, primarily due to a lack of surveillance and identification of diseases. While South Texas remains a hot-spot for flea-borne typhus, the incidence of other Rickettsial diseases is uncertain. Working in conjunction with other partners in the Western Gulf Center of Excellence in Vector-Borne Diseases, including UTEP and UTMB, we initiated and participated in a long-term collection, identification, and testing effort for ticks and

fleas to assess the risk of common tick- and flea-borne diseases. While the 2020 season was disrupted in March 2020 with SARS-COV2 concerns, surveillance activities have resumed in September 2020. Collection efforts include working with local animal shelters, field collections, and partnering with veterinarians to receive samples. To date, we have identified 842 ticks, consisting of 4 species, and 52 fleas, consisting of 2 species. The most common tick species collected in animal shelters and veterinarian clinics was *Rhipicephalus sanguineus*. Additionally, the most common tick and flea host were dogs and cats. However, natural areas (wildlife management areas and state parks) the most common tick species collected through the flagging method was *Amblyomma maculatum*. Testing is underway for the specimens. We discuss the temporal and geographic patterns, as well as future efforts to expand this study.

91 Use of sticky traps (AGO) for the surveillance of Aedes aegypti (Diptera: Culicidae) in three municipalities of Colombia.

Susanne Ardila-Roldan (dimidiata@gmail.com), Diana Marcela Lucumi-Aragón, Suljey Cochero, Laureano Mosquera, Yoldy Benavidez

Introduction: in Colombia, Aedes aegypti dengue vector is distributed in 73% of the territory. Currently due to the lack of availability of a vaccine, prevention and control actions are based on PAHO recommendations that include the strengthening of entomological surveillance systems. In this sense, it is necessary to implement surveillance strategies for the country. Objective: To evaluate the use of AGO sticky traps in three municipalities of Colombia with support from CDC-INS.
Methods: the use of AGO traps was evaluated in the municipalities of Valledupar, Palmira and San José del Guaviare. Where neighborhoods with greater and lesser transmission of dengue were selected to install traps in homes. The specimens were collected weekly as a surveillance method. A descriptive and correlation analysis was carried out with the data, differences were established between neighborhoods and municipalities using the Mann Whitney and Kruskal-Wallis U test. Finally, surveys were conducted to measure community satisfaction and level of trust.
Results: A total of 8999 mosquitoes were collected; 6215 in Valledupar, 1716 in Palmira and 1068 in San José del Guaviare. Statistical differences were found between neighborhoods in San José del Guaviare ($P = 0.0003$) and Palmira ($P < 0.0001$). Inverse correlations were presented with respect to precipitation and the number of mosquitoes. The percentage of satisfaction of the traps by the community was higher than 75%.
Conclusions: The use of AGO traps allowed the capture and monitoring of Ae aegypti females in localities with greater and lesser transmission of dengue in regions with different characteristics, which confirms its usefulness in entomological surveillance for these regions, being a methodology of low cost, acceptance and use.
Key Words: Aedes, dengue, vector insects, vector control, surveillance, entomology.

Legislative and Regulatory Symposium I

92 Laws and regulations you need to know about right now!

Angela Beehler (angela@mosquitocontrol.org)

A primary benefit of American Mosquito Control Association (AMCA) membership is legislative and regulatory advocacy. This session is designed to keep you in-the-know on the most important issues facing our industry today, which will save you time, money, and headaches down the road. Within 180 minutes you will hear the key points of information gathered over two years by some of the most dedicated professionals involved in public health mosquito control. We promise to provide you with what you need to know right now in order to have a successful 2021 season and the best resources available.

93 Science, hearsay and politics - does anyone win in the end?

Mark Newberg (mnewberg@central.com)

Concerns with fluoride treatments in water, anti-vaccination legislation, flat earthers - where does science fit in with public opinion, public health and politics? Surprisingly, there is survey evidence in favor of the application of pesticides - possibly more than you might think. Identify allies and create support for your program with citizens who want to protect their lifestyles and family from mosquito-borne disease.

94 Interacting with the EPA: an end-users' perspective.

Edward Foley (Foley@LCMCD.org)

Lee County Mosquito Control District (LCMCD) takes an active approach of engagement with various regulatory agencies including the United States Environmental Protection Agency (EPA). Active engagement from the end users perspective is often considered an extremely powerful message for policy makers to take into account. For years, LCMCD has worked to stay abreast of current issues facing mosquito control as well as worked with partners, such as the American Mosquito Control Association, to provide thoughtful comments representing our needs. Since 2014, LCMCD has hosted 3-4 individuals from the EPA's Office of Pesticide Products to spend a week in South Florida engaging in hands on mosquito control work. Positive experiences with mosquito control districts are ways in which policy makers are able to see our challenges in the most real world of settings. Here are some of the routes in which we stay engaged with the EPA, as well as ways you can get involved as well!

95 Improving public information about pesticide risks and regulations

Susan Jennings (jennings.susan@epa.gov)

OPP regulates the manufacture and use of all pesticides (including insecticides, herbicides, rodenticides, disinfectants, sanitizers and more) in the United States and establishes maximum levels for pesticide residues in food, thereby safeguarding the nation's food supply. EPA has expanded public access to information about risk assessment and risk management actions to help increase transparency of decision making and facilitate consultation with the public and affected stakeholders.
In addition to our regulatory functions, we provide information and coordinate with partners and stakeholders on issues ranging from worker protection to misuse of pesticides. We participate in a variety of partnerships related to pesticide use, including the Pesticide Environmental Stewardship Program, a voluntary private and public partnership dedicated to reducing pesticide use and risk, and Integrated Pest Management in Schools.

96 Updates to EPA Registration and Efficacy Testing of Pesticide Products Under PRIA 4

Jennifer Saunders (saunders.jennifer@epa.gov)

EPA-registered pesticide products are an important part of pest management programs to accomplish control of invertebrate pests. The Agency registers a wide range of vector control products, including wide-area mosquito adulticides and larvicides, skin-applied repellents, pesticide-impregnated clothing and nets, and modified mosquitoes. Product efficacy data for public health pests are required to be submitted to support a pesticide registration. The Agency has a number of guidelines intended to assist in the development of appropriate protocols to test product efficacy in support of pesticide registration. The Pesticide Registration Improvement Act (PRIA 4) mandated that EPA revise and implement four of its current efficacy guidelines by 2021, including EPA Product Performance Test Guideline 810.3500 Premises Treatments, originally published in March 1998. To increase clarity and consistency in efficacy testing and to include current scientific standards, in 2019 the Agency published a revised version of the guideline which now contains recommended test methodologies for a wide range of products intended to kill, control, flush, and/or knock down invertebrate premises pests, including mosquitoes.

97 Pyrethroids: Where Are We Now

Nina Dacko (ndacko@hotmail.com)

Pyrethroids are one of the only two chemical classes currently available for the control of adult mosquitoes. It is well known that mosquitoes transmit diseases at the adult life stage and that it is the adult biting female who is responsible for complaints and impedance for the pubic to enjoy the outdoors, or for impedance of emergency response. It is important that these tools remain available at large for mosquito control personnel to be able to control adult mosquitoes. The current registrations of many pyrethroids were up for review in 2020 and the status of applicable mosquito control pyrethroids registrations, FQPA safety factors, ecological risk mitigation proposals, and interim decisions will be discussed.

98 Pesticide residue on rice plants from mosquito control adulticide applications

Marcia Reed (mreed@fightthebite.net), Sarah Wheeler, Jay Gan, Junlang Qiu

The Sacramento-Yolo Mosquito and Vector Control District applies adulticide mosquito control products aerially to approximately 35,000-45,000 acres of rice field habitat annually, with either pyrethrin or
naled as the active ingredient. Over the entire summer growing season these applications amount to approximately 500,000 acres of treatments. In collaboration with the University of California, Riverside, the District evaluated residue levels of pyrethrin, piperonyl butoxide (PBO) and naled left on rice plants after singular applications and also evaluated the total accumulation of residue over the course of an entire mosquito control season. In addition to samples of the growing plant, rice grain was collected at the time of harvest and tested for these same active ingredients. This presentation will highlight results from two study areas, one which was treated with only a pyrethrin/PBO pesticide, and a second area which was treated initially with a pyrethrin/PBO pesticide but rotated to a naled pesticide mid-way through the season. Studies of this type highlight that mosquito control pesticide applications differ significantly from typical agricultural applications and therefore should be viewed differently from a regulatory standpoint.

99 Legalization of Cannabis: Operational and Regulatory Hurdles to Mosquito Control in California

Samer Elkashef (selkashef@fightthebite.net), Peter Bonkrude, Gary Goodman, Jennifer Henke

On November 8, 2016, California voters passed the Adult Use of Marijuana Act (Proposition 64) which allowed the recreational use of cannabis. Starting in 2018, licenses were issued by the State of California to sanction the cultivation of cannabis and the sale of it for commercial use. As the State's farmers expanded the planting of cannabis, the interaction between vector control District activities and these new farms came into focus. Several vector control Districts in California received calls from their local County Agricultural Commissioners on the use of adulticides. The specific concern was centered around a positive detection of etofenprox on cannabis destined for sale. This presentation will go over the work done by the Mosquito and Vector Control Association of California's Regulatory Affairs Committee on tackling the operational and regulatory challenges that cannabis grows present to mosquito control agencies.

Latin American Student Competition/Latin American Symposium I

100 Polymorphisms in the vgsc of *Aedes aegypti* in Mexico and their impact on resistance to pyrethroid insecticides: bifenthrin and deltamethrin

Andre Gabriel Castro Bautista (andrecastrobautista@gmail.com), Beatriz López, Cecilia Martínez, Gustavo Ponce-Garcia, Adriana Elizabeth Flores-Suarez

The control of *Aedes aegypti* (L.), a vector of arbovirosis such as dengue, has been compromised by the rapid increase in resistance to commonly used insecticides, particularly resistance mechanism due to point mutations (kdr) in voltage gated sodium channel gene (vgsc).
In this study polymorphisms were determined in the vgsc of *Ae. aegypti* populations from Mexico and the relationship of its frequency with the phenotypic response to exposure to pyrethroid insecticides.

101 Kdr mutations in the vgsc of *Aedes aegypti* (L.) in Mexico and their impact on deltamethrin resistance

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One of the mechanisms that has most contributed to resistance to pyrethroid insecticides in vector mosquitoes are point mutations (kdr) present in the voltage gated sodium channel. In Mexico, 3 of the 13 kdr mutations have been reported in *Aedes aegypti* (L.) mosquitoes, so this study shows the mutations present in the gene sequences of the vgsc of *Ae. aegypti* from Mexico and their impact on deltamethrin resistance.

102 Functional response of Toxorhychites moctezuma (Diptera: Culicidae) on Aedes aegypti larvae

Heriberto Villegas (beto_villegasrmz@hotmail.com), Adriana Elizabeth Flores-Suarez, Salvador Flores-Breceda, Idelfonso Fernandez-Salas, Gustavo Ponce-Garcia

The functional response of Toxorhynchites moctuzuma was evaluated in *Aedes aegypti* mosquito larvae. Larvae from each of the predator larval stages, with different densities of prey larvae (1,2,4,8,16), were placed individually in triplicate. In the first 3 densities 100% predation, in the others

79.1% and 47.91%. Search ability decreases as larval density increases. Handling time is shorter with less larval density.

103 Life tables of an Aedes aegypti population under uncontrolled laboratory conditions of Bogotá, Colombia

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Aedes aegypti is an efficient vector of arboviruses such as dengue, zika, chikungunya and yellow fever, among others. The worldwide distribution of this vector has been possible due to the ability to adapt to new environments, influenced by climate change. There is evidence concerning that *Ae. aegypti has* gradually been colonizing higher areas. In that sense, is important to undertake studies related to surviving and fitness of the insects in order to generate information to implement surveillance and vector control measures. The objective of this project was to generate knowledge of life tables, population parameters and the strength of adults emerging from *Ae. aegypti* in higher localities. Different stages of the mosquito were collected in Yopal (Casanare). Half of these individuals were raised under uncontrolled conditions in the laboratory of Entomology of La Salle university of Bogota, located at 2600 masl, (experimental colony) another one half was maintained with humidity and temperature similar to that reported for the sampling area (control colony). Both colonies were maintained for two generations. Daily records were taken of egg hatching, larval stages, pupa stage, adult emergence, mortality and survival. The differences of the life tables between control and experimental colonies were statistically significant. *Ae. aegypti* survived in the conditions of Bogota, in addition the influence of temperature on both life cycle and life expectancy was evident. This species showed a good capacity to adapt to temperatures such as that of the city of Bogotá, because it has been possible to maintain the experimental colony for several generations. This information is important to take into account for entities responsible for entomological surveillance in the city.

104 Toxics Sugar, Potential Insecticide to Anopheles darlingi and Aedes aegypti in the Peruvian Amazon

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The difficult task of controlling vector-borne diseases such as malaria, dengue and Zika in the Peruvian Amazon, relies heavily on different types of insecticides which have contributed to resistance to multiple insecticide classes over the past several decades. It is imperative that we continually search for novel control alternatives with toxic effects, easy to use and friendly to the environment. Our study focuses on assessing the toxicity of artificial sweeteners (sugar alcohols) to two mosquitoes common to the Peruvian Amazon, Anopheles darlingi and Aedes aegypti. Experiments were conducted using adult female and male of Anopheles darlingi (F79-F81) and Aedes aegypti (F4-F5) 1-2day old, which were exposed to a mixture of sucrose and four different artificial sweeteners (Xylitol, Mannitol, Erythritol and Sorbitol) at different concentrations (90/10, 75/25, 50/50, 25/75, 10/90). The experiment consisted of three replicates with three subsets for each artificial sweetener. Mortality was monitored and recorded daily for 10 days. Sucrose solution (10%) was used as a control to verify the lethal effect of the sweeteners. The effects of the toxicity affected the longevity of the mosquitoes in each treatment with high mortality between 24-48 hours using high concentrations (90/10, 75/25 and 50/50) of Erythritol, Xylitol and Mannitol for males and females of Anopheles darlingi. However, for Aedes aegypti, only

Erythritol showed similar effects. Preliminary results suggest that Erythritol is a strong candidate with insecticidal properties, with the potential of becoming a new tool for the control and surveillance of disease vector mosquito species in the Peruvian Amazon.
Key words: artificial sweetener erythritol, Anopheles darlingi, Aedes aegypti, control, Amazon

105 Biological effectiveness of thermal fog Icon® 2.5 EW (Syngenta code A13117E, Lambda cyhalotrina 2.5%, 25 g. i.a./ L) for the control of mosquito Aedes aegypti vector of dengue, chikungunya and Zika virus in southern Mexico.

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During the present study, we evaluated the effectiveness of the Icon® 2.5 EW formulation (Syngenta code A13117E, Lambda cyhalotrina 2.5%, 25 g. i.a./ L) applied as a thermal fog against the local mosquitoes Aedes aegypti of Tapachula, Chiapas state, Mexico, which endemic to diseases transmitted by this mosquito.

Prior to the study, local Ae. aegypti mosquitoes were collected and reproduced massively under laboratory conditions (27 ° C ± 2; 50-70% RH); for the bioassays, F1 female mosquitoes, 2-3 days old, fed with 10% sucrose solution were used.

Four houses were selected, and cages were placed with 15 female mosquitoes described above; the mosquitoes within cages were distributed in the living room, kitchen and bedroom. Then, Icon® 2.5 EW formulation (Syngenta code A13117E, Lambda cyhalotrina 2.5%, 25 g. i.a./ L) was applied at a dose of 0.2 mg i.a./m3 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. After 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 Icon® 2.5 EW formulation (Syngenta code A13117E, Lambda cyhalotrina 2.5%, 25 g. i.a./ L) on Ae. aegypti was 99.72% in the living room, 99.44% in the kitchen and 99.17% in the bedroom; meanwhile, the mortality in the controls was equal to 0%. The results obtained in the present study demonstrate the high efficacy of Icon® 2.5 EW formulation applied in thermal fog, inside homes, on Aedes aegypti mosquito.

Aerial Control

106 Record keeping requirements for small Unmanned Aerial Vehicles (sUAVs) conducting mosquito control

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Small Unmanned Aerial Vehicles (sUAVs), also known as drones have been integrated into mosquito control operations around the world and recently into the United States. Many high tech companies have been providing these systems for years without the knowledge of record keeping requirements within the US. Individuals and agencies throughout the US have spent valuable time learning how to establish legal UAV spray programs, including working through the Part 137 process.

Those who have started the implementation of UAV spray programs have been struggling to find digital ways to track pesticide applications for record keeping. This is due to the fact that some of these UAVs lack the ability to provide off the shelf flight and pesticide records that meet most State pesticide application record requirements.
Three Rivers Mosquito and Vector Control (Klamath Falls, Oregon, USA) has partnered with AirData UAV (El Dorado Hills, California, USA) to utilize the data produced by and extracted from these UAVs and create records that meet both the Federal Aviation Administration's requirements for maintenance/flight records and the Department's of Agriculture pesticide application records. In addition to the records being created with the AirData UAV system, the data extracted by the system produces GIS data that can be used for further analysis and more detailed reporting.

107 Deluge and COVID: Midland County Michigan's Dam 2020 Problems

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During 14-19 May, 2020, several inches of rain fell on Midland County, Michigan and the greater region. This resulted in the failure of the two dams in Midland County. Water from both Wixom and Sanford lakes was released in a matter of hours and rushed through areas downstream causing over $200 million in property damage. Many roads and bridges were destroyed/damaged creating a significant logistical challenge to Midland County Mosquito Control's (MCMC) response to address flooded mosquito larval habitat. Furthermore, MCMC was only half staffed with field personnel due to the inability to obtain certified/registered pesticide applicator status because of COVID-19 restrictions. The department had never before been so low staffed at a time of such a significant need. Therefore, MCMC arranged and oversaw two aerial applications targeting adult mosquitoes covering 120,000 acres. These were the first aerial adulticiding operations in the history of the department. During the two weeks of the aerial operation, truck-mounted fogging was focused on areas outside of the aerial spray blocks. Contrasts are discussed between May 2020 and June 2017 floods regarding mosquito numbers and relative species abundance.

108 Efficacy of an aerial ULV application of Duet HD

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The effectiveness of aerial ULV application of Duet HD was evaluated over a rural area in Volusia County Florida. The spray area was 2,739 acres and the chemical was applied at a rate of 0.7 fl/oz per acre from a rotary winged aircraft. Eight sampling stations were placed beside a road close to the center of the spray polygon. Each station consisted of a "T" shaped PVC pole with one impinger on top holding two Teflon coated slides and two mosquito cages hanging from the cross arms. For wild mosquito population evaluation, four light traps baited with dry ice were operated in the spray treatment area the night before and the night after the spray application. One light trap was also run in the control area on the same nights. Wild mosquitoes from the spray area were captured 24 hrs before application, placed in cages ~2 hrs prior to spray and hung on poles ~30 mins before spray commenced. After completion of the spray application, the slides and mosquito cages were collected and transported to the lab. Mosquito mortality was determined at 60 minutes post spray application. The density and size of the droplets were determined for each slide. Caged mosquito mortality was 78% after 60 mins and there was a 33.8% decrease in mosquitoes captured in light traps post-treatment. 3,270 droplets were analyzed with a mean VMD of 22.4 microns and a VMD range of 12.2 to 36.22 microns. Additional trials will be conducted to further determine efficacy and how Duet HD fits into our IPM program.

109 Joining Forces: Controlling Aquatic Vegetation and Mosquitos Utilizing Drone Technology

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Through the years, herbicides have become increasingly more efficient for selective treatments on non-native and invasive plant species. However, while herbicides have advanced, the way in which we apply them has remained relatively unchanged through the years. The Lee County Hyacinth Control District (LCHCD) has joined efforts with the Lee County Mosquito Control District (LCMCD) to target mosquito breeding hot spots throughout the county. Water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia stratiotes*) are free floating invasive aquatic plant species that are known hosts for *Mansonia* and *Coquillettidia* larvae, both aggressive mosquito species. Utilizing Unmanned Aircraft Systems (UAS), otherwise known as drones, allows LCHCD to eliminate nuisance breeding areas by providing access to waterbodies which have been historically difficult to treat or inaccessible by standard conventional means. As technology improves, drones have the potential to revolutionize the way in which we access, target, and treat aquatic vegetation and reduce mosquito populations.

110 Characterization of the Distribution of Unmanned Aerial Spray Systems for Adulticiding and larviciding

JANE BONDS (jasbonds@gmail.com), Brad Fritz, Harold Thistle

Unmanned Aerial Vehicles' (UAV's) provide operators with unprecedented access to real time imagery, revolutionizing our surveillance techniques, allowing for rapid access to what would otherwise be difficult to reach areas in the region of interest. The next obvious step is to use the same platforms to deliver the control agent. In collaboration with researchers in Asia, where Unmanned Aerial Spray Systems (UASS) have been successfully deployed for 30 + years, and in collaboration with our agricultural colleagues we have been advancing our knowledge of these systems. However, the majority of the research efforts focused on agricultural applications. Consequently, there is an urgent need for detailed characterization data on the spray systems and application methods for vector control to ensure safe and effective applications. This project is funded by the Deployed War-Fighter Protection program.

The aim of this project is to develop two platforms (a larger one for wide area applications and a smaller one for urban) each will be retrofitted with systems that can transition between larviciding and adulticiding. These systems can be used to simply and precisely apply pesticides to control vectors over a larger area than ground equipment, at reduced cost and complexity and increased precision compared to manned aircraft. This system will be remotely piloted, distancing the operator from potentially difficult or dangerous applications and improve worker safety and efficiency.

Considering the different requirements of larviciding and adulticiding, two separate characterization techniques will be necessary for accurate distribution measures. The system for larviciding will focus on deposition with flux measures for off target movement. The system for adulticiding will focus on the downwind catch of the spray plume with precise measures of deposition for non-target effects. The two methods will use the same sampling devices with the location and resolution differing. Once standard testing methods are in place, they will be used as part of the design, construction, and optimization process focusing on sprayer systems ready for immediate implementation in military interventions. With a detailed understanding of the spray distribution, these systems will undergo field efficacy testing. Finally, field data from the fully optimized and characterized systems will be used to validate a new CFD model for spray distribution characterization in combination AGDISP.

In summary, the primary objectives of this project are to develop standard methods for characterizing the UASS spray applications. Then to use these methods to design and optimize UASS spray systems for multiple vector control application scenarios. Field verification will support the optimal deployment of UASS and provide information for pesticide product labeling and risk assessment modeling efforts.

111 Simple, flexible, and comprehensive software – How do you get there?

Linda Glover (linda@frontierprecision.com), Chad Minteer

Everyone wants a simple, flexible, and comprehensive software system at the heart of their ever-evolving IPM plan. How do you get there? Frontier will share ideas based on experiences gained the last 15 years assisting mosquito control districts with implementations of fully configurable software solutions. Time has shown starting with basic software functionality and realistic expectations then enabling more functionality as changes occur will successfully meet long-term needs.
We will also overview recent product updates driven by customer input. Our FieldSeeker Core software (with workflows for Larviciding with storm drain treatments, Surveillance, and Service Request) now has improved data review, an optional VectorSurv Gateway integration, and aerial data import. Adulticiding enhancements include service request and ArcGIS Online integration as well as expanded warnings and messages for drivers. We have also gained new experiences in helping districts be more efficient by automating email notification systems or having a dedicated public notification app.

112 Cutting fogging costs with IOT devices

Mike Schem (info@foggerlog.com)

With the ever-growing logistical complexity of mosquito adulticiding, new Internet of Things (IOT) solutions can be used to make mosquito spraying cheaper by making processes more efficient. In the past 4 years FoggerLog (a mosquito technology company) has helped improve multiple fogging operations more efficiently fog over a million acres. In this talk we will address a few key tools to help improve the efficiency of mosquito adulticiding. First, we will introduce a physical Bluetooth controller that can be connected to any pesticides sprayer. The bluetooth controller when paired iPhone app can record when and where fogging is done along with about 20 other metrics including temperature, wind speed, wind direction, acres fogged, and much more. Next we will reveal how you can use another tool to plan spray missions by drawing polygons on Google Maps and deploy them straight to the field so technicians can know where they have sprayed as well as where they need to spray next. Finally, we will review a tool that allows the technician in the field to see where specific no-spray zones are located so that they can avoid spraying residences that have reported they do not want to have their house sprayed for either beekeeping or other health concerns.

113 Geographic Information Systems (GIS) as a tool to build vector-borne disease surveillance capacity in state/territorial health agencies

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The Association of State and Territorial Health Officials (ASTHO) is the national nonprofit organization representing public health agencies in the United States, the US Territories, the District of Columbia, and the public health professionals these agencies employ. ASTHO's Environmental Health

team has a successful history of enhancing vector-borne disease surveillance capacity in state and territorial health agencies using Geographic Information System (GIS). Over the last 11 years, ASTHO, with funding from the Centers for Disease Control and Prevention (CDC), has led the Peer-to-Peer Environmental Public Health Tracking Fellowship. The goal of this fellowship is to support CDC in providing unfunded states and territories with an opportunity to build environmental health surveillance capacity in their state. The Fellowship Project builds relationships between funded and unfunded health agencies through a unique mentorship experience. Three fellows throughout the years have completed pilot projects using GIS for vector-borne disease tracking and surveillance, specifically focusing on West Nile Virus, Zika, and other arboviral diseases. Through the fellowship, these states and territories were able to expand their surveillance activities by learning key tracking methods from an experienced state health department and using Esri software such as ArcDesktop, ArcGIS online, and Survey123. As part of a separate project, ASTHO hosted its first Climate Summit in 2018, which included a GIS training for insular areas on vector-borne disease surveillance workflow using free, open-source software. This same training continued in 2019 for the Pacific territories. ASTHO added an additional training on vector-borne disease surveillance using GIS for state health agencies that same year. In 2020, ASTHO provided the territories with an online training module. This presentation will discuss the success of the fellowship and trainings in enhancing GIS capabilities for vector-borne disease surveillance in state and territorial health agencies.

114 Drone surveillance of artificial larval habitats

Kathy Beadle (kabeadle@mmcd.org)

Metropolitan Mosquito Control District works to locate artificial structures that can potentially produce mosquito vectors. New drone technology allowed staff to find artificial larval habitats in places that were otherwise inaccessible. One of the locations, the Minnesota State Fair fairgrounds, attracts 2-million visitors annually which increased the importance of this work. The success further validated our drone program, increased efficiency and safety, and promoted public health.

Education/Management

115 Bridging the gap: bringing environmental stakeholders into the classroom

Andrea Miller (amiller@lcmcd.org), Wendy Samz, Mark McCreary

Use our relevant model to "bridge the gap" between your environmental message and the students in your community! Decades of proven collaborative efforts, program framework, tools and partnerships will be shared with participants to assist in the development of an engaging and sustainable environmental education program within your school system.

For decades, the Lee County Mosquito Control District has collaborated with local education institutions such as the Lee County School District and area universities to integrate research and progressive practices with relevant environmental education lessons. Each learning experience is carefully aligned to support the classroom teacher’s goals as well as the advancement of the Florida’s Sunshine State Standards across a variety of subject areas. Last year alone, the program was conducted in over 1,100 Kindergarten, Fifth Grade, Seventh Grade, High School Biology & Chemistry and Collegiate classrooms in over 80 public and private schools!

We will share with session participants the following proven key elements and tools to “bridge the gap” and integrate environmental education programs into their local school systems:
1) Relationships-Learn how to start a dialogue with your local public school district, charter schools, private schools and summer camps! Educators are constantly looking for ways to enhance student learning experiences. This can be an opportunity for your organization to create a customized program to promote your environmental education message while also providing a valuable, real world, hands-on learning experiences.
2) Know the Standards-Every school adheres to national and state benchmarks that students must meet at every grade level. Familiarize yourself with these standards and develop your curriculum to promote and align with the benchmarks. Utilize professional educators throughout the curriculum development process as well as in the classroom.
3)“In Class Field Trips”-In this time of reduced funding, instructional time constraints and test score pressures, it becomes more challenging for classroom teachers to get their students out in the field. As environmental educators, we can cultivate a curriculum that brings these interactive, hands on, standards based experiences into the classroom.
Once the program has been established, it is critical to utilize relevant technology platforms to continuously evaluate the effectiveness of your curriculum with tools such as pre & post student assessments, classroom teacher program evaluations, etc.
We are excited to support environmental educators in “bridging the gap” in their community by sharing our education program framework, tools and experiences during this session.

116 Educating by example: using a native plant pollinator garden to demonstrate ecological responsibility

Eric Jackson (jackson@lcmcd.org), Andrea Miller

In the summer of 2020, the Lee County Mosquito Control District dedicated approximately 3,000 square feet of space outside the District’s administrative building to construct a pollinator garden containing over 20 different plants native to Southwest Florida. This area was designed to promote healthy environmental stewardship by demonstrating how to attract pollinators that are sometimes believed to be negatively impacted by mosquito control efforts. The District has incorporated an interactive ‘garden walk’ component to various public tours and education events hosted throughout the year. Visitors discover the common and scientific names of plants and the insects that they attract, and learn how to create a productive pollinator garden in their own backyards. This presentation will highlight the process of creating this outdoor educational space from its inception to completion.

117 Source Reduction and Data Outcomes from NASA GLOBE Observer Mosquito Habitat Mapper Citizen Science Program

Russanne Low (rusty_low@strategies.org), Rebecca Boger

Crowdsourcing data collection is a promising approach to obtain the volume of data needed to fight the threat of vector-borne diseases, especially in under resourced communities with inadequate funds to maintain an effective vector surveillance and mitigation plan. This paper presents a summary and analysis of the first three years of GLOBE Observer Mosquito Habitat Mapper (GO MHM) data submitted by citizen scientists. We describe some of the characteristics of GO MHM data, including multi-user data submission, opportunistic sampling, and volunteer training events. An unexpected and important outcome of this project is

the reported incidence of source reduction by participants monitoring larval breeding habitats- over 95% of the container habitats reported by the citizen scientists were reported to be dumped out, covered, or treated. Our data indicates that a citizen science data collection project coupled with an opportunity for participants to report mosquito source reduction is a potentially important tool for educating citizens and promoting behaviors that support community health.

118 GRAVID: Grasping, Retrieving, Abundant, Valuable, Information Directly. Trapping young minds while educating the youth about mosquito control operations and its important role in public health today.

Cindy Mulla (cindy@pcbeachmosquito.com)

Beach Mosquito Control District designed and implemented three new educational outreach programs that successfully took flight during the 2018 - 2020 academic calendar school years. These unique individual lesson plans targeted and reinforced the basic scientific method, where students enjoyed a three-part hands-on science learning laboratory. Energy levels soared when mosquito trap count numbers sparred a friendly competition between classes. The final new program was geared towards a sixth grade English language art class. The lesson prepared students to research, write, and defend an argument. The topic covered was the pros and cons of past usage of chemical applications for mosquito control. Present integrated mosquito management (IMM) and chemical product applications including a part-per-million laboratory was combined into the curriculum.

119 Mosquito Identification for the Masses: training seasonal staff, volunteers, and building program capacity for better disease response.

Megan McNairn (mmcnairn@thewoodlandstownship-tx.gov)

Mosquito identification is the bottleneck of any program – especially if faced with a revolving door of seasonal technicians with varying backgrounds. How can a small program build a competent staff capable of accurately processing 2,000 samples a year while filling other operational roles? The Woodlands Township Environmental Services developed a streamlined, pictorial key unique to our location, drawn from a multitude of resources that forms the hub of our mosquito identification training program. Having a pared down and accessible key enables us to train volunteers quickly, adding essential bandwidth to the program during the peak summer period. This process can be applied to any surveillance program, large or small, to create a key unique to your needs. Even small operations without regular adult surveillance can benefit from a tailored identification tool. By rearing larvae collected during inspections and speciating the adults, we are not only better able to identify where to use limited larviciding resources to target vector species, but justify those actions to decision-makers.

120 The NACCHO model for capacity-building in local vector programs

Danielle Chatelain (dchatelain@naccho.org), Chelsea Gridley-Smith

Controlling the spread of vector-borne diseases is the responsibility of a variety of departments nationwide, including local health departments. The National Association of County and City Health Officials (NACCHO) and CDC have worked to support local public health in this effort by establishing a framework of necessary operational capabilities of a vector program: aligned with the American Mosquito Control Association's best practices. A 2017 NACCHO survey of all identified vector control programs in the United States revealed, based on this framework, that 84% of vector control programs

need improvement related to one or more core capability. On the heels of this assessment, NACCHO launched its technical assistance program for local vector programs to provide expertise and resources to support capacity-building efforts. To date, NACCHO has supported nearly 400 local health officials through 137 travel scholarships and more than $190,000 in awards for the 2017 and 2019 annual Vector Summits and two 2019 Vector Control Workshops. NACCHO has also facilitated four cohorts of the Vector Control Collaborative – a peer mentorship program - and reached 26 individual programs through one-on-one technical assistance. A key component in NACCHO's technical assistance program is the Vector Surveillance and Control workgroup, which provides leadership, guidance, and direction to NACCHO's Vector Control Program. This group reviews and disseminates best practices in vector control to assist local organizations in preventing and mitigating zoonotic diseases. Workgroup members also guide the development and delivery of technical assistance and resources tailored to local vector control programs.

121 Overview of a private industry mosquito control program using best management practices

Dan Killingsworth (dan.killingsworth@gmail.com)

Private pest control companies can achieve highly favorable results following best practices for integrated mosquito management (IMM). Heron's Forest is a gated community consisting of 182 residential homes located in Pensacola, FL. It is heavily wooded, features extensive nature trails and is bordered by a coastal saltmarsh preserve. This neighborhood is not regularly treated by municipal mosquito control. Community consensus indicated a desire for biting insect reduction in the commons areas and nature trails. Protection of the nature preserve was heavily stressed. Weekly surveillance with CDC light traps indicated mosquito issues primarily from *Coquillettidia perturbans*, *Mansonia titillans,* and *Aedes vexans,* with moderate but consistent activity from *Culex nigripalpus*, *Cx salinarius*, *Ae atlanticus*, and *Ae albopictus*. In June of 2018, weekly bifenthrin fogging barrier treatments of the commons areas and nature trails were performed along with twenty five percent of residences. After four weeks, every household had been evaluated, source reduction performed where possible and limitations of treatments ascertained. Mosquito populations within the commons areas were reduced by over ninety percent. An ancillary benefit to the scope and frequency of the barrier treatments were the markedly reduced populations of biting midges and yellow flies as the nature trails were the main harborage areas. Treatments continued in 2018 for a period of 4 months with less than 4 gallons of pesticide concentrate used in that timeframe over a two square mile targeted area. Treatment contract periods for 2019 and 2020 were five months. Feedback from a home owner association (HOA) neighborhood survey indicated overwhelming satisfaction with the program. By identifying problem species, locations of infestations, and recognition of neighborhood priorities, a successful, minimal ecological impact mosquito treatment plan was developed and implemented using best management practices.

122 Building on Experience with a Fresh Perspective

AARON LLOYD (Lloyd@lcmcd.org)

The Lee County Mosquito Control District (LCMCD) is located in southwest Florida and tasked with controlling the mosquito populations in 98% of Lee County, FL. Since its inception in 1958, LCMCD has been a leader in the mosquito control arena by developing new technologies that are effective and sensitive to Florida's unique natural habitat, researching more efficient and effective ways to combat pestiferous and disease vector mosquitoes, and ensuring that Lee County citizens can enjoy a comfortable and safe outdoor environment. Lee County has experienced a 22% population growth over

the last 10 years and is projected to be one of the fastest growing counties in Florida for the next 25 years. District leadership continues to conduct administrative and operational evaluations to ensure efficiency and adaptation to the ever-growing demands and challenges of mosquito control. This presentation will cover LCMCD's current efforts to adapt to change, both operationally and administratively, to best serve the citizens of the District.

Legislative and Regulatory Symposium II

123 AMCA federal funding opportunities

Gary Goodman (gwgoodman@fightthebite.net)

The AMCA is committed to finding new and innovative ways to expand the education and benefit to its membership. The federal funding subcommittee's charge has been to explore new opportunities through grants to meet this goal. The AMCA has been successful with two recent Centers for Disease Control and Prevention grant applications to provide additional training opportunities to vector control Districts. This talk will focus on the success of those grants along with a discussion on new directions and partnerships that the AMCA is developing to provide better understanding and education regarding vector control efforts.

124 Unmanned Aerial Systems (UAS) in Mosquito and Vector Control: A Regulatory Overview

Joel Buettner (joelb@placermosquito.org)

Unmanned Aerial Systems (UAS), continue to expand rapidly as an industry. Regulation by the FAA and other related federal and state agencies continue to be a work in progress, but are making progress. I will address the current state of regulations related to use of UAS for mosquito and vector control agencies to operate for detecting or monitoring mosquito habitat, making mosquito larvicide applications, and potential challenges with operating larger UAS and application of mosquito adulticides.

125 Status of Malathion and Chlorpyrifos Endangered Species Act Consultations

Mark Clifton (mclifton@nsmad.com)

Under Section 7 of the Endangered species act, Federal agencies are required to consult and cooperate with the USFWS and NMFS to ensure actions they take further the goals of protecting endangered species. In 2013 the National Academy of Sciences outlined an approach for pesticide registration consultations which was adopted by the EPA and USFWS. In 2018, this new consultation and evaluation process was utilized for the first time to evaluate Malathion, Chlorpyrifos and Diazinon. The results of the first consultation between the EPA and USFWS quickly demonstrated serious shortcomings in the newly adopted consultation process. In late 2018, a new working group was formed to incorporate comments from stakeholders and improve the ESA consultation process. New developments in the ESA consultation process and the reregistration status of Chlorpyrifos and Malathion will also be discussed

126 Development of a National Risk Assessment Methodology for Mosquito Adulticide Usage in Proximity to Endangered Species

Rosemary Burk (rosemary_burk@fws.gov), Nancy Golden

Mosquito adulticide applications of malathion are not restricted spatially or temporally by the product labels. EPA lacked spatially refined malathion mosquito adulticide usage data at the time of the writing of their biological evaluation for the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) registration review of malathion. Therefore, we devised a method to refine the spatial extent of potential application sites. We further refined the overlap area of potential use sites with ranges of species listed under the Endangered Species Act (ESA) for mosquito adulticide in our analysis. We created an overlap map layer by combining three data sources: 1) sales data from FMC (registrant); 2) information from the American Mosquito Control Association (AMCA); and 3) publicly available state data (e.g., California Department of Pesticide Regulation) when available and not captured by other data sources. Multiple sources of information were evaluated for their utility in constructing a map of mosquito control. Challenges to overcome in our methodology included: lack of a definitive source of information where malathion is used as a mosquito adulticide; the epidemiology of arboviruses is difficult to predict; malathion is a critical tool in managing pesticide resistance in mosquito populations and protecting public health; and the 15-year period for registration review for the product. The methodology developed provides a framework for future ESA consultations on FIFRA pesticide registration reviews when sufficient usage data does not exist for a labeled use, and a probabilistic risk assessment is not possible.

127 Seeking a Public Health Exemption for Mosquito Control under the Endangered Species Act

David Brown (dabrownsoj@gmail.com)

As more species listings occur under the Endangered Species Act the AMCA explored the possibility of a unified approach to FIFRA/ESA consultation for professional-use mosquitocides that could minimize the need to develop measures on a product-by-product basis. The concept involved language on the public health mosquito control label that would point to Best Management Practices as part of the Directions for Use. This paper will provide a brief overview of the discussions and negotiations that occurred between all parties.

128 An approach to uniform labeling in implementing the outcome of FIFRA/ESA mosquitocide consultation

Bernalyn McGaughey (bmcgaughey@complianceservices.com)

This presentation will provide an update on AMCA's discussions with the Environmental Protection Agency Office of Pesticide Programs (EPA OPP), the US Fish and Wildlife Service (USFWS) and (potentially) the National Marine Fisheries Service (NMFS, together with USFWS, "the Services") regarding the development of a model program in support of streamlined Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)/Endangered Species Act (ESA) consultation for mosquito control products used by AMCA members (primarily, US Mosquito Control Districts). The goal is to (1) develop and have accepted a single labeling statement (or collection of statements) for ESA compliance that can be used on any FIFRA-registered pesticide with professional mosquitocide uses; (2) achieve a US Fish and Wildlife Service (FWS)-accepted Best Management Practices (BMP) and preparedness guide or manual that sets AMCA-agreed standards for mosquito control while protecting ESA-listed species; and (3) obtain an EPA-accepted label mitigation statement reflecting goals (1) and (2). To do this, AMCA and its consultants have developed a conceptual outline of a national mosquito control consultation plan that can streamline FIFRA/ESA consultation. AMCA initiated discussion on this idea by meeting with EPA OPP and explaining the basic idea that a consistent label for professional-use mosquitocides can accommodate

both EPA OPP's concerns with the safe use of these products and the Services concern about protecting ESA-listed species.

The tools used in professional mosquito control are of small volume and frequency of use when compared, for example, to the use of pest control methods in cropping systems. While the same active ingredient (or mechanism) may be used in both settings, the rates, timing, and methods of application are vastly different and thus present different exposure and risk scenarios to humans and non-target organisms. However, under FIFRA regulatory review practices currently employed by EPA's OPP, where risk evaluation is driven by all uses on a label, with the heaviest use often driving the label's language, the unique methods used in and needs for mosquito control may not be fully addressed, resulting in overstatement of risk for mosquitocide applications or lack of context of risk from mosquitoes themselves as vectors of human diseases. This can result in unworkable and unnecessary mosquitocide use restrictions, loss of active ingredients available to control mosquitoes, increased chance of target pest resistance, inhibitions on immediate response to human disease threats, and public mistrust of professional mosquito control programs.

Adding further concern about restrictions on available tools and their labeling, are the EPA OPP publications of the final Biological Evaluation (BE) determinations on malathion and chlorpyrifos and draft BE determinations on methomyl and carbaryl, which conclude potential risk to ESA-listed species from the use of these products in most settings, including mosquito control. At the writing of this abstract, the partner evaluations under the FIFRA/ESA consultation process - - the Services Biological Opinions (BiOps) on EPA OPP's action to re-register these products - - had not yet been published. When BiOps are published, they are likely to come with specific requirements for EPA OPP to take certain labeling or other actions to protect ESA-listed species that the Services considers at risk of harm from product use.

Potentially, these active ingredients could be lost for mosquito control or at best, labeled directions for use could become extremely burdensome for any active ingredients remaining registered for mosquito control. AMCA believes that rather than developing label directions for the protection of ESA-listed species for every mosquito control product independently, there is a more efficient way to ensure the protections necessary for ESA-listed species. Professional mosquito control is driven by local public health entities and the timing and threats of local mosquito outbreaks. AMCA therefore wishes to develop a program of best management, education and collaboration that can be generically referenced under nationally registered label's directions for use and implemented in a well-informed local setting. The regulatory agencies will need to understand the setting and agree to treat it with the uniqueness it deserves.

Phase 1 of this proposed project to set the stage with the agencies involved (primarily EPA-OPP and FWS) is underway at this writing. AMCA believes that there are two existing mechanisms that serve as foundational examples for mosquitocide labeling and ESA-listed species protection in the FIFRA/ESA consultation setting. These are:

- U.S. Fish & Wildlife Service Handbook for Mosquito Management on National Wildlife Refuges (June 2018): This handbook took many years to develop, and it is now implemented as a national program for providing best management practices to both control mosquitoes and protect non-target species. If a product's label pointed to a document like this, the use of the recommended BMPs in the handbook could provide the mitigation the Services are looking for with respect to listed species protection

- Pesticide Registration Notice 2005-1. Labeling Statements on Products Used for Adult Mosquito Control: This notice was developed in response to labeling challenges arising as a result of the implementation of the Food Quality Protection Act (FQPA). It provides an approach to labeling professional use mosquito control adulticides and was developed with input from AMCA. It suggests that mosquitocide uses can be handled with the uniqueness they require.

These documents are only examples of "calling out" special measures to address mosquitocide use and therefore provide examples for consistent labeling and workable BMP's. Using these models, we hope to see the involved agencies address the outcome and implementation of FIFRA/ESA consultation process by making labeling and BMPs work together. This presentation will explain what these examples provide and how they can be modified and/or combined to protect species while presenting minimum inhibition of mosquito control. Because agency interactions have only begun, we will also address to what point AMCA discussions with agencies have come.

129 Creating a BMP for mosquito control near pollinators

Michael Riles (michael@pcbeachmosquito.com)

Best management practices (BMP) for mosquito control applications near pollinators is a much-needed document for the American Mosquito Control Association. Forming the document is a rigorous and time-consuming process. These BMP's are situated from the Beekeepers and Mosquito Control: Building a Bridge communication symposium in Orlando, Florida at the 2019 annual meeting. An outline for the document has been formed and the next steps of authoring the document is discussed.

130 Mosquito control on National Wildlife Refuges

William Meredith (William.Meredith@delaware.gov)

Latest perspectives concerning conducting operational mosquito control on U.S. Fish and Wildlife Service (USFWS) National Wildlife Refuges. Update on the status and implementation of the USFWS's new "National Handbook for Mosquito Management on National Wildlife Refuges." Other topics include the USFWS's issuing refuge-specific annual Special Use Permits to enable local mosquito control programs to work on-refuge, coping with endangered species issues on-refuge, and developing refuge-specific Mosquito Management Plans.

Twenty Years of West Nile Virus: Past, Present and Future Symposium I

131 Overview of West Nile Virus in the United States

Janet McAllister (jvm6@cdc.gov)

West Nile virus (WNV) was first identified in Uganda in 1937. WNV is normally circulated between birds and mosquitoes with horses and humans as incidental or dead-end hosts. Culex spp mosquitoes are the main vectors of the virus in the United states. Prior to 1999 the virus was commonly found in Africa, West Asia and the Middle east with periodic outbreaks occurring in Europe. In 1999 New York City was saw WNV identified for the first time in North America. Subsequently the virus spread across the continental United States. The virus is now endemic in North, Central and South America. The history of WNV in the US, trends in virus activity and novel things learned along the way will be discussed.

132 Changing the Public Perception of Mosquito Control

David Brown (dabrownsoj@gmail.com)

Mosquito control prior to 1999 was generally conducted as “nuisance control”, with isolated control measures to address local outbreaks of Eastern, St. Louis, or Western Equine encephalitis. The introduction of West Nile virus changed how mosquito control is conducted and necessitated a change in how the public perceives adult mosquito control measures. By looking at events surrounding the first urban aerial adulticide missions that the Sacramento-Yolo Mosquito and Vector Control District conducted, this presentation will discuss the challenges of informing the public on what needs to be done to stem a disease outbreak, how a disease control program should be developed, and the need to have the political will to implement the program when disease thresholds are met.

133 Responding to WNv Disease Outbreaks in Areas without Established Mosquito Control Districts

Daniel Markowski (dmarkowski@vdci.net)

Prior to the introduction and isolation of West Nile virus (New York City, 1999) there had not been a major mosquito-related disease outbreak in the United States for approximately 20 years. With the virus’ rapid spread across all 48 contiguous states, there was a need for communities to combat the virus and the mosquitoes that transmitted it. Although there were sporadic occurrences of mosquito-borne viruses (SLE, EEE, WEE, LAC) in the US, mosquito control programs across the country were dwindling in the late 1990s. As a result, many municipalities relied upon private contractors to fill the need to combat WNv and initiate a balanced, integrated program for their residents. Vector Disease Control International (VDCI) was just one of those private contractors. Our staff was on the frontline of the infection as it spread throughout the Northeast and into the Southeast in 2003. By the time it reached the Northwest a couple years later, we helped multiple communities throughout the region both in the air and on the ground. Many of our most stable and complete programs today are the result of initial concerns about WNv. As many communities soon realized, properly administered mosquito control programs could not only reduce the risk of disease transmission, but we were also able to safe guard their communities from future disease threats and reduce the annoyance of pesky mosquito complaints, as well. The establishment of some of these mosquito control programs and the methods we used to build these programs from the ground up will be discussed.

134 Genomic epidemiology of West Nile virus in California

Karthik Gangavarapu (gkarthik@scripps.edu)

Since its introduction in 1999, West Nile virus has become endemic in the United States and has caused 45,000 confirmed human cases and 2,000 deaths. The virus causes localized outbreaks in the summer but the size and timing of these outbreaks is heterogeneous within and across different states and counties. To investigate the drivers and dynamics of seasonal West Nile virus outbreaks, we partnered with vector control and other public health labs across the United States and started the WestNile 4k (https://westnile4k.org/) project. As the first phase of the project, we sequenced over 700 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. Using a combination of genomic and epidemiological data, we were able to quantitatively assess the contribution of environmental and ecological factors to West Nile virus transmission in California. The

high spatio-temporal sampling allowed us to understand the overwintering dynamics of West Nile virus in counties with varying climatic conditions. We applied a similar methodology to elucidate the transmission of the virus on a localized scale in three cities: San Diego (San Diego county), Bakersfield (Kern county), and Davis (Yolo county). Our study shows how genomic epidemiology can be used on a city and state-level to investigate mosquito borne viral outbreaks and develop effective mitigation strategies.

135 West Nile Virus in Dallas County

Scott Sawlis (scott.sawlis@dallascounty.org)

Dallas County Mosquito Control functions as a division of Dallas County Health and Human Services to conduct regular, year-round, and thorough mosquito surveillance throughout the county and respond quickly with adulticide applications when mosquitoes are found to be positive for West Nile virus. WNv was first identified in Dallas County in June 2002 from an avian tissue sample. Since then, there has been variation in the severity of our yearly WNv cycle, with the largest outbreak occurring in 2012. In that year, 398 human cases of WNv were reported including 21 fatalities. Following this outbreak, we updated our procedures to increase mosquito surveillance throughout the county and created new, full-time positions within our mosquito control division. Currently, over 7,000 mosquito traps are set yearly from which approximately 5,500 mosquito samples are tested by our departmental lab. We are able to maintain our robust WNv surveillance and control program through the utilization of a contractor and with the cooperation of the 25 municipalities of Dallas County and the Texas Department of State Health Services.

136 West Nile virus in the Northeast: current challenges and future directions

Priscilla Matton (brismosqpc@comcast.net)

The Northeast region encompasses nine states: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Pennsylvania. The geography and funding mechanisms differ significantly in the region. Current challenges faced by the region include expanded seasonal activity and balancing resources, local infrastructure, new vectors or other arboviruses. Lack of public interest for West Nile virus is a concern. Different approaches to surveillance and human case monitoring will be a factor moving forward. Greater communication between agencies, further research on surveillance methods and climate change will be explored.

Latin American Symposium II

137 Mosquitocidal Potential of the Widow Spider α-toxin

Abraham Landeros (landerosa2@jacks.sfasu.edu), Kaleth Salazar, Lindsay Porter

In mosquito control, new tools are ever needed and insect-specific toxins represent a viable option. In this study, homology-based resolution determined the α toxin sequence of brown widows and bioinformatic analysis, spatiotemporal expression, and recombinant production were employed to deduce toxic properties. Patchy sequence conservation was observed, expression is ubiquitous, and the

protein is large with multiple ankyrin domains, similar to other insect toxins. Data here support its potential for development as a mosquitocidal toxin.

138 Use of drones at fine scale for the association of demographic, socioeconomic and environmental factors with the abundance of Aedes aegypti (Linnaeus) mosquitoes Diptera: Culicidae, in persistent areas for the transmission of Dengue in Tapachula, Chiapas.

Kenia Mayela Valdez Delgado (kenia.valdez@insp.mx), Ildefonso Fernández Salas, Rogelio Danis Lozano, Graciela González Farías, Víctor Muñiz Sánchez, Cecilia Izcapa-Treviño, Luis Alberto Cisneros Vázquez, José Genaro Ordóñez González, David Moo Llanes, Moo Llanes

An efficient and timely tool to visualize, analyze and determine the factors associated with the abundance of Aedes aegypti mosquitoes is necessary in a country that faces diseases such as dengue, zika and chikungunya every day. Drones collect detailed spatial information in real time at a relatively low cost and their use avoids many of the limitations associated with satellite data, e.g. long repetition times, cloud contamination, low spatial resolution, lack of homogeneity in camera angle or shooting time. Our study goal was to evaluate a high-definition surveillance system based on the use of drones to determine risk areas for the presence of Ae. aegypti mosquitoes in Tapachula, Chiapas. We collected aerial images of 205 houses at 80 m to identify and map breeding sites, tree cover and the backyard conditions of premise condition index. At the same time, ground surveillances used to obtain entomological indexes, demographic, socioeconomic data and premise condition index too. In addition, we compared the use of the aerial surveillance versus traditional program surveillance tools. We found that drone aerial surveillance could use as a tool for identifying the probability of Ae. aegypti mosquito abundance in the residential environment. The maps obtained from the drone information can be add to the maps already used by the local vector control program, which will help improve decision-making with local conditions, with adequate coverage and opportunity to take action at all levels. Finally, an algorithm can be add to send real-time alerts in presence of high entomological risk houses.

139 The importance of the prevention of the Aedes aegypti mosquito in Puerto Rico during the COVID-19 pandemic

Julieanne Miranda-Bermúdez (jmiranda@prvectorcontrol.org), Rafael Saavedra, Marianyoly Ortiz-Ortiz, Grayson Brown

Aedes aegypti is the most serious vector for dengue, Zika, and chikungunya. This mosquito is present year-round in Puerto Rico as is the public health threat from these endemic arboviruses. The Integrated Vector Management strategy used by the Puerto Rico Vector Control Unit (PRVCU) relies heavily on community mobilization programs. The community mobilization division within the PRVCU organizational structure implements a variety of community engagement, education, and partnership programs. Due to COVID-19, PRVCU developed educational videos, virtual educational talks, and digital support material. Three videos were developed for elementary and high school levels, and a story reading about the mosquito Ae. aegypti. A virtual summer camp was developed and delivered through social media. Between March and August 2020, the PRVCU has instructed more than 5,600 students from 160 schools in Puerto Rico. Also, more than 25 educational virtual talks were delivered to a total of more than 2,000 people. The PRVCU delivered 6,000 mosquito repellents, 650 larvicides, and 10,000 Ae. aegypti mosquito prevention educational materials [these numbers will be updated before the presentation]. Other on-going initiatives were strengthened such as text messaging, educational posters displayed in businesses, loudspeakers, and the use of the PRVCU's downloadable application to reduce

breeding sites. Although this effort was effective, we need to continue improving methods for correlating community outreach efforts with the actual impact on vector populations and, ultimately, human disease. In this presentation, we will discuss our efforts at improving that methodology.

140 Resistance to temephos in Aedes aegypti (L) from Mexico

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Aedes aegypti (L) is the main vector of dengue and other arboviruses in Mexico. The Ministry of Health reported 10,357 cases at the epidemiological week 37 of 2020. The use of organophosphate insecticides began in 1981 when temephos was introduced, prolonging its use for almost 40 years. Resistance to temephos has been recorded in other countries in Latin American, but no in Mexico. The present work aims to determine the frequency and intensity of the resistance with the use of 1X, 5X, and 10X of the Diagnostic Dose (DD) of 0.0125 mg/L (WHO 1998). We evaluated fourteen populations of Ae. aegypti from eight states of Mexico, exposing 25 larvae per replicate (4 replicates) of the third late and fourth early larvae instars in 250 ml glass beakers with the DD of temephos. All populations of Ae. aegypti evaluated resulted resistant to temephos (mortalities <90%). The intensity of resistance was moderate for the 79% of the populations and high intensity was found for the 36% of the populations analyzed. We demonstrate that the resistance to temephos in Ae. aegypti is high with moderate and high intensity; it is urgent to incorporate the management of resistance to temephos in mosquito control programs in Mexico.

141 A regional arbovirus surveillance system for the Caribbean basin and Latin America

Nicole Nazario (nnazario@prvectorcontrol.org), Joanelis Medina, Michael Jimenez, Marianyoly Ortiz-Ortiz, Grayson Brown, Luz Crespo

Xenomonitoring (monitoring vector populations for the presence of vector-borne pathogens) has long been a limited resource in Latin America and especially in the Caribbean basin. The recent outbreaks of dengue fever have illustrated this as the various island countries have had difficulty getting their mosquito pools tested on a timely and economical basis. Thus, the ability to target vector control operations to those areas with active virus circulating in the vector population has been consistently compromised. To help alleviate this problem, the Puerto Rico Vector Control Unit (PRVCU) has established a service-oriented molecular biology laboratory that is now offering mosquito pool testing on an economical basis throughout the region. The laboratory mirrors the main system used by the CDC Dengue Branch whose technicians assist in implementing new protocols as they are developed. Hence, the laboratory will always be capable of conducting the newest tests for whatever pathogen is of concern. This presentation describes that laboratory, its services, and procedures for having mosquito pools tested.

142 Effectiveness of Actellic® 300 CS (Pirimiphos-methyl 28.9%) as alternative ULV formulation to control indoor and outdoor adult Aedes aegypti resting populations, at Monterrey, Northeastern México

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Increased pyrethroids resistance in Latin American countries is challenging Vector Control Programs to move either to newly developed insecticide groups or to safer and well-known

organophosphate compounds. Actellic® 300 CS is a capsule suspension formulation designed to protect residuality when acting by contact during indoor residual spraying (IRS). However, Actellic® 300 CS studies focusing on its airborne properties have been poorly documented. Considering a couple of interesting facts: being an organophosphate product and presenting very low dermal and oral toxicity (>5000 mg a.i.); we conducted a small-scale ULV treatment upon 10-households in Monterrey city, NE Mexico.
Groups of female Aedes aegyptiAedes aegypti were placed in 15 x 10 x 30 cm cages distributing two at room indoors, and one at outdoor house backyards. Two control houses were used concurrently. Actellic® 300 CS was prepared to mix a 833-ml commercial bottle up to complete 10 L of water. The average volume of households was 175 m3, thus we calculated that a dose of 0.02 g of a.i./m3 or 20 g a.i./1000 m3 were sprayed. There was not documented ULV indoor dose data, so we decided to use it for our cold fogging trial. Our aim was to explore the potential results of airborne activity of the capsule formulation. The flow rate was 150 ml/min while the mean diameter of the microdroplet were 23.7 microns.
Results: Indoor and outdoor 24-h mortality resulted in 100% for both house areas, respectively. Females Ae. aegypti were knocked-down 1-h after spraying as high as 99.2% and 97.5%, indoor and outdoor, respectively. Results show an optimistic potential of recommending Actellic 300 CS as a house ULV treatment during severe Dengue outbreaks in Latin America.

Operations I

143 Strategic use of prehatch larvicides can optimize your mosquito control operations

Mark Smith (mmcd_mes@mmcd.org)

Mosquito abatement districts have many prehatch formulations and strategies available to use in their daily operations, but which are best to optimize effectiveness and efficiency? A review of the Metropolitan Mosquito Control District's operational prehatch considerations may assist in developing new ideas and methods in your organization.

144 2020 bites! Volusia County Mosquito Control operational improvements

Miranda Tressler (mtressler@volusia.org), Sue Bartlett, Tim Machardy, Caroline Efstathion

Volusia County Mosquito Control is a dependent district of about 340,000 acres in central Florida. Our robust program consists of a variety of habitats including salt marsh, floodwater, and domestic mosquitoes. Daytona Beach, a popular destination location, is located within our district and a key area for treatments for large events and on-going tourism.
Volusia’s integrated mosquito management program tackles mosquitoes by ground and air using a variety of specialized equipment. The district is inspected daily by seven Field Inspectors who conduct proactive larviciding and respond to customer service requests in their assigned areas. Surveillance is conducted using sentinel chickens and a variety of mosquito traps to monitor virus activity and key species. This data collected is reviewed to plan truck ULV operations using our nighttime crew of part-time drivers.
Our aircraft inventory consists of a MD 520 Notar and a recently purchased Bell 206 Long Ranger. Our aerial operations program conducts routine inspections in our salt marsh, sod farms, and rural areas adjacent to housing developments or populated areas. Our MD Notar helicopter is equipped for

larviciding and adulticiding, with our recently purchased Bell in the conversion process to be utilized next season.
Volusia's environmental operations, which is recently fully staffed, has developed an extensive resistance management plan to improve efficiency of operations and products used in the field. As our program continues to fill vacant positions and overcome the various challenges of COVID-19 we are preparing for new challenges in the upcoming 2021 mosquito season.

145 Phase 1 and 2 is in our back pocket- Let phase 3 begin in earnest! Utilizing classic mosquito biocontrol agents within local conservation preserves and park lands in Harris County, Texas Precinct 4.

Anita Schiller (aschiller@hcp4.net)

Totaling a combined 10,000 acres of varied public recreation lands, Harris County, Texas Precinct 4 is home to 39 precinct owned multi-use parks, including pocket parks, large complex sports fields, conservation forest preserves, botanic gardens and close to 60 miles of hard surface, all weather trails. Conventional pesticide-based mosquito adulticiding takes place on a calendar basis in all sport league parks, prior to special events and when requested by park managers on an "as needed" basis; however, pesticidal mosquito interventions are not allowed in the precincts' designated conservation preserves. One core mission of the mosquito biological control initiative is reducing biting populations of anthropophilic, medically significant, and opportunistic species within parks and preserves where trail connectivity links visitors with vectors, as well as along park to residential area boundaries. Being a novel program, a roadmap to meet objectives identified three phases for the operation which were Phase 1: identification and evaluations of biocontrol agents (bca's); 2: bca production; and 3: application and release of the bca's.
Here we are sharing the initiative's' current biocontrol agents, their rearing and production parameters and demonstrate opportunities for integrating augmentative and inundative biocontrol strategies and address conservation concerns.

146 Rise of the machines: BG-Counters' expanding role in CMCD's mosquito surveillance program

Rebecca Heinig (rheinig@cmcd.org), Jorge Puente, Peter Brake, Nathan Phillips, Keira Lucas

Collier Mosquito Control District initiated its BG-Counter program in 2017 with 10 traps. As of the 2020 field season, we had one of the largest BG-Counter networks in the country, with 27 permanent traps placed throughout the District. This presentation will discuss the District's experience with this technology, including an assessment of labor inputs vs. outputs, as well as the lessons we've learned in scaling up our program. We'll also introduce side-by-side data from our weather station pilot program, which was designed to enhance the value and utility of the information generated by the BG-Counters.

147 Controlling invasive Aedes in Los Angeles County Schools

David Lopez (dlopez@glacvcd.org)

Late in the summer of 2011 *Aedes albopictus* was rediscovered in Los Angeles County. At the time, Greater Los Angeles Vector Control District (GLACVCD) put together an intensive and exhausting door to door inspection and truck mounted larviciding campaign in the area of the initial finding. The initial rediscovery of *Aedes albopictus* was followed four years later with the detection of *Aedes notoscriptus* and *Aedes aegypti*. These tiny black and white, invasive mosquitoes started making their

way into neighborhoods and schools alike. In schools, the bite pressure of these invasive mosquitoes can disrupt classes and in some cases cause parents to remove their child until the problem has been addressed and fixed. As a result, our agency begun to focus control efforts in Los Angeles Unified School District (L.A. Unified) which is the second largest school district in the country. Do to the size of the school district we needed to establish a training program for the appropriate school staff that focused on source identification inside and outside of the classrooms, use of appropriate control methods, the importance of documentation, and addressing the challenges that schools faced by being part of a union.

148 Developing a seasonal ULV training model that incorporates social distancing without sacrificing hands-on interaction

Rebecca Riley (rebecca.riley@phs.hctx.net), Elisa Castillo, Arthur Baltrip

The COVID-19 pandemic posed a unique challenge for training seasonal ULV drivers in 2020. Current training for these positions relied on face-to-face interaction and on-the-job instruction making it difficult to deliver without modifications. Prior to the arrival of seasonal staff, developing a new training model that incorporated social distancing while ensuring internal and state requirements were met was a necessity. Resources were limited and included basic business software, Adapco Monitor IV, and GeoTracker. The addition of basic learning management software and some creative thinking were the final pieces to developing a product that allowed us to successfully provide online classroom modules and socially distant on-the-job training. The final product included new training content, flexible delivery options, and scored assessments.

149 2020 Hurricane Response

Broox Boze (bboze@vdci.net), Malcom Williams, Daniel Markowski, Buddy Hollis

Vector Disease Control International (VDCI) has a long history of aiding mosquito control efforts necessary for recovery after natural disasters like hurricanes and major floods. No matter how many times we've done it, each storm, year, and geography present a unique set of challenges. When these situations arise, state and county agencies implement emergency response plans and many rely on Federal Emergency Management Agency or private contractors for assistance in reducing mosquito populations that can alter arbovirus transmission cycles, cause intolerable stress, hamper reconstruction efforts, and disrupt normal community function. This presentation illustrates many of the challenges faced by our team while performing large scale emergency response during a record-breaking season with 4 named storms making landfall in Louisiana alone.

150 Automated county level mosquito surveillance program

HANAN LEPEK (Hanan@senecio-robotics.com)

Monitoring local mosquito population is a tedious job. Surveillance is limited to the man power and number of hours a county mosquito abatement district can put on counting mosquitoes coming in from the plethora of field traps. An abatement district which lack sufficient man power, would often use landing rates and bite counts as a method to measure adult mosquito activity in a specific area. Imagine, what if a county could have spread hundreds of low-cost mosquito traps without concerning if it has enough man power for the job? Join the lecture and stay updated with the latest news about a game changer technology and how mosquitoes can be monitored over large areas. During the presentation actual results and solution architecture will be discussed. The presentation will demonstrate how deep

learning neural networks and advance software and hardware tools are combined into a single solution, advancing mosquito surveillance operations to a whole new level.

151 Are early adopters of Unmanned Aircraft Systems (UAS) transforming vector control agencies across the United States?

Bill Reynolds (breynolds@leateam.com)

The use of unmanned aircraft systems (UAS) has grown exponentially in the last 15 months and transformed mosquito control operations across the United States. This presentation will focus on many of the agencies that have incorporated UAS for aerial surveillance, imagery, and applications and the specific solutions the technology solved to some common challenges surrounding the inspections of habitats, documentation of environmental events, and aerial applications to control immature and adult mosquito populations. Participants will also learn about the latest advancements in UAS technologies and future capabilities.

Rated SIT: Sexual Content No Children Allowed Symposium

152 Developing Sterile Insect Technique for Aedes aegypti control in the U.S.

Kenneth Linthicum (kenneth.linthicum@usda.gov)

Aedes aegypti mosquitoes pose a significant public health threat to the world as a vector of Zika, dengue, chikungunya and yellow fever viruses. The control of this domestic mosquito is highly problematic given the multitude of cryptic immature stage development sites that they can utilize. Sterilization of insect pest populations through radiation using Sterile Insect Technique (SIT) has been in use for controlling agricultural pests and has been available for mosquito control since the mid-1950s. However, SIT is not currently used by mosquito districts in the U.S. as a routine control method in Integrated Vector Management plans. Given the recent interest in genetically modified mosquitoes and *Wolbachia* infected mosquitoes for controlling mosquito populations, a potentially more cost effective and in-house operation involving radiation is being developed between the U.S. states of Florida, California and Texas and some of their local mosquito control districts, the University of Florida, and the USDA to sterilize locally colonized strains of mosquitoes. To properly evaluate the survivorship and population size of wild populations and the movement of released *Ae. aegypti* following treatment and release, a mark-release-recapture study was performed. Marked irradiated male *Ae. aegypti* were released every week in a North Florida community. We present our findings on survivorship, distribution, movement of released mosquitoes, and issues encountered with such a technique and its application towards control programs involving Ae. aegypti male sterilization with radiation.

153 Startup costs associated with an X-ray SIT Program at the Lee County Mosquito Control District

David Hoel (Hoel@lcmcd.org), Rachel Morreale, AARON LLOYD, T. Wayne Gale

Sterile insect technique (SIT) is an older technology that has only within the last several decades gained traction as a control tool useful to integrated vector management. Various agricultural pests are targeted by SIT, and SIT has recently been shown useful for controlling *Aedes* container-breeding mosquitoes, vectors of yellow fever, Zika, chikungunya and dengue viruses. A small scale X-ray

sterilization program was begun in 2017 at the Lee County (Florida) Mosquito Control District (LCMCD), after consultation with the International Atomic Energy Agency (IAEA) and mentoring from IAEA, the Centers for Disease Control and Prevention, and the University of Florida. LCMCD is a sizeable organization compared to most mosquito control districts within the US, however, our experience in standing up an SIT program demonstrates that with proper budgeting, such a program is possible for other districts. Chief costs associated with an SIT program include labor ($320K to $570K/year (including employee benefits)), capital equipment $600K, and facility construction or modification. From mid-2017 to mid-2020, LCMCD spent approximately $1.9M before the first releases of *Ae. aegypti* began in June, 2020. LCMCD releases 100,000 sterile males per week and will soon attempt 500,000/week after the arrival and installation of specialty equipment necessary to increase production. The 2020 SIT cost to LCMCD for personnel, consumables, and travel-training is $650,000.

154 Just add water - a game changing tool to control Aedes aegypti

Kevin Gorman (kevin.gorman@oxitec.com), Zoe Barnes, Ben Sperry

Oxitec has developed a game-changing new product to aid the fight to control *Aedes aegypti,* the vector of dengue and Zika and other dangerous diseases. Also known as OX5034, this product is a self-limiting male-only mosquito that is combined with a 'just add water' rearing box, providing *in situ* rearing and release of a male-only adult cohort directly in the field. The exiting adult males fly off in search of wild females to mate, passing on their self-limiting gene to all progeny, killing only the female offspring. Oxitec has focused the design of this 'just add water' product on accessibility, scalability, and simplicity, to bring an effective control tool to communities, for use by municipalities, service providers, and retail customers. The first validation of this new product was carried out in Indaiatuba, São Paulo, Brazil in 2019/2020 and resulted in 95% suppression, 6 weeks faster than was predicted, and with zero females released. In 2021, Oxitec will also be carrying out pilot projects of this just add water product in the Florida Keys, to further demonstrate its safe, simple, and effective use in controlling *Ae. aegypti* in areas at risk from disease transmission.

155 Planning and implementation for genetically modified male release trials in the Florida Keys

Andrea Leal (aleal@keysmosquito.org), Chad Huff

After receiving federal, state, and local approvals, the Florida Keys Mosquito Control District is collaborating with Oxitec Ltd. on trial releases of genetically-modified male mosquitoes for the control of *Aedes aegypti*. These trials are the first of in the United States. Due to this, extensive community engagement and project planning has occurred throughout the regulatory process and following approvals. Trials are set to begin in 2021.

156 Technology to make SIT feasible at scale, including automated monitoring, sex sorting, packaging and distribution

Ralph Breslauer (rsb5779@gmail.com)

In order to practically implement SIT at scale in the field, numerous tasks need to be automated. This will allow us to overcome the cost and resources limitations of today's manual processes by moving them to computer driven automated ones. From automating identification and counting of mosquitos from existing traps, to large scale AI driven sex sorting, to packaging and then distributing sterile male mosquitos by hand release, truck, drone or air, depending on local needs. Come and hear about the

current state of this technology and near term plans. In addition, after being selected by the EU Innovation Council for their Green Deal program learn about the the large scale demo facility for SIT being built as a global resource for those considering adding SIT to their integrated mosquito control program. This is being done in conjunction with leading partners from Europe and America.

157 Natural Vector Control (NVC) – Using SIT to prevent dengue in the midst of an epidemic

Nitzan Paldi (nitzan@forrestinnovations.com)

Despite extensive efforts to prevent recurrent Aedes-borne arbovirus epidemics, there is a steady rise in their global incidence.

We present a Sterile Insect Technology (SIT)-based program that utilizes sterile male mosquitoes generated by treatment with specific double stranded RNA and thiotepa, to effectively suppress a local Aedes aegypti population. To test the efficacy of this approach, a field study was conducted in a Brazilian city (Jacarezinho), which presented a history of 3 epidemics of dengue in the past decade. Sterile male mosquitoes were produced from a locally acquired Aedes aegypti colony, and releases were carried out on a weekly basis in predefined areas. The releases were divided in two intervention periods over a period of two years, for seven months (INT1) and then another five months (INT2), whereby INT2 was effectively a reversal of study and control areas from INT1. Two regions of Jacarezinho (Parana, Brazil), with similar size, layout, historic mosquito infestation index, socioeconomic patterns and comparable prevalence of dengue cases in past outbreaks, were selected as the study areas.

We show that the successful relative suppression (up to 95% lower than control) of the local mosquito population in INT1 was associated with a 16 fold lower incidence of dengue in the treated area (264 cases per 100,000 inhabitants) compared to the control area (4,360 dengue cases per 100,000 inhabitants). When the control and treatment areas were reversed during the second intervention period (INT2), the relative reduction of dengue incidence in the treated versus control areas was similar (590 and 8,070 per 100,000 inhabitants respectively).

The Secretary of Health of the State of Parana, Brazil, has provided formal accreditation to the Forrest's NVC and commercial projects have now begun in several cities in Parana State.

158 Moving gene drive technology from laboratory to field deployment: designing field trials.

Anthony Cornel (anthony.j.cornel@gmail.com), Gregory Lanzaro

The goal of the University of California Irvine Malaria Initiative is to contribute to malaria eradication using genetic technologies. We will discuss overall strategies (suppression vs modification), field site selection, baseline data collection, community/regulatory engagement and post-release surveillance. The UCIMI is currently in the field site characterization phase on two geographically isolated oceanic archipelagos, namely The Democratic Republic of São Tomé and Príncipe (West Africa) and the Union of the Comoros (East Africa). We believe that oceanic islands provide the best environment for a confined field trial. We will discuss our ongoing research activities.

Twenty Years of West Nile Virus: Past, Present and Future Symposium II

159 More than West Nile virus – maintaining priorities within a full vector program

Jennifer Henke (jhenke@cvmvcd.org), Kim Hung, Jeremy Wittie

The Coachella Valley Mosquito and Vector Control District in southern California was founding in 1928 for the control of eye gnats and added mosquitoes to its program in the 1950s. Surveillance for arboviruses began in 1977 following detections of St. Louis encephalitis virus in residents.
West Nile virus was first detected in the Coachella Valley in 2003, which was also the last time that SLEV positive mosquito samples were detected until 2015. In the time of SLEV no longer being a priority, West Nile virus was the priority of the District's surveillance, operations, and public outreach teams. Besides the re-emergence of SLEV, the District has also added a robust red imported fire ant surveillance and control program (2005) and inspections and treatments for the invasive mosquito *Aedes aegypti* (2016). Since 2014, West Nile detections have not followed the previous patterns of SLEV or western equine encephalomyelitis virus (WEEV). Whereas the latter two viruses are typically first detected near the Salton Sea at the east end of the valley and slowly move their way inward to the western cities, West Nile has recently been detected sporadically in the western cities and then detected later in the season in the eastern end of the valley. In 2019, West Nile was detected in multiple cities simultaneously, at higher rates and more abundantly than in any other year.
Maintaining priorities and balance at a vector control district is a necessary and sometimes difficult balance. Here, we will review the changing structure of the programs to ensure that the district could minimize the risk of virus transmission to the residents while maintaining other vector control programs.

160 Making the most of mosquito and arbovirus surveillance data

Christopher Barker (cmbarker@ucdavis.edu)

Integrated vector management (IVM) programs rely on surveillance data to guide mosquito control decisions to protect human health. These data arise from diverse sources and vary in both quality and quantity, with a high degree of uncertainty associated with surveillance observations when evaluated at spatial and temporal scales fine enough to target control. Since 1999, the presence of West Nile virus as an ongoing human health concern in the USA, combined with emerging computing resources and other technologies, has spurred exciting advances in tools that translate data into evidence for integrated vector management. In this presentation, I review the advances in this area during the twenty years since the arrival of West Nile virus.

161 Vector index as a driver for control

Hannah Romo (hannahromo@gmail.com), Brad J. Biggerstaff, Roxanne C. Connelly

Surveillance-generated indices such as mosquito abundance, sentinel avian seropositivity, or vector infection rates help control agencies determine when control actions mediating adult mosquito populations should occur. The vector index (VI), the sum of the products of the average number of mosquitoes collected per trap-night and an estimate of the infection rate over vector species, was incorporated into many vector surveillance programs following the introduction of West Nile virus (WNV) into the continental United States. The index is roughly proportional to the number of WNV positive mosquitoes in a given area per trap night and studies have shown that the VI is positively correlated with human risk. For agencies making public health vector control decisions, the VI represents a measure of action, with thresholds for control often set at the community level. In areas where there is a single primary WNV vector, species-specific surveillance strategies and integration of surveillance data into the VI is straightforward. For communities with multiple WNV vectors, incorporation of abundance and infection rate data from multiple species and traps into the VI can be

challenging. We examine different components of the VI and analyze how the inclusion of surveillance data from multiple WNV vectors can impact the association of the VI with human cases.

162 Real time West Nile virus forecast: operational challenges

Nicholas DeFelice (nicholas.defelice@mssm.edu)

West Nile virus (WNV) is the leading cause of domestically acquired arthropod-borne viral disease in the United States. However, there is considerable inter-annual variation in the number of human cases. As a consequence, effective allocation of public health resources is challenging and often reactive, a circumstance that highlights the need for accurate, real-time forecasts of the burden of disease. Recently, we showed that accurate and reliable predictions of seasonal WNV outbreaks can be made using a mathematical model that represents WNV transmission dynamics among mosquitoes and birds, as well as spillover to humans. The mathematical model representing WNV transmission is optimized using a data assimilation method and two observed data streams: mosquito infection rates and reported human WNV cases. The coupled model-inference framework is then used to generate retrospective ensemble forecasts of historical WNV outbreaks. Next, these retrospective forecasts are used to calibrate estimation of real-time expected accuracies for various predicted features: outbreak peak timing, peak magnitude, and total number of infected mosquitoes for the season and the number of human cases in the next 4 weeks and over the season. Weekly forecasts of WNV are generated in real time using this calibrated system for four California Counties during the 2018 and 2019 outbreak seasons. Here, we present the forecasting framework, and an evaluation of the real time forecasts, and we discuss limitations of the current real-time monitoring network. Overall, the real-time forecasts are able to estimate accurately the peak timing, peak magnitude, and total number of infected mosquitoes for the season in real-time prior to the peak of infected mosquitoes. WNV forecasting is potentially an important evidence-based decision support tool for public health officials and mosquito abatement districts; however, to operationalize real-time forecasting, more resources are needed to reduce human case reporting lags between illness onset and case confirmation.

163 CDC Perspective and Recommendations for Future West Nile Virus Vector Control

Roxanne C. Connelly (csz5@cdc.gov), Christopher Gregory

Vector control programs across the United States vary widely. The distinctiveness of each control program can be attributed to funding, disease burden, the complex natural cycle of mosquitoes, movement and variation of amplifying hosts, weather, and human behavior. After 20 years of West Nile virus presence in the continental United States, many advances have been made involving scientific-based evidence as drivers for mosquito control actions, including use of the Vector Index, early season control and integrated mosquito management, and mosquito or other sentinel-based surveillance as early warnings that inform triggers for control activities. Unfortunately, there are still major gaps in the capacity to conduct surveillance and evidence-based recommendations for vector control across the US.

The Centers for Disease Control and Prevention (CDC), Division of Vector-borne Diseases (DVBD), funds states through Epidemiology and Laboratory Capacity funds and five Vector-borne Disease Centers of Excellence. Additionally, CDC works with states and local agencies to evaluate vector control techniques for vectors of West Nile virus. The Arboviral Diseases Branch within DVBD is developing a 5-year West Nile Virus Strategic Plan composed of multiple intersecting components that together address the key questions of where, when, and how interventions should be implemented and maintained to reduce the

total burden of WNV neuro-invasive disease. The strategy assumes the need for multidisciplinary expertise including public health entomology, communications, social sciences, epidemiology, ecology, health economics & analysis, virology, policy, program evaluation, program management, and modeling, and simultaneously explores prevention at the personal and community level.

Public Relations

164 Announcing RoboSIT: The European Union to invest in Senecio Robotics building automated Sterile Insect Technique facility

Hanan Lepek (Hanan@senecio-robotics.com)

The European Union Innovation Council selected Senecio Robotics for its Green Deal program, building an end-to-end pilot facility making SIT affordable, robust and accessible to all.
The multi-million-euro program, under the umbrella of the Horizon 2020, the largest r&d program in the world, promotes the use of green technologies for the benefit of human kind.
The Sterile Insect Technique is gaining evidence as a promising tool for suppressing local populations by releasing large numbers of sterile male mosquitoes.
Leveraging automation and AI were the missing component as labor efforts required to manually monitor, rear, separate and release the mosquitoes were not economical.
Senecio, an Israeli award winner in AI and robotics work with governments, companies, NGOs and mosquito manufacturers, to support their efforts in commercializing and scaling SIT operations.
In this presentation, you will learn about the novel RoboSIT program and the collaborations Senecio is seeking with top tier international companies and organizations, driving the SIT to new limits.
Join the lecture and stay up to date with the latest information about the future of SIT technology.

165 Maintaining School Outreach Momentum While Navigating COVID-19 Distance Learning in Placer County

Meagan Luevano (meaganl@placermosquito.org)

Placer Mosquito and Vector Control District responded to the 2020 COVID-19 pandemic by adapting our mosquito control and outreach programs to keep staff safe. For public outreach programs, this required the District to pivot its efforts to all digital platforms. While the District has existing online mediums like social media, email newsletters and an actively updated website to reach the public, our successful school outreach program was reliant on in-person assemblies for over six years. To continue to provide meaningful outreach to elementary school aged students, we took our existing school assembly script and transformed it into a recorded virtual video assembly experience with enhanced graphics, quick transitions and even some slapstick comedy to engage students. The virtual assembly was quickly filmed, edited and tested on students to gauge reactions and assess engagement levels. The virtual assembly is currently being disseminated to Placer County schools and we are tracking its success.

166 Humanizing Mosquito Control

Elizabeth Morabito (elizabethm@newsreview.com)

AMCA's Joe Conlon put it best at the 2018 Ohio Mosquito and Vector Control Association Conference. During his speech, he told the room full of attendees that they needed to "humanize

mosquito control." If a district is able to do so, they are far more likely to get the assistance from community members so desperately needed to successfully safeguard those very lives. Mosquito and vector control is a tough job performed by teams who are often stretched thin and simply cannot do the work alone without community member cooperation.
N&R Publications considers ourselves to be experts in mosquito-focused communications as we boast a portfolio of 20 such publications (with two more in the works) which have been published for districts across the country since 2009. They can be seen at www.nrpubs.com/mosquito-vector-control/.
We will discuss the key components of humanizing mosquito control which is based primarily in the concept of storytelling. Communications theory proves that a reader likely won't consider changing their behaviors or beliefs unless they are emotionally engaged. This is done by telling stories of real people in the readers' own communities.
In addition, our publications are strategically structured and contain key elements on each page to effectively engage readers of all intensity levels. Some may read the publication cover-to-cover, while others may not even open it up but will still see the call-to-action on the back, whereas others may just look at the pictures or read the sidebars. We will discuss these key elements in districts' communication materials and go through our own publications as examples.
We find that oftentimes mosquito and vector control districts are so busy hitting the pavement and doing the work day in and day out, that they forget about how important marketing their work is. We are passionate about the difference these folks make in the lives of people. Not just so their community members can enjoy the great outdoors, but so they don't fall prey to the host of horrifying diseases mosquitoes carry.
Humanizing mosquito control matters. That's what we do.

167 Using a digital media campaign to fight the bite

Eric Jackson (jackson@lcmcd.org), Jamie Fowler

In an effort to raise community awareness of mosquito bite prevention during Southwest Florida's seasonal peak mosquito activity, the Lee County Mosquito Control District worked with a local media broadcasting company and developed a digital media campaign for the months of June and July of 2020. The campaign utilized native ads, interstitials, and a variety of digital downloads to get the message out to citizens of Lee County, FL. The campaign anchored to a slogan commonly used by mosquito control districts and public health agencies across the country: Fight the Bite. This presentation covers the District's Fight the Bite summer campaign of 2020 from inception to conclusion, highlighting the metrics of the project and lessons learned.

168 Scaling brick walls to advance understanding about vectors and their control

Judi Anderson (judia@kroegerpr.com)

Chemicals terrify members of the general public and elected officials. They don't want them in the air, in their food and water, on their clothes, or on their bodies. Rumors in the news media and in social media about chemicals amplify and feed the paranoia. Faced with a barrage of misinformation, people evaluate their risks and those of their children through a different lens than those who work with chemicals and understand their proper use. So, how do we break through the communications barriers when people we try to educate just stop listening and start building a brick wall?
Updating and educating community members is routine in many vector management organizations but understanding the nuances of risk communications is a specialized category of outreach. It's often

complicated by individuals who know too much (or think they do) and by those who know too little. For those for whom English is a second language (who may be illiterate or marginally literate in their native language) is also challenging but crucially important. Like many native English speakers, they share a pervasive sense of distrust that overshadows their concerns about vector borne diseases and, more importantly, vector control and disease prevention. Understanding the cultural nuances and other constraints that are in play within the spectrum of audiences helps resolve some of the communications issues. Successful dialogues help restore confidence in community control of vectors and the role of individuals (it takes a village) in avoiding devastating, sometimes deadly vector-borne diseases.
This presentation will focus on ways to help turn the tide of misinformation and misunderstanding. It will highlight attitudes from current surveys and explain the ramifications of risk and risk communications. It will provide guidance on giving advice, giving comfort, and educating someone whose last science class was in the 8th grade. It will highlight what works, what doesn't. It will provide effective approaches that can be used with consumers, elected officials, critics of all stripes, and thought leaders in crucial communities. It offers resources for assistance. Everyone involved with vector control needs these tools and a study ladder to scale the brick wall of communications barriers.

169 Buzzin' on a Budget

Jason Fritz (jason.fritz@wilco.org), Nicole Evert, Elise Huebner

The West Nile virus (WNV) outbreak in 2012 led to the formation of the Integrated Mosquito Management (IMM) Program at Williamson County and Cities Health District (WCCHD). The program began in 2013 as a pilot to assess its value and viability. Since its inception, the IMM program has expanded to include 8-member cities, employing one full-time program lead and a part-time seasonal position. WCCHD has also chaired an IMM Working Group since 2014 that consists of member city representatives that develop response guidelines and consistent public messaging.
Thus far, the program has been limited to adult mosquito surveillance between May-November using Centers for Disease Control and Prevention (CDC) Gravid traps and sending specimens to the Texas Department of State Health Services (DSHS) Laboratory for arbovirus testing. In previous years, the program has also utilized Biogents-Sentinel, CDC Light Traps, and aspirators for mosquito collection. During the 2019 season there were 16 static traps throughout the 8 member cities, with 2 traps in unincorporated county land. While surveillance is completed by WCCHD staff, mosquito control operations are the responsibility of the cities under the guidance of WCCHD.
Since 2013, the IMM program has detected 46 WNV positive mosquito pools, 14 from 2020. Seven human and one equine case have been reported, including 3 human WNV cases this year. Additionally, the IMM program has developed a "Best Management Practices" document, notification guidelines, and implemented a new spreadsheet to track surveillance data collected in the field and from the DSHS laboratory. This year the IMM program created and released a weekly arbovirus surveillance report.
In conclusion, WCCHD operates an IMM program with limited resources and diverse group of stakeholders. This provides a blueprint for other local health departments to successfully maintain an IMM program.

Operations II/New Product

170 UAS Digital Elevation Imagery for Field Application Design

Marty Scholl (mscholl@fightthebite.net)

Agricultural and wetland fields can change in many ways from year to year. Often times existing imagery does not depict accurate field features such as borders, obstructions, vegetation, or water impoundments. It is important for mosquito control applications to be properly applied and to the correct locations and acreages to maximize the control efforts. This discussion will provide an overview of utilizing survey grade UAS technology to quickly fly and produce accurate field topography maps. Examples of utilizing the various data sets provided by a single imagery collection flight will be included to help visualize the intended outcomes and implementation into District operations.

171 Florida Mosquito Control District and Open Program Capabilities during the COVID-19 Crisis

Lola Whittingham (lrw47@miami.edu), Imelda Moise, Marah Clark, Vincent Omachonu, Rui-De Xue

The purpose of study is to understand how the COVID-19 outbreak has impacted the capabilities of mosquito programs to implement key mosquito measures to mitigate emergence and/or re-emergence of arthropod-borne arboviral diseases. In a self-administered online survey, we examined capabilities of all Florida mosquito control programs during the COVID-19 outbreak (both state-approved mosquito districts (N=63) and public health programs (N=27)). Descriptive statistics and bivariate analysis were used for analysis. The response rate was 85.6% (77/90). Of the responding programs, 57.5% (n=42) were Board of County Commissioners programs, 21.9% (n=16) were independent tax districts, 13.7% (n=10) were municipal programs, and only 6.8% (n=5) were either health or emergency departments. Except for arbovirus surveillance which 75.0% (n=51) of programs did not perform, most programs either fully or partially performed larval (61.8%) and adult (78.9%) surveillance, and many programs conducted species-specific control for Aedes aegypti (L.) (71.9%, n=46), Aedes albopictus (Skuse) (85.9%, n=55), Culex quinquefasciatus (Say) (88.2%, n=60), and Culex nigripalpus (Theob.) (90.5%, n=57). Findings underscore the importance of ongoing mosquito control activities and suggest that Florida mosquito control programs are vigilant and have significant capability to handle potential mosquito-borne disease threats. Arbovirus surveillance systems such as laboratory testing of mosquito pools and testing of human and nonhuman specimens for arboviruses persist as challenges that need improvement especially during times of crisis.

172 Sirenix, lethal ovitrap killing efficacy results from University Sains Malasia

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The WHO has identified lethal ovitraps as a potential new mosquito control approach. They mention the need for routine maintenance otherwise they could become ineffective or even worse become a breeding site. University Sains Malaysia recently tested the larval killing efficacy of the Sirenix lethal ovitrap. This solar powered non-pesticide trap, with seven natural attractants lures gravid females to lay her eggs. The resulting offspring are killed with acoustic larvicide. Acoustic larvicide is where mosquito larvae are killed by using resonant acoustic to rupture the dorsal tracheal trunk of mosquito larvae. This paper reports the test results as well as functionality of the Sirenix device.

173 It's registered, so it's ready to go, right? What it means to optimize a new product for operational success

Kattie Morris (kmorris@clarke.com)

What does it take to prepare a new liquid larvicide product for commercial use? This presentation summarizes the technical field work needed to prepare a new product for reliable performance. Parameters explored included testing the product in various application equipment and nozzle systems, optimizing applicator settings to achieve the desired dose, droplet size and flow rate, and observing performance in a wide range of environmental conditions and habitats. When this foundation work is done well and thoroughly, abatement programs can more readily adopt new or rotational control products with confidence.

174 Collection Performance of the New BG-Pro Mosquito Traps in Various Locations Around the World

Jennifer McCaw (jennifer.mccaw@biogents.com), Caro Degener, Alvaro E. Eiras, Scott A. Ritchie, Charles Abadam, Jay Kiser

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

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

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

175 Evaluation of x-ray irradiation technology for Sterile Insect Technique to control mosquito vectors in Harris County, Texas

Dagne Duguma (Dagne.Duguma@phs.hctx.net), Kevin Pritts, Bret Nash, Max Vigilant, Rebecca Riley, Chris Fredregill

With the increased prevalence of resistance to the limited insecticides available to control mosquito vectors and nuisance pests, there is a renewed interest in the use of Sterile Insect Techniques (SIT) to control mosquitoes. The SIT was successfully used to eradicate pests of medical and veterinary importance such a Screwworm fly *Cochilomyia hominivorax* from the Americas. This method is species-specific and environmentally friendly method with potential to suppress populations of important mosquito disease vector populations in integration with other control strategies with little or no impact on non-target organisms. We are currently developing the SIT program using x-ray radiation technology targeting three important vector species of concern in *Aedes aegypti*, *Ae. albopictus*, and *Culex quniquefasciatus* in Harris County. We are currently evaluating different doses of irradiation,

establishing mass rearing, and pupae sorting protocols for operational use of the method. Preliminary results of these activities will be presented during the upcoming AMCA annual meeting.

176 Novel automated sorter: larvae, male and female pupae continuous separator

Hanan Lepek (Hanan@senecio-robotics.com)

Rearing mosquitoes in the lab often requires the sorting of the larvae from the pupae, and usually also the sorting of female and male pupae.
To date, the process relies on manual sorting using glass plate separators, based on the size differences, with a technician pouring batches of hundreds to a few thousands of a mix of pupae and larvae in between the glass separator plates.
Join us to learn about a novel automated compact size and affordable machine, enabling the continuous flow of pupae and larvae, resulting in sorted larvae, male pupae and female pupae being placed in different trays for a clean and fast sorting process.
The innovative approach also enables the technician to oversee multiple automated sorters, achieving a high throughput per hour, instead of having a technician per separator.
Join the lecture to stay up to date with the latest information about the new generation of pupae and larvae automated separators.

177 Quantitative and qualitative analyses of two Biogents traps: the BG-Pro trap and the BG Counter 2 with the BG trap station for the 2020 mosquito season in Gem County, Idaho.

Jason Kinley (director@gcmad.org), Michael Weber, Martin Geier

The Gem County Mosquito Abatement District, located in Emmett, Idaho conducted a season-long quantitative and qualitative study of two different trap styles manufactured by the Biogents Corporation. The two trap styles analyzed were the BG-Pro trap set up in a CDC trap configuration and the BG Counter 2 with the BG trap station configuration. For analysis of the BG-Pro trap, a comparison study to the CDC CO2-baited light trap was conducted. One trap of each type were placed in historical surveillance locations and the different traps were positioned approximately 100 yards away from each other to ensure lures, baits, and lights were not competing for mosquito attractiveness. Twelve hours after deployment the traps of both types were collected, the catch from the trap period was sorted, counted, and identified and comparisons were made. The BG Counter 2 trap with the BG trap station was positioned in cellular signal challenged areas to test the new cellular unit installed on the BG Counter 2. In addition, the collections from each deployment were sorted, counted and identified to determine the quality of the counter as it relates to the total number of mosquitoes collected. Results for both trials will be presented.

CDC Hurricane Cooperative Agreement Funding Symposium I

178 CDC Hurricane Cooperative Agreement Funding

Roxanne C. Connelly (csz5@cdc.gov), Jeff Borchert

The Centers for Disease Control and Prevention awarded $51,136,347 in extramural funding for response, recovery, preparation, mitigation, and other expenses directly related to the consequences of Hurricanes Harvey, Irma, or Maria that made landfall in 2017. Funding specific to vector-borne diseases, including intramural and extramural (partners and jurisdictions), was $37,628,235. States and territories

that received funding were Florida, Georgia, Louisiana, Mississippi, Texas, Puerto Rico, and United States Virgin Islands. Intramural work utilizing these funds was focused on mosquito surveillance, insecticide resistance, and evaluation of novel mosquito control techniques in the hurricane-affected areas. Extramural funding recipients' activities included implementation of novel mosquito control techniques, training for public health pest control applicators, replacement mosquito surveillance and control supplies utilized in the aftermath of the 2017 hurricanes, insecticide resistance testing and training, and source reduction. All grantees were expected to develop, or revise, hurricane preparedness and response plans specific to vector control. One deliverable resulting from the hurricane funding will be a special issue of the Journal of the American Mosquito Control Association, planned for release in 2020, that will address natural disasters and mosquito control response.

179 It's best to be prepared: Lessons learned from the past prepared Georgia for Hurricane Michael.

Thuy-Vi Nguyen (thuy-vithi.nguyen@dph.ga.gov), Rosmarie Kelly, PhD, MPH

BACKGROUND: Onsite assessments for mosquito breeding sites are critical after a hurricane makes landfall. Due to lack of forward assessment activities and the uncertain path of hurricane Irma, it was difficult to determine what areas would be most affected, making it challenging to determine the availability of EH Strike Team members from unaffected areas. However, lessons learned from assessing the public health response from hurricane Irma has helped improve future responses. With the continuation of positive human cases of arboviral diseases in Georgia, such as La Crosse Encephalitis, St. Louis Encephalitis, Eastern Equine Encephalitis, and West Nile Virus, mosquito control methods, especially during emergency response related to hurricanes, are critical components of the public health system.

METHODS: Vector Surveillance Coordinators (VSC) and Environmental Health Specialists (EHS) around the state are trained to respond during natural disasters regarding mosquito surveillance and control. Environmental Health (EH) Strike Team members are comprised of EHS from around the state. The state entomologists organized and revised state emergency response plans for mosquito control to include VSC and EH response activities. Vector Surveillance and Control Trailers were strategically staged within public health districts throughout the state in preparation for natural disasters prior to Hurricane Irma.

RESULTS: Prior to hurricane Michael making landfall, EH Strike Team members from potentially unaffected areas were notified to prepare for deployment. A senior EH Strike Team leader with prior deployment experience from Hurricane Irma deployed to Albany ahead of the team to expedite EH related community recovery and plan team activities. EH Strike Teams were deployed to support the Albany and Columbus District EH programs in a timely manner. One DPH Vector Surveillance Coordinator (VSC) from the coastal region provided aid to the affected regions during both hurricanes by performing mosquito surveillance and control.

While vector surveillance and control trailer supplies had been replenished after hurricane Irma, surge vector control supplies (larvicide, DEET wipes and spray) were shipped to the affected area from the Athens District, the Macon District, and the DPH EH office to support the response. These surge supplies were readily available for EHS use after hurricane Michael to protect the public and expedite recovery activities.

CONCLUSIONS: Previous experiences with hurricanes and tropical storm response led to an increased focus on responding to mosquito issues after the storms. The operational experience documented in an after-action report from the hurricane Irma EH response provided a good reference for improving the

EH operational response activities before and after hurricane Michael. The after-action report information was part of the improvement process that enhanced DPH's vector surveillance and control training program and support of partner agencies. The improvement process enhances future response efforts with cost efficient planning methods. The DPH's Vector Surveillance and Control program in collaboration with EH Strike Team support are major components to reduce the public's risk of exposure to mosquito-borne disease.

180 Enhancing resources and capacity of entities that do mosquito control in Texas

Whitney Qualls (wqualls@amcdfl.org)

Hurricanes Harvey, Irma, and Maria in 2017 resulted in severe weather disasters throughout the Gulf Coast regions, Florida, and Puerto Rico causing a combined 265 billion dollars in damages, being three of the top six costliest hurricanes in history. In response, the United States Center for Disease Control activated its cooperative agreement to aid in response, recovery, preparation, mitigation, and other expenses related to these three hurricanes. Areas impacted by the three hurricanes were invited to apply for funds under the 2017 Hurricane Crisis Cooperative Agreement (Hurricane Crisis CoAg) to build capacity in several public health areas directly related to Harvey, Irma, and Maria. The Texas Department of State Health Services under the Hurricane Crisis CoAg received >$6,000,000 to use towards increasing capacity and to aid in recovery for vector control projects related to Hurricane Harvey. Funds have been used to increase State and Local Capacity. At the local level funds have been contracted to local health departments and mosquito control districts throughout jurisdictions impacted by Hurricane Harvey. A total of 28 contracts to entities that perform mosquito control have been awarded. The presentation focused on projects, statuses, and challenges for the Hurricane Harvey impacted jurisdictions in Texas that were awarded funds.

Student Paper Competition I

181 Pyrethroid and organophosphate resistance in Culex tarsalis

Billy Mortola (bmortola@pacific.edu)

As vectors of encephalitis viruses, Northern California Cx. *tarsalis* populations exhibit resistance to pyrethroid insecticides and some may exhibit resistance to organophosphates likely due to an upregulation of detoxifying enzymes and target-site mutations such as *kdr* and *ace-1*. The goal of the study is: 1) Determine detoxifying enzyme levels and *kdr* status of individuals previously exposed to pyrethroids in bottle bioassays. 2) Determine prevalence of organophosphate resistance with bottle bioassays; characterizing detoxifying enzyme levels and *ace-1* mutations.

182 Metabolic resistance in Florida Aedes aegypti mosquitoes

Sierra Schluep (sschluep@ufl.edu), Eva Buckner

To date, every Florida *Aedes aegypti* mosquito population tested has been resistant to permethrin, the state's most widely used pyrethroid adulticide. To determine the mechanism responsible for permethrin resistance in Florida *Ae. aegypti*, I am performing CDC bottle bioassays with metabolic resistance enzyme inhibitors. Thus far, one-half of the populations tested have exhibited

permethrin metabolic resistance. Determining the metabolic enzymes responsible for resistance will help mosquito control programs make informed adulticide product choices.

183 Effects of three successive ground ULV adulticide applications on Culex mosquito abundance, age structure, and West Nile virus infection

Kristina Lopez (kalopez@wisc.edu), Patrick Irwin, Susan Paskewitz, Lyric Bartholomay

We evaluated the impact of three successive daily applications of Anvil 10+10 on *Culex* vector species control in the Northwest Mosquito Abatement district, Wheeling IL, USA. Mosquitoes were collected daily for three weeks. *Culex* mosquitoes were counted, identified to species, dissected for parity estimation, and tested for West Nile virus. Results showed a significant increase in nulliparous mosquitoes in the treated site but no difference in abundance. Results from West Nile virus testing are ongoing.

184 Aedes aegypti Insecticide Resistance at Different Temperatures and Different Exposure Treatments

Xochitl Estrada (xochitl087est@gmail.com), Christopher Vitek

The interaction between temperature and insecticide resistance may influence efficacy of control efforts. We exposed an *Aedes aegypti* population from the lower Rio Grande Valley, TX to different temperatures representing seasonal temperatures. *Aedes aegypti* were exposed during their larval or adult stage. Adult exposed mosquitoes were tested following short (<7 days) or long (≥ 14 days) exposure. Adults were tested for resistance to permethrin or deltamethrin using the CDC Bottle Bioassay.

185 Transfluthrin diffusers targeting Phlebotomus and Culex in a Mediterranean environment

Remy Powell (remy.t.powell@gmail.com), Seth Britch, Kenneth Linthicum, Robert Aldridge, Dan Kline, Alexandra Chaskopoulou, Frances Golden, Michail Miaoulis, Ioannis Giantsis

We investigated the efficacy of transfluthrin spatial repellent targeting natural populations of disease-vector *Culex* and *Phlebotomus* species in both open air and semi-confined outdoor spaces at a field site in Thessaloniki, Greece. Spatial repellents could mitigate evolution of resistance and improve on standard residuals that require contact with target vectors. We found that transfluthrin could reduce collections of these genera in both locations for several weeks and should be investigated further in other environments.

186 Evaluating tickborne disease risk on Shelter Island, NY

Kate Thornburg (ket67@cornell.edu), Beau Payne, Alex Novarro, Laura Harrington

Shelter Island, NY has established tick populations can impact human health. We sought to develop surveillance methods that require minimal resources year-to-year. Dragging and flagging was performed at seven locations over three months in 2020 to determine variability and density of adults and nymphs (DON) *Amblyomma americanum* (DON =64.4) and *Ixodes scapularis* (DON=6.7). In addition, historical data were examined to refine abundance patterns revealing decreasing *A. americanum* and steady *I. scapularis* abundance with time.

187 Aedes aegypti mosquito odorant receptor signaling necessary for optimum embryo viability over multiple gonotrophic cycles

Olayinka David (odavi022@fiu.edu), Kevin Sanchez, Andre Costa-da-Silver, Matthew DeGennaro

We characterized the reproductive competence of *Aedes aegypti* odorant receptor mutant mosquitoes across two gonotrophic cycles using individual mosquito fecundity/viability assays. Surprisingly, mutant mosquitoes suffered a significantly reduced embryonic viability in the second reproductive cycle, despite retaining a similar capacity to ingest blood-meal and store sperm as wild-type. Mixed genotype cross-mating experiments revealed this reproductive defect to be female dependent. Our findings have the potential to pave the way for a new vector control strategy.

188 Vector Competence of Aedes aegypti influenced by larvicide exposure

Robert Aldridge (mr.entomology@gmail.com), Barry Alto, Roxanne C. Connelly, Bernard Okech, Blair Siegfried, Kenneth Linthicum

A variety of larvicides were bioassayed to produce dose-response curves against *Aedes aegypti*. Adults were generated by exposing larvae to concentrations that would yield sub-optimal (i.e., ≥LC25 , ≤LC50) mortality. Surviving exposed adults were then fed dengue virus-1 via bloodmeal, and their vector competence was compared to unexposed adults. Our results describe the difference in survivorship between larvicides and the effect that prior larvicide exposure has on vector competence in the adult stage.

189 Habitat Associations and Focal Powassan Virus Persistence in Southern Maine

Lindsay Baxter (lb694@cornell.edu), Laura Harrington, Rebecca Robich, Charles Lubelczyk

Maine's Wells National Estuarine Research Reserve contains sections of native forests and invasive plants including Japanese barberry and Eurasian honeysuckle. *Ixodes scapularis* collected from invasive shrub areas has consistently revealed a focality of Deer Tick Virus (DTV). To understand virus persistence, we measured microclimate, tick abundance and infection in three locations across invasive shrub gradients. Rodent host communities also were recorded. Results show abnormally low tick abundance and no DTV in 2020.

NASA Earth Observations for Improved Vector-borne Disease Surveillance Symposium

190 Earth observations applied to a changing world: NASA Health and Air Quality Applications

JOHN HAYNES (jhaynes@nasa.gov)

Remote sensing data and technology provide valuable information that can bridge gaps of environmental, spatial, and temporal data for tracking vector-borne diseases. These geospatial data can complement field observation data, highlighting real-time conditions of the aquatic, atmospheric, and terrestrial ecosystems. Although the field of geospatial health remains in its infancy, scientific collaborations between multi-disciplinary research groups can allow the development of robust research questions that advance our scientific understanding of diverse environmental health challenges such as vector-borne disease risks. In this presentation, we will introduce the NASA Health and Air Quality

Applications area and describe the significance of applied environmental health research using NASA satellite data. We will also provide an overview of applied research projects that integrate remote sensing data and technology to examine human health risks associated with vector-borne disease, water-related illness, and air pollution.

191 A Thermodynamic Paradigm for Studying Disease Vector's Habitats & Life Cycles Using NASA's NextGen Remote Sensing Instruments

Jeffrey Luvall (jluvall@nasa.gov)

Global public health is entering a new informational age through the use of spatial models of disease vector/host ecologies driven by the use of remotely sensed data to measure environmental and structural factors critical in determining disease vector habitats, distributions, life cycles, and host interactions. The vector habitat microclimates can be quantified in terms of the surface energy budget measured by satellites. The epidemiological equations (processes) can be adapted and modified to explicitly incorporate environmental factors and interfaces required by a specific disease and its vector/host cycle. Remote sensing can be used to measure or evaluate or estimate both environment (*state functions*) and interface (*process functions*).

Remote sensing can be used to measure or evaluate or estimate both environment (state functions) and interface (process functions) defining vector habitats. The products of remote sensing can be integrated directly into the epidemiological equations to significantly enhance our understanding of disease vector's life cycles and habitats. The next generation of NASA's remote sensing instruments recently operational will provide a significant enhancement in our ability to study disease vector's life cycles and habitats. Three new instruments have become operational on the International Space Station (ISS) In June 2018, ECOSTRESS (The ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station), a five channel, thermal IR instrument with 70 m resolution and approximately 4-5 day repeat cycle of day/night pairs along with DESIS a hyperspectral sensor system 235 channels (between 400 and 1000 nanometers), 30 m resolution, and data only being acquired on demand. In November 2018. GEDI (Global Ecosystem Dynamics Investigation). GEDI is a high-resolution laser ranging of Earth's forests and topography. These instruments set the stage for NASA's new global designated observables set of remote sensing measurements collecting hyperspectral and multispectral thermal data called SBG (Surface Biology Geology). The SBG is currently in the planning stage. The availability and use of level 1-4 data products generated from these ISS instruments will be discussed.

192 Achieving >90% Sensitivity in Forecasting Malaria Risk 12 weeks in advance in the Amazon

William Pan (william.pan@duke.edu), Mark Janko, Ben Zaitchik, Andres Lescano, Carlos Mena, Francesco Pizzitutti, Gabriela Salmon-Mulanovich

In the Americas, almost 90% of malaria is reported in the Amazon, where large-scale interventions reduced reported cases from 1.03 million in 2000 to 0.44 million in 2011. However, since 2011, malaria began to rebound and today, nearly all reductions achieved over the prior two decades have vanished. Between 2011 and 2017, Amazon-basin countries experienced a 167% increase in malaria cases, the largest percent increase compared to any other region in the world. Several factors contributed to this increase, including a strong El Nino Southern Oscillation (ENSO) in 2011-12 that produced favorable conditions for transmission, social unrest causing massive migration, rapid resource extraction leading to both vector habitat expansion and human exposure, and the end of the Project for

Malaria Control in Andean Border Areas (PAMAFRO), which was supported by the Global Fund and provided comprehensive malaria control in Venezuela, Colombia, Ecuador, and Peru from 2006-2010. Governments throughout Latin America have taken greater responsibility in conducting vector-borne disease surveillance and control. The current systems do not operate in real-time as complete data on cases is reported with an approximate 1-4 week lag. Thus, intervention and response tends to be reactive to past outbreaks rather than preventive for future outbreaks. Our team has engaged scientists from Peru and Ecuador, along with key government stakeholders to design a geospatial tool to support real-time identification of potential malaria hotspots. With support from NASA HAQ, we have developed a multi-layered system that produces forecasts of malaria in real-time with high spatial resolution. Our system is capable of forecasting malaria outbreaks 12 weeks in advance with greater than 90% sensitivity. We achieve this modeling performance by leveraging data from a land data assimilation system (LDAS) that provides real-time hydro-meteorological information, human population density model, ongoing interventions, and weekly malaria surveillance from the government surveillance system, which are then combined to estimate an ecologically-constrained regional model that produces outbreak forecasts at large spatial scales, then run a conditional, district-level Bayesian forecast model to improve spatial identification of risk. In addition, we have developed an Agent Based Model to evaluate different intervention scenarios, including insecticide-treated nets, indoor residual spraying, and prophylaxis. Our models were validated using data from the Loreto Region of Peru where 95% of cases in Peru are reported. We are working with the Peruvian Centers for Disease Control and the Ecuadorian Ministry of Public Health to train and implement the system into their current infrastructure

193 VectorSurv Gateway tools for tracking the spread of invasive Aedes and risk for Aedes-borne viruses

Christopher Barker (cmbarker@ucdavis.edu), Jody Simpson, Marisa Donnelly

The VectorSurv Gateway is an online data management system first launched in 2006 to allow for storage, visualization and analysis of mosquito and arbovirus surveillance data by mosquito control and public health agencies in California. The system is fully scalable and now serves multiple states and territories across the U.S., allowing each state to manage its own data, laboratory testing, and related policies. This presentation will describe recent advances for the VectorSurv system that integrate NASA earth observations to track the ongoing spread of invasive *Aedes albopictus*, *Aedes aegypti*, and *Aedes notoscriptus* and the risk for local transmission of dengue, Zika, and chikungunya viruses in the United States.

194 Multiregion modeling and prediction of human arboviral disease: West Nile virus in South Dakota, Louisiana, and elsewhere

Justin Davis (justinkdavis@ou.edu), Michael Wimberly

The risk to a human population of a mosquito-borne pathogen can be estimated by testing nearby mosquitoes. It is often assumed in practice that the relationship is intensely local. An infected mosquito warrants a control response within the estimated maximum flight range of its trap site, for example, but is not used to inform control decisions or estimates of human risk farther out, where that mosquito could never carry that infection.

Here we argue that West Nile virus (WNV) mosquito infection data are informative of human WNV risk at far larger scales. We fit generalized additive models of annual human WNV cases by state in the US

from 2004-2019 as functions of mosquito infection rates from two sentinel states, South Dakota and Louisiana. Linear functionals on lagged environmental data from a daily gridded meteorological data set (gridMET) are included as covariates to control for the influence of weather events. The importance of the mosquito data is demonstrated by likelihood ratio tests with simpler models in which one or both states do not contribute those data.
We find that data from these sentinel states significantly improve the ability to predict human WNV several states away. However, there are years in which mosquito data from these two states differ significantly. That is, mosquito data relate to human risk at scales that far exceed the practical thresholds set by the practice of mosquito control, but mosquito data are not universally informative; some modeling is necessary to carry these data carefully across large distances.
We discuss the large-scale processes, especially seasonal bird migrations, that partially synchronize human risk over large spatial scales. Environmental influences on WNV risk, especially temperatures in the early winter, are also identified.

Mosquito Identification: Whats in a name? Symposium

195 Mosquitoes of the World: Biodiversity, Barcodes and Biosurveillance

Yvonne-Marie Linton (linton.Yvonne3@gmail.com)

Effective vector-borne disease interventions rely on entomological intelligence—high-quality, current information related to the correct identification, associated biology, and distribution of arthropod vectors. Well-curated archive reference collections are of critical importance to solving modern vector-borne disease problems, increasing in value as taxonomic resources decrease and biotechnology improves. Along with DNA barcode reference libraries, most recently we have achieved whole genome sequences from the NMNH museum specimens, further increasing their value. Incorporating molecularly identified vectors into geospatial analysis vastly improves the quality of vector-borne disease risk predictions. These data-driven, actionable entomological intelligence products address the taxonomic impediment and reflect our forward-facing vision to tackle tomorrow's vector-borne disease threats.

Along with recent advances in our arsenal against mosquito-borne disease, this talk aims to captivate and inspire wonder in the audience with focus on the glorious morphological diversity of mosquitoes and their unique array of ecological and behavioral characteristics.

196 How the USNM collection can inform taxonomic studies, develop novel identification tools, and track distributions

David Pecor (pecord@si.edu)

The United States National Museum (USNM) Culicidae collection is housed within the Smithsonian Institution National Museum of Natural History (NMNH) and managed by the Walter Reed Biosystematics Unit (WRBU). Consisting of nearly two million specimens, the USNM Culicidae collection is considered the largest and most comprehensive mosquito collection in the world. The scientific utility of well-maintained insect collections is well documented. Beyond proper documentation of observations, collections can inform future taxonomic studies, monitor distribution changes over time

and be used to develop novel identification tools. Modern taxonomy requires a multisource approach combining both morphological and molecular evidence of species and lineages. A well-maintained collection of specimens can be a permanent source for gathering both morphological and molecular evidence. DNA barcoding has arguably been one of the most effective answers to the global taxonomic impediment, providing non-taxonomists with evidence for species identification and discovery. Looking beyond DNA barcodes to the prospect of using Next Generation Sequencing (NGS) to rapidly and cheaply sequence the whole genomes of thousands of individual specimens, it is clear scientific collections will retain their usefulness for generations to come. With mosquito distributions changing along with the climate, it is more important than ever to continue diligent surveillance and documentation of mosquito distributions overtime. New county and state-level distribution records, particularly vector species, should be documented by permanently preserved specimens and the collection data made available to the public. Finally, scientific collections can aide in the development of novel identification tools. Molecular-based diagnostic tools require a library of expertly curated reference libraries of DNA sequences to draw from for rapid diagnoses. A well maintained scientific collection of expertly identified material linked to frozen DNA samples ensures assays are highly accurate and reflect the current taxonomy.

197 National surveillance methods and how the data informs mosquito management

Roxanne C. Connelly (csz5@cdc.gov)

MosquitoNet is a mosquito surveillance database set up during the 2016 Zika response to assist CDC with understanding the distribution and insecticide susceptibility status of Zika vectors in the US. The system has evolved to include records of presence/absence, abundance data, and insecticide resistance status of selected mosquito species (selection dependent on user) by some health departments who have resources to share their data voluntarily. The only agencies required to report data to the MosquitoNet system are ELC Grantees and Hurricane Relief Funding grantees. A few non-health department mosquito surveillance and control agencies report to this system voluntarily. Because the source of the data coming into MosquitoNet is severely restricted, excludes most entities that conduct mosquito surveillance and control, does not provide real-time information, and because spikes and dips in funding to support local and state mosquito surveillance continue to occur, the lack of consistent, real-time, actionable data will continue to relegate the current system to an accountability database. An improved system of data modernization for mosquito surveillance would include a real-time national mosquito surveillance system that can be utilized for decision making for federal, state, and local jurisdictions, and one that is not restricted to data entry based on being a grantee of the Federal Government.

198 Updating the county-level distribution of mosquitoes in the USA

William Sames (mosquitodoctor@yahoo.com)

This presentation will discuss the need to update county-level distributional data for mosquitoes especially in areas which do not have routine or periodic vector surveillance programs. Methods include extracting mosquito distributional data from peer-reviewed publications, government documents, and other literature, the examination of and inclusion of data from specimens in university or private mosquito collections, collaborating with others who have mosquito surveillance data, and collecting in counties with insufficient data. Publishing the data in a peer-reviewed journal is important for public

access. Data may also be incorporated into national databases. In this context, examples of studies to update the county-level mosquito species data for Texas and other states are discussed. The personal, professional, and community benefits of surveillance will also be discussed.

199 A wave of new mosquito species in the USA, and developing resources for recognizing them

Nathan Burkett-Cadena (nburkettcadena@ufl.edu)

From the 16th to the 21st century, just four exotic mosquito species established in North America, *Aedes aegypti, Aedes albopictus, Aedes togoi, Culex pipiens/quinquefasciatus*. In the past twenty years, an equal number of exotic mosquito species (*Aedeomyia squamipennis, Aedes japonicus, Aedes pertinax, Culex panocossa*) have been introduced and established in the eastern USA, and several native species (*Aedes scapularis, Culex coronator, Culex declarator, Culex interrogator*) have experienced rapid, large scale expansions in distribution. In the near future, additional species are likely to be introduced in the US. Recognizing exotic and distribution-expanding species represents a significant challenge for mosquito control districts that conduct mosquito surveillance. Regional morphologic keys are valuable for routine surveillance but are inadequate for recognizing introduced or distribution-expanding species. DNA-barcoding (sequencing of cytochrome oxidase I gene fragments) is a gold standard for species identification, but is not easily accessible, due to expense and technologic limitations of many surveillance-performing entities. Morphological characters of adult and larval mosquitoes have been studied intensely for more than a century and provide a reliable path for identification of "new" mosquitoes. Numerous print and online resources are available that should be incorporated into each district's library of mosquito taxonomy materials to increase awareness of exotic species and increase the likelihood of recognizing them. Training and retaining entomologists, however, is a major challenge for many districts. Combined, mosquito control districts in the USA sample mosquitoes from thousands of sites daily. Their efforts could detect exotic vector species with sufficient time to prevent their establishment, if the exotic species is recognized upon initial collections.

200 Developing a regional taxonomic guide using morphology and molecules

Brian Byrd (bdbyrd@wcu.edu)

The Harrison et al. (2016) "The Mosquitoes of the Mid-Atlantic Region: An Identification Guide" was a collaborative masterwork by Dr. Bruce Harrison (1937-2018) that manifested after decades of field and microscopy efforts. Representative mosquito specimens were often "crowd sourced" and contributed by more than 50 individuals (e.g., vector biologists, medical entomologists, surveillance specialists/identifiers, mosquito control professionals, and others) over a 20-year period. To improve upon existing identification keys, specimens of each species were reviewed microscopically and, when necessary, molecular (i.e., DNA sequencing) approaches were employed to verify species-specific identities or validate novel morphologic characters for diagnostic purposes. Examples of challenging morphological issues (i.e., difficult couplets), ultimately resolved by molecular approaches, are presented in this talk. Specific examples include the classic "pip/res" issue with *Culex pipiens* and *Culex restuans* and the "atlanticus/tormentor" challenge with *Aedes atlanticus* and *Aedes tormentor*.

201 Insights into mosquito diversity and ecology through DNA barcoding

Lawrence Reeves (lereeves@ufl.edu)

DNA barcoding is a molecular method for identifying species through DNA that can be applied to a range of questions related to mosquito diversity and ecology. Globally, there are more than 3,500

mosquito species. Many of these can be distinguished relatively easily through morphological characters, but others are morphologically similar and require substantial training and experience to identify. Some are members of complexes of closely related species that are often indistinguishable morphologically. It can be particularly challenging to identify mosquito specimens that represent species that have been introduced and become established outside their native ranges, especially when such species are initially detected, and their identity and geographic origins are unknown. In these cases, DNA barcoding can be a valuable tool for quickly determining mosquito species identities. Through DNA barcoding, we are able to recognize species introductions and determine the identity of the introduced species, confirm species identifications, identify cryptic mosquito species, or re-assess mosquito diversity. Further, DNA barcoding has been applied to mosquito blood meal analysis, and is useful in characterizing the host associations of mosquito species.

Behavior & Biology I

202 Silver-doped nanoceria halt egg development in ovarioles of Aedes aegypti mosquitoes

Mona Mathew (mona.mathew@ucf.edu)

This abstract was submitted and accepted for the AMCA 86th annual meeting; however, the meeting was cancelled due to COVID19. Here, we have updated the abstract with the latest findings. Development of resistance in mosquitoes against pesticides is a consistent problem for integral vector management. Suppressing mosquito populations through the perturbation of fecundity, such as Sterile Insect Technique (SIT), can potentially address this issue. SIT is successful in controlling vector populations, but requires the production and release of thousands to millions of sterile insects in the field. Hence, novel methods that target fecundity while minimizing the development of resistance are necessary. We are therefore exploring the potential of nanoparticle-based mosquito control agents. Our investigation of well-characterized silver-doped cerium oxide nanoparticles (AgCNPs) has shown promising larvicidal potential and influence on life-history traits of *Aedes (Ae.) aegypti* larvae. Further, our studies show that these nanoparticles impact the egg development in adult female *Ae. aegypti*. Mosquitoes develop primary follicles that mature into pre-vitellogenic ovaries. Following a blood meal and the activation of associated pathways, these ovaries progress into oviposited eggs. Here, we describe that the process of vitellogenesis can be disrupted through the administration of AgCNPs resulting in developmentally arrested ovaries, thereby reducing egg clutch by ~11%. Maximum intensity z-projection images of ovaries revealed that the growth arrest occurred around 16h post blood meal when compared to the egg-growth timeline of control ovaries. The growth arrest is evidenced by the size of the oocyte and thus the degree of vitellogenin accumulation. This developmental arrest can provide insight into how nanomaterials could be used as novel mosquito control agents that target dipteran reproduction and fecundity.

203 Cisterns as challenging peridomestic Aedes aegypti habitats in the United States Virgin Islands

Krystal Seger (krystal.seger@doh.vi.gov), Corey Day, Esther Ellis, Gouthami Rao, Brett Ellis, Brian Byrd

Household rainwater-catchment systems (RCSs) and subterranean cisterns may provide large, yet often cryptic, habitats for mosquitoes. Within the United States Virgin Islands (USVI), more than 80% of

the population uses RCSs and cisterns for water storage. Given the persistent risk of dengue transmission and recent outbreaks of Zika and chikungunya viruses in the USVI, strategies to reduce *Aedes aegypti* abundance must consider both common and cryptic peridomestic habitats, including cisterns. Household cistern surveys were conducted on the islands of St. Croix, St. John, and St. Thomas in 2019 to determine 1) if cisterns are common habitats for *Ae. aegypti* or other mosquitoes of public health relevance, 2) homeowner practices to treat (kill) mosquitoes found in cistern water, and 3) structural methods (e.g., screens on drainage or overflow drainage pipes) used to prevent mosquitoes from entering the cisterns. The cistern sampling protocol included visualization of adult and immature mosquitoes and simultaneous collection efforts by aspiration and aquatic net sweeps. Of the 164 cisterns inspected, 46% (95% CI: 38%-53%) had evidence of mosquitoes; the dominant species present was *Ae. aegypti*. The odds of detecting mosquitoes in a cistern were 5.45 times higher at locations where residents reported they had observed adult mosquitoes coming out of their cisterns (95% CI: 2.25 – 14.21); resident mosquito management practices in cisterns did not correspond with decreased odds of mosquito detection. Cistern structural or chemical characteristics were not significant predictive risk factors for the probability of detecting mosquitoes. Cisterns in the USVI commonly provide habitats for immature and adult *Ae. aegypti* mosquitoes, which could inhibit the effectiveness of mosquito control strategies. Our results suggest the clear need for additional studies to determine the seasonal productivities of cisterns (including mosquito egress/ingress) and evaluate physical and chemical control methods.

204 Impact of radiation on Aedes aegypti microbiome in relation to SIT

Robert Aldridge (mr.entomology@gmail.com), Neil Sanscrainte, Alden Estep, Adam Rivers, Kenneth Linthicum

The sterile insect technique is making a return and is seen as a potential method of control for Aedes aegypti populations. Radiation is commonly used to sterilize the mosquitoes for SIT, however radiation may also impact the microbiome of the adults following exposure and emergence. We explore the differences in the mosquito bacterial microbiome between irradiated (low and high dose), and non-irradiated adults. Furthermore, we assess if a microbiome can be introduced to the irradiated cohorts and if there is any difference in survivorship between inoculated/irradiated and non-inoculated/irradiated treatment groups

205 Non-target effects of autodissemination approaches for mosquito control

Corey Brelsfoard (corey.brelsfoard@ttu.edu), Sri Jyosthsna Kancharlapalli, Scott Longing

Auto-dissemination is a method of pesticide self-delivery, which is premised on the use of insects as the delivery agent. This method has recently attracted attention for mosquito control, particularly to target container breeding species such as *Aedes aegypti* and *Aedes albopictus*. The intended goal and appeal of autodissemination approaches are that small amounts of a highly potent IGR are delivered to cryptic mosquito breeding sites. Current field studies suggest that these strategies can be successful at reducing mosquito populations. However, while direct targeting of cryptic locations seems like a significant advantage over large scale applications of insecticides, this could actually be more harmful to non-target organisms by delivering these highly potent long lasting growth inhibitors to the exact places that other beneficial insects visit, such as locations where many anthophilous insects seek nectar sources. Here we discuss experiments that examined for non-specific transfer of pyriproxyfen (PPF) to artificial nectar sources and honey bees. Data suggests males dusted with PPF deliver lethal doses to artificial nectar sources in laboratory cages. Furthermore, we demonstrated

dusted males indirectly transfer PPF to female *Ae. albopictus* and honeybee foragers. We discuss the results in the context that with any pesticidal approach, there are risks to non-target organisms and the risk may be acceptable in times of mosquito control need, particularly in association with disease outbreaks. However, it's important to understand the level of risk to non-targets and not assume any effects are negligible because PPF is used in small amounts.

206 Contradicting 355 years of mosquito larval physiology and respiratory dogma

Herbert Nyberg (sales@newmountain.com)

Unquestioned for over 355 years the role of the mosquito larvae siphon and spiracles were cited as the port for breathing, intaking oxygen and expelling metabolic waste. A detailed investigation into acoustic larvicide, the phenomenon of rupturing the dorsal tracheal trunk by applying acoustic energy at resonance with its gas, resulting in larval mortality, revealed significant conflicts with traditional theories. The study identified a previously not described structure, the "Tracheal Occlusion" which is a termination at the posterior limits of the dorsal tracheal trunk and felt chamber interface. This structure was identified as a critical component for the acoustic larvicide to be effective. We identified that the tracheal system is maintained at a high pressure also aided by the tracheal occlusion. The tracheal system being isolated and maintained at high pressure along with experiments demonstrating no obligate need to exchange metabolic gassed with the atmosphere shows the larvae likely depend on the exchange of metabolic gasses primarily from the water environment.

207 A synthetic lure for Anopheles gambiae (Diptera: Culicidae)

Mahmood Nikbakhtzadeh (Nik.Nikbakht@gmail.com), Woodbridge Foster

Sugar is the only diet for male mosquitoes and a complementary meal for females. Searching for natural sources of sugar is a common behavior of many mosquito species, which is believed to be mediated by semiochemicals. Floral nectars, extra floral nectaries, damaged tissues of plants and rotten fruits are the most source of sugar in nature. We have provided further evidence for the high attraction of *Parthenium hysterophorus* L. (Asterales: Asteraceae) for *Anopheles gambiae* Giles. Furthermore it has been shown what chemicals could be involved in chemical attraction of *Ae. gambiae* to this favorite plant. Successive olfactory assays helped us to recognize the attractive chemicals of *Parthenium* to *Ae. gambiae* and a synthetic mimic lure was developed based on these compounds, consisted of α-pinene, camphene and cis-β-ocimene. Laboratory experiments indicated attraction strength of this blend for *Ae. gambiae*. This lure can be used in surveillance or control programs of mosquitoes in tropical Africa, where *Ae. gambiae* sensu stricto transfer malaria among local residents.

208 Invasive aedes species population dynamics survey in the city of South El Monte

Harold Morales (hmorales@glacvcd.org)

After the rediscovery of Aedes albopictus in September of 2011 in the city of South El Monte (SEM), Los Angeles County, CA, the city became the focus of intensive surveillance and control efforts that continued uninterrupted until the middle of 2014, when Ae. albopictus had started to spread and an additional invasive species, Aedes aegypti, was detected in the neighboring City of Commerce. As a result, our agency redirected surveillance and control efforts to the new affected areas, so that concentrated efforts of yard inspections accompanied by larvicide and/or adulticide applications and the monitoring of 16 surveillance sites were drastically scaled back to the occasional service request and the monitoring of one surveillance site. In 2017, six years after the initial finding of Ae. albopictus, routine

surveillance detected Ae. aegypti for the first time in SEM. Since then, a noticeable and constant declined in *Ae. albopictus* abundance has been apparent in the remaining surveillance site, prompting an investigation into the present mosquito situation in the city. The aim of the survey is twofold, to better understand the current *Aedes* species composition by reinstating past surveillance sites and to revisit problematic properties to conduct inspections and administer a brief questionnaire to evaluate resident knowledge retention and behavior change as a result of the three yearlong intensive intervention in the city.

209 Seasonal and temporal patterns of host-seeking mosquitoes in a Coachella Valley rural area

Kim Hung (khung@cvmvcd.org), Arturo Gutierrez

The collection bottle rotator trap or sequential trap helps show peak activity of host-seeking mosquitoes, which can guide the timing of adulticide applications. A sequential trap was set on a weekly basis from July 2018 to July 2019 (52 weeks) to collect mosquitoes from an hour before sunset to after sunrise. The habitat was rural surrounded by large amounts of agricultural operations and the marshy Salton Sea. This area has sources for huge numbers of virus-carrying and nuisance mosquitoes such as *Culex tarsalis* and *Psorophora columbiae*. A weather station was set simultaneously to record the temperature, wind, and relative humidity during the collection period. Nighttime summer temperatures were an average of 38°C at sunset and cooled down to 23°C through the night while relative humidity rose from 27% to 50%. Despite the high temperature and low humidity, mosquito activity peaked about an hour after sunset and then was sustained at a lower levels throughout the night with a slight peak a few hours later. The after-sunset peak was consistent in the spring, fall, and winter, suggesting that sunlight may be the primary cue for mosquito activity. The second peak may be due to the lower wind speed during that time of night. Additional results on abundance and seasonality will be discussed.

210 Nasophilia in Sabethes mosquitoes: Blood host facial feeding behavior and mechanisms.

Connor O'Brien-Stoffa (cobrienstoffa@gmail.com), Robert Hancock, Shawn Ward

Female mosquitoes use a combination of thermotaxis, chemotaxis, and phototaxis to locate suitable blood hosts. We observed lab populations of *Sabethes* species (*S. cyaneus* and *S. chloropterus*) displaying a strong preference for the nasal region of the human face. This nasal preference appears consistently under different treatments, such as manipulation of blood host respiration and odor. Comparison between living hosts and inanimate sensory models, with controllable thermal and chemical cues, will help us separate the relative importance of host stimuli. Our study adds to literature on a rarely documented phenomena; demystifying the biting behaviors originating within the *Sabethes* sylvatic cycle.

CDC Hurricane Cooperative Agreement Funding Symposium II

211 CDC CoAg grant: Florida update

Marah Clark (marah.clark@fdacs.gov)

In 2018, the Florida Department of Health (FDOH) was awarded funding from the Hurricane Crisis grant through the Center for Disease Control and Prevention's (CDC) Cooperative Agreement to

augment the state's mosquito control response capacity after a natural disaster. The funding is divided between five projects and the Florida Department of Agriculture and Consumer Services (FDACS) provides technical support and guidance. It is important to note that unlike other states, FDACS, not the FDOH, provides the regulatory framework and support for the 88 Mosquito Control Programs (MCPs) in the state. The MCPs vary greatly in size based on budget, area of responsibility, and administration. The projects include mosquito control operations, mosquito resistance testing, operational sterile insect techniques, community clean ups and tire amnesty, and also administrative needs. Overall, this funding has been well received by Florida's MCPs and their response capacity improvements have varied based on the program needs and range between adding equipment that will aid the MCPs functions and response time, outreach materials, and pesticides.

212 Investigating insecticide susceptibility in Florida domestic mosquito populations

Eva Buckner (eva.buckner@ufl.edu), Daviela Ramirez, Ana Romero-Weaver, Natalie Kendziorski, Sierra Schluep

Aedes aegypti, *Aedes albopictus*, and *Culex quinquefasciatus* are three important domestic mosquito species in Florida. *Aedes aegypti* and *Ae. albopictus* are vectors of dengue, chikungunya, and Zika viruses. *Culex quinquefasciatus* is a vector of West Nile, eastern equine encephalitis, and St. Louis encephalitis viruses. Control of these mosquitoes is essential to protecting the public health of Floridians. However, resistance to multiple adulticide active ingredients (AI) has been detected in populations of these mosquitoes, and the extent of this resistance unclear. Therefore, we evaluated the susceptibility of Florida populations of *Ae. aegypti*, *Ae. albopictus*, and *Cx. quinquefasciatus* to four pyrethroid (deltamethrin, etofenprox, permethrin, sumithrin) and two organophosphate (malathion, naled) AI using the CDC bottle bioassay method. While 30% of the 13 *Ae. albopictus* populations tested were resistant to at least one AI, 100% mortality was documented at the end of the 2-hour bioassay for all populations. Fourteen *Ae. aegypti* and 28 *Cx. quinquefasciatus* populations were tested, and these species were most susceptible to malathion (*Ae.* mortality at diagnostic time: 99 ± 2%; *Cx.*: 63 ± 24%) and naled (*Ae.*: 93 ± 17%; *Cx.*: 43 ± 34%). Deltamethrin was the pyrethroid that caused the highest *Ae. aegypti* mortality (35 ± 20%). All other pyrethroids killed < 10% *Ae. aegypti* by the diagnostic time. No pyrethroid achieved a mortality rate > 20% against *Cx. quinquefasciatus*. Knowing which insecticide active ingredients yield the highest mortality rates for domestic mosquito populations ahead of a natural disaster will allow for faster, targeted, more effective mosquito control post-disaster.

213 CDC grant supports Louisiana gulf coast mosquito control district

Herff Jones (hjones@iberiagov.net)

It is no surprise the southern United States is most vulnerable to the impacts of hurricanes, and tropical storms; particularly when these tropical weather events enter or generate in the Gulf of Mexico. Iberia parish is a southwest Louisiana coastal parish adjacent to the nation’s largest hardwood swamp. The parish is surrounded by over three hundred sixty thousand agriculture, and aquaculture acres. Iberia’s southern border is the Gulf of Mexico and fully exposed to storm surge from extreme tropical weather events. Typically, a named storm event will result in more than half of the state’s parishes declared for disaster relief. The conditions post-landfall quickly elicit enormous floodwater mosquito populations. Aerial mosquito abatement capability is a significant, effective, and particularly useful operational tool post-disaster. Additionally, mosquito control by air is a great value to the citizens of our parish as they attempt to recover. The utilization of CDC grant funding to acquire, outfit, and modify an aircraft for aerial

mosquito spraying will dramatically reduce the costs of providing this type of operational control intervention, and save valuable local tax dollars. In-house aerial operations will increase efficiency, efficacy, and reliability without the need for complete reliance on contract services. More importantly, these enhanced operational capabilities will directly translate to added health protection for the citizens of Iberia parish.

214 Building sustainable mosquito control response capacity in Harris County through the 2017 Public Health Response Cooperative Agreement

Chris Fredregill (chris.fredregill@phs.hctx.net), Rebecca Riley, Dagne Duguma, Max Vigilant

The 2017 Public Health Response Cooperative Agreement funding from the Centers for Disease Control and Prevention has allowed the Harris County Public Health (HCPH) Mosquito & Vector Control Division (MVCD) to address gaps in the delivery of post disaster mosquito control services to affected communities. The gaps were identified during response efforts to the unprecedented flooding produced by Hurricane Harvey which, in 4 days, dumped ~1 trillion gallons of water on Harris County, flooding many areas, destroying homes and vehicles and stranding residents from services. Specific gaps identified included: a sustainable effort to provide mosquito education and personal protective supplies, the ability to quickly survey/treat inaccessible areas, the ability to larvicide large areas, the deployment of novel control techniques, the incorporation of novel Insecticide Resistance Management, and the need for increased adulticiding capacity. Projects currently in progress are in various stages of completion and will be discussed in this presentation.

Student Paper Competition II

215 Knowledge, attitudes, and practices regarding tick-borne diseases in Long Island, New York

Mervin Keith Cuadera (mc2658@cornell.edu), Emily Mader, Amelia Greiner Safi, Laura Harrington

Tick-borne diseases (TBDs) are endemic in Long Island, yet resident knowledge, attitudes, and practices are not well-characterized. We administered an online questionnaire to evaluate their general beliefs and knowledge about TBDs, tick precautions, and willingness to pay for control. Most residents were concerned about TBDs, but prevention practices varied by county and demographics. Knowledge gaps existed regarding chronic Lyme and Lyme disease treatment. Increased anxiety about ticks also increased willingness to pay for control.

216 Mosquito diversity, host feeding patterns and arboviral risks at the Nashville Zoo

Cierra Briggs (clb374@cornell.edu), Rayan Osman, Brent Newman, Margarita Woc Colburn, Heather Schwartz, Laura Harrington, Abelardo Moncayo

The Nashville Zoo experienced arbovirus transmission in 2017. To understand ongoing transmission risk, we sampled mosquitoes over four months in 2020 using multiple trapping methods. *Culex* mosquitoes were analyzed for arboviruses, and engorged mosquitoes were preserved for host feeding analysis. During 2020, MIRs for WNV, SLEV and FLAV were 0, 0, and 6.32, respectively. New mosquito species distributions were identified demonstrating the utility of zoological parks as sentinels for both emerging pathogens and vector species.

217 Modeling the ecological niches and potential distributions of La Crosse vectors

Corey Day (coreyallenday96@gmail.com), Rebecca Trout Fryxell, Mona Papes

La Crosse encephalitis is a mosquito-borne illness that affects children in southern Appalachia. La Crosse virus is vectored by *Aedes triseriatus, Ae. albopictus*, and *Ae. japonicus*. Using previously recorded occurrence data, we developed ecological niche models to identify environmental variables that correlate with vector occurrences and to predict the distributions of each species in a county with endemic La Crosse encephalitis. The resulting models can be used for targeted vector surveillance and management.

218 Combined effects of juvenile hormone analog and Toxorhynchites rutilus on adult Aedes aegypti emergence prevention, size, and susceptibility to infection with Zika virus

Abdullah Alomar (a.alomar@ufl.edu), Bradley Eastmond, Barry Alto

Mosquito control practices primarily aim to decrease the population size of adult mosquitoes by targeting larval stages. Pyriproxyfen is a juvenile hormone analog that prevents the emergence of adults from pupae, but does not kill larvae. Pyriproxyfen mode of action, therefore, allows other natural sources of mortality like predators to further reduce numbers of larval mosquitoes. Here we experimentally evaluated the effects of pyriproxyfen in combination with predatory mosquito *Toxorhynchites rutilus* on phenotypic traits of adult *Aedes aegypti*, including susceptibility to infection with Zika virus. The combination of pyriproxyfen and *Tx. rutilus* treatment showed further prevention of adult emergence in *Ae. aegypti* than either treatment alone. Size of adults tended to be large in treatments containing predators or those mimicking the daily rate of predation. Zika virus (ZIKV) infection in adult *Ae. aegypti* was reduced in predator treatment only relative to pyriproxyfen treatment. Disseminated infection, saliva infection, and viral titers of ZIKV were similar between treatments. Our results suggest that the combination of pyriproxyfen and *Tx. rutilus* can prevent adult mosquito emergence, but surviving adults may have fitness advantages of being larger. We found minimal influence of exposure of *Ae. aegypti* larvae to pyriproxyfen and *Tx. rutilus* on ZIKV infection.

219 Efficacy of above-ground liquid larvicide treatments against Culex species in the Chicagoland suburbs

Haley Johnson (hejohnson4@wisc.edu), Justin Harbison, Mark Clifton, Susan Paskewitz, Lyric Bartholomay

In the interest of developing new approaches to vector species of *Culex*, we used truck-mounted spray to broadcast Altosid Liquid SR-20 to treat neighborhoods in the North Shore Mosquito Abatement District in Skokie, IL U.S.A. Treatment and control sites were sampled with gravid and host-seeking traps operated daily for 9 weeks. Larval mortality bioassays were conducted with containers of exposed larvae placed at front and backyards of trap sites to assess product dispersal and lethality.

220 Mitigation Techniques for Mosquitoes in Rainwater Harvesting Systems

Charlotte Pfamatter (charlotte.pfamatter@live.longwood.edu), Curran Atkinson, Kathy Gee, Mitchell Woodward

In 2017, 65 rainwater harvesting systems in the southeast U.S. were assessed to determine the quantity and species of mosquitoes present. In 2019, three techniques expected to decrease the presence of mosquitoes in rainwater harvesting systems were evaluated; a before and after design was employed to enumerate the quantity of larvae and adults. The results from this research, as well as

resulting recommendations regarding the mitigation of mosquitoes in rainwater harvesting systems, will be presented.

221 Non-target effects of three common Ultra-low Volume adulticides on Red Swamp Crawfish (Procambarus clarkii)

Timothy McNamara (tmcnamara@agcenter.lsu.edu)

In recent years, claims have been made that Ultra-Low Volume (ULV) mosquito sprays have negatively impacted crawfish production. However, no research has been conducted to examine toxicity of ULV products to crawfish. We examined the acute and chronic effects of three ULV products (Dibrom, Duet, and Kontrol 31-67) on the red swamp crawfish (*Procambarus clarkii*) and found that field realistic exposures pose minimal risk.

222 North American Mosquito Project: Population Genetics of Culex tarsalis using Crowdsourcing Methodology

Julie Tsecouras (jtsec001@ucr.edu), William Walton, Lee Cohnstaedt

Culex tarsalis mosquitoes were collected using crowd sourcing throughout North America. The samples were sequenced using RADseq to identify 7,632 SNPs throughout the genome. The population-level allele frequencies identified six distinct populations with no association to genetic isolation-by-distance. This implies evolutionary adaptations separating the populations such as summer estivation, winter diapause, and desiccation resistance given the West to East geographic establishment pattern.

Spatial Repellents to Protect Civilian and Military: Laboratory and Field Evaluations Symposium

223 Efficacy of a spatial repellent to protect against malaria and Aedes-borne viruses: outcomes from phase III clinical trials.

Nicole Achee (nachee@nd.edu)

Spatial repellents have demonstrated effects against outdoor, daytime, and early-evening biting mosquitoes, which target vectors of human pathogen transmission that traditional interventions may not be completely effective against. Endorsement of a WHO global policy recommendation of a spatial repellent intervention for public health use has, however, been lagging due to lack of rigorous epidemiological evidence of human health impact. The importance of a WHO global policy for implementation of spatial repellents includes a potential increase in investments and efforts to develop a new generation of effective active ingredients and product formulations into the disease control/eradication arsenal. Two large-scale clinical trials evaluating the same novel spatial repellent intervention have recently concluded in Iquitos, Peru and Sumba, Indonesia. The clinical trial in Peru aimed to measure the reduction in risk from infection with dengue and/or Zika viruses. The clinical trial in Indonesia aimed to demonstrate protective efficacy against malaria infections. Outcomes from both trials have been presented to the WHO Vector Control Advisory Group for assessment. This presentation will share findings from both trials, provide an overview of further planned studies, and outline lessons learned for consideration in future spatial repellent research and development.

224 Spatial repellent and synergistic activities of pyrethroid acids

Jeffrey Bloomquist (jbquist@epi.ufl.edu), Liu Yang, Gary Richoux, Edmund Norris, Ingeborg Cuba, Kenneth Linthicum

Because mosquito populations have become resistant to a wide variety of insecticides, new control technologies are needed, and one proposed method is the deployment of spatial repellents. We discovered that several pyrethroid acids have spatial repellent activity greater than DEET, often more active than the parent pyrethroids, and with little cross resistance in a pyrethroid-resistant Puerto Rico strain of *Aedes aegypti* mosquitoes. Further investigation revealed that the acids can synergize not only contact repellent standards but also other pyrethroid components as well as the parent pyrethroids themselves. Synergism by the pyrethroid acids is expressed as both increased spatial repellency as well as human bite protection. Electrophysiological studies confirmed that pyrethroid acids were detected by mosquito antennae, and there was little resistance to olfactory sensing of these acids in antennae from female Puerto Rico strain mosquitoes carrying kdr mutations. The results suggest that the pyrethroid acids have useful properties that could augment the activity of repellent formulations.

225 Field evaluation of transfluthrin treated military materials against Phlebotomine sand flies (Diptera: Psychodidae) in Thailand

Alongkot Ponlawat (alongkotp.fsn@afrims.org)

The effect of transfluthrin applied to military netting materials was field tested to determine the impact on sand fly populations in rubber tree plantations in Chanthaburi province, Thailand. Two different military barrier structures (HESCO; 2 x 2 x 2.5 m, and ULCAN; 3 x 3 x 2 m) were constructed and lined with two types of netting materials; thick felt-like material and ultra-lightweight camouflage netting. Transfluthrin treated strips were hung inside the military barrier structures. The effectiveness of the treated strips was evaluated by sampling natural sand fly populations using CDC light traps baited with dry ice. Traps were operated for 14 hours (1800-0800) at 3 time points (1 day before application and at 0 and 2 weeks post application). All collected sand flies were separated by sex and morphologically identified to the species level and counted. The majority of sand flies captured at this location were Sergentomyia iyengari. The number of females collected by CDC light traps was analyzed using a generalized linear mixed model with Poisson distribution and a log link function. The presence of transfluthrin treated strips significantly reduced sand fly populations up to 2 weeks post application. Our findings demonstrate that spatial repellent treatments of military materials could potentially serve as an effective tool for the military and for sand fly control in Thailand.

226 Sustained release devices for Transfluthrin-based repellents

Nagarajan Ramasamy Rajagopal (nagarajanrrajago@ufl.edu), Dan Kline, Christopher Batich

Mosquitoes are vectors for various diseases and the need for newer repellents has increased as they develop resistance. Long-term spatial repellents are still a goal for small areas such as personal space and tents. With the recent registration of Transfluthrin in the United States, there is growing interest to deploy this exceptionally effective pyrethroid in a variety of situations. Sustained release devices are being designed and developed to provide long term repellency. These devices will be used to protect tent entrances and the ankles of personnel to provide personal protection. Preliminary testing results have proven efficiency lasting up to 4 months. Bioassays of mosquitoes were conducted to measure the efficacy in the adjacent areas. Thermogravimetry and Spectroscopy studies are used to investigate the effects of solvents on dispersion and sublimation of transfluthrin. This is essential for the device to emanate. Air

sampling and spectrometry were used to determine concentrations of transfluthrin in the surrounding air. The devices were tested in a semi field setting for the efficiency by bioassay tests at various distances and heights. Quantitative analysis of air borne concentrations was carried out by air sampling into Tenax tubes. The devices are being designed in a way they can be produced economically.

227 Transfluthrin spatial repellent on US military materials reduces mosquito incursion in a hot-arid environment

Robert Aldridge (mr.entomology@gmail.com), Seth Britch, Kenneth Linthicum, Dan Kline, Frances Golden, Jeremy Wittie, Jennifer Henke, Kim Hung, Arturo Gutierrez, Melissa Gutierrez, Cirillo Lora

Treatment of perimeters of US military materials such as camouflage netting with standard residual pesticides may protect health and morale of US military personnel in the field by reducing incursion of disease vector or nuisance biting insects such as mosquitoes or sand flies into protected areas. However, standard residual pesticides rely on target insects resting on treated surfaces to accumulate lethal or sub-lethal doses; those that do not contact the treatment may still host seek. Furthermore, heavy mortality from residuals translates to evolution of resistance and subsequent loss of efficacy. Emerging availability of diverse spatial repellents and toxicants such as transfluthrin leveraged as residuals offers an alternative to standard residual formulations less likely to induce resistance. Residual applications of transfluthrin on US military materials could form a volatile repellent plume allowing target insects the opportunity to escape, only inducing mortality if insects linger for example after becoming trapped in a tent, and not requiring contact with treated surfaces. In this study we investigated the capability of transfluthrin on two types of US military material in a variety of realistic scenarios to reduce natural populations of disease vector and nuisance mosquitoes in a cool arid desert field environment. We found that transfluthrin could substantially reduce target insect incursion into protected areas, and in two scenarios reduce collections outside protected areas, for up to 16 days showing that this compound could be an effective element in the US Department of Defense pest management system. We also observed variation in transfluthrin efficacy across species which has implications for designing integrated vector management using a variety of measures that harmonize in a system to reduce incursion across the community of biting insects that may be present

228 Defining airborne transfluthrin concentrations that elicit Aedes aegypti mosquito flight behavior outcomes

Anne-Claire Limon (aclimon@ucf.edu)

This abstract was submitted and accepted for the AMCA 86th annual meeting. The meeting was cancelled due to the COVID19. Here, we have updated the abstract with our current progress. Synthetic pyrethroids have long stood as a gold standard in protection against mosquitoes. Due to their vapor pressure, they have potential as spatial repellants and volatile insecticides. Specifically, the volatile synthetic pyrethroid transfluthrin is highly effective against mosquitoes at relatively low airborne concentrations. To date, there is a limited amount of data linking mosquito behaviors such as confusion, repellency, excitation, knock-down and death to quantitative airborne threshold concentrations of transfluthrin. We previously developed a method to detect and quantify trace airborne concentrations of transfluthrin via active air sampling and thermal desorption-gas chromatography-mass spectrometry (TD-GC-MS). This method has now been coupled with custom built, all-glass mosquito flight chambers. These chambers enable the creation of transfluthrin-containing

atmospheres, collection of airborne transfluthrin samples via active air sampling and the simultaneous documentation of exposed *Aedes aegypti* flight behaviors via high-speed videography.These new tools and approach will allow for the quantitative definition of the impacts from sub-lethal airborne transfluthrin concentrations on mosquito flight behaviors, which can guide the optimal use of transfluthrin in mosquito control strategies.

229 IVCC: Partnering on bite prevention product development and delivery in Africa and Asia

Jason Richardson (jason.richardson@ivcc.com)

IVCC is a unique Product Development Partnership (PDP) dedicated to the development of innovative vector control solutions. Established in 2005, our work has largely focused on replacing pyrethroids for indoor control of malaria vectors in Africa. With the successes on that front we have broadened our focus to address the urgent need to identify effective tools to prevent outdoor transmission to address populations not protected by bednets or indoor residual spraying. Working with manufacturing partners and control programs, we are supporting several field tests to evaluate the potential for passive pyrethroid emanators to protect populations from mosquito-borne diseases. This presentation will summarize the projects we are supporting and planning.

40 Developing an effective bioassay to investigate repellency of military materials treated with transfluthrin spatial repellent

Frances Golden (frances.golden@usda.gov), Bianca Moreno, Seth Britch, Robert Aldridge, Rachel Dillard, Ingeborg Cuba, Kenneth Linthicum

Spatial repellents such as transfluthrin applied as a residual to military materials can be highly effective at reducing incursion of mosquitoes and sand flies into protected spaces such as small perimeters of camouflage netting in the field. Ideally, transfluthrin will repel host-seeking females from these spaces without killing them, thus reducing the opportunity for the evolution of resistance. However, we found that bioassays with small samples of transfluthrin treated materials using a published technique (Jiang et al. 2019) rapidly killed all sentinel mosquitoes and prevented us from measuring changes in repellency across a time series of weathered samples. Here, we describe modifications to the Jiang et al. protocol to investigate the repellency of field-exposed samples of military materials treated with transfluthrin on three separate laboratory-reared colonies of *Aedes aegypti*. We discuss the various attempts made, as well as the final outcome.

230 Potential US military applications of transfluthrin: treated materials, emanators, and space sprays

Seth Britch (Seth.britch@usda.gov), Kenneth Linthicum, Dan Kline

There is an increasing need for new vector control agents by military and civilian populations which is made more acute by the widespread resistance to pyrethroids in important mosquito species. Spatial repellents such as transfluthrin provide an alternative to pyrethroids. We conducted studies across a variety of ecological regions to investigate the capabilities of transfluthrin applied as a residual on US military materials, applied as a space spray, and emanated from diffusers at reducing incursion into protected spaces by disease vector mosquitoes. We found that transfluthrin may substantially reduce vector mosquitoes, but that efficacy varies by environment, target insect, substrate, and other key factors. Transfluthrin holds great promise to contribute significantly to integrated vector management systems.

Mosquito Control District and Department of Defense Collaborations Symposium

231 Enhancement of Collier Mosquito Control District's insecticide resistance management program through collaborative efforts with the Navy Entomology Center of Excellence

Keira Lucas (klucas@cmcd.org), Rachel Bales, Alden Estep, Christy Waits, Neil Sanscrainte

The use of integrated mosquito management (IMM) is paramount to reducing populations of disease vector mosquitoes, such as Aedes aegypti and Culex quinquefasciatus. IMM approaches should include a comprehensive insecticide resistance management program for the rational use of mosquito control materials. For Collier Mosquito Control District (CMCD) and many other vector control agencies, the CDC bottle bioassay has previously been the only method for insecticide resistance testing. In 2017, CMCD joined an interagency collaborative effort with the Navy Entomology Center of Excellence – CMAVE Detachment, United States Department of Agriculture – Agricultural Research Service, CDC Southeastern Center of Excellence in Vector Borne Disease and several other Florida mosquito control districts to better understand the status of pyrethroid resistance in the State of Florida. Here we report widespread pyrethroid resistance in Collier's vector mosquito populations, the impact of interagency collaborations on CMCD's pesticide resistance management program and operational decision making, and CMCD's role in the current cooperative efforts in understanding pyrethroid resistance in the State of Florida.

232 Cooperative Research Linkages of Florida Mosquito Control Districts and the Navy Entomology Center of Excellence

James Cilek (james.e.cilek.civ@mail.mil), Alden Estep

The Navy Entomology Center of Excellence (NECE) is the only US Department of Defense activity whose mission is dedicated to worldwide operational entomology support. This effort includes the development and evaluation of novel products and insecticide application technologies to protect deployed forces from arthropod vectors that transmit human pathogens. Formerly known as the Disease Vector Control Center, NECE has collaborated with over 50 civilian federal, state, and local agencies including Florida mosquito control districts. These linkages have increased the Center's capacity to carry out its mission by conducting several of its research projects in an operational setting. The current presentation will highlight some of the cooperative work that NECE has conducted with Florida districts. (The views expressed in this article are those of the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the U. S. Government. The author is also an employee of the U.S. Government. This work was prepared as part of his official duties. Title 17, U.S.C., §105 provides that copyright protection under this title is not available for any work of the U.S. Government. Title 17, U.S.C., §101 defines a U.S. Government work as a work prepared by a military Service member or employee of the U.S. Government as part of that person's official duties.)

233 Mutual benefits through collaboration between Anastasia Mosquit Control District and US military organizations

Rui-De Xue (xueamcd@gmail.com)

Anastasia Mosquito Control District (AMCD), St. Augustine, FL has collaborated with military organizations since 2004. The collaborators and related projects included: NECE, Jacksonville, FL (NECE is the major collaborator and the 1st project was testing drone for control of adult mosquitoes in 2004-2005) for applied research on personal protection, insecticide and equipment evaluation, and employee training. US Army, Texas & Washington DC for personal protection techniques and arbovirus detection, and AFPMB through DWFP about decision making evidence thresholds for vector mosquito control. Other indirect collaboration projects for military through USDA/ARS/Center for Medical, Agricultural, and Veterinary Entomology, Gainesville, FL. AMCD gained numerous number of benefits through the collaboration in the field of applied research and education, such as new technology for mosquito control, improved control operation efficiency, enhanced employee training, and promoted reputation of AMCD in the field of mosquito control.

234 Innovative Readiness Training: An Air Force and mosquito abatement district collaboration to benefit public health

Mark Breidenbaugh (mbreiden@kent.edu)

The Air Force is tasked with maintaining a large-area aerial spray capability to protect troops from disease vectors world-wide. In order to maintain proficiency and readiness for prompt emergency response, the Air Force Aerial Spray Unit engages with real world integrated mosquito management programs in various locations within the continental United States, where aerial mosquito control is an effective tool. Many of these locations are located on federal property but can also include community applications over cities and counties. The formal program used to comply with federal regulations for a military aircraft to make a mosquito control application over a community is called the “Innovative Readiness Training” (IRT) Program. This mechanism allows the Air Force to interact directly with civilian communities to complete mutually beneficial projects. This paper will discuss the various ways in which IRT projects partner with mosquito abatement districts to form effective collaborations ultimately protecting public health. The discussion will also include basic information on how to participate in this program.

Behavior and Biology II

235 Mark-release-recapture studies of Aedes aegypti populations on Captiva Island, Florida in conjunction with a sterile insect release program

Steven Stenhouse (Stenhouse@lcmcd.org), Rachel Morreale, Danilo de Oliveira Carvalho, Aaron Lloyd, David Hoel

Lee County Mosquito Control District is currently developing a sterile insect technique (SIT) program for the control of *Aedes aegypti*. In order for any SIT program to be successful, population estimates of the target pest within the treatment area are necessary for determining the amount of sterile males that must be released to effect population reduction and suppression. Mark-release-recapture (MRR) studies are thus required to estimate populations and are vital to a sterile release program. Furthermore, these studies aid in the assessment of the survivorship and dispersal of marked sterile mosquitoes in the field. To this end, we have conducted four MRR studies in our release area on Captiva Island, Lee County, Florida. In each of the four trials, we have refined and improved our

methods. In this presentation I will discuss our needs for MRR studies, the work we have done thus far, and will delve into our methods, highlighting some of the things we have learned that might prove useful for other workers attempting MRR studies with their local mosquito populations. Finally, I will discuss our results and how those help to improve our sterile male releases.

236 Chemical lure development using high-throughput screening system for Aedes aegypti surveillance tools

Daeyun Kim (daeyun.k@ku.th), Theerachart Leepasert, Michael John Bangs, Theeraphap Chareonviriyaphap

Natural volatile host cues play a critical role for mosquito orientation and locating an obligatory blood source for egg production. Similar olfactory activation responses has allowed the use and development of artificial chemical attractants to lure mosquitoes to trapping devices. The discovery of new odor attractants continues as a means of enhancing surveillance without the need of live animal or human hosts. We evaluated five KU (Kasetsart University) chemical lure candidates using a high-throughput screening system (HITSS) assay for response by Aedes aegypti in laboratory and semi-field settings. The HITSS assay measured a response from 10 µL of each lure in a 2.75 L volume chamber. The highest preference index (PI) value was from KU lure #1 for both insecticide-susceptible (PI = 0.144 ± 0.048) and resistant (PI = 0.083 ± 0.052) female Ae. aegypti. Insecticide susceptibility status did not significantly ($p = 0.402$) influence attractive responses. Subsequently, various amounts: 0, 1, 5, 10 and 20 µL of KU lure #1 was compared to increase the HITSS PI-value, but the results were not significant ($p > 0.05$). To scale up, all five KU lures were re-evaluated in a semi-field screened house assay (SFS). Lure treated and untreated Biogent Sentinel® (BGS) traps were placed 10 m apart to measure attractive response of released Ae. aegypti field population inside a 140 m^3 space. The number of captured females in each trap were compared. Based on semi-field findings, the laboratory-based HITSS can accurately represent attractive behavior of Ae. aegypti. The optimized KU lure #1 BGS® trap attracted the most females (PI = 0.163 ± 0.054, $p < 0.05$) while the other chemical candidates provided little evidence of attractiveness compared to controls ($p > 0.05$). The BG® lure, a product containing a mixture of different chemical attractants, was evaluated in a direct comparison study using 10 g of lure per BGS® trap, resulting in significantly less ($p = 0.032$) captured than those attracted by 0.5 g of the optimized KU lure #1. However, the KU lure #1 did not achieve the level of attraction produced by carbon dioxide alone (PI = 0.423 ± 0.050). Further study is required to assess and increase the attraction level of candidate lures for Ae. aegypti and other mosquitoes of public health importance.

237 Sequence Resolution and Analysis of Insect-Specific Toxin from a Widow Spider

Kaleth Salazar (kalethsalazar1997@gmail.com), Lindsay Porter

The use of synthetic pesticides in vector control has faced many challenges that include the risk of environmental contamination and threats to public health. Biopesticides as an alternative have been studied and even effectively employed in mosquito control. However, continued research in additional alternatives to these methods are needed due to the persistent challenge of resistance development. More recently, research into spider toxins as biopesticides has ensued with promising results. In this study, we investigated widow toxin potential utility as a biopesticide. Specifically, the brown widow deltalatroinsectotoxin (LGδ-LIT) active protein sequence was fully resolved using homology-based *in silico* probing of transcriptome libraries paired with stepwise Sanger sequencing. The corresponding region for other widow species that have publicly available sequence data was compared to LGδ-LIT.

Despite size similarity, these δLITs are variable in ankyrin domain number and arrangement as well as distribution throughout the protein. Using this data, a list of constant and variable toxin features was prepared to determine minimal insecto-toxicity characteristics revealing only a small subset of amino acids may be necessary for activity. Constant regions include a large proportion of small hydrophobic amino acids. Moreover, we analyzed the spatiotemporal expression patterns of this and other widow toxins including a predicted vertebrate-specific toxin. We found that LGδ-LIT expression is ubiquitous not only throughout the spider but also throughout life stages. These data suggest that these insect-specific toxins are not toxic to the spider and thus could perhaps be engineered for a narrow range of taxon-specific activity. Moreover, comparison to putative vertebrate- and crustacean-specific toxins indicates that differences in domain distribution characteristics might contribute to taxon-specificity in activity. Information in this study contributes to the knowledge of protein properties required for a suitable, narrow-spectrum biopesticide that could be used as a mosquitocide.

238 The effects of size and circadian activity patterns of nontarget pollinators on susceptibility to mosquito adulticides

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Application of mosquito adulticides is a critical element in interrupting active arbovirus transmission and in nuisance mosquito abatement. The goal of an Integrated Mosquito Management Program is to reduce populations of mosquito pests and vectors while minimizing impacts to non-target species. Insect pollinators are high profile nontarget organisms that may be affected by mosquito adulticide applications. Considering recent declines in some pollinator populations, and the high public awareness of pollinator issues, it is important to characterize the factors that affect the susceptibility of pollinators to mosquito adulticides. Further, much of the work on this topic has focused on the European honeybee, an economically important, albeit nonnative and largely agricultural species. We investigated several factors that may affect the extent to which nontarget native pollinator species (the monarch butterfly and common eastern bumblebee) are exposed or susceptible to mosquito adulticide (malathion) applications. Specifically, we investigated how the size of a monarch butterfly caterpillar affects its ability to feed and develop from malathion ULV spray-exposed milkweed host plants, how the nocturnal roosting habits of eastern bumblebees and monarch butterflies affect susceptibility to malathion ULV spray applications, and how feeding from a malathion ULV spray-exposed milkweed hostplants affects susceptibility to natural enemies in monarch caterpillars.

239 Comparison of mosquito capture rates with a BG Sentinel trap when baited with dry ice dispensed in either a cooler jug or steel tumbler

Caroline Efstathion (cefstathion@volusia.org), Raymond Lucas, Taylor Ely, Sue Bartlett

The Biogents BG Sentinel trap has become a staple in many mosquito control districts for its ability to attract and capture *Aedes aegypti* and *Ae. albopictus.* The attractant BG lure is often additionally supplemented with dry ice, usually contained in cooler jugs. Cooler jugs are bulky, take up a lot of storage space and need a large quantity of dry ice to fill them. Our objective was to determine if a smaller steel thermos filled with dry ice, placed inside the BG trap, collected as many mosquitoes as a trap baited with dry ice in a cooler jug. Two BG Sentinel traps were set up at two sites in New Smyrna Beach, Florida. Both traps were baited with a BG lure and dry ice. One trap was baited with dry ice inside a cooler jug placed next to it and the other with a steel thermos placed inside. Traps were run overnight for six trap nights and trap positions were switched each night. At site 1, the total number of mosquitoes

collected in the trap with the cooler jug was 294 and the trap with the steel thermos was 210. At the second site, the cooler jug trap collected a total of 776 mosquitoes and the steel thermos 467. No significant differences were found between the number of mosquitoes collected in a BG trap with the cooler jug and steel thermos at either site (Site 1 $t(8)=0.46$, $p= 0.6573$; Site 2 $t(10)=1.01$, $p=0.3343$). Species composition was similar with both types of dry ice delivery containers. Our results suggest that a steel thermos, which uses less dry ice and takes up less storage and transport space, is as effective as a larger cooler jug at collecting mosquitoes as a supplementary attractant with the BG Sentinel trap.

240 Outdoor screen house tests of citronella and cedar oil tiki fuel against Aedes aegypti

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Burning citronella and cedar oil in tiki torches resulted in significantly ($p<0.05$) fewer *Aedes aegypti* bites than non-treated controls in outdoor screen house studies. Repellency was calculated to be 66%, 75%, and 70% at 0.25, 1.25, and 2.25 hrs. post mosquito release, respectively. Overall repellency was 71%.

241 SIT IRL: Developments for the Aedes aegypti sterile insect technique program in Lee County, FL

Rachel Morreale (morreale@lcmcd.org), Steven Stenhouse, David Hoel, AARON LLOYD, T. Wayne Gale

Lee County Mosquito Control District (LCMCD) has been developing a sterile insect release program to control *Aedes aegypti* since 2017. In-house experimentation has led to substantial improvements in irradiation, blood feeding, and rearing methods. Improvements in membrane blood feeding have allowed for the change from live vertebrate hosts with comparable egg outputs. Additionally, LCMCD has obtained several pieces of equipment that are essential for scaling up our mass rearing operations. These advances in technology facilitate the processes of larval rearing and of sex separation. Background population surveillance using BG Sentinel traps has been occurring at the pilot study site on Captiva Island since June 2017 and has now surpassed the two year goal proposed by the International Atomic Energy Agency. This consistent monitoring has provided an abundance of information regarding the population dynamics of *Ae. aegypti* over time. Baseline sterility is also being assessed in eggs that were collected from oviposition cup monitoring. Several mark-release-recapture (MRR) studies have been performed to assist in population estimates, dispersal of released males, and duration of released sterile male survival through marked male recaptures. Operational releases of sterile male *Ae. aegypti* began on June 10, 2020 and have been occurring twice weekly since. Ongoing surveillance of adult trapping and oviposition cups have provided insights into the impacts that these releases have had to the population.

242 MosID: An optical platform and algorithms for diverse mosquito species identification

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Vector surveillance is a key pillar to successful integrated pest management. Despite its importance, there is limited entomological capacity to identify and sort mosquito species at peak season. Some mosquito control organizations may not have the resources to devote entomologists to sorting through the multitude of specimens which are captured during routine surveillance, and as a result either train technicians to sort specimens, perform less surveillance than is optimal, or do not perform routine surveillance at all. While significant efforts have been devoted to the development of

image recognition for mosquito species to aid in this process, practical implementation of these algorithms for routine surveillance practice has been elusive. Building on a characterization of optical requirements for distinguishing morphological features between species, our team designed MosID, a custom optical platform to facilitate high-quality image capture of mosquitoes. A previously developed computer vision system which achieved 95% accuracy on wild caught specimens across 25 species, has been tuned to the new optical system of MosID. Initial retraining and testing on 1068 lab bred specimens from five species (*Aedes aegypti*, *Culex pipiens ss*, *Anopheles gambiae ss*, and *Anopheles stephensi*) achieved 100% accuracy in MosID. Data of wild caught specimens from MosID is currently being gathered for further tuning, expansion of algorithms to include more species, and subsequent testing in MosID on wild caught specimens from these species.

Recent Large Scale Wolbachia Trials and Progress Towards Commercialization Symposium

243 History overview of Wolbachia as applied to mosquito control

Stephen Dobson (sdobson@mosquitomate.com)

The recent renaissance of autocidal technologies against mosquitoes follows a period of ~50 years that is notable for its absence in mosquito control. In this brief historical overview, we will review the excitement and enthusiasm that culminated in the mid 20th century and what advances have been made in the interim. The goal is to prepare the audience for the subsequent symposium presentations, providing historical context and background. The discussion will include the original identification of *Wolbachia pipientis*, the discovery that *Wolbachia* caused sterility in mosquitoes, and additional important biological discoveries and inventions that have led to the recent field trials and EPA registration as a biopesticide against mosquitoes.

244 15.Consideration of a small pilot study using Wolbachia against Ae. aegypti in urban Miami. What do you do if it works?

William Petrie (William.Petrie@miamidade.gov)

Given the increasing incidence of M-B D's worldwide, and the shortcomings of current mosquito control capabilities, global agencies (e.g. WHO) have encouraged the development of novel vector control strategies, including utilization of SIT approaches to address these challenges. The Zika outbreak in Miami-Dade County in 2016 highlighted the potential health and economic consequences for southern Florida. A six-month trial was conducted in Miami in 2018 utilizing *Wolbchia*-infected males to attempt suppression of *Aedes aegypti* in an urban environment. Results were positive, within the confines of the study, which shows the method can be made to work. Contention is that, in our enthusiasm to adopt new science and novel techniques, and in our excitement over the possibilities, perhaps not enough attention has been paid to considerations outside science e.g. funding & logistics, local politics, public opinion, sustainability. Questions concerning how to scale-up a given technique, and how to measure success, for example, are not trivial questions. Enthusiasm over novel approaches should not be dampened, of course, but in addition to the science, perhaps our profession needs to collectively consider the broader range of issues impacting any technique, and to address in advance the question…What do you do if it works?

245 Male mosquitoes with Wolbachia: from planning to implementation in Ponce, Puerto Rico

Marianyoly Ortiz (mortiz@prvectorcontrol.org), Julieanne Miranda-Bermúdez, Jose C Sanchez, Nicole Nazario, Rafael Saavedra, Grayson Brown

Wolbachia are bacteria found in approximately 60% of insects but not in *Aedes aegypti*. When introduced into laboratory populations of this mosquito, and males released mate with wild females lacking *Wolbachia*, those females' eggs won't hatch. This novel mosquito control method has been evaluated in several countries including the USA, resulting in up to 95% suppression of the mosquito population. Recently, we began a large randomized trial to evaluate the impact of male mosquitoes with *Wolbachia* in suppressing the *Ae. aegypti* population locally, as well as its capacity to reduce disease incidence.

To start the project, a strong stakeholder and community engagement plan was implemented. PRVCU successfully presented the project to key government officials, environmental groups, academics and others. Ponce, a southern municipality, was selected to implement the trial given its historically high number of arbovirus cases in the past. Over 120 communities were selected for the study and divided in 38 clusters (19 treatment sites and 19 controls). Adult mosquito populations were monitored weekly using Autocidal Gravid Ovitraps (AGOs). Serosurveys were conducted annually to determine the incidence and prevalence of arboviruses in the communities under study.

The community was informed and consulted about the project via community meetings, house to house visits and educational booths. After the COVID-19 pandemic, education was achieved via virtual meetings, phone calls and house visits following strict social distancing practices. In order to reach a broader audience, a media workshop and small media campaign were conducted in June 2020. These community and communication efforts resulted in more than 85% support of the community as indicated by a survey to over 2,500 Ponce residents. With this community support and the one from key stakeholders, weekly male mosquito releases began in September 2020, two years after stakeholder engagement was initiated.

246 Mass suppression of wild Aedes aegypti population with sterile male Wolbachia mosquitoes in Fresno County, California

Jodi Holeman (jholeman@mosquitobuzz.net), Steve Mulligan, Jacob Crawford, Stephen Dobson

From 2016-2019 the Consolidated Mosquito Abatement District (CMAD) has operated under a USEPA experimental use permit (EUP) to study the use of *Wolbachia* infected male *Aedes aegypti* mosquitoes for control in selected urban areas of Fresno County, California. This presentation will summarize the four-year process of this evaluation including the necessary partnerships for evaluation, the tools and resources required to meet EUP requirements and key factors for success in public engagement. This presentation will also summarize final outcomes of the study and the future of SIT as a component of an integrated mosquito management program at CMAD.

247 Automated production and release of sterile males enables large-scale suppression of wild Aedes aegypti populations

Bradley White (bradwhite@google.com)

The range of the mosquito *Aedes aegypti* continues to expand, putting more than two billion people at risk of arboviral infection. The sterile insect technique (SIT) has been used to successfully combat agricultural pests at large scale, but not mosquitoes, mainly because of challenges with consistent production and distribution of high-quality male mosquitoes. In this talk, I will discuss the automated processes that we have developed to rear and release millions of competitive, sterile male

Wolbachia-infected mosquitoes, and use of these males in a large-scale field trials around the globe. Collectively, our results support the prospects for commercialization of automated SIT public health and nuisance-mosquito control programs.

Current Mosquito and Vector Research in Utah Symposium

248 Field evaluations of atmospheric turbulence and effects on female mosquito flight activity

Neil Vickers (neil@slcmad.org), Kelly Huang, Kirsten Meredith, Greg White, Ary Faraji, Marcus Hultmark

Orientation of flying insects to essential resources is often modulated by a variety of sensory cues that are considered to be passive scalars since, once released into the atmosphere, their displacement is primarily dictated by prevailing flow conditions. For adult female mosquitoes seeking a blood meal, attractive scalar cues emitted by potential hosts include carbon dioxide, temperature, moisture and body odors. Behavioral responses to plumes of these scalars have largely been evaluated in laminar flow wind tunnels or other small bioassay chambers. By design, such approaches limit the turbulent fluctuations in the flow and do not reflect the much larger range of turbulent scales relevant to these insects in their natural habitats. In order to evaluate the actual field conditions under which mosquitoes respond to scalar cues, we utilized anemometers that recorded the three-dimensional characteristics of wind in close proximity to CO_2-baited traps in both open wetland areas around the Great Salt Lake and canopied, riparian habitat in a suburban setting. Trap catches of mosquitoes were registered every 15 minutes over monitoring periods that included typical mosquito activity windows along with simultaneously recorded anemometer data. We show that female mosquitoes appear to be capable of responding to scalar CO_2 plumes over a wide range of turbulence and wind magnitudes and these measures vary widely within and across habitats. Anemometer recordings also revealed that the dynamic flow properties characteristic of field situations were not captured in a typical laboratory wind tunnel used in behavioral experiments. We plan to utilize these field data to accurately and controllably recreate natural turbulence conditions in wind tunnel experiments with the goal of improving our understanding of the orientation behaviors and strategies employed by female mosquitoes to effectively navigate scalar plumes in order to locate potential hosts.

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249 Determining translational effectiveness of the CDC bottle assay for monitoring insecticide resistance in arthropod field populations with agriculturally associated insect pests and pollinators

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Resistance to synthetic chemical insecticides is a worldwide concern for many arthropod vectors. The CDC bottle assay assesses resistance by testing populations against verified diagnostic doses and times for an insecticide. This assay is routinely performed with mosquitoes, sandflies, and other vectors to define insecticide susceptibility. This better informs field application with the goal of reducing disease vector populations. Agricultural systems regularly apply insecticides as an effective method for pest management. Lygus bugs (*Lygus hesperus*) in alfalfa seed and alfalfa weevil (*Hypera*

postica) in forage production systems can be particularly damaging. Alfalfa production in the western U.S. relies substantially on pyrethorid and organophosphate insecticides. Agricultural insecticide application intends to eliminate pests to minimize crop damage and loss, but this use must be managed carefully to avoid negatively impacting beneficial insect predator and pollinator populations. Many agricultural settings are in close proximity to insect vector habitats that are regularly monitored and controlled by integrated pest managers. Determining translational effectiveness of the CDC bottle assay technique for agricultural areas with potential vector control overlap will invaluably expand the ability to assess susceptibility and insecticide use. The objective of this study was to determine whether the bottle assay could be used to determine insecticide susceptibility for field collected Lygus bugs, alfalfa weevil, and alfalfa leafcutting bees using formulas of pyrethroids, organophosphates, and newer agricultural insecticide options. Bioassays were conducted in 1,000-ml glass bottles each containing approximately 25 agricultural insects collected from a Utah State University alfalfa research farm. Chlorpyrifos, λ-cyhalothrin, indoxacarb, and flupyradifurone are being evaluated. A series of concentrations were tested and replicated at least 4 times for each insecticide. Mortality was determined after a 24-hour observation window and susceptibility curves were developed. From the assessments performed, the CDC bottle assay can be used to develop insecticide susceptibility curves in agriculturally associated insect pests and pollinators. Insect pest managers could benefit immensely from the use of this tool for predicting insecticide effectiveness in farm settings and in overlapping habitats of human disease vectors.

250 Improving Mosquito surveillance and control using Metagenomics to characterize populations and their viral, endosymbiont and general microbiome signatures.

Aurelie Kapusta (4urelie.k@gmail.com), Edgar Javier Hernandez, Toni Schwarz, Daniele M. Swetnam, Nadja Reissen, Greg White, Robert Schlaberg, Mark Yandell, Ary Faraji

Understanding the distribution of mosquitoes and the pathogens they host is important for surveillance, and prioritizing areas to control. We address these questions in the Salt Lake City area for three species of mosquitoes using Next-generation-sequencing-based techniques that allow simultaneous identification of mosquito species and detection of hundreds of organisms from all kingdoms.

We collected female *Culex pipiens*, *Culex tarsalis*, and *Aedes dorsalis*, between May and September 2019 from rural, industrial or urban locations. This led to a total of 58 samples, each of which corresponds to a total of 50 mosquitoes (when available) of a species of interest. RNA and DNA extraction was performed on the samples, and we proceeded to sequence the RNA. The sequencing reads were submitted to the IDbyDNA Inc. metagenomics analysis pipelines (including the Explify® product), that assign the reads to a wide range of taxa, allowing us to assess the presence or absence of a large range of species.

Our preliminary metagenomics analyses show that sample composition is highly variable. Mosquito genomic contribution ranges from 35 to 80% of the sample, which may provide enough material to study populations structure. The viral compositions range from 0.03 to 33%, and they are dominated by mosquito-specific viruses (e.g. the Alphamesoniviruses *Houston virus* and *Nam Dinh virus, Negev virus*, etc.). Phylogenetic analyses reveal that the Salt Lake City 2019 viral consensus sequences tend to cluster together, indicative of new viral strains. We also note that the small ribosomal unit (16S) of *Wolbachia* endosymbionts can be detected in all samples of *Culex* species. Characterizing *Wolbachia* strains in these populations could be an asset to the possible future use of Wolbachia based mosquito control methods.

We have sampled three species of mosquitoes through time and space, and characterized their viral, endosymbiont and general microbiome signatures. Our results demonstrate the potential of our approach for improving mosquito surveillance and control.

251 Innovation and research at the Salt Lake City Mosquito Abatement District to adapt to new challenges and to take advantage of emerging technologies

Greg White (greg@slcmad.org), Ary Faraji

Existing methods of doing things will not always suffice in meeting and new and upcoming challenges. In addition, there are often better approaches to performing tasks that which are found through innovation. In order to make improvements in the field of mosquito control the Salt Lake City Mosquito Abatement District (SLCMAD) engages in research and innovation. This presentation will highlight some of the recent efforts made at SLCMAD to enhance mosquito control at their own District as well as benefit the broader mosquito control field. These research and innovation areas include studying the impact of aerial adulticide control sprays on non-target insects to help answer the questions of regulators and address some environmental concerns, working with local university engineering students to create new application, surveillance and research equipment using new technologies and ideas, investigating common mosquito repellent devices to help provide better answers for the public on how to avoid mosquito bites and finally improving routine surveillance traps to save mosquito control programs time and money.

252 Developing a peptide-based diagnostic platform to detect past infection with mosquito-borne viruses using human convalescent serum

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Mosquito species in many geographical regions are known to be vectors of human infectious diseases. Unfortunately, performing rapid and accurate serological surveillance for past infections in a population is difficult. We consequently sought to develop a multiplexed peptide-based platform that could identify human antibodies produced during past infection with a range of mosquito-borne viruses. As such, we predicted 866 15-mer peptides that were specific to each of 10 virus species through a novel bioinformatics workflow based on 10,000 Flavivirus protein sequences. The best performing peptides for each virus taxon were identified by applying machine learning to the results from high-throughput peptide array experiments on 137 convalescent human sera. We then transitioned the 10 best-performing peptides for each of eight virus species (Zika, Chikungunya, West Nile, Dengue subtypes 1-4, and yellow fever viruses) to an enzyme-linked immunosorbent assay (ELISA) platform for subsequent experiments. We first compared the performance of our multiplexed peptide-based ELISA against that of other serological assays performed on characterized and uncharacterized convalescent sera collected from Brazil, Chile, Guatemala, Honduras, and Sri Lanka. These results showed that our multiplexed ELISA showed high sensitivity and moderate specificity for Zika virus, with lower values for detecting past infection with other viruses included in our assay. We observed that the seropositivity rate for prior Zika virus infection in these countries ranged from 15-72%. In addition, our analysis of longitudinal samples identified anti-Zika IgG earlier than three weeks post-infection, which is faster than many of the other commercially available tests. Our findings are relevant to a variety of immunological applications including serological surveillance, diagnostics, vaccine development, and characterizing the host immune response during and after Zika infection.

253 Clinical Necessity for Mosquito Monitoring and Research in Utah

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Infection occurs at the intersection of host, pathogen, time and place. Vector borne disease fulfill three of the four requirements by seasonally bringing pathogens to the neighborhood where human hosts can be exposed. Most clinicians recognize vector borne diseases at the level of tick, mosquito or fly, and few recognize the genus or species-specific relationship between vector and pathogen. Generally, mosquito monitoring, control and abatement agencies report to the species level, and while critical to the understanding of the ecology of the organism and it's changing environment, most clinicians that do not deal with vector borne disease regularly fail to grasp the significance of these details. Collaborations between mosquito monitoring, control and abatement agencies, local and state health departments and clinical staff, especially during high incident seasons can improve healthcare provider understanding of disease transmission and improve the diagnostics and care of patients with vector borne diseases.

Larval Control

254 Initial and residual efficacy of s-methoprene and pyriproxyfen products against Culex quinquefasciatus Say under semi-natural conditions in Orange County, California

Robert Cummings (rcummings@ocvector.org), Tim Morgan, Sokanary Sun, Xiaoming Wang, Kiet Nguyen, David Taylor, Tianyun Su

Common features found in residential yards, such as fountains, neglected swimming pools, ornamental plant containers, plastic bins, and a wide variety of other water-holding objects, play an important role in mosquito production in urban/suburban landscapes. An ideal immature mosquito control product to apply to these peri-domestic breeding sources would be one that provides effective extended control and minimizes retreatments. Several sustained release formulations containing juvenile hormone (JH) analog s-methoprene (Altosid®), and JH mimic pyriproxyfen (SumiLarv®) were evaluated to determine the initial and residual efficacy of these insect growth regulators (IGR) against southern California's most abundant "backyard" mosquito, *Culex quinquefasciatus* Say. We assessed the inhibition of emergence (IE) of adults from pupae using small (18.2 L), medium (128.7 – 182 L), and large (1,820 L) semi-natural mesocosms. Altosid pellets (4.25% a.i.) were applied at 10 lb/ac, and Altosid briquet (8.62% a.i.) and Altosid extended residual briquet (2.1% a.i.) both were applied at 1 briquet /mesocosm. The SumiLarv® 0.5G (0.5% a.i.) was dosed at 0.777 g/L a.i. and 0.016 g/L a.i. in the medium- and large-sized tanks, respectively. Every two weeks, four to six egg rafts from wild and colony strain *Cx. quinquefasciatus* were added to the various-sized test containers in treatments and untreated control (UTC); three replicates were made for each treatment and UTC, and data for adult emergence from all replicates in a given assignment were composited for total IE calculation. On a bi-weekly basis, 50 healthy pupae from each replicate were collected and transferred to rearing chambers situated under insectary conditions, and successful adult emergence as indicated by presence of undeformed adults was evaluated until all pupae died. For all Altosid products tested, results demonstrated variable, mostly lower than desired IE, suggesting evidence of s-methoprene tolerance in wild *Cx. quinquefasciatus*, as well as product performance issues. For the SumiLarv® 0.5G , however, complete control efficacy was achieved for 125 and 30 days in the medium- and large-sized tanks, respectively.

255 Altosid® P-35 field trial to flood-irrigated mosquito production sites in Gem County, Idaho.

Cody Johns (deputydirector@gcmad.org), Jason Kinley

The Gem County Mosquito Abatement District (GCMAD) conducted a field trial with Altosid® P-35, an extended insect growth regulator granular product, on a 60-acre flood-irrigated mosquito production site in Emmett, Idaho. Emmett experiences a high elevation desert climate; with high daytime temperatures, long day lengths, and a high groundwater table with flood irrigation as the primary form of agricultural irrigation. The primary mosquito species targeted was *Aedes nigromaculis*. The P-35 product was applied at a rate of 3.3 pounds of granule per acre using an all-terrain vehicle with a Fimco® granule spreader mounted to the back. The test site was repeatedly irrigated at 2 to 3 paddocks at an irrigation event, and access was limited after the first flooding. Nearby "control" sites irrigated similarly by same property owner provided larval abundance counts for comparison. The trial yielded >90% efficacy in larval suppression for at least 33 days.

256 Buffalo at the MOUT – Bti and methoprene

Robert Aldridge (mr.entomology@gmail.com), Bianca Moreno, Frances Golden, Seth Britch, Barbara Bayer, Rachel Shepherd, Neil Sanscrainte, Alden Estep, Jeffrey Stancil, Jedidiah Stancil, Jeff Wahl, Kenneth Linthicum

Control of adult mosquitoes such as *Aedes aegypti* and *Culex quinquefasciatus* is difficult because they will seek refuge in cryptic peridomestic habitats. However the control of immature stages is less challenging, especially if a pesticide can penetrate through or over obstacles to treat their developmental containers. We evaluated the use of a buffalo turbine sprayer to apply VectoBac12AS (Bti) and Altosid (methoprene) to plastic containers positioned in a mock outdoor urban environment. The results illustrate how the buffalo turbine in conjunction with VectoBac12AS or Altosid is able to penetrate over and through buildings to actively or prophylactically treat containers and control larval *Ae. aegypti* and *Cx. quinquefasciatus*

257 Review of area-wide larvicide applications within the Coachella Valley

Jennifer Henke (jhenke@cvmvcd.org)

The Coachella Valley Mosquito and Vector Control District first detected *Aedes aegypti* within its jurisdiction in 2016. Since then, the District has conducted several area-wide larviciding application missions to reduce the mosquito population. A brief review of this work will be presented, with a focus on the work completed in 2020. This year, we compared two rates made with VectoBac WDG (active ingredient: Bti) to each other. We also made a series of aerial applications at a lower rate than we had previously used, planning to compare trap captures in the area in 2020 to areas where applications with a higher rate were made in previous years). The presentation will conclude with the District's plan for using this application method as part of its ongoing IVM program.

258 Sacramento-Yolo Mosquito and Vector Control District Evaluation of Sumilarv 0.5G in difficult to control Culex pipiens sources

Steven Ramos (sramos@fightthebite.net)

The Sacramento-Yolo Mosquito and Vector Control District (District) performed efficacy evaluations of Sumilarv 0.5G, a sand granule pyproxifen-based insect growth regulator in catch basins and dairy lagoons. These types of sources were chosen because they are difficult to control *Culex*

pipiens breeding habitats due to the fluctuations in water depth and/or have organic byproduct that tends to diminish the effectiveness of other residual products currently available. In dairy lagoons, the District evaluated Sumilarv 0.5G at the annual max label rate of 20 lbs per acre and the mid label rate of 10 lbs per acre and observed extended control at both rates. These applications were performed on similar dairy lagoons in close geographical proximity to one another. In catch basins, Sumilarv 0.5G was tested at multiple application rates ranging from 10g to 70g per basin with some level of season long control achieved at these varying rates. This presentation will discuss the potential effectiveness of Sumilarv 0.5G as a new control option in difficult to control *Culex pipiens* sources.

259 Seasonal efficacy and operational observations of autodissemination traps targeting invasive Aedes mosquitoes in Southern California

Angela Caranci (acaranci@northwestmvcd.org), Gregory Williams, Tristan Hallum, John Lopez, Jesus Ramos

Autodissemination traps have been proposed as a novel means of controlling urban and peridomestic populations of *Aedes* mosquitoes by taking advantage of the characteristic skip oviposition behavior displayed by adult females. As the range of *Aedes aegypti* has continued to expand, vector control professionals have adopted the use of autodissemination traps as part of integrated vector management programs. The aim of this study was to determine if adult surveillance trap data could serve as adequate end point measures of autodissemination efficiency. Autodissemination traps employing pyriproxyfen were deployed in residential areas with follow up adult surveillance performed to asses seasonal abundance measures. Additionally, early stage operational metrics were monitored over time to more accurately reflect the application rate of traps throughout a season. Initial programmatic findings support the presence of *Ae. aegypti* breeding in oviposition traps, confirming local vector populations successfully interact with the units regularly. However, high level of trap failures throughout the service period may lead to marked variation in successful application.

260 Evaluation of Larvicidal Efficacy of Allium sativum Garlic Bulb extract and synthesized Green Silver Nanoparticles against Aedes albopictus (Diptera: Culicidae).

Shabab Nasir (flourenceshabab@yahoo.com), Muhammad Waris

Aedes mosquitoes are the most important group of vectors having ability of transmitting pathogens including arboviruses that can cause serious diseases like dengue, Zika and West Nile virus in human. Biosynthesis and the use of green silver nanoparticles (AgNPs) is a vital step to find out reliable and ecofriendly control of these vectors. For this purpose, *Aedes* (*Ae*.) *albopictus* larvae (2^{nd} and 3^{rd} instar) were exposed against leaves extract of *Allium sativum* (Garlic) and silver nanoparticles (AgNPs) synthesized from this extract to evaluate their larvicidal potential. Synthesized AgNPs were detected by Ultraviolet-Visible spectroscopy, Fourier transform infrared spectroscopy, and XRD. Different concentrations (50-250 ppm) were prepared from leaf extract and synthesized AgNPs and applied on *Ae. albopictus* larvae. These treatments were run in five replicates along with positive control (temephos) and negative control (dechlorinated water). Mortality data was noted after 12, 24, 36 and 48h and subjected to Probit analysis. The nanoparticles were more toxic with least LC_{50} (49.92 ppm) & LC_{90} (95.50 ppm) values as compared to the plant extract (131.25 & 182.72 ppm) respectively. The extract of *Allium sativum* was also analysed through HPLC to know its chemical constituents. This study suggest this plant extract and synthesized nanoparticles as excellent alternative to the most hazardous existing chemical pesticides to

control the vector mosquitoes. This is a vibrant technique to reduce the aquatic toxicity due the use of insecticides for larval control of mosquitoes.

261 Wide Open Thinking On Wide-Area Applications

Derek Drews (ddrews@clarke.com)

Applying larvicides through air blast equipment is an emerging application method for public health that borrows practices from both the traditional adulticiding and larviciding approaches. Having gained notoriety controlling container-breeding species during the Zika outbreak in Miami-Dade County, air blast applications have gained traction with abatement programs across the country looking for more efficiency and flexibility in larval control. This session examines the many facets of wide-area applications, highlights lessons learned, and identifies best practices gleaned from field trials and operational work with air blast equipment.

Disease & Vector Studies

262 From qualitative to quantitative mosquito metabarcoding: an in tandem multilocus identification methodology

Ioannis Karakasiliotis (ioakarak@med.duth.gr), Katerina Kassela, Adamantia Kouvela, Michael de Courcy Williams, Konstantinos Konstantinidis, Charikleia Tziaferi, Maria Goreti Rosa Freitas, Andreas Nearchou, Elisavet Gatzidou, Stavroula Gatzidou, Georgios C. Boulougouris, Nikolas Dovrolis

In the era of emergence and re-emergence of mosquito-borne diseases, a high throughput trap-based mosquito monitoring is essential for the identification of invasive species, study of mosquito populations and risk assessment of disease outbreaks. Mosquito DNA metabarcoding technology has emerged as a highly promising methodology for unbiased and large-scale mosquito surveillance. Previous endeavours towards quantitative metabarcoding highlighted the need of novel barcodes for species discrimination that amplify target loci with similar efficiencies. The quantification efficiency of current metabarcoding methodologies is highly error prone. In the present study, we developed a methodology of in-tandem identification and quantification using the discriminating power of cytochrome oxidase subunit I (COI) combined with a secondary multilocus identification and quantification using three loci of 28S ribosomal DNA. 28S rDNA encompasses hypervariable regions flanked by regions with absolute conservation amongst genera minimizing mismatches with metabarcoding primers. Our methodology, based on a continuously expanding 28S rDNA database, was able to identify individual species in pools of 100 mosquitoes with 95.94% accuracy and resolve with high accuracy ($p = 1$, $\chi 2 = 2.55$) mosquito population composition providing a technology capable of revolutionizing mosquito surveillance through metabarcoding.

263 Vector competence of Peruvian mosquitoes for orthobunyaviruses isolated from mosquitoes captured in Peru

Michael Turell (mturell@erols.com), David Dohm, Roberto Fernandez, Terry Klein

Mosquitoes collected in the Amazon Basin, near Iquitos, Peru, were evaluated for their susceptibility to two orthobunyaviruses; Itaqui and Mutucuru viruses (order Bunyavirales). The virus strains used were originally isolated from pools of mosquitoes captured near Iquitos, Peru, in 1996 and 1997. Mosquitoes were fed on hamsters inoculated with one of the two viruses, and then held in an

incubator maintained at 26°C for 7-21 d until tested for infection, dissemination, and transmission by bite. At moderate viremias, several *Culex* (*Melanoconion*) species were susceptible to Murutucu virus, while none of the *Aedes serratus, Psorophora albigenu,* or *Culex* (*Culex*) *coronator* that fed on the same hamster became infected. However, at higher viremias (>10^9 plaque-forming units/ml), both *Ae. serratus* and *Cx. coronator* became infected. When exposed to Itaqui virus, both *Culex* (*Melanoconion*) *pedroi* and *Cx. coronator* had similar infection profiles. Additional studies on biting behavior, mosquito population densities, and vertebrate reservoir hosts of these viruses are needed to determine the role that these species play in nature in the maintenance and transmission of these viruses in the Amazon Basin region.

264 Detection of dengue virus natural infection in Aedes aegypti from northern Peru by combined, portable real-time quantitative polymerase chain reaction and next generation sequencing

Carmen Flores-Mendoza (cfmendoza6@gmail.com), Marisa Lozano, Fanny Castro-LLanos, Victor O. Zorrilla, Liz j. Espada, Karin S. Escobedo-Vargas, Victor Lopez, Michael Laurin Fisher, Tal-Beth Cohen, Alden Cohen, Gissella Vasquez

Aedes aegypti, the yellow fever vector, which also transmits Dengue virus (DENV), Chikungunya virus (CHKV), Zika virus (ZIKV) and Mayaro virus (MAYV), is one of the most important vector threats globally. There are different methods for arbovirus detection in *Ae. aegypti* with reverse transcription polymerase chain reaction (RT-PCR) and quantitative real time PCR (qRT-PCR) offering a reduced sample processing time and comparable or better sensitivity than virus isolation. We compared two approaches for DENV detection in field collected *Ae. aegypti*, an optimized Flavivirus RT-PCR and a field-deployable qRT-PCR (Biomeme Pan-Dengue Virus) combined with MinION sequencing confirmation. A total of 689 *Ae. aegypti* (74 pools) collected in 2016-2019 from 12 Peruvian military bases (294 mosquitoes, 34 pools) and 22 civilian communities (395 mosquitoes, 40 pools) located in coastal and jungle regions in northern Peru were tested. Lab-reared *Ae. aegypti* experimentally infected with DENV-2 were included as positive controls in addition to standard positive controls. Four and eight DENV positive pools (Ct = 8.9 - 23.19) were detected by FU1/cFD2 RT-PCR and Biomeme qRT-PCR, respectively. All four Flavivirus RT-PCR positive pools corresponded to Biomeme DENV positive pools with Ct higher than 18. RT-PCR amplicons (250 bp) were sequenced; BLASTn analysis showed 97-99% identity with DENV-3 (accession KJ643590.1). Biomeme DENV positive pools were sequenced using MinION; 3 mosquito pools were negative and 5 mosquito pools were positive for DENV-3. MinION sequencing results coincide with FU1/cFD2 amplicon sequencing for 4 mosquito pools. These 4 DENV-3 mosquito positive pools belong to collections performed in 2017 from military and civilian communities in Piura coinciding with a dengue outbreak in this state during the coastal “El Niño”. Our results indicate that our RT-PCR/ amplicon sequencing approach and the combined portable Biomeme qRT-PCR/MInION sequencing provide comparable results for DENV natural infection detection in field-collected *Ae. aegypti*.

265 Using Satellite Data to Enhance One Health Networks in Vector Control

Helena Chapman (helena.chapman@nasa.gov), Sue Estes, JOHN HAYNES

The One Health concept emphasizes the interconnectedness between human, animal, and environmental health. Through transdisciplinary collaborations, scientists, and community practitioners can lead initiatives that examine risk factors, advance current practices, and conduct interventions that mitigate risk of pathogen or other environmental exposures. As a significant global health concern, vector-borne diseases represent an estimated 17% of all communicable diseases, directly affecting

human and animal health. By incorporating the One Health concept into vector control, this holistic approach can strengthen disease surveillance programs and facilitate communication among stakeholders and community members. To address the global burden of vector-borne diseases, Earth-observing satellite data can allow end users to assess environmental conditions and identify habitats of key disease vectors such as mosquitoes and ticks. These remote sensing data can be combined with field observation data from citizen scientists to examine environmental risks (e.g. mosquito-breeding sites) in affected communities, and hence validate the interpretation of scientific findings. In this presentation, we will describe how cross-cutting scientific research and applications like remote sensing that incorporate the One Health concept can advance our scientific understanding of vector-borne disease risks and encourage community initiatives to safeguard population health. We will also offer opportunities for further scientific collaboration and professional networking within the wider One Health community.

266 The optimization and use of scented sugar baits as a possible early monitoring system for West Nile virus activity

Kara Kelley (kkelley@fightthebite.net), Marcia Reed, Sarah Wheeler

At the Sacramento-Yolo Mosquito and Vector Control District (SYMVCD) continuous effort is made to improve the early detection of West Nile virus (WNv) activity. To that effect, the use of sugar bait stations to expand WNv surveillance was examined in collaboration with the University of California Davis. Virus titers in sugar baits tend to be extremely low compared to other surveillance methods therefore multiple steps were taken to optimize the sugar bait apparatus for increased sensitivity. Evaluations began with assessment of wicking materials to determine whether hydrophilic foam provided a better alternative to the cotton plugs that had previously been deployed. The RNA extraction and RT-qPCR parameters were optimized for this sample type. Additionally, evaluations were made to determine if the sugar solution or the hydrophilic foam would have an effect on the outcome of the RT-qPCR results. In 2019, sugar bait stations were deployed for a week in areas where dead birds or mosquito pools came back positive for WNv. In 2020, sugar bait stations were deployed for a week at sites with unknown virus activity to determine if sugar baits could be utilized as an effective early indicator for WNv activity. An overview of the assay optimization and results will be presented.

267 The development of a spatially resolved ensemble forecast model of West Nile virus transmission in the Coachella Valley, CA

Matthew Ward (mjwa88@gmail.com), Nicholas DeFelice, Meytar Sorek-Hamer, Krishna Vemuri, Jennifer Henke

West Nile virus (WNV) is the leading cause of domestically acquired arboviral disease in the continental United States and exhibits considerable inter-annual and geographical variation in transmission. Although transmission of WNV exhibits a pronounced sensitivity to a complex seasonal ecology, our ability to predict the timing, duration and magnitude of local WNV outbreaks remains limited. As a consequence, effective allocation of public health resources is challenging and often reactive, a circumstance highlighting the need for accurate, fine spatial scale real-time forecasts of transmission. Here, we report on our ongoing development of a spatially refined model that uses ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) data to capture the variability in micro-climates across the Coachella Valley, CA and incorporates it into a graphical

model describing local WNV transmission dynamics. The inclusion of ECOSTRESS' high spatial resolution (70 m) and highest repeat frequency (1-5 days) thermal infrared data in the state space model provides structure and allows us to capture tipping points within micro-ecosystems. The model-inference system can then be used to better understand the spatial variability of the outbreak and the relationship between zoonotic amplification and potential human spillover events in real-time. This work is an initial step in the development of a statistically rigorous framework for spatially resolved indicators of WNV risk.

268 The Caribbean-Appalachian Transect as a critical corridor for mosquito-borne diseases

David Bruce Conn (bconn@berry.edu), Denise Andriot Conn

For centuries, movement of humans and animals across the Caribbean Basin has been accompanied by dissemination of infectious diseases and their insect vectors. In the past decade, first-time incursions of Chikungunya and Zika viruses into the Western Hemisphere were made possible by burgeoning populations of *Aedes* mosquitoes throughout the tropical and subtropical Americas, including Caribbean islands. Large and widespread populations of alien invasive mosquito species, especially *Aedes aegypti* and *Aedes albopictus*, have the potential to exacerbate spread of these and other major human diseases, including dengue and yellow fever, along this corridor. Because of this epidemiological concern, we are developing a system for monitoring potential areas that support high densities of these vector species. From 2018-2021, we conducted surveys in key areas across the Caribbean Basin and the southeastern United States of America (USA). Our site studies extended from southern Caribbean islands to localities across the Gulf and Atlantic coastal plains and of Florida and Georgia, across Georgia's Piedmont, and ending atop the Cumberland Plateau of Tennessee, which is the first significant abrupt elevation rise along what we have termed the Caribbean-Appalachian Transect. Surveys in the Caribbean were single-day samplings, while surveys in the USA ranged from single-day to multiple-day events over various periods of time. We have used a combination of water sampling for larvae, along with various traps and human landing catches for adults. Invasive species have dominated the mosquitoes collected, especially in urban sites, with *Ae. aegypti* occurring in: Bassettere, St. Kitts; Road Town, Tortola, British Virgin Islands; Charlotte Amalie, St. Thomas, U.S. Virgin Islands; San Juan, Puerto Rico; Naples, Florida, USA. The dominant species in Georgia and Tennessee was *Ae. albopictus*, with small numbers of *Aedes japonicus*. We have collected native mosquito species with potential to vector diverse diseases in locations across the southeastern USA.

269 Sentinel chicken surveillance methodologies and best practices

Milton Sterling (drummermp@gmail.com)

Mosquito-borne disease monitoring includes sentinel chicken surveillance among the arsenal of surveillance tools being utilized in an integrated mosquito management program, to prevent the increased arbovirus activity before infections occur in people, and instituting interventions to significantly reduce risk of transmission to humans and horses. This presentation provides an overview of the sentinel chicken surveillance methods and best practices as it relates to mosquito-borne disease surveillance, in particular the various types of Encephalitic viruses such as West Nile, St. Louis, and Eastern equine. Topics include program methods and tools utilized in serum collection and safety, serum data analysis and interpretation, serum testing for virus antibodies, and the importance of sentinel chicken monitoring for vector populations. The sentinel chicken surveillance program as an epidemiological means, provides precise data on location and time of viral transmission, continuous

detection of virus activity throughout the season, and detects increased arbovirus activities in locations where dead bird and/or mosquito surveillance is not practical or performed.

270 Honey-card based arbovirus surveillance in the United States

Kristen Burkhalter (ktb3@cdc.gov), Brad J. Biggerstaff

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 proposed as an alternative or supplement to pool-based testing, but there have been few systematic field evaluations of this method in the United States. We conducted field trials during the summers of 2018 and 2019 to develop algorithms for the operational implementation of honey cards to supplement routine arbovirus surveillance programs conducted by mosquito control districts in the US.

Author Index

Author followed by abstract number

AMCA AWARDS

HONORARY MEMBERS

1937	Leland O. Howard (USDA)	1970	Robert L. Vannote (NJ)	1998	Eugene J. Gerberg (MD)
1938	C. C. Adams (NY)	1971	Richard W. Fay (USPHS)		Glen C. Collett (UT)
1944	Thomas J. Headlee (NJ)	1972	Christian T. Williamson (NY)	1999	Donald R. Johnson (GA)
	William B. Herms (CA)		Alan R. Stone (MD)	2001	Fred W. Knapp (KY)
	J. A. LePrince (USPHS)	1974	Edward S. Hathaway (LA)	2003	E. John Beidler (FL)
	Louis L. Williams, Jr. (USPHS)	1976	Theodore G. Raley (CA)	2004	David A. Dame (FL)
1948	Robert D. Glascow (NY)	1979	John A. Mulrennan, Sr. (FL)	2005	Donald J. Sutherland (NJ)
	Willard V. King (USDA)		Thomas D. Mulhern (CA)	2006	Martin S. Chomsky (NJ)
1951	Lewis W. Hackett (CA)	1981	Austin W. Morrill, Jr. (CA)	2013	Judy Hansen (NJ)
	Robert Matheson (NY)	1983	William R. Horsfall (IL)	2013	Henry Rupp (NJ)
1955	Harold F. Gray (CA)		Anthony W. A. Brown (WHO)	2017	Sammie Dickson
1958	Louis A. Stearns (DE)	1991	Kenneth L. Knight (NC)		
1964	George H. Bradley (USPHS/USDA)	1994	Harold C. Chapman (LA)		
1965	Arthur W. Lindquist (KS)		Lewis T. Nielsen (UT)		
1967	Fred L. Stutz (FL)				

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)	1985	Norman G. Gratz (WHO)	2007	E. John Beidler (FL)
	William R. Horsfall (IL)	1986	James R. Caton (CA)	2008	David A. Dame (FL)
1973	Don M. Rees (UT)	1987	Jay E. Graham (UT)	2009	Dan Ariaz (NV)
	Thomas D. Mulhern (CA)	1988	Lewis T. Nielsen (UT)		Gary Breeden (VA)
1974	Anthony W. A. Brown (WHO)	1989	Andrew J. Spielman (MA)	2010	Mir S. Mulla (CA)
	Donald L. Collins (NY)	1990	Glen C. Collett (UT)	2011	Dave Brown (CA)
1975	Daniel M. Jobbins (NJ)	1991	Harold C. Chapman (LA)	2012	Sammie L. Dickson (UT)
	Arthur W. Lindquist (USDA)	1992	D. Bruce Francy (CO)	2013	Wayne Crans (NJ)
1976	Austin W. Morrill, Jr. (CA)	1993	Gilbert L. Challet (CA)	2014	Chester G. Moore (CO)
	Carroll N. Smith (USDA)	1994	Ronald A. Ward (MD)	2015	Jorge Arias
1978	James B. Kitzmiller (FL)	1995	T. Wayne Miller (FL)	2016	Graham White (FL)
	William D. Murray (CA)	1996	Marshall Laird (New	2017	Randy Gaugler (NJ)
1979	Richard F. Peters (CA)	1997	Robert K. Washino (CA)		Allan Inman (CA)
1980	William E. Bickley (MD)	1998	John D. Edman (MA)	2018	Bill Meredith (DE)
	John N. Belkin (CA)	1999	Bruce F. Eldridge (CA)		Roger Nasci (IL)
1981	Stanley J. Carpenter (CA)	2000	Judy A. Hansen (NJ)	2020	Joe Conlon (FL)
	Roland E. Dorer (VA)	2001	Gary G. Clark (USPHS)	2021	Steve Mulligan (CA)
1982	Kenneth L. Knight (NC)	2002	Lucas G. Terracina (LA)		
	William C. Reeves (CA)	2003	Robert J. Novak (IL)		
1983	Harry D. Pratt (GA)	2004	James D. Long (TX)		
	John A. Mulrennan, Sr. (FL)	2005	James W. Robinson (FL)		
1984	George T. Carmichael (LA)	2006	John L. Clark Jr. (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)	1981	A. Ralph Barr (CA)	2002	Thomas G. Floore (FL)
	Donald L. Collins (NY)		Gilbert L. Challet (CA)		Sherry McLaughlin (TX)
	Theodore G. Raley (CA)		Edgar A. Smith (VA)	2003	Wayne L. Kramer (NE)
1973	Francis P. Creadon (CA)	1982	Hugo A. Jamnback (NY)		John L. Clarke, Jr. (IL)
	Vernon Conant (NJ)		Donald R. Johnson (GA)	2004	Yadira N. Rangel (Venezuela)
	Austin W. Morrill, Jr. (CA)		Harold D. Newsome (MI)		James W. Robinson (FL)
1974	Leslie D. Beadle (USPHS)		James V. Smith (GA)	2005	Major S. Dhillon (CA)
	John H. Brawley (CA)	1983	Richard F. Darsie (CO)		William H. Meredith (DE)
	John W. Kilpatrick (GA)		Ronald A. Ward (DC)	2006	William J. Sames (WA)
	T. Oscar Fultz (GA)	1984	Samuel G. Breeland (FL)	2007	Henry R. Rupp (NJ)
	Howard R. Greenfield (CA)		Donald J. Sutherland (NJ)	2008	Allan Inman (CA)
	Paul J. Hunt (FL)	1985	John C. Kuschke (NJ)		Manuel Lluberas (FL)
	William C. McDuffie (USDA)		James R. Caton (CA)	2009	Joe Conlon (FL)
	Donald R. Johnson (GA)	1986	C. Lamar Meek (LA)	2010	Norbert Becker (Germany)
	Helen Sollers-Riedel (DC)	1987	John C. Combs (CA)	2011	Harry Savage (CO)
1975	Lewis E. Fronk (UT)	1988	Chester G. Moore (CO)		L.A. Williams (SC)
	Joseph G. McWilliams (USN)		Margaret Parsons (OH)	2012	Lal S. Mian (CA)
	Lewis J. Ogden (USPHS)	1989	John S. Billodeaux (LA)		Edsel M. Fussell (FL)
	Rajindar M. Pal (WHO)		Edgar S. Bordes, Jr. (LA)	2013	Kenneth J. Linthicum (FL)
	Kenneth D. Quarterman (USPHS)	1990	Richard D. Morton (WA)	2014	Diann Crane (MN)
	Herbert F. Schoof (USPHS)		Lucas G. Terracina (LA)		Daniel Kline (FL)
1976	Robert A. Armstrong (MA)	1991	David A. Dame (FL)	2015	Mark Latham (FL)
	Osmond P. Breland (TX)	1992	Jerry Mix (TX)	2016	Rui-de Xue (FL)
	George B. Craig, Jr. (IN)	1993	William E. Hazeltine (CA)		William Reisen (CA)
	Claude M. Gjullin (USDA)	1994	Sally A. Wagner (MI)	2017	Michael Turell (MD)
	T. Wayne Miller (FL)	1995	Frederick W. Wagner (KY)	2018	Gary Goodman (CA)
1976	Donald J. Pletsch (Mexico)	1996	Donald J. Sutherland (NJ)	2019	Angela Beehler (WA)
	Glenn M. Stokes (LA)		Ronald A. Ward (MD)	2020	Michael Riles (FL)
	Luis M. Vargas (Mexico)	1997	Roger S. Nasci (CO)	2021	Mustapha Debboun (CA)
1978	Richard C. Axtell (NC)	1997	Thomas J. Zavortink (CA)		
1979	Marco. E. C. Giglioli (BWI)	1998	James D. Long (TX)		
1980	James D. Gorman (FL)	1999	Hilton B. Munns (CA)		
1980	Donald E. Weidhaas (FL)	2000	Leroy J. Bohn (VA)		
	E. John Beidler (FL)		Dreda McCreary (VA)		
	Eugene J. Gerberg (MD)	2001	Charles T. Palmisano (LA)		

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)	1996	Carl R. Tanner (IL)	2010	Gordon Patterson (FL)
	Leslie E. Fronk (UT)		Sammie L. Dickson (UT)		Gary Clark (FL)
	Jesse B. Leslie (NJ)	1997	Charles T. Palmisano (LA)		Yasmin Rubio-Palis
1981	Linda G. Raiche (CA)		George J. Wichterman (FL)	2011	Angela Beehler (WA)
	Margaret S. Slater (NY)	1998	Douglas B. Carlson (FL)		Roxanne Connelly (FL)
1982	K. G. Nolan (NY)	1999	Charles Beesley (CA)	2012	Truc Dever (CA)
	Charles F. Scheel (IL)		Donald R. Johnson (GA)	2013	Robert Peterson (MT)
1983	Coyle E. Knowles (NY)	2000	Peter B. Ghormley (CA)	2014	Salvador Rico (TX)
1984	Ray Treichler (DC)		David A. Brown (CA)	2015	Kristy Burkhalter (CO)
1985	Lawrence T. Cowper	2001	Donald Menard (LA)		Elizabeth Cline (CA)
	Janice B. Wells (NY)		Joel Margalit (Israel)	2016	Angela Beehler (WA)
1986	T. Oscar Fultz (GA)	2002	Dennis Moore (FL)		John Biedler
1987	Sharon A. Colvin (IL)		Henry R. Rupp (NJ)	2017	Peter Connelly (FL)
1988	Daniel D. Sprenger (TX)	200	James R. McNelly (NJ)		Larry Smith (GA)
1989	Fred C. Roberts (CA)		Robert Bonnett (MN)	2018	Stephen Sickerman (FL)
1990	Leonard E. Munsterman (IN)	2004	James R. Brown (FL)		Isik Unlu (NJ)
1991	James D. Long (TX)	2005	Mark Newberg (IL)	2019	Brian Byrd
1992	Charlie D. Morris (FL)		Susan Maggy (CA)		Rui-de Xue
1993	Robert J. Novak (IL)	2006	Teung Chin	2020	Levy Sun (CA)
1994	James W. Robinson (FL)	2007	Karl Malamud-Roam (CA)		Harry Savage (CO)
	Dan L. Ariaz (NV)	2008	Wiliam H. Meredeth (DE)		
1995	Sally Kuzenski (LA)	2009	Rep. Dennis Cardoza (CA)		

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)	2001	John F. Reinert (FL)
1982	Lloyd E. Rozeboom (IL)	2002	Richard F. Darsie (FL)
1983	Kenneth L. Knight (NC)	2003	Richard C. Wilkerson (MD)
1984	Thomas J. Zavortink (CA)	2004	Kazua Tanaka (Japan)
1985	Stanley J. Carpenter (CA)	2005	Ronald A. Ward (MD)
1986	Elizabeth P. Marks & John Reid (Australia)	2006	William K. Reisen (CA)
1987	James B. Kitzmiller (FL)	2008	Maria-Anice Sallum (Brazil)
1988	Allan R Stone (MD)	2010	Daniel Strickman (MD)
1989	Pedro Galindo (Panama)	2011	Rampa Rattanarithikul, Ph.D. (Thailand)
1990	Peter F. Mattingly (UK)	2012	Maureen Coetzee, Ph. D. (South Africa)
1991	Jose P. Duret (Argentina)	2013	John F. Anderson (CT)
1992	Bruce A. Harrison (NC)	2014	Graham White (FL)
1993	Edward L. Peyton (DC)	2015	Elena B. Vinogradova (Russia)
1994	Theodore H. G. Aitken (CT)	2016	
1995	Oswaldo P. Forattini (Brazil)	2017	George F. O'Meara (FL)
1996	A. Ralph Barr (CA)	2018	Dr. L. Philip Lounibos (FL)
	Michael W. Service (UK)	2019	Norbert Becker
1997	Christine J. Dahl (Sweden)	2020	Jan Conn
1998	Ralph E. Harbach (UK)	2021	Ken Linthicum
1999	Yiau-Min Huang (DC)		
2000	Lewis T. Nielsen (UT)		

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.	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, Sr.	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	
2019	William Opp	Gordon Patterson	
2020	Lucas Terracina	Scott Willis	
2021	Lew Nielsen	Sam Dickson Mark Blackmore	

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)	2010	Peter Connelly (FL)
1998	William German (FL)	2011	David Sullivan (MT)
1999	Gary A. Mount (FL)	2012	Stephanie Whitman (WY)
	Daniel F. Boyd (GA)	2013	Larry Erickson (IL)
	David W. Waldron (GA)	2014	Gerry Hutney (FL)
	J. David Waldron (GA)	2015	Joe Strickhouser (NC)
2002	Robert E. Richard (TX)	2016	Terry Couch (FL)
2003	Allen W. Wooldridge (FL)	2017	Clark Wood (IL)
2004	John L. Clarke, Jr. (IL)		Malcom Williams (AR)
2005	Ernest Danka (IL)	2018	Larry Smith (FL)
2006	Willie N. Cox (IL)	2019	Peter DeChant
2007	Bob Bonnett (MN)	2020	Martin Geier
2009	Clarke Hudson (IL)	2021	Bill Reynolds
	Bill Strange (ID)		

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
2019	James Binnall	North Shore MAD, Illinois
	Corey Boyer	Shasta MVCD, California
	David Delgado	Virgin Islands DH
	Aubrey Drummond	Virgin Islands DH
	Gerald Michael Hart	Indian River MCD, Florida
2020	Chad Kirkley	St. Tammany Parish MAD, Louisiana
	Trinidad Haro	Coachella Valley MVCD, California

2021	Reynaldo Morales	Puerto Rico VCU
	Rafael Saavedra-Hernandez	Puerto Rico VCU
	Marc Kensington	Coachella Valley MVCD, California
	Andrew Dewsnup	Salt Lake City MAD, Utah

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
	Linda O'Connor**	University of
	Joshua R. Ogawa*	Oregon State
	Matthew Eaton*	Concordia College
	Linda M. Styer*	U. California, Davis
2007	Jennifer Armistead	University of Florida
	Robert D. Anderson*	University of
	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 -
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 **	University of California
	Edmund Norris***	Iowa State University
2018	Annie Rich***	University of Georgia
	Katelyn Haydett***	University of Georgia
	Jay Brown*	University of Georgia
	Christopher Bibbs*	Anastasia Mosquito Control
	Shiloh Judd**	Louisiana State University
2019	Casey Parker*	
	Ed Norris**	
	Meredith Beaulieu***	
	Raji Joshua***	
	Christopher Bibbs***	

* $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	2019-2020	Jason Kinley
1966-1967	Jay E. Graham	1993-1994	John A. Mulrennan, Jr.	2020-2021	Ary Faraji
1967-1968	Harry D. Pratt	1994-1995	Chester G. Moore		

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AMCA TREASURERS

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

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SECRETARY, EXECUTIVE SECRETARY, EXECUTIVE DIRECTOR

1935-1943	Thomas D. Mulhern*	Secretary	1992-1993	Harold C. Chapman	Executive Director
1944-1950	Thomas D. Mulhern	Secretary	1993-1994	Lucas G. Terracina	Acting Executive Dir.
1950-1952	Thomas D. Mulhern	Executive Secretary	1994-1995	Robert T. Graham	Executive Director
1953-1973	Theodore G. Raley	Executive Secretary	2006-2015	Sarah B. Gazi	Executive Director
1973	Theodore G. Raley	Executive Director	2015-2016	Lori Jensen	Executive Director
1974-1978	Thomas D. Mulhern	Executive Director	2016-2017	Bill Schankel	Executive Director
1979-1980	William D. Murray	Executive Director	2017-2019	Heather Gosciniak	Executive Director
1980-1985	Thomas D. Mulhern	Executive Director	2019-2020	David Butler	Executive Director
1985-1986	James R Caton	Interim Executive	2020 -present	Megan MacNee	Executive Director
1986-1991	Harold C. Chapman	Executive Director			
1991	Lucas G. Terracina	Acting Executive Dir.			
1992	Mark Vinsand	Executive Director			

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BUSINESS MANAGER

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

TECHNICAL ADVISOR

2000-2020	Joseph M. Conlon
2020-present	David Brown

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