

SALT LAKE CITY MOSQUITO ABATEMENT DISTRICT

Executive Director's Report

April 2024

1. Personnel:

Personnel	
Staff	Seasonal
12	10

Type of Work	2024	3 - Year Average
Adulticiding	0.00	0.00
Wetlands / Rural	201.50	99.17
Fish Culture	30.50	19.50
Catch Basins / Gutters	7.00	0.00
Tree Holes	1.00	0.00
Prison	8.00	0.00
Service Request	13.50	2.17
Traps	232.00	55.00
Laboratory	330.75	189.33
Office / Administration	887.50	694.00
Equipment Maintenance	280.25	282.83
Facility Maintenance	177.00	190.75
Training	196.75	97.83
Education	107.00	8.67
Unmanned Aerial System	52.00	13.50
CSU Grant	20.50	0.00
Other Grants	0.00	0.00
Other / Errands	120.75	125.42
Comp. Time Used	71.75	67.42
Vacation	191.00	113.92
Additional Hours	47.75	0.00
Holidays	0.00	0.00
Sick Leave	31.50	60.17
Total	3,008.00	2,019.67

2. Office Activities:

- CFO Fairbanks successfully filed the 2023 ACA 1094-B and 1095-B IRS forms online on 1 April 2024.
- Laboratory Director Bibbs shared anthrone protocols with Dr. Bethany McGregor at the USDA on 1 April 2024.
- Laboratory Director Bibbs visited the wind tunnel laboratories of Dr. Neil Vickers at the UoU on 1 April 2024.
- Laboratory Director Bibbs provided a letter of recommendation of previous seasonal Jarom Brandow on 1 April 2024.
- Executive Director Faraji and Assistant Director White attended the bi-weekly meetings of the Rocky and High Plains Vectorborne Center on 1 April 2024.
- Molecular Biologist Byers met with Nick Delisi from St. Tammany Parish MCD in Louisiana to provide assistance with establishing in-house pathogen testing on 2 April 2024.
- Aerial Operations Supervisor Sorensen attended an AMCA Drone Steering Committee meeting on 2 April 2024.
- Aerial Operations Supervisor Sorensen attended a USU Aviation Program Advisory Committee meeting on 2 April 2024.
- CFO Fairbanks met with Mazhar Kathi, General Manager of the Radisson Hotel Salt Lake City Airport, about catered meals and discounted hotel rooms for visitors on 3 April 2024.
- Executive Director Faraji, Assistant Director White, Aerial Operations Supervisor Sorensen, and Trustee Mooers attended the weekly meetings of the Owner/Architect/Engineers on 3 April 2024.
- Executive Director Faraji and CFO Fairbanks met with Zion's Public Finance in regards to financial forecasting on 4 April 2024.
- Executive Director Faraji met with Dr. Nicole Kep from CSU in regards to surveys on 4 April 2024.
- Laboratory Director Bibbs conducted a phone call regarding insectaries with Dr. Stephen Dobson from the University of Kentucky and MosquitoMate on 4 April 2024.
- Executive Director Faraji met with Dr. Nicole Kep from CSU in regards to surveys on 4 April 2024.
- Molecular Biologist Byers attended and presented at the Pacific Southwest Center of Excellence on 4-5 April 2024.
- Laboratory Director Bibbs conducted a phone call with Dr. Brad Willenberg from the UCF on 8 April 2024.
- Education Specialist Rehbein applied for the Utah Pollinator Habitat Program grant on 8 April 2024.
- Executive Director Faraji met with Gary Gygi in regards to repellent bottling and Hazmat/OSHA requirements on 9 April 2024. He provided a tour of the facility.
- Executive Director Faraji and Assistant Director White met with Dr. Brian Foy from CSU in regards to the Rahp Vec Workshop on 9 April 2024.
- Education Specialist Rehbein conducted a safety meeting for the staff on 9 April 2024.
- Assistant Director White and staff met with architects from Anastasia MCD on 9 April 2024.
- Education Specialist Rehbein met with Greg, Ryan Lusty, Dan Miller, and Sean Amodt to discuss the UMAA Spring Workshop on 9 April 2024.

- Executive Director Faraji and Assistant Director White attended the monthly meetings of the Utah Mosquito Abatement Association on 10 April 2024.
- Executive Director Faraji, Assistant Director White, Aerial Operations Supervisor Sorensen, and Trustee Mooers attended the weekly meetings of the Owner/Architect/Engineers on 10 April 2024.
- Executive Director Faraji attended a CDC Cross Center Working Group meeting on Efficacy of Operational Mosquito Control on 10 April 2024.
- Education Specialist Rehbein and Laboratory Director Bibbs attended, presented, and staffed the booth at the Utah Public Health Association annual conference on 10-11 April 2024.
- Assistant Director White presented at the Colorado One Health Symposium on 11 April 2024.
- Executive Director Faraji and Assistant Director White met with members of the Ouelessebougou Alliance on 11 April 2024.
- Executive Director Faraji met with other mosquito control directors (Metropolitan MCD in Minnesota and Lee County MCD in Florida) to discuss establishment of an exchange program on 11 April 2024.
- Assistant Director White and Education Specialist Rehbein with Department of Corrections regarding the prison on 12 April 2024.
- Assistant Director White and staff met with Teton County Weed and Pest Control regarding MAKD on 15 April 2024.
- Education Specialist Rehbein attended a AMCA Media Cause meeting on 15 April 2024.
- Laboratory Director Bibbs met with Dr. Ilia Rochlin, SLCMAD Biostatistician, in regards to MAKD on 16 April 2024.
- Laboratory Director Bibbs and Molecular Biologist Byers met with Liz Hard from MAD-Davis in regards to aerial evaluations on 16 April 2024.
- Executive Director Faraji attended and presented at the Entomological Society of America's Pacific Branch meetings on 14-18 April 2024.
- Aerial Operations Supervisor Sorensen attended the Florida Aerial Fly In at Lee County MCD on 15-18 April 2024.
- Laboratory Director Bibbs, Molecular Biologist Byers, and Education Specialist Rehbein met with staff at the Hogle Zoo on 17 April 2024.
- Assistant Director White attended a Cross Center Working Group meeting on insecticide resistance on 18 April 2024.
- CFO Fairbanks met with Troy Rendon and Eric Waite, Canon Solutions on 18 April 2024.
- Education Specialist Rehbein attended the Jordan River Commission TAC meeting on 18 April 2024.
- Laboratory Director Bibbs and Molecular Biologist Byers attended the ACCESS Research Symposium on 19 April 2024.
- Education Specialist Rehbein wrote an iNaturalist journal post for the Utah's Wasatch City Nature Challenge project on 22 April 2024.
- Executive Director Faraji and CFO Fairbanks met with Zion's Public Finance in regards to financial forecasting on 23 April 2024.
- Education Specialist Rehbein met with Kelsey Mitchell from Western IPM Center to discuss grants on 23 April 2024.
- The District hosted the SLC Planning Commission for an open house regarding the northwest development on 23 April 2024.

- The District hosted the Utah State Department of Natural Resources Division of Wildlife Resources in regards to the fish biological control program on 24 April 2024.
- Education Specialist Rehbein led a nature walk with Zabrina and Syd from Tracy Aviary at the Day-Riverside Library on 24 April 2024.
- Executive Director Faraji, Assistant Director White, Aerial Operations Supervisor Sorensen, and Trustee Mooers attended the weekly meetings of the Owner/Architect/Engineers on 24 April 2024.
- Executive Director Faraji attended a quarterly advisory meeting for the Northeast Center of Excellence in Vector-borne Diseases on 24 April 2024.
- CFO Fairbanks met with Erik Daenitz from Zions Public Finance to discuss financial forecasting on 24 April 2024.
- Executive Director Faraji met with Dr. Olivia Winokur from Pacific Southwest Center of Excellence in Vector-borne Diseases on 25 April 2024.
- Education Specialist Rehbein met with Dr. Neil Vickers to discuss broader impacts of his NSF grant on 25 April 2024.
- Laboratory Director Bibbs met with Dr. Neil Vickers regarding a potential joint employee on 25 April 2024.
- Education Specialist Rehbein met with and was interviewed by Laura Robertson, an undergraduate student at Princeton, who is working on a semester project about mosquitoes and the USCF on 25 April 2024.
- Executive Director Faraji met with Joe Camacho from Target Specialty Products on 25 April 2024.
- Executive Director Faraji met with Dr. Haley Johnson from Valent Biosciences on 25 April 2024.
- Executive Director Faraji met with Ryan Arkoudas from Clarke on 25 April 2024.
- Executive Director Faraji met with Midvale Mining on 25 April 2024.
- Executive Director Faraji and staff met with Jonah Hill in regards to the front fish tanks on 25 April 2024.
- Molecular Biologist Byers met with Ryan Lusty from Magan MAD regarding pathogen testing and Rahp Vec Workshop on 25 April 2024.
- Assistant Director White and Aerial Operations Supervisor Sorensen provided a Catalyst Center Drone Pilot Class tour of the facility on 26 April 2024.
- Executive Director Faraji and Assistant Director White attended the bi-weekly meetings of the Rocky and High Plains Vectorborne Center on 29 April 2024.
- Executive Director Faraji attended the defense of PhD Candidate Sajjad Khan from Indiana University on 30 April 2024.
- Executive Director Faraji and Assistant Director White met with Dr. Brian Foy and Dr. Tim Burton from CSU in regards to the Rahp Vec Workshop on 30 April 2024.
- Aerial Operations Supervisor Sorensen attended a door hardware meeting with architects and sub-contractors on 30 April 2024.
- CFO Fairbanks attended a URS Annual Comprehensive Training on 30 April 2024.
- Education Specialist Rehbein was interviewed by Alexandria Bonilla from KSL News Radio to discuss the upcoming mosquito season, what our operations are like, and ways people can prevent mosquitoes on 30 April 2024.

3. Shop/Field Activities:

- All vector surveillance trap poles have been placed in the field. Surveillance starts the week of 1 April 2024.
- All calibrations and maintenance are continuing.
- Vehicle and equipment maintenance continues.
- Facility maintenance continues.
- De-winterization of facility and equipment continues.
- Drone/UAS applications have begun (136 acres were treated via UAS in April).

4. Field Data:

Control:

ACRES TREATED

	Adulticide		Larvicide		Total
	Ground	Aerial	Ground	Aerial	
April's Total	0.00	0.00	167.90	288	155.90
April's 3 Year Avg.	0.00	0.00	6.97	0.00	6.97

Service Requests:

MOSQUITO SERVICE OPPORTUNITIES RECEIVED BY MONTH

	March	April	May	June	July	Aug.	Sept.	Oct.	Total
2024	5	17							22
3-Year Avg.	3.67	10.33	29.67	42.00	33.00	22.33	12.67	20.33	174.00

Inspection and Surveillance:

Larval Collections		
Species	April	5-Year Average
<i>Ae. campestris</i>	0	2.2
<i>Ae. dorsalis</i>	29	10.0
<i>Ae. fitchii</i>	0	0.2
<i>Ae. increpitus</i>	0	0.4
<i>Ae. nigromaculis</i>	0	0.0
<i>Ae. niphadopsis</i>	0	0.0
<i>Ae. sierrensis</i>	0	0.0
<i>Ae. varipalpus</i>	0	0.0

<i>Ae. vexans</i>	0	0.0
<i>Cx. erythrothorax</i>	4	0.0
<i>Cx. pipiens</i>	0	0.4
<i>Cx. tarsalis</i>	22	12.4
<i>Cs. incidens</i>	0	0.2
<i>Cs. inornata</i>	15	9.0
<i>An. freeborni</i>	0	0.0
Total	70	34.8

5. Weather:

April's weather was warmer (by 2.3°) and drier (by 0.65") than normal.

Temperature:

	Monthly Avg.	Normal	High	Low
March	44.9°	45.8°	68°	25 °
April	54.1°	51.8°	81°	32 °

<https://w2.weather.gov/climate/index.php?wfo=slc>

Precipitation:

	Total for Month	Normal	Most in 24 hours
March	2.08"	1.75"	0.37" on 12 th
April	1.51"	2.16"	0.88" on 26 th

<https://w2.weather.gov/climate/index.php?wfo=slc>

Great Salt Lake (elevation in feet above sea level):

	March 1	April 1	May 1
2023	4,190.6 ft.	4,191.4	4,192.6
2024	4,193.8 ft.	4,194.3	4,194.9

<https://waterdata.usgs.gov/monitoring-location/10010024/#parameterCode=62614&period=P7D>



Vector Control, Pest Management, Resistance, Repellents

Fatally impaired glucose digestion by propylene glycol in *Aedes aegypti* (Diptera: Culicidae) and co-formulation with terpenoids for enhancing attractive toxic sugar baits

Gavin Maes^{1,2,†}, Giulia Tintorri^{3,4,†}, Irvane E. Nelson^{1,5}, Kobi A. Baker^{1,5}, Corey E. Seavey^{6,⊙}, Michele M. Rehbein¹, Gregory S. White¹, Ary Faraji^{1,⊙}, Bradley J. Willenberg⁶, Christopher S. Bibbs^{1,*,⊙}

¹Public Health Entomology for All Program, Entomological Society of America, Lanham, MD, USA, ²School of Science, Mathematics, and Engineering, Salt Lake Community College, 4600 South Redwood Road, Salt Lake City, UT 84123, USA, ³Salt Lake City Mosquito Abatement District, 2215 North 2200 West, Salt Lake City, UT 84116, USA, ⁴Westminster University, College of Arts and Sciences, 1840 South 1300 East, Salt Lake City, UT 84105, USA, ⁵University of Utah, College of Science, Science Research Initiative, 1390 Presidents Circle, Crocker Science Center, Room 310, Salt Lake City, UT 84112, USA, ⁶Department of Internal Medicine, College of Medicine, University of Central Florida, Orlando, FL 32827, USA *Corresponding author, mail: chris@slcmad.org, csbibbs@outlook.com

[†]Contributed equally as first authors to this project.

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Propylene glycol (PG) demonstrates greater efficacy than other sugar polyols. However, the attributes it confers for toxicity and possible co-formulation with other ingredients are unknown. To evaluate this, α -glucosidase and glucose oxidase reactions were performed in *Aedes aegypti* (L.) (Diptera: Culicidae) to categorize if PG behaves similarly to prior studied sugar alcohols. A combination of no-choice and choice assays was used to determine effective ratios of PG and sucrose, competitiveness against a control of 10% sucrose, and whether mosquitoes recovered from PG consumption. The final trials included β -cyclodextrin encapsulated cinnamon leaf oil, clove stem oil, patchouli oil, garlic oil, cedarwood oil, and papaya seed oil formulated with 5% sucrose + 5% PG. PG functioned as a linear competitive inhibitor of α -glucosidase. The efficacy of PG was synergized by co-ingestion with equivalent ratios of sucrose. Unlike the high diuretic response to other sugar alcohols, PG resulted in diminished excretion regardless of being co-formulated with sucrose or terpenoids. PG is not especially competitive against unadulterated sugar meals but is likewise not clearly repellent. Although mosquitoes did not recover from ingestion of the glycol meals, there was no indication that mortality would continue to accumulate once the treatments were removed. Of the terpenoids tested, cinnamon and patchouli caused ~50% or less mortality; garlic, cedarwood, and clove caused 80–90% mortality; and papaya seed caused 100% mortality, exceeding all other test groups and the formulation blank. PG is a useful supporting ingredient in attractive toxic sugar bait formulations with flexibility in formulation.

Key words: glucosidase, fecal, plant extract, encapsulated oil, sugar alcohols

Introduction

Attractive toxic sugar baits (ATSB) are a formulation and delivery system for toxicants meant for ingestion by a mosquito in order to kill (Revay et al. 2015). This system is point-source in nature, requiring mosquitoes to visit the area of application as they seek nutrient sources, disperse, rest, or look for oviposition sites (Müller and Schlein 2006, Müller et al. 2010, Beier et al. 2012, Sissoko

et al. 2019). The repertoire of potential ingredients is appealing with ATSB, particularly because of the improved viability of toxicants that are otherwise not as easy to use against adult mosquitoes, such as *Bacillus thuringiensis* var. *israelensis* (Bti) (Davis et al. 2021), dinotefuran (Khallaayoune et al. 2013), erythritol (Gilkey et al. 2018, Baker et al. 2023), and garlic oil (Junilla et al. 2015, Revay et al. 2015). However, there are still many avenues for exploring

OPERATIONAL NOTE

A CASE REPORT ON PRODUCT ROTATION TO MANAGE SEVERE *LYSINIBACILLUS SPHAERICUS* RESISTANCE IN *CULEX PIPPIENS* FROM SALT LAKE CITY, UTAH

CHRISTOPHER S. BIBBS, R. BRADLEY SORENSEN, ARY FARAJI AND GREGORY S. WHITE

Salt Lake City Mosquito Abatement District, 2215 North 2200 West, Salt Lake City, UT 84116

ABSTRACT. The Salt Lake City Mosquito Abatement District (SLCMAD) detected a 20,000-fold resistance to *Lysinibacillus sphaericus* (*Lsph*) in *Culex pipiens* occurring in catch basins of Salt Lake City during 2016. In response, SLCMAD suspended use of *Lsph* and rotated use of spinosyn and s-methoprene products for the next three years. At the end of the third year, *Lsph* was evaluated again and efficacy similar to susceptible colony strains. During the second year of *Lsph* use, technicians observed lack of control of larvae at some urban sites. Bioassays performed during 2021 showed recurrence of some resistance to *Lsph* to varying degrees across SLCMAD urban areas. The rapidity with which resistant phenotypes reemerged clarifies that SLCMAD cannot in the near future rely on repeated use of *Lsph*, even after suspending use for three years and using within-season product rotations. Prior reports in other research groups have found long-term selection to *Lsph*, as is the case at SLCMAD, to not regress in spite of halting use of the products. However, our findings offer some optimism that regression may be relatively quick. More operational review is needed, and future work should characterize resistance alleles in field populations. Collectively, there is a lack of concrete data supporting the prevailing assumptions from adjacent industries that were adopted into mosquito abatement. We provide this short note as additional guidance for mosquito and vector control districts weighing options to remediate *Lsph* resistance.

KEY WORDS Catch basin, insecticide resistance monitoring, larvicide, susceptibility, urban

In 2016, the Salt Lake City Mosquito Abatement District (SLCMAD) detected relatively localized, but severe, resistance in local *Culex pipiens* L. arising from catch basins only within the SLCMAD service area after long-term reliance on *Lysinibacillus sphaericus* (Myer and Neide) (*Lsph*) for control of mosquito larvae (Su et al. 2019). The product was used in catch basins of Salt Lake City for over 12 years with no rotation of active ingredients. Up to 3 individual applications of *Lsph* were conducted in approximately 17,000 catch basins annually. The product was not rotated because *Cx. pipiens*, in addition to catch basins, also thrives in a variety of other larval habitats within urban/suburban environments. Thus, SLCMAD had speculated that the genetic introgression from these habitats, which include artificial containers in private residences that are inaccessible and receive no larval treatments, may be enough to suppress *Lsph* resistance buildup. However, not only was resistance to *Lsph* detected, but the resistance ratios also exceeded 20,000-fold as compared to areas approximately 27 km (17 miles) away within the Salt Lake City metropolitan region (Su et al. 2019). Insecticide product rotations (Hemingway et al. 1997, Yamamura 2021), mosaic treatment patterns (Hemingway et al. 1997), and multi-modal mixtures with different active ingredients (Zahiri and Mulla 2003, Sudo et al. 2018) are proposed methods of preventing or remediating insecticide resistance. Laboratory experiments and mathematical models from several other pest management industries have been

used to develop these methods (Sudo et al. 2018, Yamamura et al. 2021).

Managing insecticide resistance in the field is difficult because of poor understanding of how various strategies functionally change the observed resistance in mosquitoes and other vectors (Karunaratne et al. 2018, Lucas et al. 2020). It is assumed that the aforementioned resistance management strategies are effective in vector control, but operational reviews to answer if those same strategies result in changes in the field is currently an area with sparse documented research (Dusfour et al. 2019). At present, plans for restoring field efficacy, especially if resistance alleles are still abundant in the population, are not yielding concrete guidance to mosquito abatement districts for managing resistance that is already prevalent (Hemingway et al. 1997, Ping et al. 2001, Ranson et al. 2010, Macoris et al. 2014). For example, product rotation between *Bacillus thuringiensis* var. *israelensis* de Barjac (*Bti*) and *Lsph* has instigated more acute reversal of resistance development to *Lsph*, whereas mixtures resulted in a slower decline in resistance (Zahiri and Mulla 2003). Cross resistance also is typically unidirectional, with an example being that s-methoprene cross resistance is thus far understood to be unidirectional from s-methoprene to *Lsph* (Su et al. 2019, Su et al. 2021). Does this mean that product rotation should obey a specific order of insecticide classes?



Mosquito (Diptera: Culicidae) species diversity and abundance patterns across tree height and microclimatic gradients in Indiana, USA

Sajjad Khan¹ · Madison G. Abel¹ · Christopher S. Bibbs² · Ary Faraji² · Luis F. Chaves^{1,3}

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Abstract

Climate, land use and land cover change influence infectious disease dynamics, particularly vector-borne diseases. Knowledge about mosquito ecology in southern Indiana is limited. Here, we present results from a season long study where we sampled mosquitoes at the Hickory Ridge Fire Tower in Hoosier National Forest, Monroe County, Indiana, USA. Using BG-Pro traps with BG-Lure and LED lights weekly from 23 May to 31 October 2023, we collected 178 mosquitoes over 24 weeks of sampling, encompassing a total of 120 trap-nights, with an average of 1.48 ± 3.41 (SD) mosquitoes per trap-night. The species accumulation curve for all the samples was flat, indicating a comprehensive sampling of species. We collected 10 species with a Chao2 \pm SE species richness estimate of 14.46 ± 7.14 . The dominant species was *Aedes vexans* ($n=58$, 36%), followed by *Culex* spp. (composed of morphologically indistinguishable *Culex pipiens* and *Culex restuans*) ($n=51$, 31%), *Culex erraticus* ($n=16$, 10%), and *Aedes triseriatus* ($n=15$, 9%). Because mosquitoes are ectothermic, they are highly sensitive to microclimatic variables such as temperature, humidity, and rainfall. Our time series analysis showed a significant association of mosquito abundance with the variability (SD and kurtosis) of the environmental variables we studied highlighting the importance of weather fluctuations in mosquito ecology. Our study highlights how weather variability shapes mosquito abundance, thus impacting disease vectors like *Culex* spp. and *Aedes triseriatus* with implications for arbovirus transmission in the context of climate change.

Keywords Hoosier National Forest · Weather variability · Mosquito ecology · Schmalhausen's Law · Kurtosis · Time series analysis

Introduction

Climate, land use and land cover change are key drivers of mosquito-borne diseases. Mosquitoes are ectotherms and therefore sensitive to microclimatic conditions (Clements 1992; Mayer 2000; Silver 2007). Changes in incidence and prevalence of mosquito-borne diseases are affected by

mosquito abundance, and proximity of human beings to mosquitoes, among many other factors that are linked to climate and land use and land cover change. Mosquitoes are the most important disease vectors in Indiana and transmit pathogens causing diseases such as West Nile virus (WNV) fever, St. Louis encephalitis, and La Crosse fever. Indiana is home to 59 mosquito species which also include disease vectors from many different genera, such as *Culex*, *Aedes*, *Anopheles*, and *Culiseta* (Siverly 1972). In 2023, the Indiana Department of Health reported 13 human infections of WNV while all 92 counties have reported WNV-positive mosquito pools (CDC 2023).

Several studies have shown that adult mosquitoes exhibit vertical stratification due to differences in factors such as temperature, relative humidity, oviposition sites, and blood-meal sources at different tree height levels inside a forest habitat (Novak et al. 1981; Pinto et al. 2009; Hendy et al.

✉ Sajjad Khan
khansaj@iu.edu; sajjadkhan@email.arizona.edu

¹ Department of Environmental and Occupational Health, School of Public Health, Indiana University, 2719 E 10Th St, Bloomington, IN 47408, USA

² Salt Lake City Mosquito Abatement District, 2215 N 2200 W, Salt Lake City, UT 84116, USA

³ Department of Geography, Indiana University, 701 E Kirkwood Ave, Bloomington, IN 47405, USA