# SALT LAKE CITY MOSQUITO ABATEMENT DISTRICT

## Executive Director's Report

### December 2023

1. **Personnel:**

| Personnel | |
|---|---|
| Staff | Seasonal |
| 12 | 4 |

| Type of Work | 2023 | 3 - Year Average |
|---|---|---|
| Adulticiding | 0.00 | 0.00 |
| Wetlands / Rural | 4.00 | 0.00 |
| Fish Culture | 26.50 | 42.25 |
| Catch Basins / Gutters | 0.00 | 0.00 |
| Tree Holes | 0.00 | 0.00 |
| Prison | 1.50 | 0.00 |
| Service Request | 0.00 | 0.00 |
| Traps | 1.00 | 19.92 |
| Laboratory | 281.00 | 150.67 |
| Office / Administration | 979.50 | 696.42 |
| Equipment Maintenance | 223.00 | 250.83 |
| Facility Maintenance | 85.50 | 214.83 |
| Training | 7.00 | 2.33 |
| Education | 58.00 | 2.58 |
| Unmanned Aerial System | 15.00 | 4.50 |
| CSU Grant | 167.00 | 0.00 |
| Other / Errands | 74.00 | 127.83 |
| Comp. Time Used | 129.50 | 52.25 |
| Vacation | 172.75 | 85.67 |
| Additional Hours | 0.00 | 6.42 |
| Holiday | 92.00 | 129.33 |
| Sick Leave | 61.75 | 64.92 |
| **Total** | **2,379.00** | **1,850.75** |

2. **Office Activities:**

- Executive Director Faraji conducted a conference call with US Bank regarding new credit cards for DSLASA on 4 December 2023.

- Assistant Director White conducted a video conference call with Norah Saarman from Utah State University on 4 December 2023.
- Executive Director Faraji, Laboratory Director Bibbs, and Molecular Biologist Byers conducted a conference call with Biostatistician Rochlin regarding various projects on 5 December 2023.
- Executive Director Faraji and Assistant Director White attended a weekly video call with CSU/RaHP Vec on 6 December 2023.
- Executive Director Faraji, Assistant Director White, and Urban Field Supervisor Sorensen attended a weekly OAE construction meeting on 6 December 2023.
- Executive Director Faraji, Trustee Liddle, and Trustee Vickers attended the quarterly board meeting of the Davis-Salt Lake Aerial Spray Authority on 6 December 2023.
- Executive Director Faraji conducted a video call with Mike Banfield and Ashok Joshi regarding a DWFP grant proposal on 7 December 2023.
- Executive Director Faraji attended a video conference call with the Northeast Center of Excellence for Vector-Borne Diseases as an Advisory Council on 11 December 2023.
- Executive Director Faraji, Assistant Director White, and Urban Field Supervisor Sorensen attended a meeting with MOCA (Owners Representatives) on 12 December 2023.
- Assistant Director White conducted a video conference call with partners on the Mali Mosquito Control Project on 12 December 2023.
- Executive Director Faraji and Assistant Director White attended the monthly meetings of the Utah Mosquito Abatement Association on 13 December 2023.
- Executive Director Faraji and Assistant Director White attended a weekly video call with CSU/RaHP Vec on 13 December 2023.
- Executive Director Faraji, Assistant Director White, Laboratory Director Bibbs, and Urban Field Supervisor Sorensen attended a weekly OAE construction meeting on 13 December 2023.
- Executive Director Faraji and CFO Fairbanks met with Trustees Mooers and Vickers to discuss amended and proposed budgets on 13 December 2023.
- Members of staff hosted the Department of Water Resources on 14 December 2023 regarding fish and our biological control program.
- Laboratory Director Bibbs and Molecular Biologist Byers conducted interviews with SRI candidates on 14 December 2023.
- Urban Field Supervisor Sorensen and GIS Specialist Dewsnup met with electrical engineers on 14 December 2023.
- Laboratory Director Bibbs and Molecular Biologist Byers met with Rudolpho Probst from the University of Utah on 15 December 2023.
- Executive Director Faraji met with Tim Burton, Program Coordinator of the CSU RaHP Vec on 19 December 2023.
- Urban Field Supervisor Sorensen met with electrical engineers and Rocky Mountain Power on 19 December 2023.
- Executive Director Faraji and Assistant Director White attended a weekly video call with CSU/RaHP Vec on 20 December 2023.
- Executive Director Faraji, Assistant Director White, and Urban Field Supervisor Sorensen attended a weekly OAE construction meeting on 20 December 2023.
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**3. Shop/Field/Lab Activities:**

- Trap maintenance and fabrication continues.
- Vehicle/equipment maintenance and cleaning continues.

## 4. Weather:

December's weather was warmer (by 4.3º) and drier (by 0.46") than normal.

**Temperature:**

| | Monthly Avg. | Normal | High | Low |
|---|---|---|---|---|
| November | 43.6º | 41.7º | 71º | 24º |
| December | 36.5º | 32.2º | 57º | 20º |

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

**Precipitation:**

| | Total for Month | Normal | Most in 24 hours |
|---|---|---|---|
| November | 1.74" | 1.32" | 0.62" on 19th |
| December | 0.94" | 1.40" | 0.56" on 3rd |

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

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

| | November 1 | December 1 | January 1 |
|---|---|---|---|
| 2022 | 4,188.7 | 4,188.8 | 4,192.6 |
| 2023 | 4,192.1 | 4,192.3 | 4,189.4 |

https://waterdata.usgs.gov/monitoring-location/10010024/#parameterCode= 6214&period=P7D

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Research

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Behavioral Ecology

# Dancing in the purple rain: color affinity and oviposition choices in *Aedes sierrensis* (Diptera: Culicidae)

**Christopher S. Bibbs[1,2,*], Kai Casci[2], Thomas D. Widmer[1], M. Andrew Dewsnup[1], Kaia Jay[3], Kirsten D. Meredith[3], Ary Faraji[1,3], Neil J. Vickers[3]**

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The western tree hole mosquito, *Aedes sierrensis* (Ludlow) (Diptera: Clucidae), is a pestiferous mosquito with a range extending over the entire pacific seaboard and into portions of the intermountain west. As a peridomestic heartworm vector, it demands at least some level of surveillance to understand its abundance. However, the species is refractory to a majority of conventional vector surveillance approaches for tracking mosquitoes. To find more options for *Aedes sierrensis* surveillance, a variety of oviposition attractants were evaluated in arena-style choice assays using colony reared adults. A range of infusion treatments (e.g., alfalfa, oak, and beetroot) were examined and then combined with investigations of liquid color as well as ovicup color and entryway position. These studies revealed that *Ae. sierrensis* have an affinity for purple coloration, plain water, and larger entryway sizes for oviposition cups. A prototype ovicup was 3D-printed using purple filament and multiple types of entryways, and used to re-test infusion waters. No particular attraction differences were detected after normalizing for purple color. Comparisons to black 3D-printed cups yielded surprising observations that male mosquitoes also aggregated on purple cups while females sheltered, but not necessarily oviposited, in black cups. Although this was only a laboratory-based assessment, these studies provide useful information for future field trials of potential oviposition traps for surveillance of *Ae. sierrensis*.

*Key words:* attractant, vector, ovitrap, color, infusion

## Introduction

Mosquito monitoring is critical for understanding, keeping historical records on, and ultimately targeting nuisance or vector mosquito species for abatement purposes (Chen et al. 2011, Crepeau et al. 2013, Connelly et al. 2020). Ubiquitous vectors, particularly invasive species, are major focus areas for mosquito abatement programs (Crepeau et al. 2013, Connelly et al. 2020). However, when dealing with highly regionalized species, such as the western tree hole mosquito, *Aedes sierrensis* (Ludlow), there is a distinct lack of basic information. Deficiencies in basic information, in turn, make it difficult to properly implement associated research, surveillance, and interventions.

Despite a patchy distribution and cryptic morphological sister species (Arnell and Nielsen 1972), *Ae. sierrensis* manifests as a target for mosquito abatement because of aggressive nuisance biting, opportunistic blood feeding, and often hyperlocal density that can plague unwitting residents in peridomestic environments (Scoles et al. 1993). This species is of further significance because it is a putative vector of dog heartworm, *Dirofilaria immitis* (Leidy), in western states (Walters and Lavoipierre 1982, Scoles et al. 1993, Tran et al. 2022). The role of this species in heartworm epi-cycles is largely unclear (Tran et al. 2022), in part due to an eclectic biological niche (Maciá and Bradshaw 2000), making surveillance outside of landing catches (human or otherwise) largely ineffective (Walters and Lavoipierre 1982, Garcia et al. 1988, Chaves et al. 2020). Surveillance deficits for this species has resulted in routinely occurring nuisance complaints within riparian areas and edges in SLCMAD and other regions of the western United States (Scoles et al. 1993, Tran et al. 2022), while also potentially maintaining *D. immitis* circulation within urban and periurban green belts.

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Short Communication

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Vector Control, Pest Management, Resistance, Repellents

# Enhancing toxic sugar meals against *Aedes aegypti* (Diptera: Culicidae) by adulterating with erythritol in combination with other active ingredients

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Attractive toxic sugar baits (ATSBs) are an underexploited method for mosquito control. For ATSBs to be more widely accepted, demonstrably effective ingredients need to be verified. We investigated erythritol as a toxic additive in sugar meals against *Aedes aegypti* (L.) for potential future use in ATSBs. Erythritol is a sugar alcohol that is commonly used as a sugar substitute, while also being toxic to mosquitoes. Our studies tested formulations of erythritol, sucrose, and blends of both. Secondary investigations included combinations with the active ingredients *Bacillus thuringiensis israelensis*, spinosyn, and boric acid. Adult *Ae. aegypti* were separated into test groups and provided various combinations. Formulations containing erythritol, with or without another toxicant, exhibited 90% mortality within 72 h of observation ($P = 0.03192$). Additionally, erythritol appeared more effective when combined with sucrose in a 1:1 ratio (5% concentration each). This combination showed a 24% and 85% increase in mortality when combined with boric acid and *Bti*, respectively, at 48 h compared with equivalent groups containing only 10% sucrose. Erythritol appears to kill adult mosquitoes, even in relatively low concentrations, without another toxicant being required. However, erythritol also effectively enhances kill of main ingredient toxicants such as boric acid and *Bti*, showing a supporting role. The low concentration of erythritol needed to provide significant kill, its ability to fill in as both a sugar base and toxicant, and its ability to be safely handled by humans makes erythritol a strong candidate for use as a supporting ingredient in future bait formulations.

*Key words:* mosquito, sugar alcohol, sugar bait, sugar meal, *Bti*

## Introduction

*Aedes aegypti* (L.), the yellow fever mosquito, has been expanding to previously uninhabited regions at a particularly alarming rate (Reinhold et al. 2018, Kraemer et al. 2019, Iwamura et al. 2020), including to areas not originally forecasted as risk zones for establishment (Gloria-Soria et al. 2022). The continued spread of *Ae. aegypti* favors human adjacency (Harrington et al. 2001, Ponlawat and Harrington 2005), stilting its role in the transmission of Zika, chikungunya, yellow fever, and dengue viruses (Powell et al. 2018, Souza-Neto et al. 2019). When coupled with the progress loss in effectiveness of spray-centric vector prevention strategies (Nannan 2015, Karunaratne et al. 2018), it accelerates interest in delivery methods and ingredient choices that break the paradigms of current best practices.

A promising alternative method for mosquito control comes in the form of sugar meals laced with the toxicant. This way of presenting active ingredients takes advantage of the sugar-feeding behavior present in both male and female mosquitoes (Foster 1995, Sissoko et al. 2019). When integrated with an attractant, usually fermented fruit or floral aromatics, you can make an attractive toxic sugar bait (ATSB). Mosquitoes are drawn to the solution via the attractant, with the hope that they will then be enticed to ingest the sugar solution, being then killed via the toxin. Many different attractants, pesticides, and synergists have been used and tested in ATSB formulations, with mixed results (Fiorenzano et al. 2017, Alomar et al. 2022).

It is less explored what occurs when restructuring the sugar meal part of the formulation. To that end, a foundational study was conducted analyzing various sugars and their standalone effectiveness as toxicants (Airs et al. 2019), to which lactose was toxic and arabinose seemed both phagostimulant and toxic. A similar study

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Research

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# Do it yourself: fabricating and evaluating a mosquito (Diptera: Culicidae) blood-feeding device to replace a commercial option

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Tools for rearing hematophagous insects, such as mosquitoes (Diptera: Culicidae), in an insectary are essential for research and operational evaluations in vector biology and control. There is an abundance of low-cost options for practitioners without conventional infrastructure. However, few midrange options exist that provide a balance of efficiency and low material waste. We present here a reproducible design for an electrically powered blood-feeding device that offers long-term reusability, low material waste, and customizability for different species or experiments. The limitation is the requirement for electricity, but the gain is a simple, low-skill device that can be modified as needed. To validate the design, assessments of feeding angle and blood-feeding success were compared between the Salt Lake City Mosquito Abatement District artificial membrane feeder (SLAM) and a commercial system (Hemotek). Engorgement in *Aedes aegypti* (80–90%), *Culex pipiens* (50–80%), and *Culex tarsalis* (30–75%) was similar between the 2 units, resulting in nearly identical fecundity outcomes between devices. Additionally, 45° angles were more successful, generally, than presenting the feeders flat or vertical to the mosquitoes ($df_{3,48}$, $P = 1.014 \times 10^{-15}$). This angle is simple to present with the SLAM device. Materials for in-house reproduction of the SLAM system are now widely available in regions with access to e-commerce and shipped goods. This results in a device schematic that should fit well into a relatively modular, do-it-yourself paradigm where the practitioner needs only to assemble some materials without complex engineering. This article provides schematics, cost comparison, and validation of the in-house-made SLAM system.

*Key words:* artificial membrane feeder, rearing, blood feeding, vector, Hemotek

## Introduction

Research on hematophagous insects, such as mosquitoes (Diptera: Culicidae), is intrinsically limited by successful blood consumption during colony rearing or experiments. Historically, blood feeding of various insects can require host animals or volunteers offering an arm, which may also invite ethical scrutiny and complex regulations that may, or may not, directly influence the feasibility of the study (Achee et al. 2015). Aside from the logistical burden of acquiring exogenous blood meals, technical limitations on how to deliver the blood can also hamper scientific and operational investigations. In the case of mosquitoes, blood must be offered at or above body temperature and can compromise laboratory hygiene if not contained in a membrane or specialized device. The importance of accessible technology escalates when you consider that these devices can be an integral part of research beyond colony rearing, such as efficacy bioassays (Tsurukawa and Kawada 2014, Morimoto et al. 2021) or infectivity studies (Witmer et al. 2018, Sri-in et al. 2020). Improvements in technology have yielded designs for both disposable and reusable self-manufactured devices.

Most low-resource designs will repurpose disposable materials that are readily available (Tseng 2003, Costa-da-Silva et al. 2013, Finlayson et al. 2015, Siria et al. 2018, Chalida et al. 2020, Tyler-Julian et al. 2021, Faber et al. 2022). Unfortunately, they also generate waste from disposable material accumulation and often exhibit reduced integrity because of plasticware or other materials that age poorly. They can also be time consuming to construct enough of them to use routinely with large numbers of colonies. Single-use materials are advantageous when the alternative is unsuccessful blood feeding; for example, in countries where infrastructure or tools are limited (Costa-da-Silva et al. 2013, Finlayson et al. 2015, Siria et al. 2018, Chalida et al. 2020, Faber et al. 2022). However, there is a distinct absence of midrange devices that are scalable while also having a good balance of efficiency, ease of use, and low waste.

The most widely used midrange systems use recirculating water baths for balanced heating and modularization (Luo 2014, Dias et al. 2018, 2021, Faber et al. 2022). They also tend to require additional components, such as miscellaneous glassware, heating elements or hot plates, and tubing. There have been notable improvements in this

pollutants

*Review*

# Are Adult Mosquito Control Products (Adulticides) Harmful? A Review of the Potential Human Health Impacts from Exposure to Naled and Dichlorvos (DDVP)

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**Abstract:** We performed a thorough systematic review of published literature to determine potential links between human health impacts and naled, a registered adult mosquito control product (adulticide), and its major degradate, dichlorvos (DDVP). A search query was performed on 8 September 2023, capturing all articles published up to that date on the Scopus and PubMed databases. Inclusion criteria were the presence of either pesticide and a measured or modeled human health outcome or risk. The search string resulted in 382 articles; however, 354 articles were excluded, resulting in only 28 articles that met the inclusion criteria. The studies that directly relate to aerosolized ultra-low volume (ULV) mosquito control applications did not report any associated deleterious human health outcomes. Results from the reviewed papers displayed no negative health effects or led to inconclusive results. No studies showed adverse health effects from aerial ULV applications for mosquito management. Our findings are congruent with the United States Environmental Protection Agency and Centers for Disease Control and Prevention recommendations that aerial applications of naled, following label parameters, do not pose an adverse risk exposure to humans, wildlife, and the environment.

**Keywords:** naled; dibrom; dichlorvos; DDVP; ultra-low volume; pesticides; aerial applications; mosquito control; adulticiding; human health



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## 1. Introduction

### 1.1. Motivation

The Food and Agriculture Organization of the United Nations and the World Health Organization are currently in the final drafting phases for the 2022 Guidance for Aerial Application of Pesticides [1]. The guidance for agricultural aerial pesticide application is Conventional (625 to 4168 or more mL/ha) and ultra-low volume (ULV) (less than 125 mL/ha) by volume of the active ingredient. The recommended ULV aerial pesticide application rate for adult mosquito control (adulticiding) is between 32 and 65 mL/ha by volume of the active ingredient. This guidance results in mosquito ULV application rates, which are 0.008–0.1% of conventional aerial agricultural applications by municipal mosquito control programs, such as the Salt Lake City Mosquito Abatement District (SLCMAD). The SLCMAD has jurisdictional boundaries over 285 square kilometers (110 square miles) in Salt Lake City, Utah, United States, and is tasked with quality-of-life enhancement and public health protection from mosquitoes and mosquito-borne pathogens. The district proactively conducts research in excess of federal and state requirements, to ensure continuing safety and efficacy of products and methods used for mosquito suppression.

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# EVALUATION OF AN AERIAL APPLICATION OF DUET HD® AGAINST *AEDES DORSALIS* AND *CULEX TARSALIS* IN RURAL HABITATS OF THE GREAT SALT LAKE, UTAH

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ABSTRACT. The Salt Lake City Mosquito Abatement District (SLCMAD) has been conducting aerial applications using an organophosphate insecticide against adult mosquitoes for several decades. In order to evaluate a potential rotation product, aerial applications of Duet HD™, a pyrethroid, were conducted under operational conditions against wild populations of *Aedes dorsalis* and *Culex tarsalis* and against colony strains of *Cx. pipiens* and *Cx. quinquefasciatus*. The erratic wind patterns of the greater Salt Lake area did not prevent sufficient droplet deposition flux at 9 monitoring locations spread across a 5,120-acre (2,072 ha) spray block within rural habitats. Three separate aerial application trials showed great efficacy against *Ae. dorsalis*. In contrast, *Cx. tarsalis* exhibited inconsistent treatment-associated mortalities, suggesting the presence of less susceptible or resistant field populations as a result of spillover from agricultural or residential pyrethroid usage. Bottle bioassays to diagnose pyrethroid resistance using field-collected *Cx. tarsalis* indicated that some populations of this species, especially those closest to urban edges, failed to show adequate mortality in resistance assays. Despite challenging weather conditions, Duet HD worked reasonably well against susceptible mosquito species, and it may provide a crucial role as an alternative for organophosphate applications within specific and sensitive areas. However, its area-wide adoption into control applications by the SLCMAD could be problematic due to reduced impacts on the most important arboviral vector species, *Cx. tarsalis*, in this area. This study demonstrates the importance of testing mosquito control products under different operational environments and against potentially resistant mosquito populations by municipal mosquito control districts.

**KEY WORDS** Adulticide, insecticide resistance, mosquito control, organophosphate, pyrethroids

## INTRODUCTION

Federal and state guidelines for protecting the public during outbreaks of mosquito-borne diseases recommend ultra-low-volume (ULV) adulticides from aircraft and truck-mounted equipment as the most effective method of reducing transmission risk to humans (CDC 2003). These adulticide applications play a crucial role in the overall architecture and success of mosquito abatement operations throughout the continental USA. Although ground applications enable responses to localized “hot” spots, the aerosol characteristics at ground level may exhibit reduced efficacy because of insufficient coverage or penetration into habitats (Reddy et al. 2006, Lothrop et al. 2007, Farajollahi et al. 2012, Faraji et al. 2016). These response deficiencies can prove critical during limited time periods to control outbreaks of mosquito vectors and their associated pathogens (Lothrop et al. 2007, Tedesco et al. 2010). Aerial applications of adulticides are more effective at providing greater land area coverage and improved mosquito contact through descending aerosolized droplets (Tedesco et al. 2010, Bonds 2012). This improved coverage is particularly important for the greater Salt Lake, Utah, area, where thousands of acres of wetlands produce immense numbers of *Aedes dorsalis* (Meigen) and *Culex tarsalis* Coquillett in mostly undeveloped areas with limited road coverage. Therefore, aerial adulticide applications remain the most effective and viable option for the Salt Lake City Mosquito Abatement District (SLCMAD) when area-wide coverage of large swathes of mosquito habitat, which are otherwise inaccessible, is of utmost importance. Selection of an appropriate active ingredient and formulation is also pivotal to ensure efficacy where parameters such as climatology, environmental conditions, topography, and insecticide resistance should be considered.

Pyrethroids and organophosphates are the only 2 pesticide classes certified for ULV applications for adult mosquito control in the USA (Davis et al. 2007). Pyrethroids exhibit very low mammalian toxicity but can be highly toxic to some aquatic organisms (Davis et al. 2007). Organophosphates are more toxic to terrestrial vertebrates but can be quickly broken down in the environment and are less toxic to aquatic organisms (USEPA 2006, Davis et al. 2007). Dibrom® (87.4% naled, AMVAC Chemical Corporation, Commerce, CA) is an organophosphate insecticide used aerially by the SLCMAD since the 1970s. The unique chemistry of Dibrom and high specific gravity of the formula enable excellent penetration through thermal inversion layers, erratic environmental conditions at ground level, and some vegetative barriers (Davis et al. 2007). Additionally, the active ingredient is susceptible to photolysis and hydrolysis, resulting in a short environmental half-life (USEPA

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