TOLEDO AREA SANITARY DISTRICT
76TH ANNUAL REPORT

MOSQUITO CONTROL
FOR A SAFE AND
QUALITY ENVIRONMENT

2022

A LETTER FROM THE GENERAL MANAGER

February 14, 2023

Mr. Mark Stutler, Director
Toledo Area Sanitary District
5015 Stickney Avenue
Toledo, Ohio 43612

Mr. Stutler:

In compliance with Section 6115, paragraph 14 of the Ohio Revised Code, I hereby submit the Annual Report for 2022. This 76th Annual Report of the Toledo Area Sanitary District (TASD) contains a financial report for 2022 as well as a budget for 2023. It also summarizes the District's operations, field activities, and achievements over the past year. This year's annual report assumes the reader possesses a certain degree of understanding regarding mosquito biology and the history and funding of the District. For more information on these topics, I encourage the reader of the report to visit the TASD website www.toledomosquito.org

2022 was a calm year for mosquito control in Lucas County. Fairly mild and dry weather throughout the season led to low mosquito nuisance populations and a lower than usual concern for West Nile Virus transmission. Nonetheless, it was an exciting year with some landmark program achievements and highlights that will be discussed throughout this report.

The techniques, insecticides, and equipment used by the District, as always, are among the most widely recommended and accepted in the industry. As a result, the District continues to be influential in educating and recommending sound best management practices throughout the state of Ohio and neighboring states.

The tremendous assistance and support we continue to receive from you and the Advisory Committee is greatly appreciated. Going forward, we will continue to do our best to fulfill our mission and provide the citizens of Lucas County with mosquito control for a safe and quality environment.

Respectfully submitted,

Paul R. Bauman
General Manager

TABLE OF CONTENTS

APPENDIX

STAFF & ADVISORY COMMITTEE

EXECUTIVE COMMITTEE

MARK A. STUTLER
Director

RUSSELL R. MILLER
Secretary-Treasurer

PAUL R. BAUMAN
General Manager

PERMANENT EMPLOYEES

BRAD BETZ
Field Supervisor

MYLES CARYER
Larviciding Chief Supervisor

LISA DIEHL
Office Manager | Bookkeeper

KELLY HAHN
Office Clerk | Assistant Bookkeeper

DARNEA MERRELL (resigned May 2, 2022)
Larviciding Chief Supervisor

JERRY MOORE
Field Supervisor

DOUG NABORS
Field Supervisor

MARK NYE
Larviciding Operations Manager

JUSTIN RIST
Breeding Source Reduction Operations Manager

HUNTER SANNER
Field Supervisor

BOB SATTLER (retired June 30, 2022)
Operations/Substation Manager

BOB SCHRAMM
Field Supervisor

DR. JENNIFER SHIMOLA
Education & Research Coordinator

THOMAS SHULTZ
Field Supervisor

JESSE STRICKLAND (hired July 11, 2022)
Field Supervisor

JACOB SUBLETT
Biologist | GIS Specialist | Assistant GM

LUKE SWIDEN (hired April 4, 2022)
Field Supervisor

BEN WHITE
Adulticiding Operations Manager

SEAN WILSON (hired April 4, 2022)
Field Supervisor

SHANNON WILSON
Field Supervisor

2022 SEASONAL EMPLOYEES

CARISSA BELL
Lab Technician

SYDNEY BIEBERICH
Lab Technician

KATTIE BRAYLOCK
Night Fogging

MELISSA CLAWSON
Lab Technician

RICHARD COLESTOCK
Night Fogging

ALEXIS CORDEL
Lab Technician

JAN CORTHELL
Night Fogging

TERI FISCHER
Night Fogging

BAILEY HETTINGER
Lab Technician

DEREK MCKINNEY
Lab Technician

GLENN NEWMAN
Night Fogging

KURT SUSDORF
Night Fogging

JACOB WEIDEN
Night Fogging

JOSH WHITE
Night Fogging

ADVISORY COMMITTEE & CONSULTANTS

JENNIFER GOTTSCHALK
Director, Toledo-Lucas County Health Department

MICHAEL K. HART
Public Information - Consultant

DAVID G. HUEY
Retired Director, Toledo Area Sanitary District

THOMAS KOVACIK
Kovacik Consulting

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Legal Counsel - Consultant

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KONNI SUTFIELD
Retired Supervisor, Toledo-Lucas County Health Department

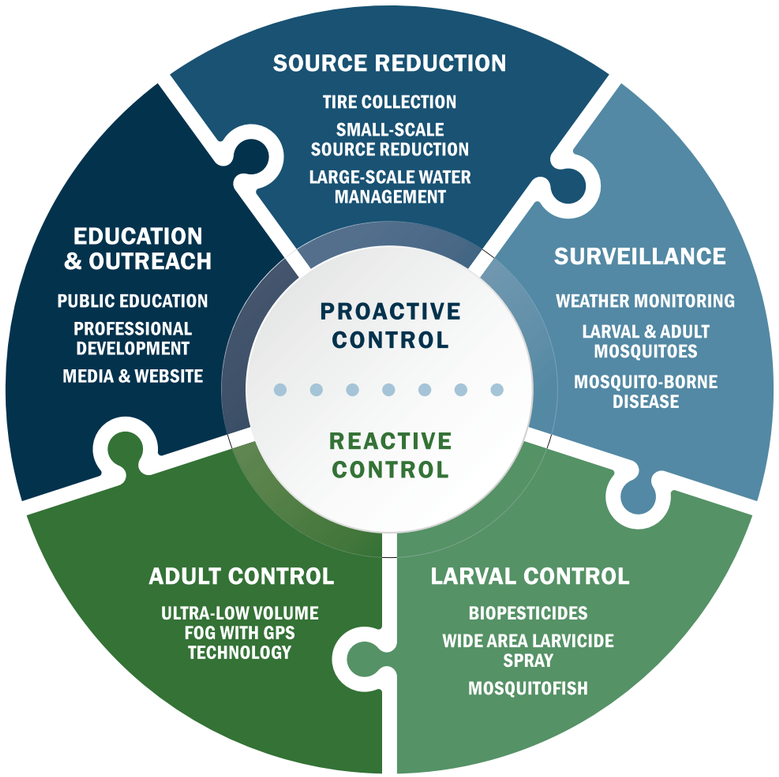
DR. R. TRAVIS TAYLOR
Associate Professor of Medical Microbiology & Immunology, UT College of Medicine

DR. RYAN WALSH
(joined November 18, 2022)
Director of Plant Conservation, The Toledo Zoo

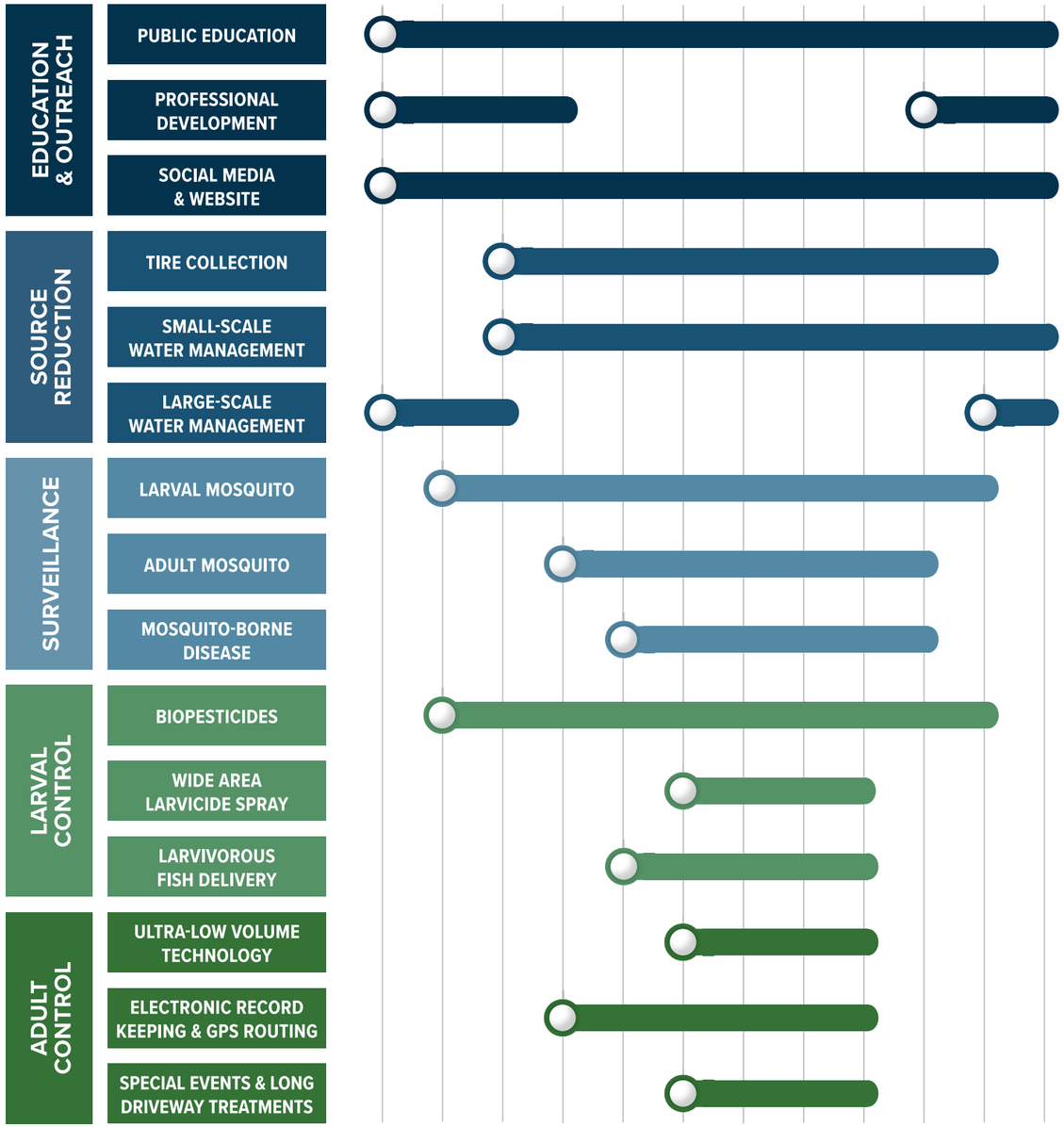
INTEGRATED MOSQUITO MANAGEMENT

The TASD practices, promotes, and firmly believes in using *integrated mosquito management* (IMM) techniques for its operations. Using IMM philosophies means that the District approaches the task of mosquito control from a holistic perspective that is both proactive to prevent mosquito proliferation and reactive to reduce established populations, when surveillance dictates the need.

The IMM approach employed by the TASD focuses on surveillance, mapping, breeding source reduction, larval mosquito control, adult mosquito control, and education/community outreach. No single phase of the IMM approach is more important than another. Each aspect of this approach is integral to reducing and controlling mosquito populations in the most efficient and environmentally conscious manner possible.



IMM ACTIVITY CALENDAR



IMM EDUCATION & OUTREACH

PUBLIC EDUCATION

TASD provided educational information concerning homeowner control and personal protection at two neighborhood associations, two career days, five classrooms, a Maumee Garden Club meeting, Imagination Station's Girl Power event, and BGSU's Pre-Veterinary Virtual Camp. TASD's book, 'Fight the Bite', was distributed to Burroughs Elementary School, Beverly Elementary School, and the Grace Community Center.

Neighborhood associations listed on the City of Toledo's webpage were contacted about mosquito control presentations during the onset of mosquito season. TASD met with the Toledo Olde Towne Neighborhood Association and the Burroughs Neighborhood Association in June to discuss services offered and online service request submission. Homeowner control flyers and repellent wipes were distributed to attendees.

Classroom visits took place in kindergarten, first grade, and seventh grade classrooms. Kindergarten students made a mosquito with craft supplies and identified their mosquito species. Using an age-appropriate field-guide, the students learned about reducing mosquito habitat for their mosquitoes. First-grade students made mosquito dippers to learn about mosquito breeding habitats and to identify mosquito larvae. Seventh grade students explored the relationship between water pollution and mosquito breeding through scientific observation and water quality testing.

TASD promoted mosquito control at three Toledo Mud Hens games hosting local school districts with ticket giveaways. These games featured an outfield wall graphic, a short video, and a public service announcement related to mosquito-bite prevention and homeowner mosquito control.

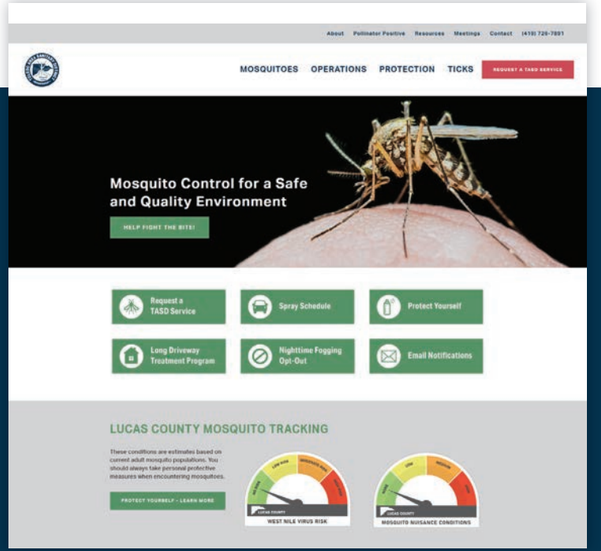
TASD's outfield signage displayed at the Toledo Mud Hens' Fifth-Third Stadium in downtown Toledo.

This honey was produced by local bees maintained and cared for at the District's office.

Native seeds were collected from TASD's prairie to demonstrate the compatibility of mosquito control and pollinator conservation.

In 2022, local honey and native seed packets were processed and packaged as pollinator-positive promotional items. Honey and seeds were produced on-site via TASD's beehive and native prairie, respectively. These items will be distributed to demonstrate the compatibility of mosquito control and pollinator conservation.

A new website design was launched in 2022 to promote TASD's mission, increase ease of use, and to more accurately track site views. A total of 27,861 website visits were recorded following its launch, with the most visits occurring in June. The homepage, spray schedule, and services were the most visited pages in 2022.



TASD's new website was optimized to make its services more accessible. Additionally, the most popular pages were collected into a quick link section on the home page for easy access.

IMM EDUCATION & OUTREACH
PROFESSIONAL DEVELOPMENT

TASD employees continued their education and promoted TASD's research by attending annual conferences hosted by the Ohio Mosquito and Vector Control Association (OMVCA) and the Michigan Mosquito Control Association (MMCA). TASD provided training on adult mosquito control efficacy evaluations for mosquito control professionals at OMVCA's annual spring seminar. TASD's research on adult mosquito control and urban insect communities, a collaborative project with the Toledo Zoo, was presented virtually at the annual MMCA conference.

IMM EDUCATION & OUTREACH
MEDIA AND SOCIAL MEDIA

TASD was the subject of three local news stories which focused on preparing for mosquito season in 2022. TASD continued its social media presence on Facebook and Instagram with a page reach of 8,164 and 341, respectively.

TOP
TASD's Skeeter Squad and activities were promoted on social media.

LEFT
Pre-treating for mosquitoes in Lucas County was aired on 13 ABC in April.

IMM SOURCE REDUCTION
TIRE COLLECTION

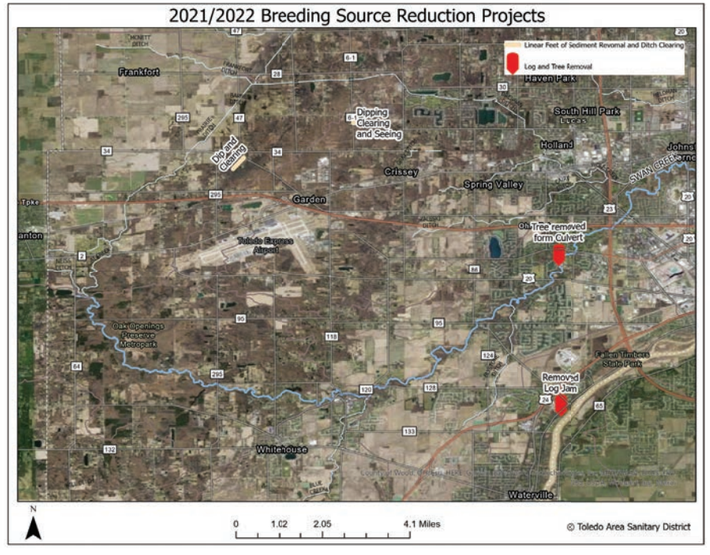
The removal or modification of potential mosquito breeding habitats is a basic component of a good mosquito control program. TASD staff is routinely involved in small-scale mosquito breeding source reduction efforts on a daily basis. One example of small-scale water management is the TASD tire collection operation. TASD collects discarded scrap tires that would otherwise breed mosquitoes and could create a public health concern. This program is designed to pick up tires that have been dumped or left in the community. These tires would otherwise not be recycled and provide mosquitoes a place to reproduce. For the past six years, TASD has partnered with tire recyclers to collect abandoned and scrap tires throughout Lucas County. The total tire collection in 2022 was 6,832 tires in six semi-trailer loads.

Abandoned tires provide a perfect habitat for numerous species of mosquitoes to develop.

IMM SOURCE REDUCTION
LARGE-SCALE WATER MANAGEMENT

In the 2021/2022 season, TASD continued to make efforts to reduce large-scale mosquito breeding habitats. TASD staff completed two projects started in the previous season, working to clear brush and to conduct ditch sediment removal. Moreover, two additional projects; the removal of a downed tree from a drainage culvert and the clearing of a log jam were completed during the 2021/2022 season. Finally, staff members continued to further the Great Lakes Sediment and Nutrient Reduction Program supported the project, located on Wiregrass ditch in western Lucas County. TASD worked with the Lucas County Engineers to obtain detailed project plans and to acquire the necessary permits to start the project.

TASD removes debris that was causing water to collect in this ditch and breed mosquitoes.



The map to the left shows the locations and approximate distances for the projects conducted in the 2021/2022 water management season.

IMM SURVEILLANCE
LARVAL MOSQUITO

A total of 6,002 adult mosquitoes were reared in TASD's insectary for surveillance and research in 2022. A total of 3,587 larval inspections were recorded in 2022 starting on March 3rd. Fifty-eight percent of larval inspections detected mosquito larvae.

Five hundred thirty-three larval samples were collected between March 16th until November 29th. Field samples typically reared between two and eight adults, though 53 percent of samples reared no adult mosquitoes.

Nineteen species of mosquitoes were identified from larval collections in 2022. The majority of mosquitoes reared for surveillance were *Aedes vexans* (25%) or *Culex pipiens* (23%). *Culex restuans*, *Aedes japonicus*, and *Aedes sticticus* each composed approximately ten percent of the adults reared. A few of the rare species (less than one percent of mosquitoes reared) identified from the insectary included *Psorophora ferox*, *Culiseta inornata*, and *Aedes atropalpus*.

Mosquito larvae are collected in the field and reared in TASD's insectary for species identification.

IMM SURVEILLANCE
ADULT MOSQUITO

Adult mosquito surveillance began on May 3rd and continued through October 3rd. TASD biological staff utilized a variety of different traps to gain insight into different facets of the adult mosquito population, including New Jersey Light Traps (NJLT), BG Sentinel 2 traps, CDC light traps, and Gravid Traps.

TASD deployed 26 NJLTs throughout Lucas County equipped with digital timers allowing for up to 7 nights of collection a week (more commonly samples were collected between Sunday through Thursday nights). There were 2,093 different NJLT trapping events in the 2022 season. The TASD laboratory staff identified 8,009 adult female mosquitoes from these traps, in 2022 (APPENDIX – Table 2). Collections from these traps were much lower

IMM SURVEILLANCE
ADULT MOSQUITO cont.

than the historical average. *Aedes vexans* were still the most predominant species collected.

TASD conducted over 300 CDC trapping events. These traps traditionally utilized CO_2 to attract host-seeking mosquitoes, respond to citizen reports of areas with high mosquito populations, and fill in gaps in our surveillance networks. The total number of female mosquitoes collected from the CDC trap was 8,392, with *Ae. vexans* and *Ae. trivittatus* being the main species collected.

BG Sentinel 2 traps continued to be used during this season. Surveillance staff conducted 336 BG Sentinel 2 trapping events and collected 12,611 female mosquitoes. These traps have been primarily used to survey and track the spread of *Ae. albopictus* within Lucas County. However, in recent years they have also been utilized to collect host-seeking *Culex spp.* mosquitoes. This year BG traps collected 9,301 female *Cx. spp* mosquitoes, some of which were used for parity dissection. Moreover, only one *Ae. albopictus* was collected for these traps this season.

In the 2022 season 29,415 gravid *Culex spp.* females were collected from over 40 different locations using modified Reiter/Cummings type box gravid traps (APPENDIX – Figure 1). Curiously, these traps collected 112 *Ae. albopictus* mosquitoes, much more than the BG Sentinel traps and showed a large expansion of the nonnative mosquito's range.

This BG Sentinel 2 trap located at Collins Park in Toledo, Ohio is used to trap *Culex spp.* mosquitoes.

IMM SURVEILLANCE
MOSQUITO-BORNE DISEASE

TASD collected, processed, and tested all related mosquitoes at our in-house Arbovirus Disease Laboratory. As a result, TASD staff tested 29,415 mosquitoes resulting in 57 qt-PCR confirmed positive test results. The seasonal minimum infection rate for the 2022 season was 1.94 (compared to 5.36 MIR in 2021). Furthermore, staff was able to develop and test two new assays for the detection of Eastern Equine Encephalitis (EEE) and La Crosse Encephalitis, making the TASD arbovirus lab one of the only places in the state capable of detecting these important viruses.

Laboratory equipment used in the detection of mosquito viruses at the District's in-house Arbovirus Disease Laboratory.

IMM CONTROL
LARVAL MOSQUITO

TASD Field Supervisors visited 3,293 floodwater sites with 786, based on surveillance procedures, were above an activation threshold warranting treatment. A total of 730 acres of water was treated in 2022. In addition, the implementation of electronic record keeping provided a positive change for accurate data analysis.

Biological pesticides or biopesticides and insect growth regulators (IGR) were utilized frequently to control mosquito larvae.

Just over 6,000 pounds of biopesticides (Bacillus thuringiensis israelenis (Bti), Lysinibacillus sphaericus, and spinosyn products) were utilized this season in floodwater, container, and catch basin treatments and over 3,000 pounds of insect growth regulators (IGR) (pyripoxyfen products) were used solely in catch basin treatments. VectoMax® FG, VectoLex® FG, AquaBac® 200G, and Censor® were used for floodwater and container treatments which equivalated to 67% of the District's total usage. These products, except Censor®, were also used in catch basin treatments totaling 1% of total product usage. The remaining 32% of product usage was Sumilarv®, strictly in catch basins.

IMM CONTROL
LARVAL MOSQUITO cont.

TASD continued the surveillance and treatment of storm sewer runoff basins commonly called catch basins. Over 1,100 basins were inspected and 51,124 catch basins were treated. The primary product used in catch basins this season was Sumilarv® 0.5G because of its potential for season-long control. Other products used in a relatively small amount for catch basin treatments include VectoMax® FG, VectoLex® FG, and AquaBac® 200G.

LARVIVOROUS FISH DELIVERY

TASD completed 37 fish delivery in the 2022 season. Staffed used both *Pimephales promelas* and *Gambusia affinis* species to conduct larval mosquito control. In the fall of the 2022 season, TASD personnel created a new fish pond at the TASD main office. While smaller than the previous ponds it will allow for easier access to the fish. Furthermore, it provides TASD staff members with training opportunities on heavy equipment operation.

IMM CONTROL
ADULT MOSQUITO

Adult control operations began the night of May 12th and continued through the night of September 21st. For the season, a little over 196,00 acres were treated. Approximately 345 long driveways were treated at least once throughout the 2022 season. The average was around 4 trucks a night on the road. The district treated 458 of 459 service requests submitted by county citizens. The fogging truck improvements for the 2022 season included a modern led light bar, that makes the trucks more visible during treatments. Technology enhancements include upgrading all the District tablets from the old mobile demand to the new Mesa 3 tablets, making it much easier for the drivers to use.

2022 NIGHTTIME FOGGING STATISTICS

- **56** NIGHTS OF FOGGING
- **219** TRUCK NIGHTS
- **459** ADDITIONAL REQUESTS RECEIVED
- **786** SERVICE MAPS TREATED

RESEARCH & DEVELOPMENT
LARVAL CONTROL IN CATCH BASINS

Following a small-scale field trial in 2021, TASD applied Sumilarv® 0.5G to catch basins throughout the county in 2022. Pyriproxyfen is the active ingredient in Sumilarv® 0.5G and is an insect growth regulator (IGR). Unlike other larval or pupal control products, IGRs do not kill mosquito larvae or pupae. Instead, IGRs prevent mosquitoes from completing their life cycle. While these products eventually result in mortality, they cannot be evaluated in the same manner as other larval or pupal control products. For traditional control products, live larvae in larval dips indicate poor efficacy. With IGRs, live larvae in larval dips do not necessarily indicate poor efficacy. Instead, the emergence of adult mosquitoes is used to properly evaluate IGR efficacy.

Water was collected from treated catch basins between three and 12-weeks post-treatment. Samples with and without mosquito larvae were setup for observation in the laboratory. Samples that contained field-collected larvae were not manipulated once collection occurred, but were monitored for adult emergence. Fifteen late instar mosquito larvae were added to field-collected water samples or to untreated dechlorinated water (experimental controls). Adult emergence was observed for samples until no immature mosquitoes remained alive in a sample. Emergence was calculated by dividing the total number of emerged adults by the total number of larvae at the start of the experiment. Emergence inhibition was calculated via:

$$\frac{Emergence_{Control} - Emergence_{Treatment}}{Emergence_{Control}} \times 100$$

Mosquito development was monitored in the laboratory for catch basins treated with Sumilarv® 0.5G.

LARVAL CONTROL IN CATCH BASINS cont.

SHORT-TERM RESIDUAL CONTROL

Water without larvae was collected from 196 catch basins between June 27th to August 31st in 2022. Over the same period, 37 samples with field-collected larvae were brought to the laboratory for observation. Larval samples varied widely in the number of larvae collected, ranging between one to approximately 200 larvae.

Laboratory controls had higher emergence, 52 ± 36% (mean ± standard deviation), than either field-collected water or field-collected larval samples. Emergence was lowest for larvae collected from the field (4 ± 9%) while water-only collections had much higher emergence (41 ± 36%) than larval collections.

Catch basins were sampled from three to twelve weeks post-treatment (Figure 2). Emergence inhibition was variable over time for water-only collections. Emergence was greatly inhibited in water-only collections during weeks three (85 ± 26%) and eight (73 ± 44%) post-treatment. However, weeks six and twelve demonstrated emergence similar to experimental controls. Emergence inhibition remained high (> 89%) in larval collections during the entire sampling period, from week three through at least week 11 post-treatment. However, larval samples could artificially magnify product performance due to the relatively low number of samples per week and wide variability in larval counts.

LONG-TERM RESIDUAL CONTROL

Pyriproxyfen can prevent mosquito emergence for more than 100 days depending on the dose. To explore whether product activity from the previous year persisted in 2022, samples were taken from catch basins in a previously treated service map and an adjacent service map that had never received a pyriproxyfen treatment (field control). Catch basins in the previously treated service map received either 25, 50, or 75 grams of Sumilarv® 0.5G in 2021. At the time of sample collection, the product had been applied for 327 days. Water from previously treated catch basins had similar emergence for all doses compared to both field control samples and laboratory controls (Figure 3). Therefore, doses up to 75 grams did not have residual effects between years.

Culex spp. mosquitoes lay boat-shaped egg clusters known as egg rafts. Egg rafts are collected to raise mosquito larvae and adults used in research projects.

PESTICIDE RESISTANCE TESTING

Pesticide resistance in adult mosquitoes is routinely monitored at TASD using the CDC's bottle bioassay. Early detection of pesticide resistance allows for the implementation of resistance management prior to a complete loss of product efficacy. Knock-down resistance and, to a lesser extent, metabolic resistance was observed in several tests during the 2021 season for both sumithrin and permethrin. Sumithrin was not tested this season as sumithrin-based formulations were not widely utilized in the field during 2022.

In 2022, eleven resistance tests were performed (Table 3). The tests assessed the performance of technical grade active ingredient (permethrin, pyrethrum, or etofenprox) and the corresponding formulation (Pursuit® 4-4, EverGreen® 5-25, or Zenivex® E4 RTU). All permethrin-based tests demonstrated susceptibility at the diagnostic time and after 24-hours (technical grade: n = 3, formulation: n = 2). Etofenprox (n = 1) and Zenivex® E4 RTU(n = 1) both showed signs of resistance at the CDC's diagnostic time (15 minutes for *Culex pipiens*). However, mortality was nearly doubled at the diagnostic time for the formulation (83% mortality) compared to the technical grade (47% mortality). Mortality at 24-hours did not increase compared to mortality at the diagnostic time for either etofenprox or Zenivex® E4 RTU. Two technical grade pyrethrum bioassays demonstrated resistance at the CDC's diagnostic time and showed some knock-down resistance at 24-hours. However, tests with pyrethrum formulations (EverGreen® 5-25: n = 2) showed susceptibility at both the diagnostic time and at 24-hours (Figure 4).

The CDC's bottle bioassay is used for early detection of pesticide resistance in mosquitoes. Glass bottles are coated with pesticides such as permethrin (left). The mortality of approximately 100 mosquitoes is monitored for two hours (right). If more than 4% of the mosquitoes tested survive past the diagnostic time, the population is considered to be potentially resistant.

RESEARCH & DEVELOPMENT

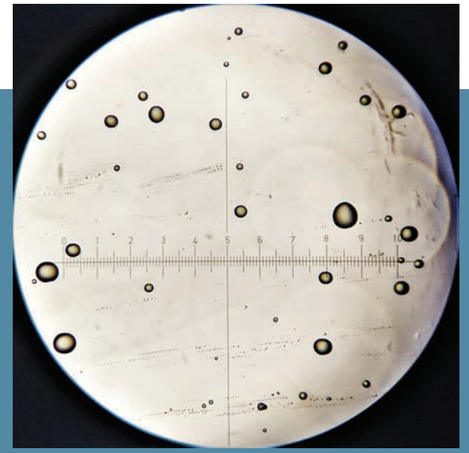
ADULT CONTROL EFFICACY

FIELD OBSERVATIONS

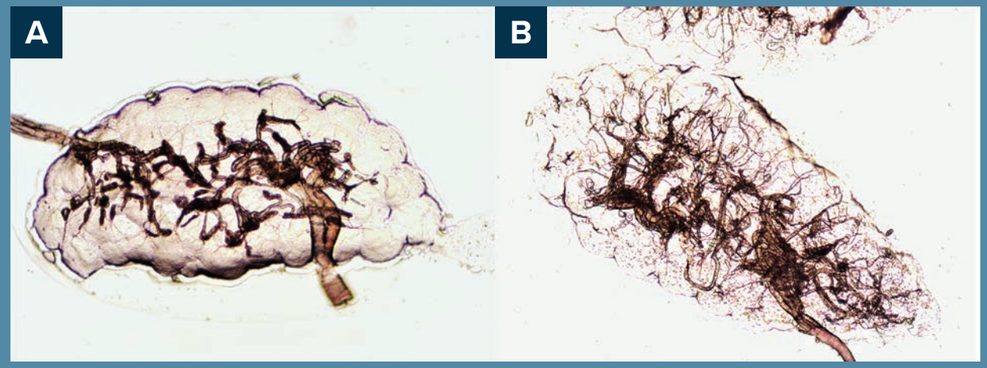
Droplet testing and machine calibration was performed on April 29, 2022.

A total of 56 efficacy observations were calculated from New Jersey light trap (NJLT) data and 87 efficacy observations were calculated from Gravid Trap (GT) data. NJLTs target a wide variety of mosquito species and gonotrophic stages (the gonotrophic cycle is based on feeding and reproduction; for mosquitoes the stages include host-seeking, blood-fed, resting, gravid, and ovipositing). Gravid Traps used at TASD target *Culex spp*. mosquitoes preparing to lay eggs. *Culex spp*. mosquitoes tend to tolerate pesticides longer than *Aedes spp*. mosquitoes. Furthermore, gravid mosquitoes have been shown to demonstrate greater resistance than some other gonotrophic stages. Therefore, it is expected that efficacy observations calculated with NJLT data will show higher success for adult control treatments than observations using GT data.

Five adult control products (BioMist® 3+15, Duet®, EverGreen® 5-25, Pursuit® 4-4, and Zenivex® E4 RTU) were included in efficacy evaluations in 2022 (Figure 5). When evaluating products with NJLT data, treatment success was 58% for BioMist® 3+15 (n = 33), 80% for EverGreen® 5-25 (n = 5), 27% for Pursuit® 4-4 (n = 15), and 100% for Zenivex® E4 RTU (n = 3). When evaluating products with GT data, treatment success was 34% for BioMist® 3+15 (n = 56), 0% for Duet® (n = 1), 45% for EverGreen® 5-25 (n = 11), 46% for Pursuit® 4-4 (n = 13), and 50% for Zenivex® E4 RTU (n = 6). Results for products with a low number of efficacy observations should be interpreted with care as sampling error is probable.



Pesticide droplets can be collected on Teflon-coated slides for observation and measurement.



Mosquito ovaries can be used to estimate population age. Ovaries from young mosquitoes have tightly wrapped tracheole skeins (A) while older mosquito ovaries show unraveled tracheoles (B).

PARITY DISSECTIONS

Generally, a successful adult control application will show a decline in the mosquito population after treatment. However, mosquito abundance may not be sufficient information to assess efficacy. Populations with many old mosquitoes have a higher risk of spreading the West Nile virus. Every time a mosquito takes a blood meal, there is a chance of West Nile virus exposure. Since older mosquitoes have presumably taken more blood meals, their risk of spreading the West Nile virus is higher than younger mosquitoes. As such, mosquito age is an important factor in understanding treatment efficacy. Recent studies suggest that population age structure, not solely mosquito abundance, is necessary to evaluate adult control applications.

Mosquito ovaries can be used to approximate mosquito age. Mosquitoes that have never laid eggs (nulliparous) tend to be younger and have ovaries with tracheole skeins. Conversely, mosquitoes that have laid eggs (parous) tend to be older and have ovaries without tracheole skeins.

Ovaries were dissected from a total of 5,115 mosquitoes in 2022. The majority of mosquitoes sampled were nulliparous (55%). The remaining mosquitoes sampled were composed of 35% parous, 7% gravid, and 2% blood-fed mosquitoes. Though *Culex pipiens* represented the majority (79%) of scored dissections, multiple *Culex* species were included in this data set including *Cx. restuans* (4%), *Cx. pipiens/restuans* (5%), *Cx. erraticus* (11%), *Cx. territans* (<1%), and *Cx. salinarius* (<1%).

The proportion of nulliparous mosquitoes was significantly predicted by days since treatment for some *Culex* species (Figure 6; $F_{10,129} = 2.68$, $p = 0.0052$, $R^2 = 0.11$). *Culex restuans* and *Culex erraticus* populations were older after treatment which could indicate an increase in disease risk. However, *Culex restuans* was poorly represented in the data set and requires more replication to be properly evaluated. Neither *Culex pipiens* nor *Culex pipiens/restuans* populations showed a change in parity following treatment. *Culex pipiens* is arguably the most important *Culex* species in this assessment as it represented the majority of *Culex spp*. sampled and is the primary vector of West Nile virus in Ohio. These results indicate that adult control treatments at TASD are not increasing the population age for *Culex pipiens*.

2022 MOSQUITO SEASON REVIEW

Following a pattern similar to 2021, 2022 began with some heavy snowfall in February, creating concern for potential spring flooding and high spring nuisance mosquito conditions. However, that was not the case. In reality, the weather turned in our favor, with little precipitation for the remainder of the spring which allowed the snow pack to melt with little to no flooding/standing water. This created another dry spring, leading to reduced treatments of residual floodwater.

The quiet spring continued into the summer, where nuisance mosquito populations remained fairly low, with occasional bumps in populations in isolated geographic regions through out the season. The presence of West Nile Virus in the mosquito population was also much lower than in previous seasons. Both of these conditions in the county adult mosquito populations lead to a reduced need for adulticide applications, allowing the District to save on seasonal labor and adult mosquito control products.

The unusual and quiet mosquito populations, however, did not translate into an inactive season: the District and its staff were still busy! In addition to having more time for efficacy evaluations, becoming comfortable with the new three operation managers model, and conducting all PCR testing of mosquitoes in-house, TASD had some notable events in 2022:

1 TASD hosted a drone treatment presentation and signed a contract for drone mosquito control larviciding applications, if needed. This new technology utilizes GPS to create treatment paths over standing water that is breeding mosquitoes. The treatments are mapped, the product application rate is calibrated, and reports and records are generated. Using a drone for treatment can be very advantageous for the District to save time and manpower in accessing areas that are difficult to treat by hand on foot.

Drones for mosquito management enable TASD to facilitate faster, more efficient applications to compact or sensitive areas.

Pan-African Mosquito Control Association (PAMCA) visit at TASD.

Pictured left to right:
Elijah Juma, Kenya, PAMCA;

Rhosheen Mthawanji, Malawi, Liverpool School of Tropical Medicine;

Otubea Ansah, Ghana, National Malaria Control Program;

Paul Bauman, General Manager and Biologist for TASD;

Rosine Wolie, Côte d'Ivoire, Institut Pierre Richet (IPR);

Jacob Sublett, Biologist, GIS Specialist, & Assistant GM for TASD;

Antonio Christophe, Cameroon, OCEAC;

Laurel Lown, PHD Student for University of Notre Dame;

Damaris Matoke-Muhi, Kenya, PAMCA;

Charles Ntege, Uganda, National Malaria Control Program;

Dr. Jennifer Shimola, Education & Research Coordinator for TASD

2 One of the more exciting events of the season involved the District being chosen to host a delegate of international mosquito professionals from Africa. This group of seven professionals came to the United States to learn about our mosquito control practices to improve current practices or implement new ideas in their battles against local mosquitoes and malaria transmission. The visit/tour was coordinated by Dr. Sam Rund from the University of Notre Dame. TASD was one of four control programs selected for the visit. The Pan-African Mosquito Control Association (PAMCA) was represented as well as researchers and entomologists from Cameroon, the Ivory Coast, Kenya, and Malawi. This visit was a great honor for the District and an amazing opportunity to learn about the challenges of mosquito control in Africa.

3 Capital improvement projects at the Stickney office continued. The restroom renovation started in 2021 and was completed. Plans and permitting were finalized for the construction of the new auxiliary building and, at the time of writing this report, the ground was broke on the project in early January 2023. Lastly, the architectural planning process for the front office renovation and new surveillance lab area continued to be developed.

A new pond was installed on the District grounds as part of the new auxiliary building project.

2022 MOSQUITO SEASON REVIEW cont.

PERSONNEL

The District welcomed Dr. Ryan Walsh from The Toledo Zoo to the Advisory Committee.

Bob Sattler retired from his position as Operations Manager and Darnea Merrell resigned from his position as Chief Supervisor of Larviciding - Tires/Pools/Containers.

The Operation Manager position was re-aligned to create three Operations Managers: Adulticiding Operations Manager (Ben White), Larviciding Operations Manager (Mark Nye), and Breeding Source Reduction Operations Manager (Justin Rist). Ultimately, as part of the realignment, the Chief Supervisor positions of Night Fogging, Water Management, and Tires/Pools/Containers were abolished and two additional field supervisor positions were added.

FINANCES

The operations for the 2022 season were funded by a special assessment of 0.34 mills on eligible properties, which resulted in collections of $3,299,989.87. Expenditures for 2022 were $2,839,884.80, leaving a budget surplus for the year of $460,105.07. A detailed 2022 financial report and budget for 2023 are noted on the following page.

The District continued to have a substantial cash carryover balance at the end of 2022, however, large portions of that cash carryover have been allocated to purchase orders for the ongoing capital improvements, fleet vehicles, heavy equipment purchases, and mosquito control products for 2023.

ENVIRONMENTAL AWARENESS

Several areas of the District's environmental sustainability efforts have been discussed in other portions of this report such as the auto tire recycling program, but the District remained committed to environmental sustainability within its operations as part of the EPA's Pesticide Environmental Stewardship Program. The highlight from 2022 for these efforts was likely the honey production and bottling from the District on-site apiary. This was an extremely popular advancement in our efforts helps to teach the public about mosquito control and being pollinator positive.

2022 FINANCIAL REPORT & 2023 BUDGET

	2022 FINANCIAL REPORT	2023 BUDGET
FUNDS ON HAND		
Petty Cash	$ 100.00	$ 100.00
Cash Book Balance	2,084,861.05	2,586,723.18
TOTAL FUNDS ON HAND	$ 2,084,961.05	$ 2,586,823.18
RECEIPTS		
Maintenance Assessments (Gross)	$ 3,299,989.87	$ 3,000,000.00
Grants	2,688.00	24,190.00
Interest Earned on Investments	4,685.72	3,000.00
Sale of Equipment & Supplies	0.00	0.00
Sale of Scrap	225.50	0.00
Adjustments & Refunds	34,157.84	0.00
TOTAL	$ 3,341,746.93	$ 3,027,190.00
TOTAL RECEIPTS & BALANCES	$ 5,426,707.98	$ 5,614,013.18
EXPENDITURES		
OFFICE & ADMINISTRATION		
Wages - Permanent	$ 407,006.16	$ 560,000.00
Wages - Temporary	51,315.00	80,000.00
Equipment	12,634.09	35,000.00
Utilities & Communications	27,390.00	45,000.00
Professional Services	256,923.10	130,000.00
Pension & Employee Insurance	491,515.61	700,000.00
General Insurance	132,308.00	200,000.00
Travel & Conference	14,877.51	25,000.00
Supplies	7,008.68	30,000.00
Education & Research	28,160.49	40,000.00
R.E. Improv., Maint. & Rental	160,183.48	1,100,000.00
Assessment Roll & Taxes	13,277.90	150,000.00
Workers' Comp. & State Auditor	9,472.96	85,000.00
Adjustments	0.00	0.00
TOTAL	$ 1,612,072.98	$ 3,180,000.00
FIELD PROGRAM		
Wages - Permanent	$ 774,830.00	$ 900,000.00
Wages - Temporary	14,058.25	65,000.00
Vehicles & Equipment	5,891.57	300,000.00
Larvicides & Insecticides	225,508.64	355,000.00
Fuel & Lubricants	53,042.58	60,000.00
Equipment Maintenance & Shop	29,438.86	40,000.00
Field Supplies & Hand Tools	77,306.11	130,000.00
Miscellaneous & Contingencies	240.00	2,000.00
Drainage Equipment Maintenance	24,977.54	30,000.00
Special Projects	0.00	0.00
Vehicle & Equipment Rental	8,920.00	30,000.00
Environmental Sustainability	13,598.27	20,000.00
TOTAL	$ 1,227,811.82	$ 1,932,000.00
TOTAL EXPENDITURES	$ 2,839,884.80	$ 5,112,000.00
BALANCE	$ 2,586,823.18	$ 502,013.18

LISA DIEHL
OFFICE MANAGER/BOOKKEEPER

APPENDIX

Table 1. TASD Product Use Summary (2022)

PRODUCT	USE PATTERN	AMOUNT USED
BioMist® 3+15 ULV	Night fogging applications	1,388 gals.
Duet® Dual Action Adulticide	Night fogging: disease response	8 gals.
EverGreen® ULV (5-25) Ground	Night fogging applications	100 gals.
Pursuit® 4-4 ULV	Night fogging applications	227 gals.
Zenivex® E4 RTU	Night fogging applications	87 gals.
Aquabac® 200G	Temporary floodwater treatment	1,316 lbs.
BVA® 2 Mosquito Larvicide Oil	Pupal and late fourth instar larval control	276 gals.
Censor® Mosquito Larvicide Granule	Temporary floodwater treatment	618 lbs.
Sumilarv® 0.5G	Larval control catch basin treatments	3,160 lbs.
VectoLex® FG	Catch basin treatments and semi-permanent floodwater	36 lbs.
VectoMax® FG	Residual floodwater applications	4,327 lbs.

Table 2. New Jersey Light Trap Collections (2022)

WEEKS:	MAY				JUNE							JULY							AUGUST							SEPTEMBER							TOTALS
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39										
MOSQUITO SPECIES																																
Ae. canadensis	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	2	1	0	0	0	0	0	3
Ae. grossbecki	0	0	3	2	1	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	5	8	0	0	0	0	0	0	13
Ae. japonicus	0	0	5	1	4	4	1	3	1	0	1	0	1	1	2	3	2	1	0	0	0	0	42	6	13	3	10	10	0	0	0	42
Ae. sollicitans	0	0	0	0	2	0	2	8	7	1	5	0	0	0	1	0	0	0	0	0	0	0	26	0	19	4	2	1	0	0	0	26
Ae. sticticus	0	14	10	14	35	10	19	4	1	5	0	0	0	0	0	0	0	0	0	0	0	0	113	38	69	5	1	0	0	0	0	113
Ae. stimulans	0	1	1	0	2	2	5	2	0	0	0	3	1	0	0	0	0	0	0	0	0	0	17	2	11	4	0	0	0	0	0	17
Ae. triseriatus	0	0	0	0	0	3	2	5	19	4	1	0	8	0	0	1	0	0	0	0	0	0	45	0	29	5	9	2	0	0	0	45
Ae. trivittatus	0	0	5	6	4	1	11	43	79	22	8	18	16	20	4	6	0	0	0	0	0	0	244	11	138	64	30	1	0	0	0	244
Ae. vexans	0	4	91	154	552	187	510	475	640	430	183	227	221	306	132	70	50	74	28	20	34	0	4388	249	2364	1061	632	82	1	0	0	4388
An. barberi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	3	0	0	0	2	1	0	0	0	3
An. perplexans	0	0	0	1	2	2	5	15	11	7	11	3	3	0	5	3	1	4	2	1	4	1	81	1	35	24	13	8	0	0	0	81
An. punctipennis	0	3	10	2	12	12	16	20	16	2	6	7	3	6	2	3	4	10	7	1	8	0	150	15	76	18	25	16	0	0	0	150
An. quadrimaculatis	0	0	1	0	5	2	7	7	5	10	6	11	9	9	4	19	17	5	58	19	11	17	214	1	26	36	103	48	2	0	0	214
An. walkeri	0	0	0	5	2	2	19	43	15	10	6	14	29	34	18	46	0	43	16	22	47	6	373	5	68	68	141	91	3	7	4	373
Cq. perturbans	0	0	0	0	0	4	81	75	38	48	23	7	4	10	19	14	0	3	2	1	4	0	333	0	198	82	46	7	4	10	2	333
Cx. erraticus	0	0	0	0	0	0	2	0	0	0	1	1	2	10	2	7	6	55	7	6	7	1	107	0	2	4	80	21	0	0	0	107
Cx. pipiens	0	6	2	2	31	27	50	38	25	27	31	20	5	5	33	24	21	29	3	13	6	1	415	10	171	83	128	23	9	5	2	415
Cx. restuans	0	41	9	10	30	34	35	22	36	8	17	12	6	8	5	5	0	3	0	5	2	2	290	60	157	43	21	9	2	14	5	290
Cx. pipiens/Cx. restuans	1	27	2	14	25	31	39	19	20	35	11	19	2	14	5	2	4	36	32	3	16	7	364	44	134	67	61	58	0	0	0	364
Cx. salinarius	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	2
Cx. tarsalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1
Cx. territans	0	2	4	9	12	23	29	38	34	6	4	1	7	20	2	0	6	6	0	2	4	0	209	15	136	18	34	6	0	0	0	209
Ps. columbiae	0	0	0	0	0	0	0	6	2	0	0	2	0	2	0	0	0	0	0	0	11	0	21	0	8	2	0	11	0	0	0	21
Ps. ferox	0	0	0	0	0	0	0	0	9	2	0	0	0	0	1	0	0	0	0	0	0	0	12	0	9	2	1	0	0	1	0	12
Ur. sapphirina	0	1	0	6	4	1	16	19	28	13	9	18	20	69	34	38	34	64	27	66	72	4	543	7	68	60	239	169	0	1	0	543
TOTAL FEMALE	**1**	**99**	**143**	**226**	**724**	**349**	**834**	**820**	**1014**	**635**	**324**	**364**	**333**	**547**	**276**	**234**	**135**	**387**	**143**	**155**	**243**	**23**	**8009**	**469**	**3741**	**1656**	**1579**	**564**	**8009**			
TOTAL MALE	**0**	**21**	**158**	**202**	**578**	**480**	**459**	**2271**	**3230**	**399**	**387**	**426**	**504**	**735**	**57**	**254**	**136**	**294**	**120**	**190**	**627**	**137**	**11665**	**381**	**7018**	**1716**	**1476**	**1074**	**11665**			

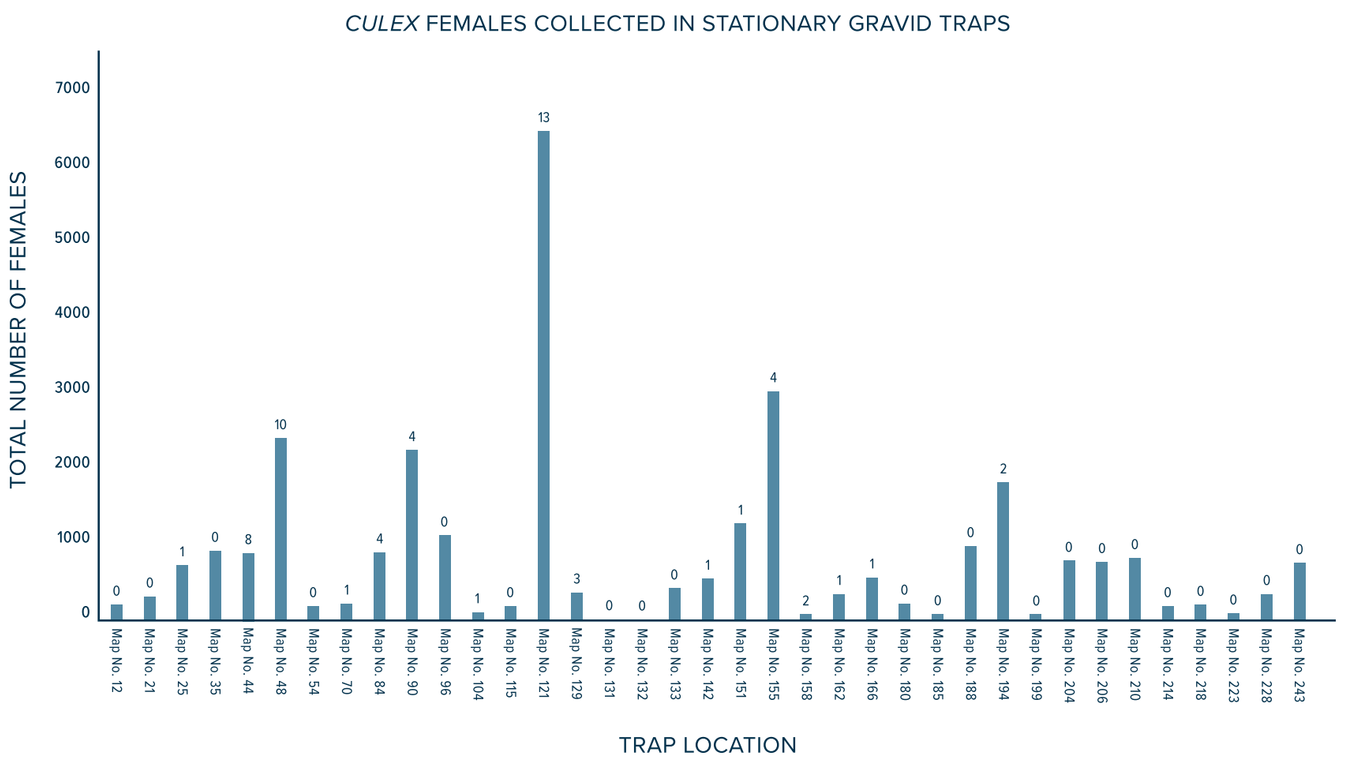
APPENDIX

Table 3. Eleven conclusive resistance tests were completed in 2022. Tests were performed on both technical grade active ingredients and their corresponding product formulation. Susceptible populations are defined as those with greater than 96 percent mortality at the diagnostic time. If the percent of non-KDR mosquitoes is lower than the mortality at the diagnostic time, then knock-down resistance is being expressed.

ACTIVE INGREDIENT	TECHNICAL GRADE OR FORMULATION	DATE	SPECIES COMPOSITION	MORTALITY AT CDC DIAGNOSTIC TIME (%)	NON-KDR (%)
Etofenprox	Technical Grade	7/19/2022	100% *Culex pipiens*	47	67
Etofenprox	Zenivex® E4 RTU	7/19/2022	100% *Culex pipiens*	83	97
Permethrin	Technical Grade	5/18/2022	"86% *Aedes sticticus* 14% *Aedes vexans*"	100	100
Permethrin	Technical Grade	6/16/2022	100% *Culex pipiens*	100	100
Permethrin	Technical Grade	6/24/2022	100% *Culex pipiens*	98	97
Permethrin	Pursuit® 4-4	6/24/2022	100% *Culex pipiens*	100	100
Permethrin	Pursuit® 4-4	6/24/2022	100% *Culex pipiens*	100	100
Pyrethrum	Technical Grade	6/10/2022	"93% *Culex pipiens* 7% *Culex restuans*"	89	71
Pyrethrum	Technical Grade	8/12/2022	100% *Culex pipiens*	88	71
Pyrethrum	EverGreen® 5-25	6/10/2022	"88% *Culex pipiens* 12% *Culex restuans*"	100	100
Pyrethrum	EverGreen® 5-25	8/12/2022	100% *Culex pipiens*	100	100

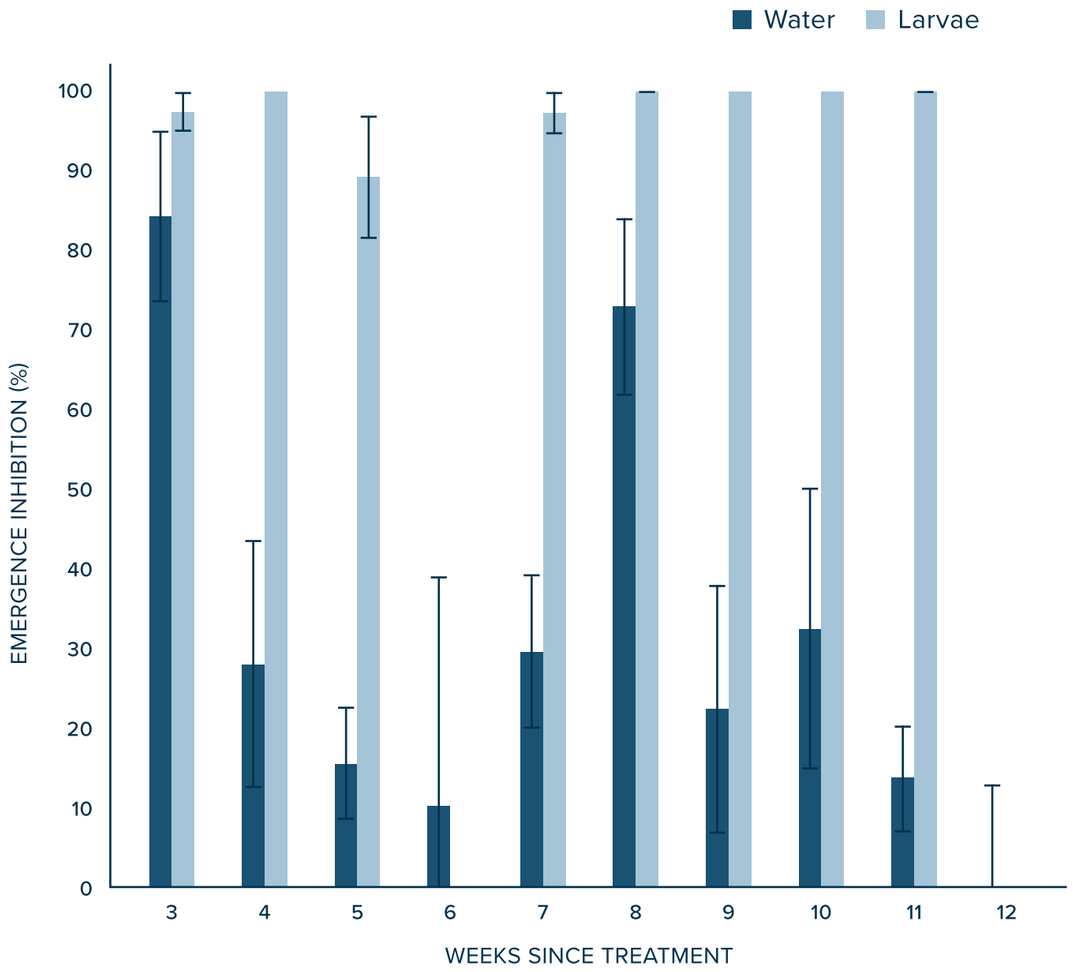
APPENDIX

Figure 1. Values above the bars are the number of positive WNV mosquito pools obtained from the site in 2022.



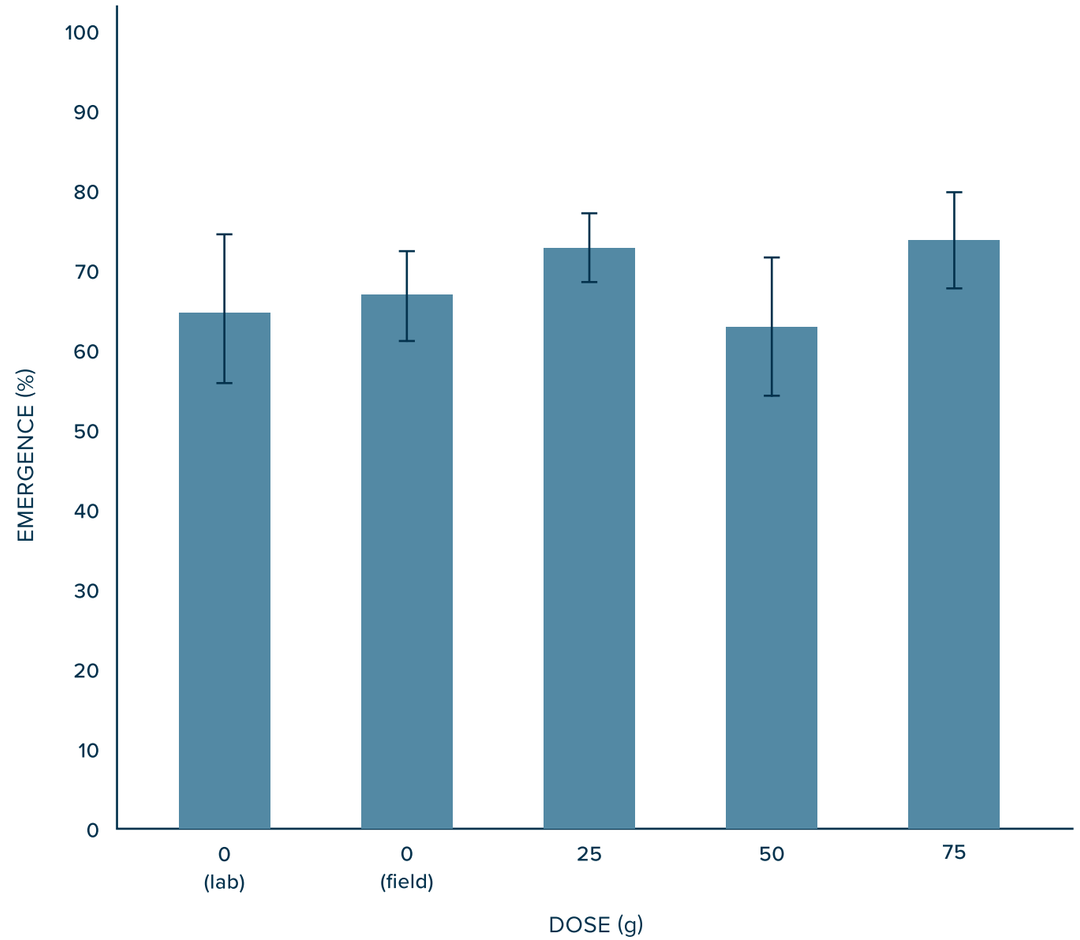
APPENDIX

Figure 2. Sumilarv® 0.5G demonstrated better efficacy when evaluated by larval collections compared to water collections. Larval collections showed low adult emergence in all observed weeks. However, the number of observations were low for larval collections. Water collections showed high emergence inhibition in weeks three and eight, but remaining weeks showed poor or no inhibition. Error bars represent standard error. Bars without standard error represent a single observation.



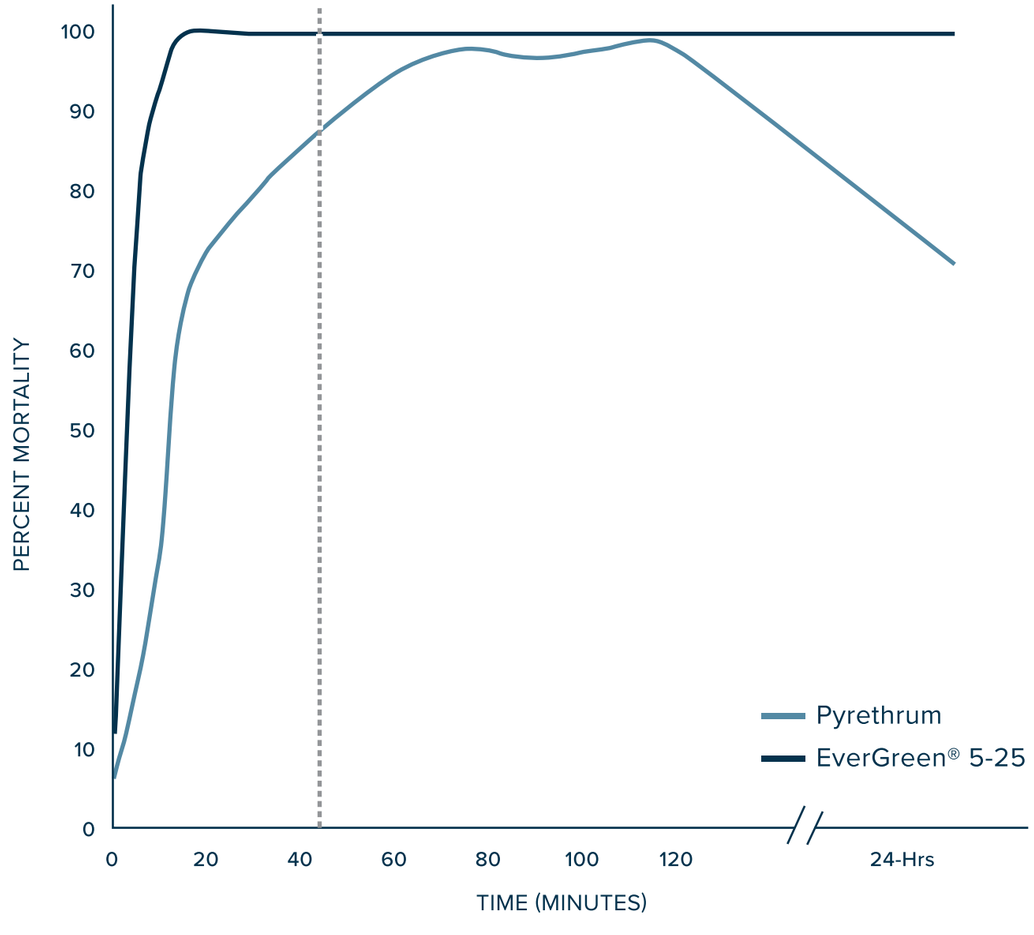
APPENDIX

Figure 3. Sumilarv® 0.5G applied in 2021 did not reduce adult mosquito emergence in 2022, regardless of dose. All treatments used laboratory-reared larvae, but differed in the source of water. Laboratory controls received dechlorinated water while field controls received water from catch basins that were not treated with Sumilarv® 0.5G in the past. Emergence was calculated by dividing the total number of adult mosquitoes by the total number of larvae added during experimental setup. Error bars represent standard error.



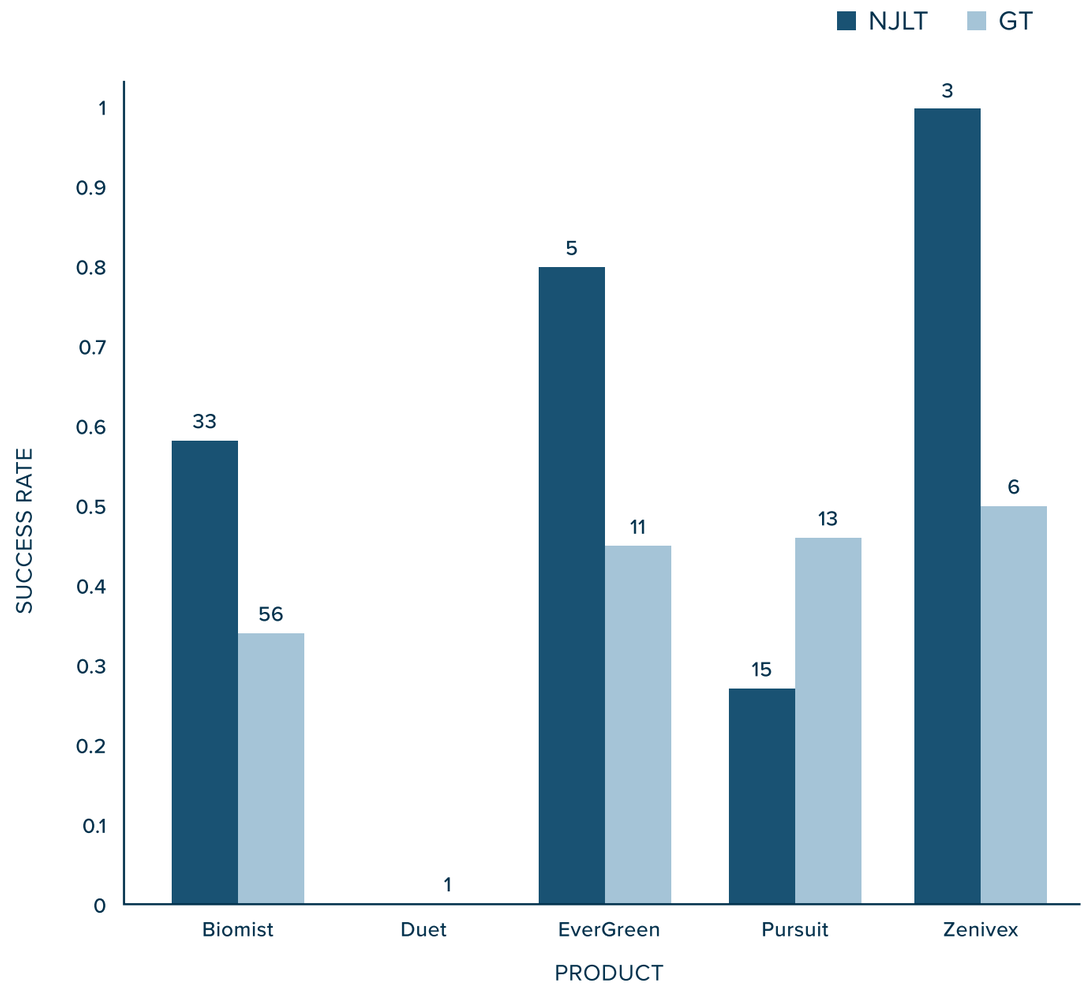
APPENDIX

Figure 4. Insecticide resistance was assessed for technical grade active ingredients and their corresponding product formulation. Mortality was averaged between two bioassays for technical grade pyrethrum and EverGreen® 5-25. Technical Grade pyrethrum showed poor susceptibility at the diagnostic time and showed signs of knock-down resistance. Conversely, the current pyrethrum formulation utilized at TASD, EverGreen® 5-25, demonstrated susceptibility at the diagnostic time and did not demonstrate knock-down resistance. The CDC's diagnostic time for *Culex pipiens* exposed to pyrethrum is denoted by the dashed vertical line. A decline in mortality after 24-hours indicates knock-down resistance.



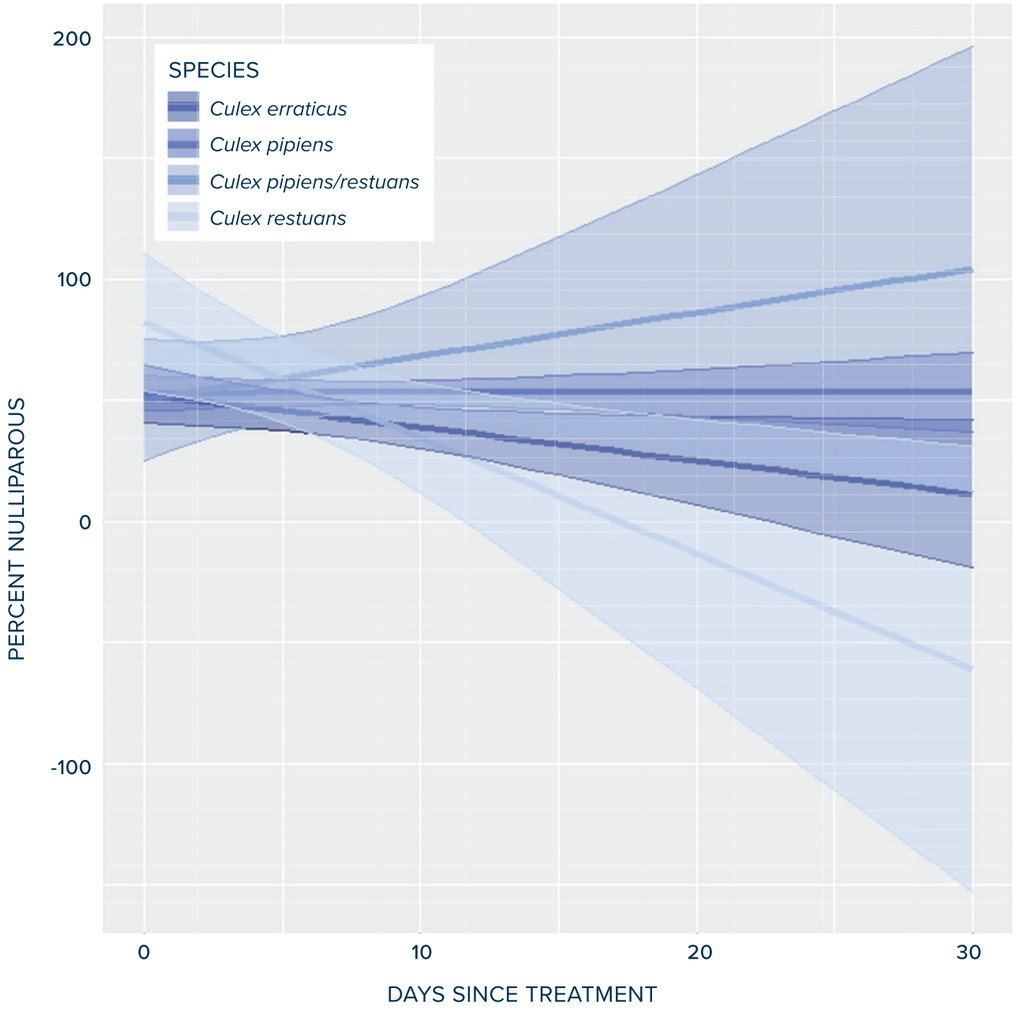
APPENDIX

Figure 5. Adult control products varied in their success at reducing mosquitoes. Mulla's formula was used to calculate treatment efficacy compared to control sites. Success rate was calculated by dividing the number of successful treatments by the total number of treatments. A successful treatment was defined as an observation where mosquito abundance was reduced by more than 30% relative to control sites. The total number of treatments are noted above bars. Bars with a low number of efficacy observations should be interpreted with care as sampling error is probable.



APPENDIX

Figure 6. Estimated population age responded differently to adult control applications based on the mosquito species being evaluated. *Culex pipiens* (n = 96) did not show a change in population age structure when treatments occured recently compared to treatments made nearly a month prior to observations. *Culex erraticus* (n = 32) showed a slight decline in young mosquitoes when treatments were more recent. The remaining species were poorly represented (n = 6) in the original data set and should be interpreted with caution. Shaded areas represent 95% confidence intervals.



NOTES

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