TOLEDO AREA SANITARY DISTRICT

75TH ANNUAL REPORT

MOSQUITO CONTROL
FOR A SAFE AND
QUALITY ENVIRONMENT

2021

A LETTER FROM THE GENERAL MANAGER

February 17, 2022

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

Mr. Stutler:

I hereby submit the 2021 Annual Report of the Toledo Area Sanitary District (TASD). This 75th Annual Report contains a financial report for 2021 as well as a budget for 2022. It also summarizes the District's operations, field activities, and achievements over the past year. This year's annual report is a slightly new format that 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.

2021 was a challenging year for mosquito control in Lucas County with the ongoing COVID-19 pandemic and a highly unusual weather pattern that greatly affected local mosquito populations and the TASD's control activities. Throughout the challenges, the TASD was able to maintain its operations and continue to provide an efficient, economical, and environmentally conscious program for its citizens. This season, many lessons were learned that will improve the District's operations and its understanding of local mosquito populations well into the future.

The techniques, insecticides, and equipment used by the District are always among the most widely recommended and accepted in the industry. As a result, the TASD 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

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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

MIKE BRUCE (retired Nov. 5, 2021)
Garage & Facilities Specialist

MYLES CARYER
Larviciding Chief Supervisor

LISA DIEHL
Office Manager | Bookkeeper

KELLY HAHN (hired Jan. 4, 2021)
Office Clerk | Assistant Bookkeeper

DARNEA MERRELL
Larviciding Chief Supervisor

JERRY MOORE (hired Apr. 12, 2021)
Field Supervisor

DOUG NABORS
Field Supervisor

MARK NYE
Field Supervisor

KAITLIN PLATE (resigned Jul. 22, 2021)
General Assistant in the Science Division

JUSTIN RIST
Water Management Chief Supervisor

HUNTER SANNER
Field Supervisor

BOB SATTLER
Operations/Substation Manager

BOB SCHRAMM
Field Supervisor

DR. JENNIFER SHIMOLA
Education & Research Coordinator

TOM SHULTZ
Field Supervisor

JACOB SUBLETT
Biologist | GIS Specialist | Assistant GM

CORY TAYLOR (resigned Mar. 3, 2021)
Field Supervisor

BEN WHITE
Fogging Chief Supervisor

SHANNON WILSON
Field Supervisor

2021 SEASONAL EMPLOYEES

DYLAN AEY
Night Fogging

SYDNEY BIEBERICH
Lab Technician

MELISSA CLAWSON
Lab Technician

RICHARD COLESTOCK
Night Fogging

ALEXIS CORDEL
Lab Technician

FRANK FULKERSON
Lab Technician

BAILEY HETTINGER
Lab Technician

DEREK MCKINNEY
Lab Technician

KURT SUSDORF
Night Fogging

JACOB WEIDEN
Night Fogging

JOSHUA WHITE
Night Fogging

ADVISORY COMMITTEE & CONSULTANTS

DR. GARY F. BENNETT
(through Nov. 4, 2021)
Professor Emeritus of Biochemical Engineering, University of Toledo

JENNIFER GOTTSCHALK
Supervisor, Toledo-Lucas County Health Department

MICHAEL K. HART
Public Information - Consultant

DAVID G. HUEY
Retired Director, Toledo Area Sanitary District

THOMAS KOVACIK
Kovacik Consulting

JENNIE LAMBERT
Special Projects Consultant, Bowling Green State University

RUSSELL R. MILLER
Legal Counsel - Consultant

DR. DANIEL PAVUK
(through Nov. 18, 2021)
Lecturer of Biological Sciences, Bowling Green State University

DR. RANDALL J. RUCH
Professor Emeritus of Biochemistry, UT College of Medicine

AMY K. STONE
Extension Educator, Ohio State University Extension - Lucas County

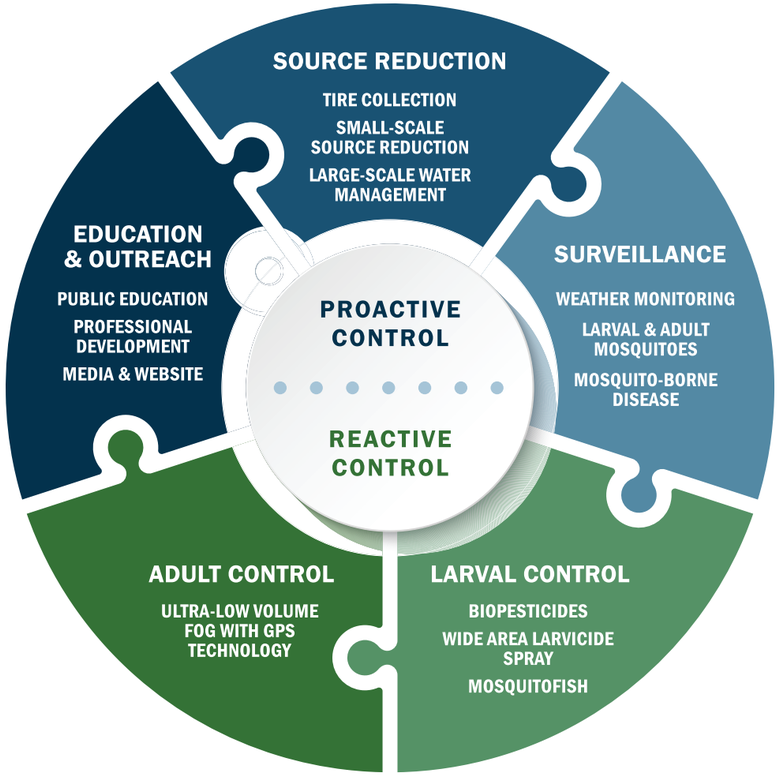
KONNI SUTFIELD
Retired Supervisor, Toledo-Lucas County Health Department

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

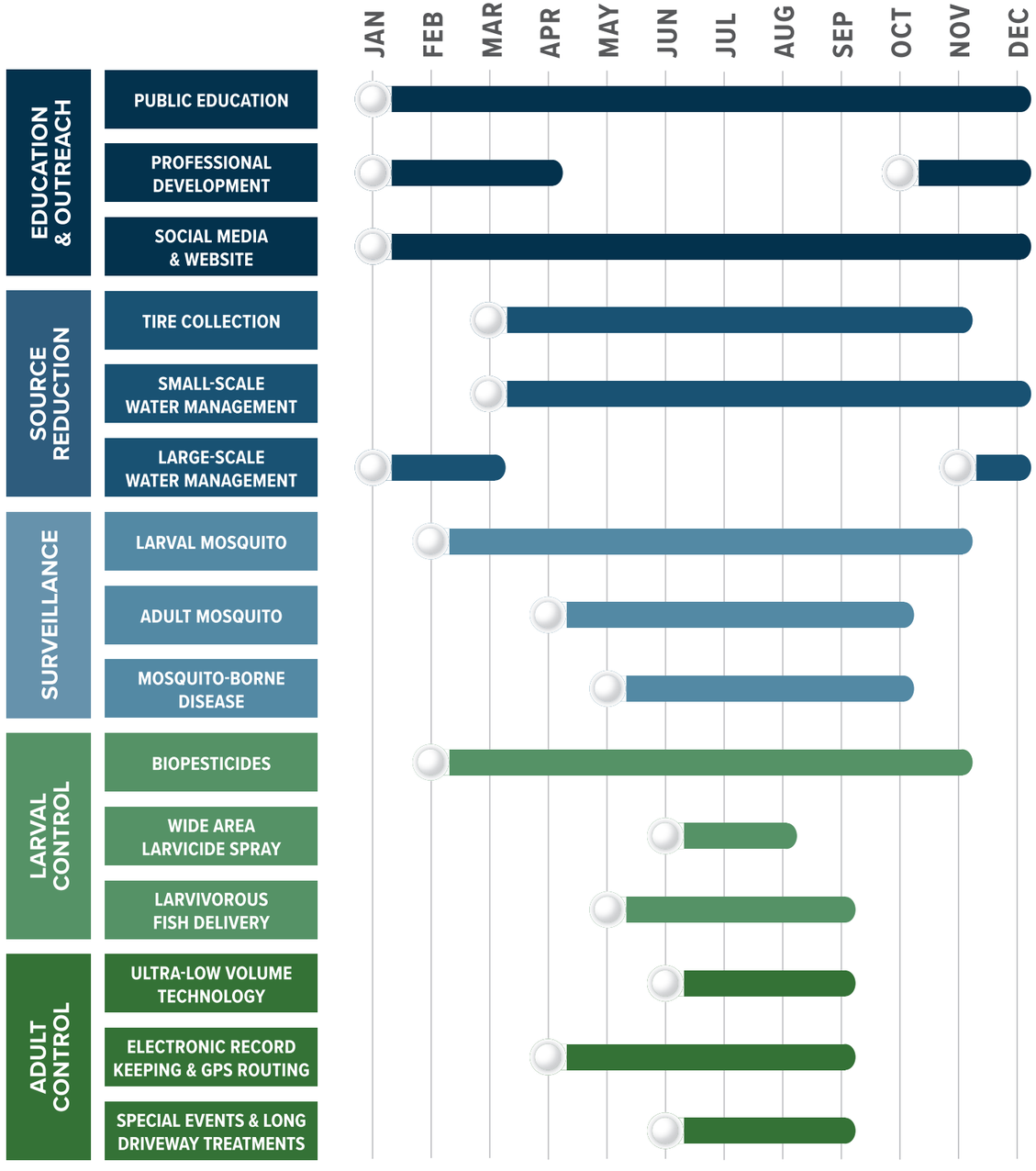
INTEGRATED MOSQUITO MANAGEMENT

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 three American Red Cross blood drives, three neighborhood association meetings, two classrooms, Imagination Station's Girl Power Event, and BGSU's Veterinary Camp.

Blood drives were scheduled during Mosquito Control Awareness week in June. At each blood drive, volunteers discussed mosquito control with attendees and distributed homeowner control handouts with repellent wipes.

TASD met with the Toledo Olde Towne Neighborhood Association, Junction Coalition, and Old West End Association in July. Neighborhood association meetings focused on recent program changes and how to submit service requests online. Homeowner control flyers and repellent wipes were given to attendees. Meetings had 61 in-person attendees and two meetings were made available to virtual attendees.

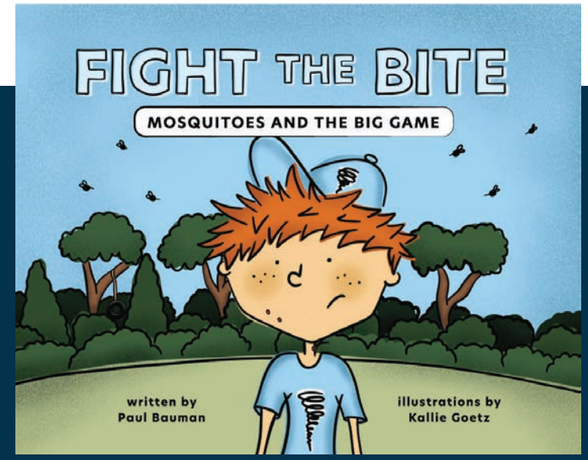
Classroom visits took place in a kindergarten and fifth grade classroom. Kindergarten students made a mosquito craft and identified their mosquito species. Using an age-appropriate field-guide, the students learned about reducing mosquito habitat for their mosquito species. Fifth grade students learned about the role of mosquitoes in the food web through a mosquito community game. Fifth grade students learned to reduce mosquitoes based on food web dynamics with mosquitofish.

Personal protection and homeowner control were promoted in collaboration with the American Red Cross in 2021.

Imagination Station's virtual Girl Power event focused on STEM careers in 2021. Attendees were informed about the role of mosquito biology and research in TASD's operations.

TASD presented to out-of-state and international students interested in veterinary biology at BGSU's virtual Veterinary Camp in 2021. TASD emphasized the role of vector ecology in veterinary medicine with a modified escape-room activity.

In addition to its active outreach activities, TASD developed passive outreach activities aimed at reaching a larger audience. Specifically, TASD authored and published a children's book to promote the importance of personal protection and source reduction. Books are being distributed to elementary schools within the county. In addition, TASD promoted educational objectives on billboards and trucks. Fifteen billboards with eight designs were commissioned throughout Lucas County to promote TASD services, homeowner control, and personal protection. Nine trucks in TASD's fleet were wrapped with educational messages promoting personal protection and homeowner control.



TASD's General Manager, Paul Bauman, authored a children's book to promote mosquito control.

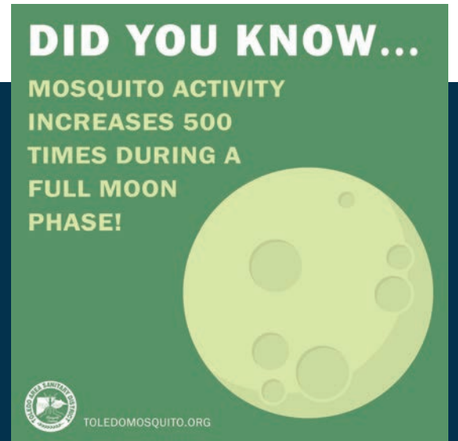
TASD provided educational messages to the public with billboards such as this one located at the corner of Huron Street and Washington Street in downtown Toledo.

IMM EDUCATION & OUTREACH
PROFESSIONAL DEVELOPMENT

All TASD employees attended ‘School Day’, an annual review of mosquito biology, mosquito control, and new technologies that are relevant to operations and conversations with the public.

TASD employees continued their education and promoted TASD’s research by attending the conferences hosted by the American Mosquito Control Association, Michigan Mosquito Control Association, and Ohio Mosquito and Vector Control Association.

IMM EDUCATION & OUTREACH
MEDIA AND SOCIAL MEDIA



TOP
TASD’s “Did you know” Series featured 13 different graphics posted on Facebook and Instagram.

TASD was the subject of nine local news stories this year which featured information on mosquito abundance, adult control treatments, and West Nile virus prevalence.

TASD continued its social media presence on Facebook with 85 posts and launched an Instagram page with 72 posts. Graphics were developed for social media platforms including 13 ‘Did you know?’ graphics, four ‘Mosquito Prevention’ graphics, and three GIFs.

RIGHT
Fight the Bite: Mosquitoes swarming in Lucas County was aired on 13 ABC in July.

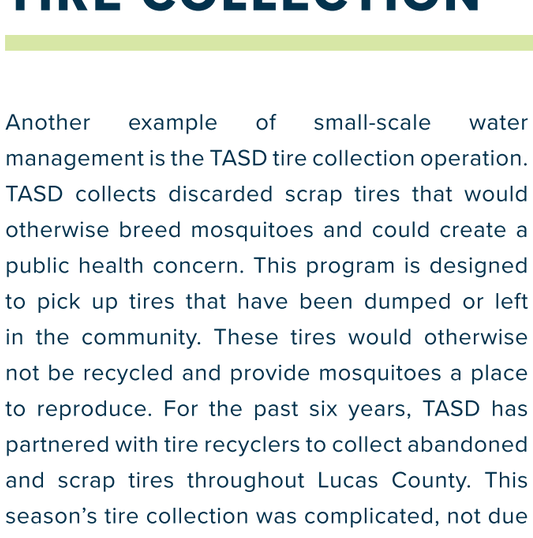
IMM SOURCE REDUCTION
SMALL-SCALE WATER MANAGEMENT

As a result of TASD’s commitment to a safe and quality environment, a "Green Committee" was created this year. This committee aims to examine TASD operations and find areas within those operations in which environmentally positive practices could be implemented. Consequently, many new program advancements are present throughout this report. One example is a small-scale water management application known as the above-ground swimming pool removal program. Swimming pools that are not being maintained properly, even those that have only been neglected for a little more than a week, can result in swimming pools that are deemed to be a public health concern by creating breeding habitat ideal for important mosquito species. In the past, a TASD employee would have to repeatedly monitor and visit these pools to treat them with a larval control product. Instead, this new program allows a homeowner who no longer wishes to utilize their above-ground pool to partner with TASD and have our staff members remove and recycle the swimming pool. This program provides benefits for both TASD and property owners. The property owner gets their unwanted swimming pool taken away at no additional cost, and TASD can remove a breeding source that would otherwise need repeated visits and treatments. In 2021, TASD was able to remove three swimming pools, and promote the program to help it grow and expand.

TASD's first above-ground swimming pool was removed from a Clark Street residence.

IMM SOURCE REDUCTION
TIRE COLLECTION

Another 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. This season's tire collection was complicated, not due to a lack of discarded tires, but due to the lack of available semi-drivers able to transport the collected tires to be recycled. Luckily TASD was able to adapt and continued to collect tires much later into the season than in any previous year. As a result, TASD was able to collect 5,393 tires in five semi-trailer loads.

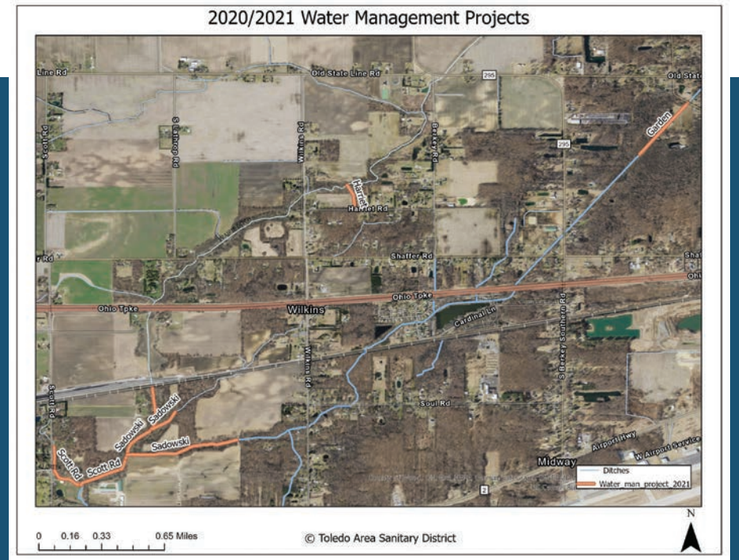


TOP
Abandoned tires provide a perfect habitat for numerous species of mosquitoes to develop.

BOTTOM
Ben White, Fogging Chief Supervisor for TASD, loading tires into the on-site semi-trailer.

IMM SOURCE REDUCTION
LARGE-SCALE WATER MANAGEMENT

In addition to conducting small-scale source reduction, TASD continued completing large-scale water management projects. Over the 2021 season, TASD completed two large-scale projects and started three more. These projects included brush and debris removal and ditch dredging for approximately 10,730 linear ft. The TASD Green Committee began to examine best practices for ditch and water management operations. Through these efforts, TASD decided to begin implementing practices that would increase the longevity of current projects and help with nutrient and sediment reduction, as well. Because of these initiatives, TASD applied for and was awarded a Great Lakes Sediment and Nutrient Reduction Program grant through the Great Lakes Commission. For this grant and future projects, TASD will install a ditch design known as a two-stage ditch. This strategy changes the shape of conventional ditches to add "shelves on the sides of the ditch." These shelves expand the size of the ditch, allowing for higher water flows and the reduction of downstream deposits of sediment and nutrients. Additionally, downstream of the two-stage ditch, TASD will install/improve a riparian zone seeded with Northwest Ohio native plant seeds. Native, riparian zones are normally found between waterways and agricultural fields. The vegetation in these zones helps reduce nutrient runoff into the waterways and sustain water banks, reducing erosion. These zones also absorb water in a more efficient manner, reducing flooding and mosquito habitat.

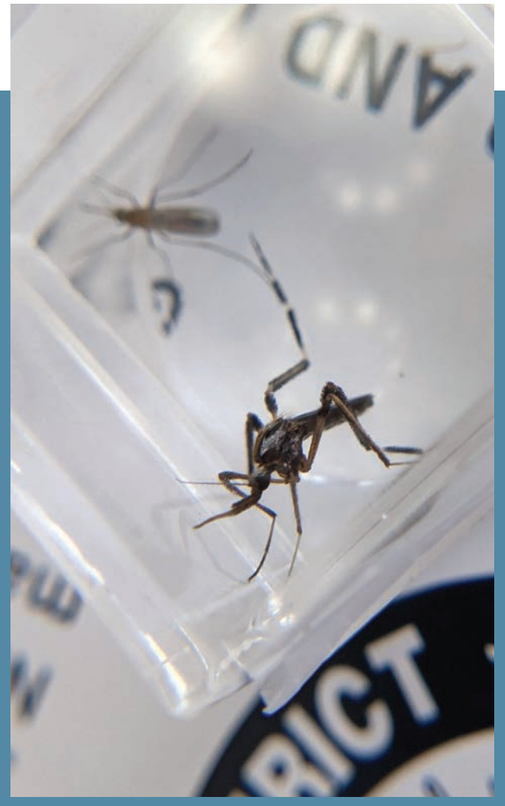


The map to the left shows the locations and approximate distances for the projects conducted in the 2020/2021 water management season.

IMM SURVEILLANCE
LARVAL MOSQUITO

Larval mosquito surveillance began on March 3rd. Larvae were collected from March 15th until November 3rd. A total of 4,392 floodwater larval inspections were made, 551 larval samples were collected, and 6,526 mosquitoes were reared in 2021. Fifty percent of collected samples reared at least one adult mosquito. Typically, one to 13 mosquitoes were reared per sample. However, one large larval sample reared 1,243 mosquitoes.

Twenty species of mosquitoes were identified from larval collections in 2021. The majority of mosquitoes reared were *Aedes vexans* (52%) or *Culex pipiens* (31%). *Culex restuans, Aedes japonicus, Aedes sollicitans,* and *Aedes trivittatus* each composed between three and five percent of mosquitoes reared. A few of the rare species (less than one percent of mosquitoes reared) identified from the insectary included *Aedes albopictus, Psorophora ferox, Psorophora ciliata, and Orthopodomyia signifera*. The *Aedes albopictus* larval collection was made on August 31st from service map 195, a new location for this invasive species.



Psorophora ciliata (foreground) and *Culex pipiens* (background) females reared in the insectary.

IMM SURVEILLANCE
ADULT MOSQUITO

Adult mosquito surveillance began on May 12th and continued through September 20th. 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. These traps have traditionally been operated Monday through Thursday nights. For the first time, this season, all NJLT were equipped with digital plug-in timers. These timers allowed traps to be operated at any time, which allowed for extra nights of collections (Sunday through Thursday nights) for these traps. As a result, with a change to seasonal staff scheduling, TASD was able to collect mosquitoes from select traps every night of the week. The TASD laboratory staff identified 14,242 adult female mosquitoes from light traps, in 2021 (APPENDIX – Table 2).

Collections from these traps were much lower than historically seen throughout the spring until midsummer when there was a large increase in the mosquito population before reducing back down to low levels. *Aedes vexans* were still the most predominant species collected.

Starting in 2021 TASD began to utilize CDC light traps to respond to citizen nuisance requests that may not have been well represented within the existing surveillance network. As a result, TASD conducted over 1,800 CDC trapping events. These traps traditionally utilized CO2 to attract host-seeking mosquitoes. TASD acquired new regulators specifically designed for use in mosquito surveillance that may have led to greater collections from these traps. Additionally, there were particular species of mosquitoes, which were not present in this year's NJLTs collections, that the CDC traps collected in larger numbers not seen in NJLTs collection over

Over eighty female mosquitoes await identification by TASD' Science Division.

IMM SURVEILLANCE
ADULT MOSQUITO cont.

the last five-year period (APPENDIX – Figure 1). These species are prolific biters and helped to explain why citizen nuisance requests increased in times when the NJLT collections did not support them.

BG sentinel 2 traps were continued to be used during this season. These traps have been primarily used to survey and track the spread of *Ae. albopictus* within Lucas County. Since its discovery in 2017 this species of mosquito has been continually discovered in more and more trapping locations. In the 2021 season female *Ae. albopictus* were collected in three new locations within the county. However, more of these mosquitoes were collected in Gravid Traps used for *Culex spp.* collection than in BG sentinel 2 traps.

In the 2021 season 81,478 gravid *Culex spp.* females were collected from over 50 different locations, which was the most ever collected by TASD (compared to 44,745 females collected in 2019). The nearly 2-fold increase in the number of mosquitoes collected was likely, in part, due to an increased trapping effort by biological staff. The population of *Culex spp.* was also more abundant compared to historical averages (APPENDIX – Figure 2). While there was an increase in the abundance of *Culex spp.* mosquitoes the seasonal West Nile virus (WNV) infection remained relatively similar to past years.

IMM SURVEILLANCE
MOSQUITO-BORNE DISEASE

TASD continued to develop its molecular lab and protocols throughout 2021. As a result, TASD staff tested 10,415 mosquitoes resulting in 77 positive test results for West Nile virus. The Ohio Department of Health again played a role in WNV detection within Lucas County testing 71,063 mosquitoes resulting in 360 positive pools identified. In all 81,478 mosquitoes were pooled and tested for WNV with 437 of those pools shown to be positive. The seasonal minimum infection rate for the 2021 season was 5.36 (compared to 5.0 MIR in 2020).

Gravid trap collections are prepared for West Nile virus testing by separating *Culex* spp. into tubes.

IMM LARVAL CONTROL

This season all larval control treatments were recorded electronically allowing for more expedient and accurate analysis of this data. Out of the 4,392 floodwater visits conducted, 1,876 resulted in surveillance shown to be above an activation threshold warranting treatment. A total of 1,167 acres of water were treated in 2021.

TASD also continued the surveillance and treatment of storm sewer runoff basins commonly called catch basins. Over 3,200 basins were inspected and 48,425 catch basins were treated.

Biological pesticides or biopesticides were utilized frequently to control mosquito larvae.

Seventy-nine percent of treatments and just over 13,595 pounds of biopesticides (Bacillus *thuringiensis israelenis* (Bti), Lysinibacillus sphaericus, and spinosyn products) were utilized this season.

LARVIVOROUS FISH DELIVERY

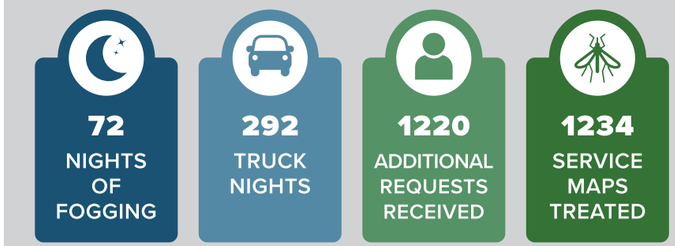
TASD completed 44 fish deliveries in the 2021 season. TASD staff used both *Pimephales promelas* (fathead minnow) and *Gambusia affinis* (mosquitofish) species for this form of larval mosquito control.

TASD's on-site aquarium room.

IMM ADULT CONTROL

Adulticiding treatments began during the evening of June 6th and continued through the night of September 30th. For the season, almost 336,000 acres were treated during adulticiding operations.

2021 NIGHTTIME FOGGING STATISTICS



RESEARCH & DEVELOPMENT
LARVAL CONTROL IN CATCH BASINS

A new-to-TASD larval control product (Sumilarv® 0.5G) was evaluated in catch basins in 2021. 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 does not necessarily indicate poor efficacy. Instead, the emergence of adult mosquitoes is used to properly evaluate IGR efficacy.

Sumilarv® 0.5G has been shown to control mosquitoes for an entire season following a single application to catch basins. However, pyriproxyfen's longevity depends on environmental conditions and application rate. TASD evaluated three application rates of Sumilarv® 0.5G per catch basin: 25, 50, and 75 grams. Only catch basins that were breeding mosquitoes at the time of treatment were included in the study.

Water was collected from treated catch basins weekly for the first six weeks following treatment and biweekly until week ten. Fifteen to twenty late instar mosquito larvae were added to field-collected water from previously treated catch basins or to untreated dechlorinated water. Adult emergence was observed for samples until no immature mosquitoes remained alive in a sample. Emergence was calculated from dividing the total emerged adults by the total number of larvae in a sample. Emergence inhibition was calculated via:

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

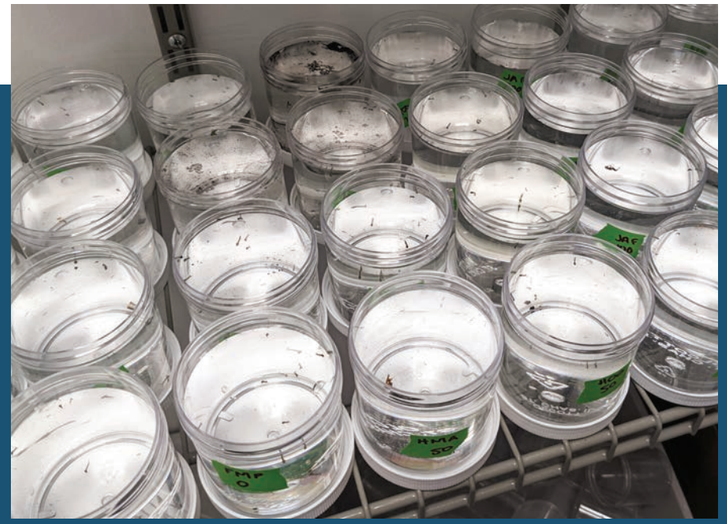
Sumilarv® was found to reduce pupation and emergence for at least ten weeks at all concentrations (Appendix – Figure 3). Field samples indicated that the product was active in at least some catch basins through week ten following treatment. Product activity was not monitored following week ten as weather conditions were not ideal for collection of larvae for the study, and the control season was ending.

RESEARCH & DEVELOPMENT
LIQUID LARVICIDE EFFICACY

Previously, TASD evaluated Bti as a liquid larval control product. A new-to-TASD liquid larval control product (Natular® SC) was evaluated in the field in 2021. Natular® SC contains the active ingredient spinosad, which has a different mode of action than Bti. As such, spinosad and Bti can be rotated for resistance management. Furthermore, Natular® SC is reported to remain in suspension with less effort than other liquid larval control products.

The application was made in an urban environment with two gallons of Natular® SC applied along a 3.73 mile route on September 8, 2021. Bioassay cups were placed at fifty-foot intervals from 0-200 feet from the treatment route prior to application and collected shortly after application. Field-treated and untreated control cups were filled with dechlorinated water and each cup received approximately fifteen mosquito larvae the day after treatment. All cups were provided with 0.5 mL of larval food (liver powder and yeast solution) at setup. Larval mortality was scored for three days following setup and dead larvae were removed daily.

Mortality was 63 percent greater in treatment samples compared to control samples. Treatment success did not depend on distance from the road and successful control was observed up to 200 feet from the treatment route (Appendix – Figure 4).



Bioassay experiment setup to evaluate liquid spinosad treatment efficacy.

RESEARCH & DEVELOPMENT
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 resistance management to be applied before product efficacy is compromised.

The CDC bottle bioassay tests for multiple mechanisms of pesticide resistance such as metabolic resistance and knock-down resistance. Pesticide susceptible mosquitoes will be inactive or behave erratically at the diagnostic time and do not recover from the pesticide exposure. Metabolic resistant mosquitoes are active at the diagnostic time during the bottle bioassay, but may or may not die at a later time during the test. Knock-down resistant mosquitoes appear dead during the initial bottle bioassay evaluation, but recover from the pesticide exposure within 24 hours.

During 2021, fourteen resistance tests were completed to evaluate the active ingredients found in our most commonly used adult mosquito control products (permethrin, sumithrin, and etofenprox). Tests were performed on *Culex* spp. and floodwater *Aedes* spp. from eggs, larvae, or pupae collected in Lucas County and reared to adults in TASD's insectary. All tests were performed on young adult mosquitoes.

Four of fourteen resistance tests were inconclusive due to high mosquito mortality in control (untreated) bottles. Mosquito mortality in control bottles can result from contamination with pesticide residues, excessive moisture, or residual diluent.

PERMETHRIN

Five conclusive permethrin resistance tests were completed between May 21 and August 5, 2021. *Culex pipiens* represented the majority

Preparation of pesticide resistance bottles.

(>90%) of adult mosquitoes in three tests while floodwater *Aedes* spp. represented the majority (>90%) of adult mosquitoes in two tests.

Culex pipiens demonstrated susceptibility to permethrin at the diagnostic time in two of three tests (Appendix – Table 2). However, all three tests demonstrated knock-down resistance. The potentially resistant test occurred nearest the onset of the 2021 adult control season while later tests demonstrated susceptibility at the diagnostic time. Knock-down resistance increased following the initial permethrin test in 2021 and was more prevalent compared to the 2020 season.

Floodwater *Aedes* spp. demonstrated susceptibility to permethrin in evaluations at the onset and towards the end of the 2021 adult control season. Floodwater *Aedes* spp. did not demonstrate knock-down resistance to permethrin.

SUMITHRIN

Three conclusive sumithrin tests were completed between July 15 and September 14, 2021 (Appendix – Table 3). Two tests demonstrated both resistance at the diagnostic time and knock-down resistance. These potentially resistant tests contained 44-100 percent *Culex pipiens*. Only one of the three sumithrin tests demonstrated susceptibility and no knock-down resistance. This susceptible test contained only floodwater Aedes spp. Sumithrin was not evaluated in 2020 so no between-season comparisons can be made.

ETOFENPROX

According to the CDC bottle bioassay materials, diagnostic times of etofenprox vary from 15 to 105 minutes for *Culex* spp. Unfortunately, some of these *Culex* spp. can only be identified via molecular assays. Therefore, the correct diagnostic time for Lucas County's *Culex* population is unclear. Floodwater *Aedes* spp. have no diagnostic times supplied by the CDC for any active ingredient. In 2020, the two conclusive etofenprox tests exceeded 96% mortality at 75 or 90 minutes of etofenprox exposure. Depending on the species composition, these results could indicate either a resistant or a susceptible population.

One strategy to resolve the issue of interpreting etofenprox results for our local mosquito population is to run calibration assays. Calibration assays involve altering the diagnostic dose (or concentration) of the pesticide solution in bioassay bottles. The concentration of etofenprox used by the CDC is 12.5 micrograms per bottle. For calibration assays, we tested 6.25, 9.375, 12.5, 18.75, 25, and 31.25 micrograms of etofenprox per bottle.

TASD completed two calibration assays with etofenprox in 2021, one for *Culex* spp. and one for floodwater *Aedes* spp. (Appendix – Figure 5). The CDC suggests that diagnostic times should be between 30 and 60 minutes. *Culex* spp. mosquitoes did not reach the suggested diagnostic time at any concentration. *Aedes* spp. mosquitoes reached complete mortality between 30 and 60 minutes at multiple concentrations, but these results were inconsistent at higher doses. Both assays demonstrated a diagnostic time of 75 minutes for a concentration of 31.25 micrograms per bottle. To achieve a desired diagnostic time of 30-60 minutes, TASD aims to repeat calibration assays in 2022 with higher concentrations of etofenprox per bottle.

RESEARCH & DEVELOPMENT
ADULT CONTROL EFFICACY

Droplet testing and machine calibration was performed on May 27, 2021. Adulticide efficacy was monitored for trends that were specific to each truck, but no trends in truck performance were observed. Therefore, droplet testing was not repeated beyond the initial calibration event.

Five adult control products were evaluated for their impact on the gravid mosquito population in 2021 (Anvil® 2+2, BioMist® 3+15, Duet®, Pursuit® 4-4, and Zenivex® E4 RTU). Gravid mosquitoes are the most difficult developmental stage to control due to their physiology and behavior. A total of 116 efficacy observations were calculated (Appendix – Figure 4). Treatment success was 56% for Zenivex® E4 RTU, 43% for Pursuit®, 39% for Anvil®, 28% for BioMist®, and 0% for Duet®. Efficacy of Zenivex® and Duet® results should be assessed with care as they had less than ten observations.

2021 MOSQUITO SEASON REVIEW

The year 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 one of the driest spring conditions the District has seen, leading to little use for residual floodwater treatment products and a more heavy reliance on Bti applications.

The quiet spring provided an opportunity for the field staff to continue to familiarize themselves with, and improve the mapping within the new electronic record-keeping system implemented by the District. It also made for conditions that were able to be entirely treated during the normal work hours/week, avoiding the need for overtime for the first year in a very long time. However, after collecting data in the spring for two previous years, the uncharacteristic lack of spring floodwater mosquitoes prevented the ability to conduct sampling for the ongoing research project looking at the efficacy and non-target impacts of residual biological larvicides in vernal pools.

As the weather warmed, adult nuisance mosquito populations remained very low, but *Culex* populations soared, creating concern for the amplification of West Nile virus (WNV) in the bird and mosquito populations. Early season adulticiding was targeted at slowing the WNV sylvatic amplification cycle by reducing *Culex* vector abundance. This strategy seemed to have worked as, overall, we had a relatively low to average seasonal Minimum Infection Rate (MIR) for WNV in the local mosquito population.

Control products shown in the TASD storage facility were difficult to acquire in 2021 due to COVID supply chain issues.

The abundance of *Culex* mosquitoes in gravid traps allowed the District to establish and refine testing procedures and protocols for its newly completed polymerase chain reaction (PCR) testing facility within the surveillance lab. Conducting in-house PCR testing of mosquitoes for the presence of WNV provided faster results that could be utilized for control planning decisions. It also permitted results to be obtained on any day of the week versus the typical two-to-three week turnaround delays from the Ohio Department of Health lab. This was a big advancement and benefit to the program.

Beginning in early July, the focus of the season dramatically changed with the weather pattern again. Above-average rainfall and frequent storms reduced concerns for *Culex* populations and WNV and shifted the District's efforts to nuisance mosquito control. Record numbers of *Aedes trivittatus* and *Aedes sollicitans* mosquitoes were observed. These aggressive biting mosquitoes made for very difficult conditions for Lucas County citizens for the remainder of the season.

In addition to the difficult mosquito season, challenges continued to present themselves in many ways throughout 2021 as TASD, and the country, continued to deal with the COVID-19 pandemic. This pandemic effected staffing, supplies, operations, finances, and organizational planning. From a personnel and staffing perspective, the District had difficulty filling seasonal positions that are relied upon for the night adulticiding operations. In terms of supplies, global PBO (adulticide synergist ingredient) shortages limited control product availability and impacted product choices for TASD. This shortage has no predicted end in sight, leading to increased advance adulticide purchases in anticipation of similar problems for the 2022 season. In-person events were still limited, forcing the District to look at alternative methods of educational outreach methods. Undeniably, the COVID-19 impacts were woven throughout the entire operations of the District.

The District purchased a new compact track loader for its breeding source reduction projects and two-stage ditch installations.

2021 MOSQUITO SEASON REVIEW cont.

PERSONNEL

After over 52 years of service to the District in an advisory capacity, Dr. Gary Bennett retired from the TASD Advisory Committee when he resigned his position.

Office Clerk/Assistant Bookkeeper, Arianna Johansen, was replaced by Kelly Hahn.

Field Supervisor/Operator, Cory Taylor, was replaced by Jerry Moore, III.

Garage & Facilities Specialist, Mike Bruce, retired. This position was abolished and the duties were assumed by the District's Operations Managers.

FINANCES

The operations for the 2021 season were funded by a special assessment of 0.34 mills on eligible properties, which resulted in collections of $2,930,309.35. Expenditures for 2021 were $2,686,755.31, leaving a budget surplus for the year of $243,554.04. A detailed financial report and budget for 2022 noted on the following page.

The District continued with large capital improvement plans to coincide with long-term re-organizational changes. Plans to construct an auxiliary building to house trucks and heavy equipment continued to be delayed by construction and supply issues. The District was able to complete the construction of the PCR lab and purchase all of the required equipment and supplies. A restroom renovation project was also started with the construction ongoing into 2022. Plans for a new surveillance lab area were contracted with a local architecture firm.

Vehicle supply chain problems were an issue as the District advertised a bid for the purchase of three new fleet trucks that no dealerships were able to meet. Not being able to purchase new fleet trucks allowed the District to use the available funds to purchase a new compact track loader for its breeding source reduction projects and two-stage ditch installations.

ENVIRONMENTAL AWARENESS

Several areas of the District's environmental sustainability efforts were previously discussed in other portions of this report such as the swimming pool and auto tire recycling programs, but the District remained committed to environmental sustainability within its operations as part of the EPA's Pesticide Environmental Stewardship Program. New recycling initiatives, expanded use of water dissolvable larvicide applications, and new two-stage ditch and filter strip installations highlight several of the ways the District is modifying its practices to perform its duties and mission in an environmentally sensitive and sustainable manner.

2021 FINANCIAL REPORT & 2022 BUDGET

	2021 FINANCIAL REPORT	2022 BUDGET
FUNDS ON HAND		
Petty Cash	$ 100.00	$ 100.00
Cash Book Balance	1,795,861.82	2,084,861.05
TOTAL FUNDS ON HAND	$ 1,795,961.82	$ 2,084,961.05
RECEIPTS		
Maintenance Assessments (Gross)	$ 2,930,309.35	$ 2,800,000.00
Grants	—	26,000.00
Interest Earned on Investments	1,045.27	1,000.00
Sale of Equipment & Supplies	12,198.32	0.00
Sale of Scrap	284.27	0.00
Adjustments & Refunds	31,917.33	0.00
TOTAL	$ 2,975,754.54	$ 2,827,000.00
TOTAL RECEIPTS & BALANCES	$ 4,771,716.36	$ 4,911,961.05
EXPENDITURES		
OFFICE & ADMINISTRATION		
Wages - Permanent	$ 385,988.89	$ 415,000.00
Wages - Temporary	33,657.38	70,000.00
Equipment	8,546.31	10,000.00
Utilities & Communications	23,394.60	40,000.00
Professional Services	50,477.36	350,000.00
Pension & Employee Insurance	480,158.11	700,000.00
General Insurance	107,890.00	130,000.00
Travel & Conference	1,012.42	20,000.00
Supplies	7,092.85	15,000.00
Education & Research	37,656.33	35,000.00
R.E. Improv., Maint. & Rental	129,745.45	645,000.00
Assessment Roll & Taxes	12,383.89	160,000.00
Workers' Comp. & State Auditor	9,151.00	50,000.00
Adjustments	0.00	0.00
TOTAL	$ 1,287,154.59	$ 2,640,000.00
FIELD PROGRAM		
Wages - Permanent	$ 795,655.38	$ 885,000.00
Wages - Temporary	15,865.50	90,000.00
Vehicles & Equipment	115,892.94	5,000.00
Larvicides & Insecticides	332,643.50	415,000.00
Fuel & Lubricants	38,469.02	45,000.00
Equipment Maintenance & Shop	19,260.03	30,000.00
Field Supplies & Hand Tools	63,215.83	65,000.00
Miscellaneous & Contingencies	564.01	2,000.00
Drainage Equipment Maintenance	8,750.86	40,000.00
Special Projects	0.00	0.00
Vehicle & Equipment Rental	0.00	20,000.00
Environmental Sustainability	9,283.65	17,000.00
TOTAL	$ 1,399,600.72	$ 1,614,000.00
TOTAL EXPENDITURES	$ 2,686,755.31	$ 4,254,000.00
BALANCE	$ 2,084,961.05	$ 657,961.05

LISA DIEHL
OFFICE MANAGER/BOOKKEEPER

APPENDIX

Table 1. TASD Product Use Summary (2021)

PRODUCT	USE PATTERN	AMOUNT USED
Anvil 2+2®	Night fogging applications	373 gals.
BioMist 3+15®	Night fogging applications	1,126 gals.
Duet®	Night fogging applications	149 gals.
Evergreen ULV 5-25®	Night fogging applications: trial use	30 gals.
Pursuit 4-4®	Night fogging applications	765 gals.
Zenivex E4®	Night fogging applications	284 gals.
Aquabac 200G®	Temporary floodwater treatment	6,182 lbs.
BVA 2®	Pupal and late fourth instar larval control	368 gals.
Censor Larvicide Granule®	Temporary floodwater treatment	379 lbs.
FourStar Bti CRG®	Catch basin treatments and containers	532 lbs.
Natular G30®	Catch basin treatments and containers	555 lbs.
Natular SC®	Larval control water dissolvable trial use	2 gals.
Sumilarv 0.5G®	Larval catch basin control trial use	3.5 lbs.
Vectobac WDG®	Urban WALS *Culex* control and disease management	450 lbs.
VectoLex FG®	Catch basin treatments and semi-permanent floodwater	614 lbs.
VectoMax FG®	Spring floodwater applications	5,865 lbs.
Demand CS® Archer IGR®	Residual barrier adult & larval mosquito control application for WNV treatment	4.8 ozs. 0.6 ozs.

APPENDIX

Table 2. New Jersey Light Trap Collections (2021)

	MAY				JUNE				JULY				AUGUST					SEPTEMBER									
WEEKS:	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	**TOTALS**						
MOSQUITO SPECIES																						May	June	July	Aug.	Sept.	**TOTALS**
Ae. aurifer	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	**1**
Ae. canadensis	1	0	9	2	5	4	1	1	0	0	0	0	0	0	1	0	0	0	0	0	24	12	11	0	1	0	**24**
Ae. cinereus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	**1**
Ae. grossbecki	0	2	0	12	6	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	22	14	8	0	0	0	**22**
Ae. japonicus	0	1	10	17	8	9	5	8	1	14	12	7	4	13	2	4	0	5	1	0	121	28	30	34	23	6	**121**
Ae. sollicitans	0	0	0	42	5	3	0	28	28	3	0	2	0	1	0	3	0	0	0	0	115	42	36	33	4	0	**115**
Ae. sticticus	0	0	10	195	164	99	107	70	87	20	15	3	0	4	0	2	0	0	0	0	776	205	440	125	6	0	**776**
Ae. stimulans	1	0	2	10	6	10	0	2	2	0	0	1	0	0	2	2	0	0	0	0	38	13	18	3	4	0	**38**
Ae. triseriatus	0	0	0	1	0	0	0	1	0	0	2	2	0	5	1	1	0	0	0	0	13	1	1	4	7	0	**13**
Ae. trivittatus	0	0	0	243	28	12	15	3	0	2	1	1	0	0	0	1	0	0	0	0	306	243	58	4	1	0	**306**
Ae. vexans	0	4	43	2935	1228	608	535	379	542	196	270	212	109	118	20	150	18	95	44	2	7508	2982	2750	1220	415	141	**7508**
An. barberi	0	0	0	1	1	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	5	1	3	0	1	0	**5**
An. perplexans	0	1	5	4	0	0	1	1	6	1	3	3	0	0	1	1	0	1	0	0	28	10	2	13	2	1	**28**
An. punctipennis	0	1	5	7	3	5	12	15	11	5	12	15	7	29	3	16	1	3	0	0	150	13	35	43	56	3	**150**
An. quadrimaculatis	0	1	0	3	1	4	9	14	92	59	119	111	91	406	307	663	43	51	31	0	2005	4	28	381	1510	82	**2005**
An. walkeri	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	0	11	0	18	1	0	0	6	11	**18**
Cq. perturbans	0	0	0	1	0	20	12	33	256	30	88	15	10	46	32	140	1	0	0	0	684	1	65	389	229	0	**684**
Cx. erraticus	0	0	1	4	0	0	1	0	0	0	0	0	0	0	104	318	11	5	0	0	444	5	1	0	433	5	**444**
Cx. pipiens	0	27	26	55	18	15	30	24	17	9	8	7	10	8	20	85	7	14	47	1	428	108	87	41	130	62	**428**
Cx. restuans	24	40	45	69	26	34	34	14	31	11	14	27	20	47	14	61	1	16	17	0	545	178	108	83	143	33	**545**
Cx. pipiens/Cx. restuans	0	0	23	30	11	29	38	14	55	68	94	121	134	99	38	35	3	71	0	0	863	53	92	338	309	71	**863**
Cx. tarsalis	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	3	1	0	0	0	**4**
Cx. territans	2	9	2	19	10	34	12	11	3	13	0	5	0	12	21	16	0	2	0	0	171	32	67	21	49	2	**171**
Cs. inornata	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	2	0	0	0	1	**3**
Cs. melanura	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	**1**
Cs. minnesotae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	**1**
Or. signifera	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2	0	0	2	0	0	**2**
Ur. sapphirina	0	0	1	0	3	1	3	2	14	17	19	12	3	13	61	94	0	22	0	0	265	1	9	62	171	22	**265**
TOTAL FEMALE	**29**	**89**	**182**	**3654**	**1524**	**889**	**817**	**620**	**1147**	**448**	**657**	**545**	**388**	**801**	**628**	**1596**	**87**	**286**	**152**	**3**	**14542**	**3954**	**3850**	**2797**	**3500**	**441**	**14542**
TOTAL MALE	**2**	**15**	**37**	**2340**	**1493**	**447**	**288**	**230**	**327**	**451**	**277**	**325**	**146**	**333**	**266**	**693**	**25**	**563**	**77**	**2**	**8337**	**2394**	**2458**	**1380**	**1463**	**642**	**8337**

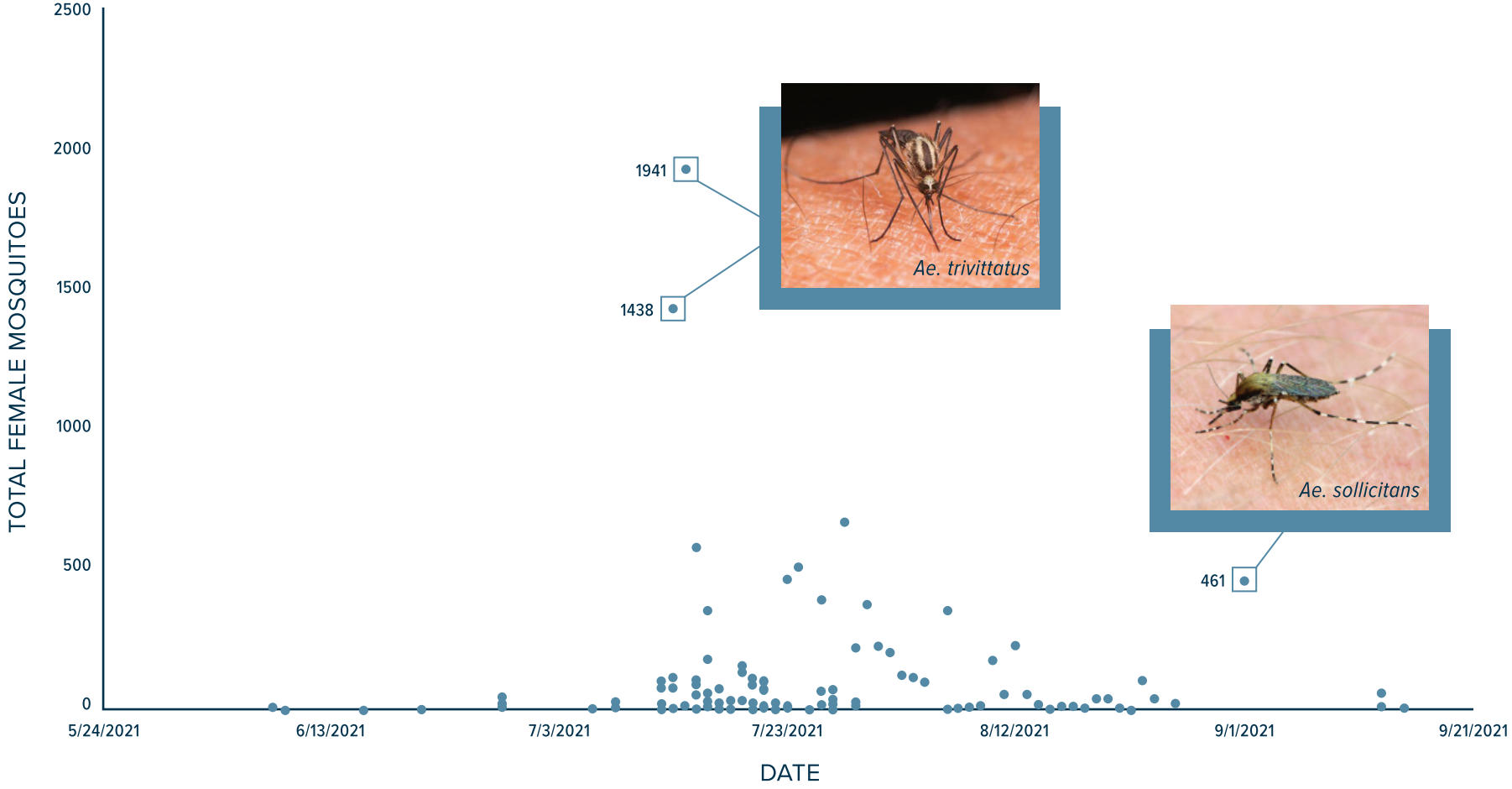
APPENDIX

Table 3. Three sumithrin and five permethrin resistance tests with control mortality less than ten percent were completed in 2021. Shaded in gray are tests that were composed of primarily *Culex* spp. mosquitoes. 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	DATE	SPECIES COMPOSITION	Mortality at CDC Diagnostic Time (%)	Non-KDR (%)
Sumithrin	9/14/2021	100% *Cx. pipiens*	93	72
Sumithrin	7/15/2021	95% *Ae. trivittatus* 2.5% *Ae. vexans* 2.5% *Ae. sollicitans*	97	100
Sumithrin	8/20/2021	54% *Ae. vexans* 44% *Cx. pipiens* 2% *Ae. trivittatus*	95	81
Permethrin	6/17/2021	90% *Cx. pipiens* 10% *Cx. restuans*	93	96
Permethrin	7/28/2021	90% *Cx. pipiens* 5% *Ae. trivittatus* 3% *Ae. vexans* 2% Unknown *Aedes*	100	87
Permethrin	8/5/2021	94% *Cx. pipiens* 6% *Cx. restuans*	98	88
Permethrin	5/21/2021	*Ae. vexans* *Ae. grossbecki* *Ae. stimulans* *Ae. sticticus* *Ae. trivittatus* *Ae. triseriatus*	100	—
Permethrin	8/2/2021	98% *Ae. vexans* 2% *Ae. sollicitans*	100	100

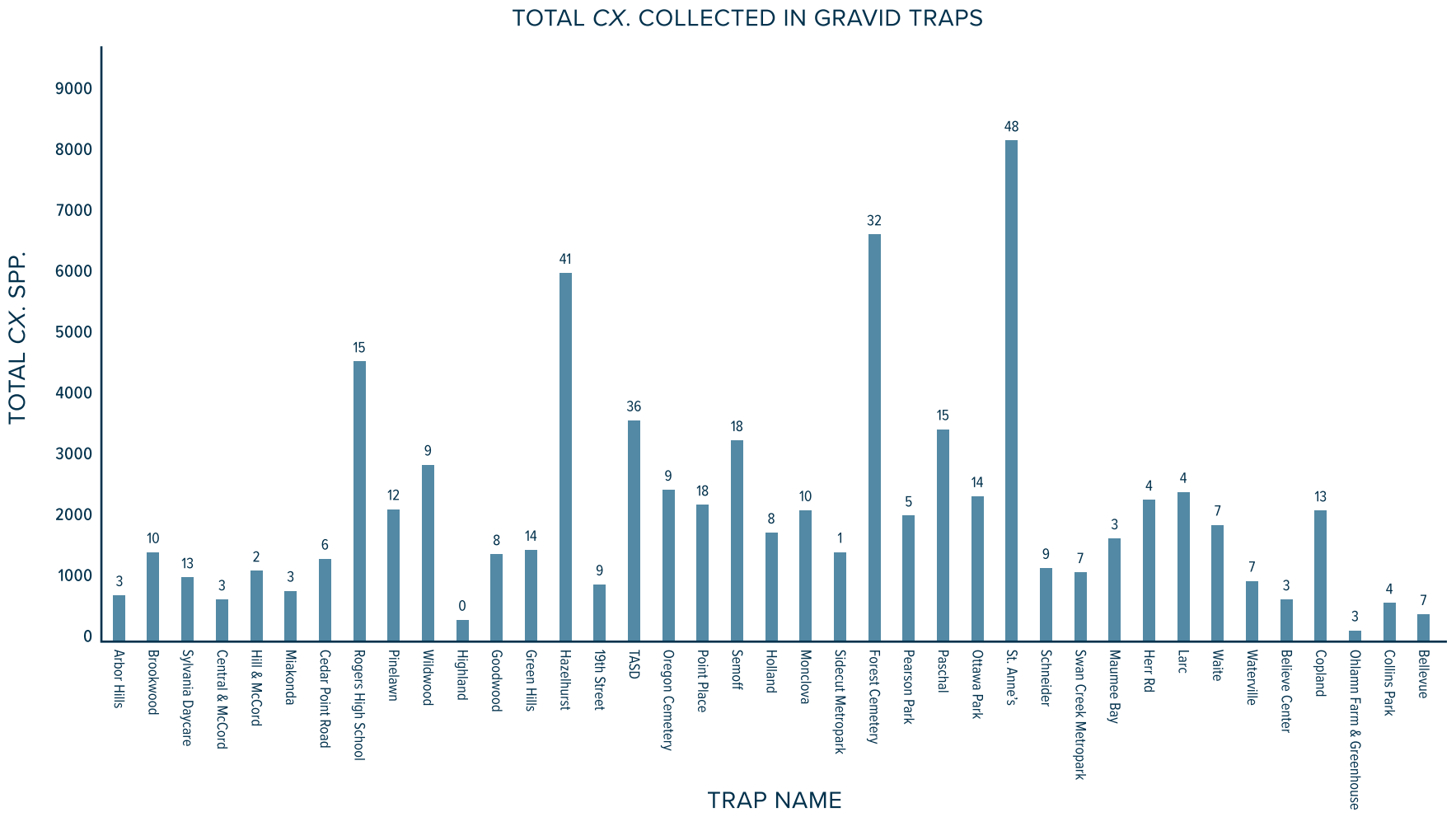
APPENDIX

Figure 1. CDC Trapping Totals (2021)



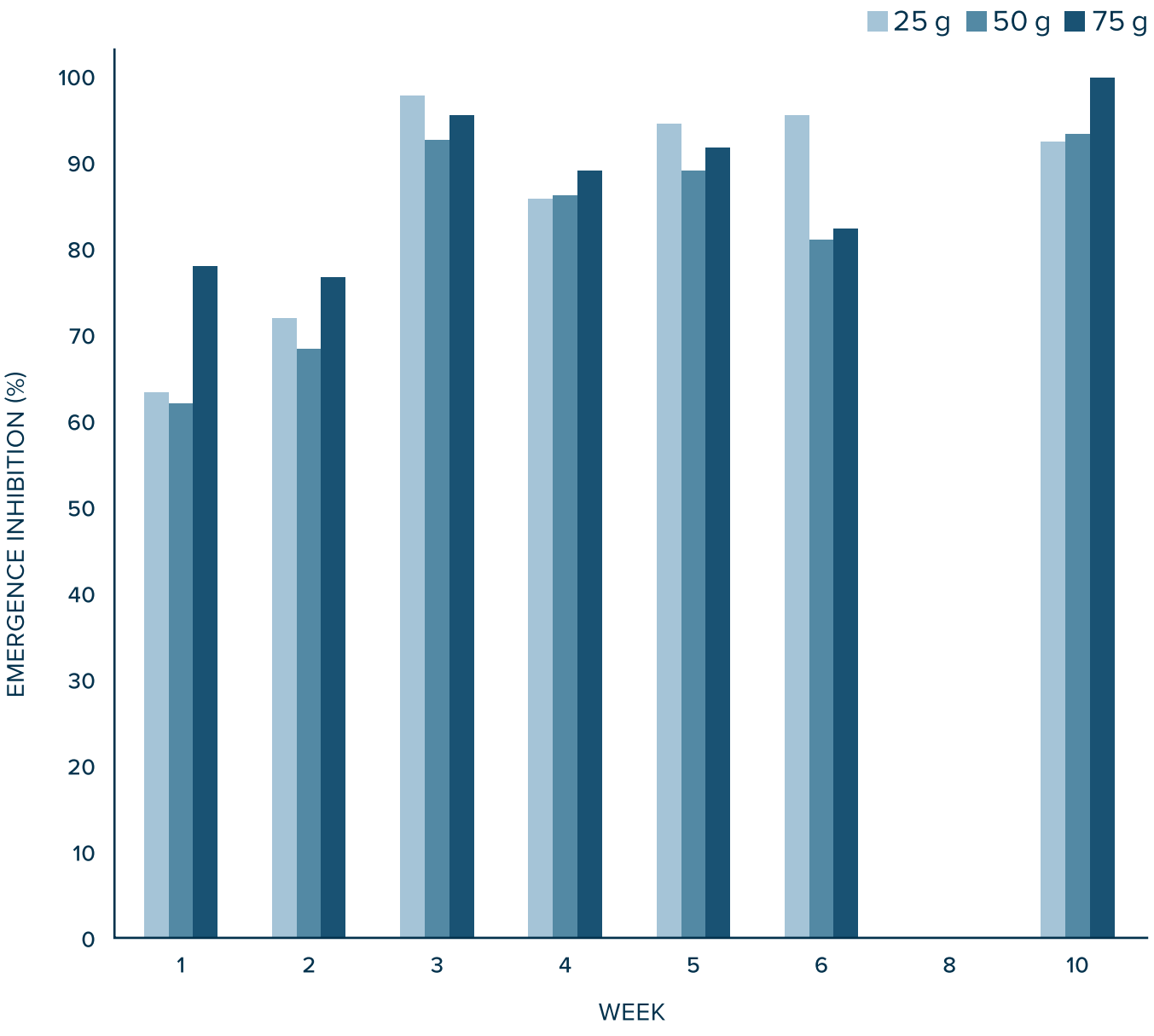
APPENDIX

Figure 2. Values above the bars are the number of positive West Nile virus mosquito pools obtained from the site in 2021.



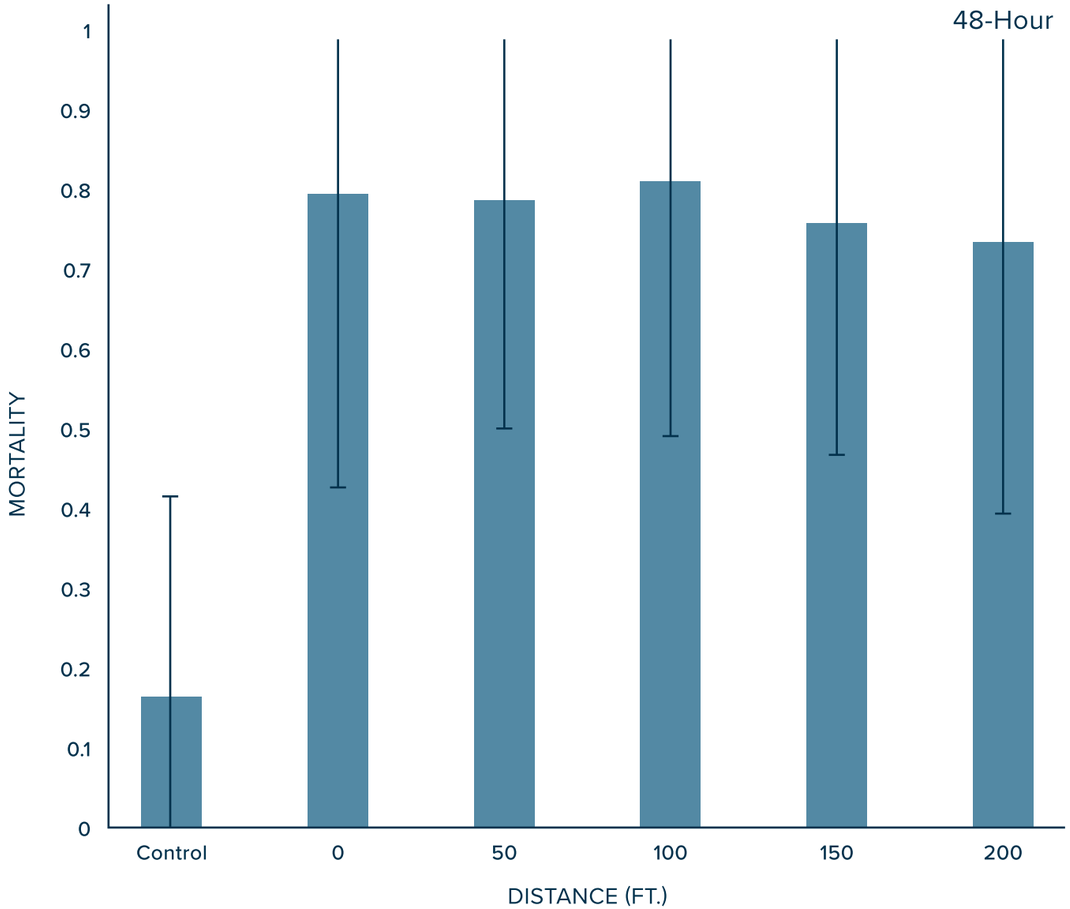
APPENDIX

Figure 3. Sumilarv® inhibited emergence for mosquito larvae in most weeks. Week eight data has zero emergence inhibition as all samples, including the controls, had high larval mortality. All doses had emergence inhibition greater than 90 percent during week ten.



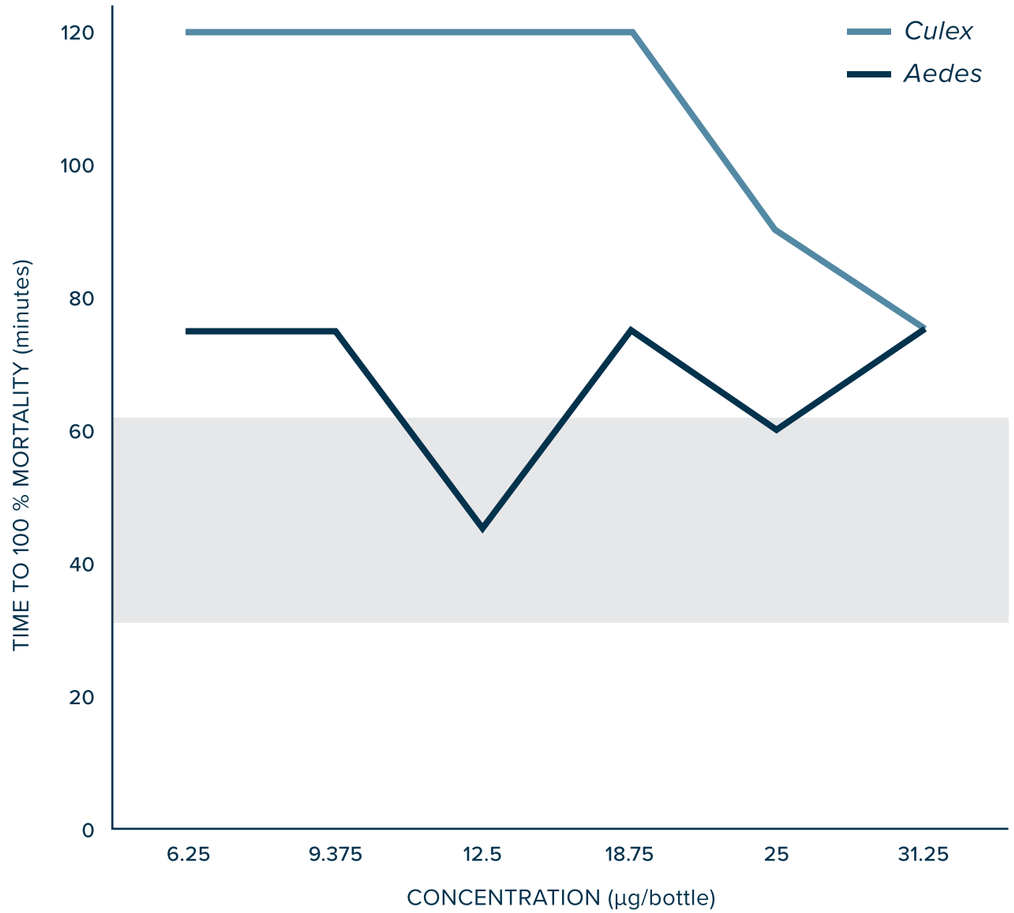
APPENDIX

Figure 4. Larval mortality was greater in treated jars compared to control jars at 48 hours in a Natular® SC bioassay. Control jars were not exposed to a field application while treatment jars were placed in the field at various distances from the treatment route. Treatment mortality did not decline with increasing distance from the treatment route.



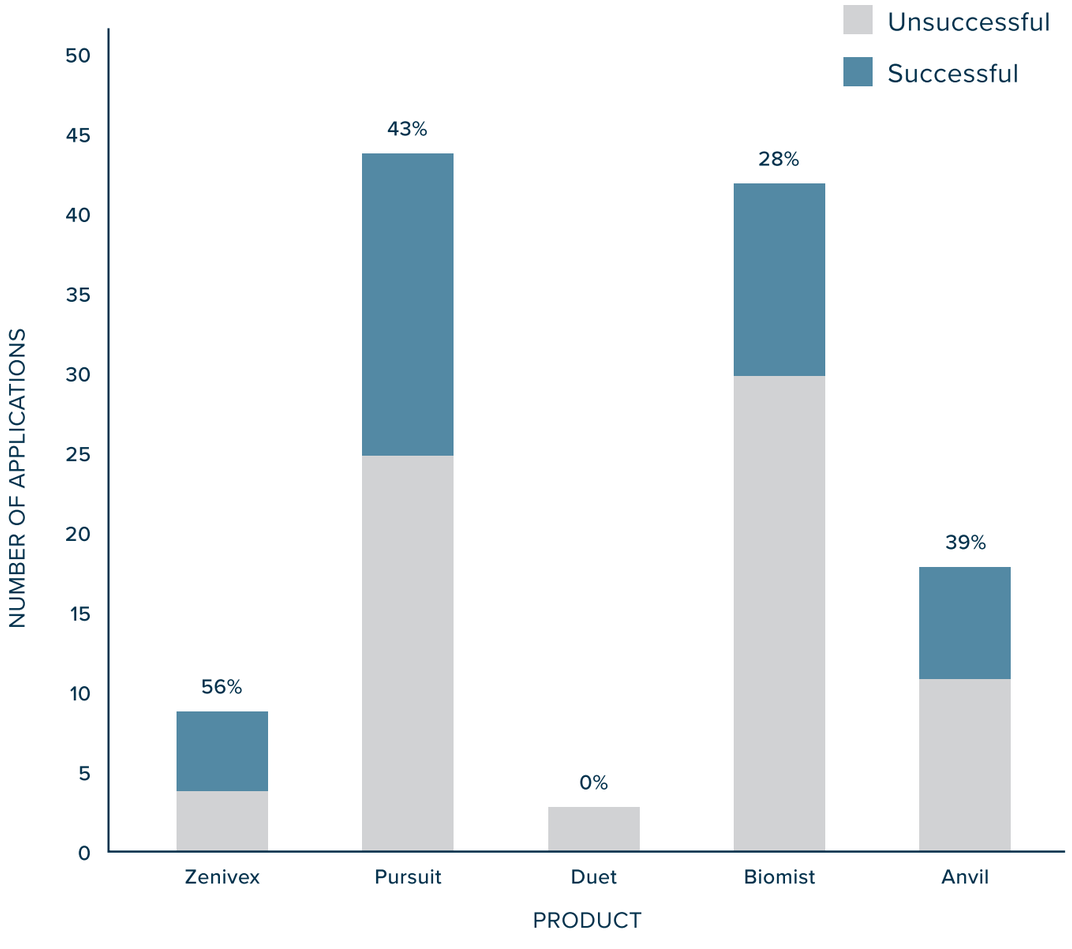
APPENDIX

Figure 5. Calibration assays were performed to determine a diagnostic dose and time for etofenprox using local mosquito populations. The CDC's resistance testing procedure suggests a diagnostic time where complete mortality occurs between 30 and 60 minutes, depicted by the grey band. *Culex* spp. mosquitoes did not reach the suggested diagnostic time at any concentration. *Aedes* spp. mosquitoes reached complete mortality between 30 and 60 minutes at multiple concentrations, but these results were not consistent for higher doses.



APPENDIX

Figure 6. Mulla's formula was used to calculate treatment efficacy compared to control sites. Successful treatments reduced mosquito abundance in gravid traps more than 30% compared to control treatments. The percent of successful applications is noted above bars.



NOTES

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