NAVY AND MARINE CORPS PUBLIC HEALTH CENTER
IMPROVING READINESS THROUGH PUBLIC HEALTH ACTION

Analysis of Mosquito Surveillance Data for Program Evaluation

2017 Report

U.S. Navy photo by James Gathany

Contents

Executive Summary

Mosquito surveillance and control is an important component of preventing vector-borne disease transmission. In 2016, Department of Navy public health response to Zika virus outbreaks led to the adoption of targeted *Aedes* mosquito surveillance and screening for Zika virus on Navy and Marine Corps installations. Data in this report contribute to our overall understanding of mosquito trapping techniques and policy implementation in response to an emerging vector-borne disease, demonstrate how data from a local program can be used to enhance mosquito control efforts, and offers a template that can be duplicated at other installations.

Background

OPNAVINST 6250.4C requires naval commands ashore and afloat to maintain integrated pest management (IPM) programs. Adult mosquito surveillance is a key component of naval pest management operations and guides installation mosquito control activities. Mosquito surveillance involves collecting, identifying, and counting both nuisance and disease-transmitting mosquito species and may also include screening mosquitoes for the presence of specific mosquito-borne diseases.

Centers for Disease Control and Prevention (CDC) light traps have been the standard method for adult mosquito trapping in the US since 1954 (Rodrigues, Hoel). They are primarily used to monitor for nuisance mosquitoes given the low burden of mosquito borne diseases in the US. Each trap utilizes a small light and a carbon dioxide (CO_2) bait source which is removable. Trap effectiveness varies and depends on the trap location and whether or not CO_2 is used. Navy and Marine Corps installations have primarily used the CDC light traps for their mosquito surveillance programs and have increased use of these traps since the emergence of West Nile virus in the US.

In February 2016, the World Health Organization declared Zika virus a Public Health Emergency of International Concern due to congenital abnormalities related to Zika virus infections. The DoD adopted a strategy for targeted surveillance of *Aedes* mosquitoes collected on DoD installations. *Aedes albopictus*, *Aedes aegypti,* and *Aedes polynesiensis* (known or potential vectors for Zika, dengue, chikungunya, and yellow fever viruses) collected on DoD installations were screened for Zika virus at US Army and US Armed Forces laboratories in addition to other viruses. The DoD directed acquisition of BG-Sentinel traps for conducting *Aedes* mosquito surveillance following studies demonstrating these traps target *Aedes* species (CDC). Installations, notably those in regions where *Aedes* vectors were known or suspected to occur, expanded their mosquito surveillance programs to include targeted surveillance for these mosquito species using BG-Sentinel traps. As a result, NH Pensacola Preventive Medicine Department acquired BG-Sentinel traps in July 2016. Guided by the Navy Entomology Center of Excellence (NECE), NH Pensacola personnel were provided training on the use of these traps and *Aedes* mosquito identification. In an effort to examine the efficacy of BG-Sentinel traps in response to Zika and better inform vector control activities aboard naval installations, this analysis describes the data collected from trapping efforts conducted by NH Pensacola, its clinics, and the installations they support across the Gulf Coast region.

Technical Notes

Mosquito surveillance data were analyzed for installations supported by NH Pensacola and its five subordinate clinics including Naval Branch Health Clinic (NBHC) Panama City, NBHC Meridian, NBHC Gulfport, NBHC Belle Chase and NBHC Whiting Field. The analyses include a comparison of BG-Sentinel and CDC light trap efficiency, species composition, and prevalence of virus positive mosquitoes.

Mosquito trapping is done at NH Pensacola and its subordinate clinics weekly from March through October except when weather doesn’t allow for trapping (e.g., rain, low temperatures). Each clinic has a predefined set of geographic locations through which it rotates for trapping and uses either a CDC light trap, a BG Sentinel trap, or in some cases both types of traps. Local standard operating procedures (SOPs) at NH Pensacola and its branch locations require the use of CO2 bait for the CDC light traps and BG-lure for BG-Sentinel traps. Traps remain in place for approximately 24 hours and then mosquito samples are collected. Male mosquitoes are discarded since they do not transmit disease and female mosquitoes from each trap are counted, identified, and submitted to the Army Public Health Center (APHC) Atlantic for pathogen testing. Trap type, coded location and collection date are recorded in a pool log. A count of 25 female mosquitoes of any species or five female *Aedes* mosquitoes collected in either type of trap prompted notification to the Public Works contractor to conduct spray operations.

The data used for this analysis were obtained from the Army Public Health Center (APHC) where all *Culex* mosquitoes are tested for West Nile virus and *Aedes aegypti* and *Aedes albopictus* mosquitoes are tested for Zika, dengue, and chikungunya viruses. APHC maintains a database of all the mosquitoes submitted by NH Pensacola along with subsequent test results.

The data received from APHC are organized by type of mosquito and test result. Specific trap locations on the Pensacola installations were not available as the routes used for setting traps are changed over time. Trap collection dates were used to categorize the data into CDC weeks. Only trap-set dates in 2017 were retained for analysis. The total number of traps per week was calculated using a combination of installation, date collected, trap number and trap type. There was one CDC Light Trap used without CO2 bait during a single trap-set date; this was excluded from the analysis.

NH Pensacola data were selected for this analysis because of the robustness of their mosquito surveillance program, their location in a high mosquito density region with risk of mosquito-borne disease, and the accessibility of its preventive medicine (PM) staff for specific information regarding the data and surveillance program. Limitations of these APHC data include the inability to associate a specific trap with a specific location and limitations in organizing data by trap type rather than mosquito taxonomy. Additionally, lack of data for a given week does not necessarily indicate no trap was set. It may indicate no mosquitoes were trapped during the timeframe which has different programmatic implications. Gaps in data due to rain or other weather-related factors are an expected challenge when monitoring mosquito population trends.

Results

In 2017 traps were set on any given work day between April and December. During this time, 5770 female mosquitoes were trapped and typed by PM staff at NH Pensacola and its subordinate clinics. Figures 1 and 2 show the breakdown of female mosquitoes collected by genus and species. Of the total mosquitoes collected, 36% were *Aedes* (all species) and 28% were *Culex* (all species) and the remaining 36% were all other mosquitoes. Five percent of the total mosquitoes collected were *Aedes albopictus* while *Aedes aegypti* was not identified in the 2017 pools. In that time period, one *Culex sp*. mosquito tested positive for West Nile Virus. It was collected on 21 Aug 2017 at NH Pensacola. There were no other positive disease tests from the mosquito pools submitted by these facilities in 2017.

Figure 1. Pie Chart of Total Females Collected by Species

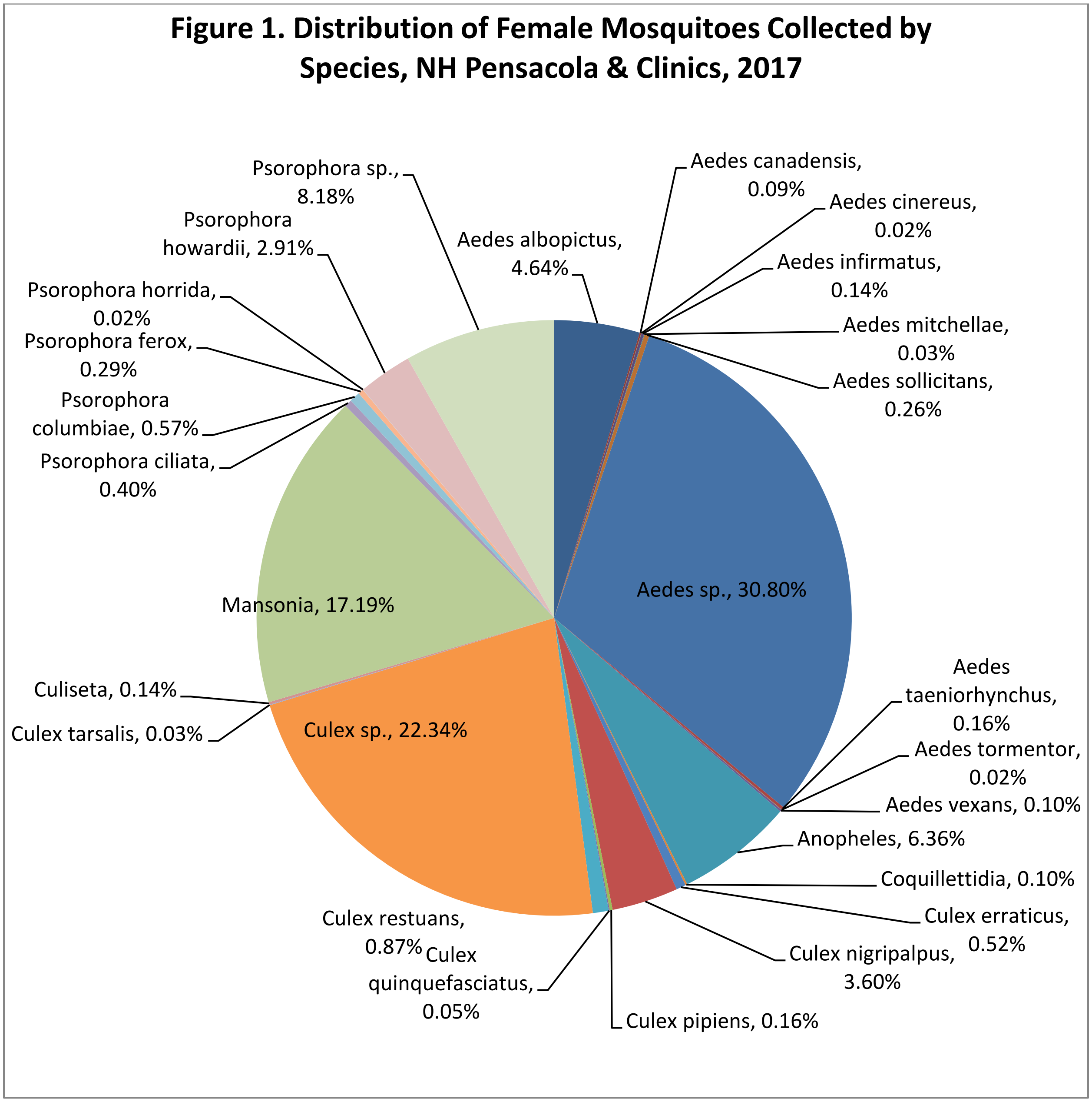


Figure 2. Pie Chart of Total Females Collected by Genus

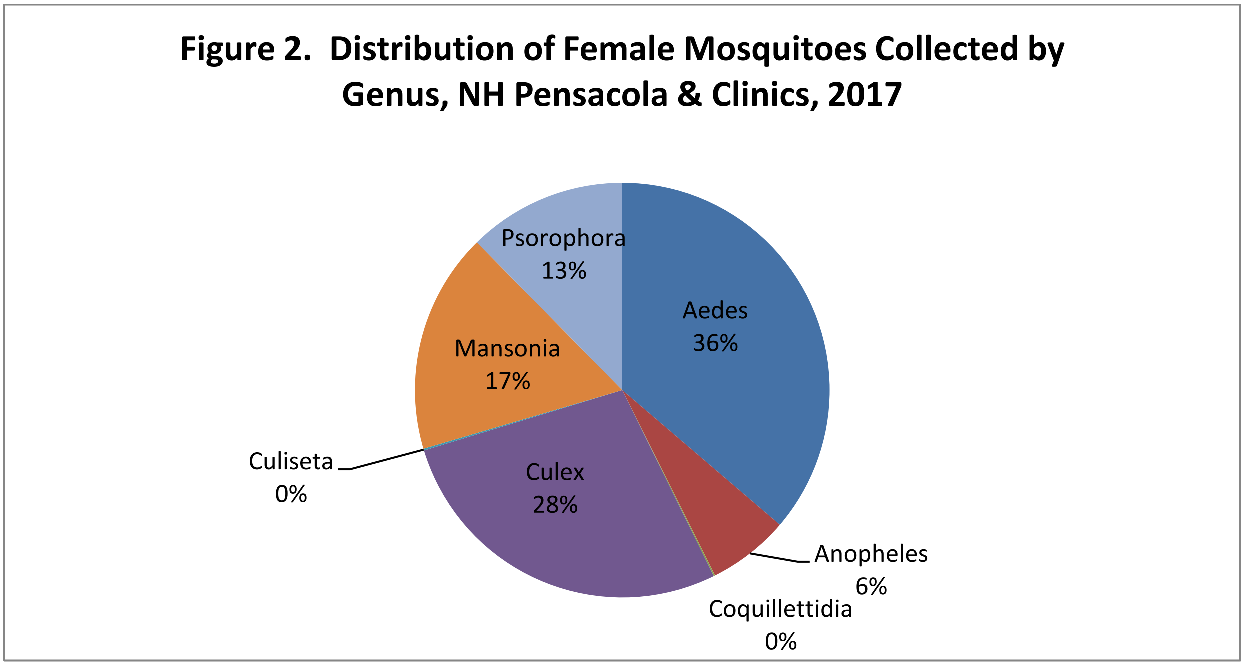


Figure 3 shows the average female mosquito count per week at all collection locations. Trends show the expected waxing and waning of counts given episodic spraying following mosquito count thresholds. The significant peak seen at week ending 22 July is due to large numbers of mosquitoes trapped at NHBC Belle Chasse and is described further below.

Figure 3. Average Number of Female Mosquitoes Trapped at NH Pensacola and Clinics, 2017

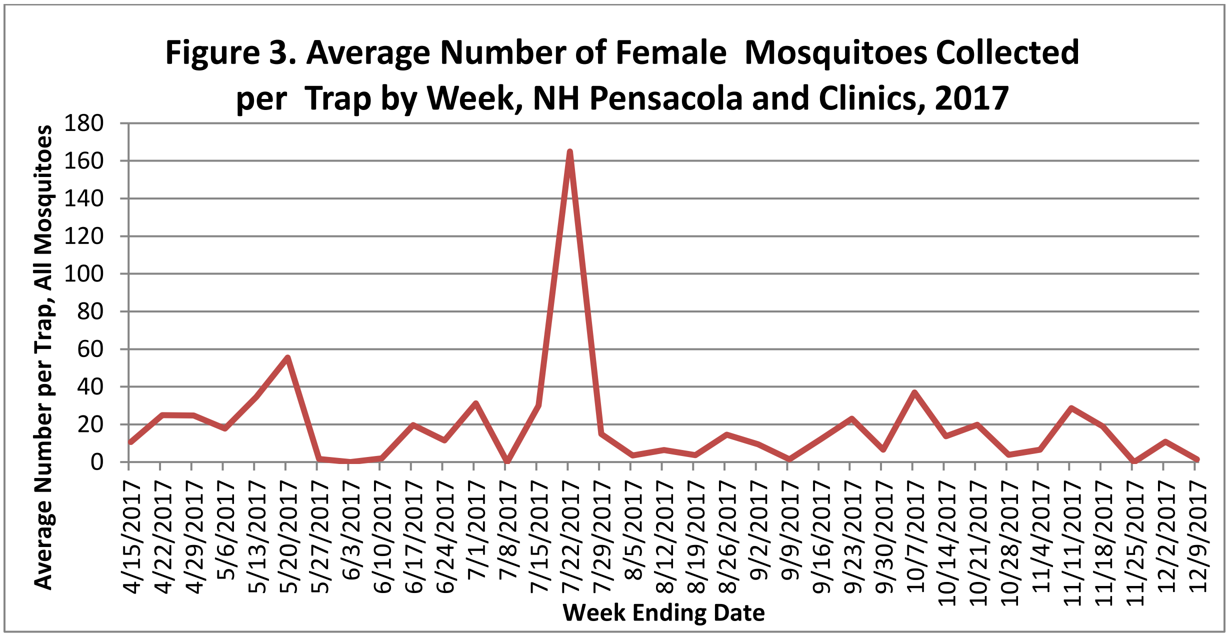
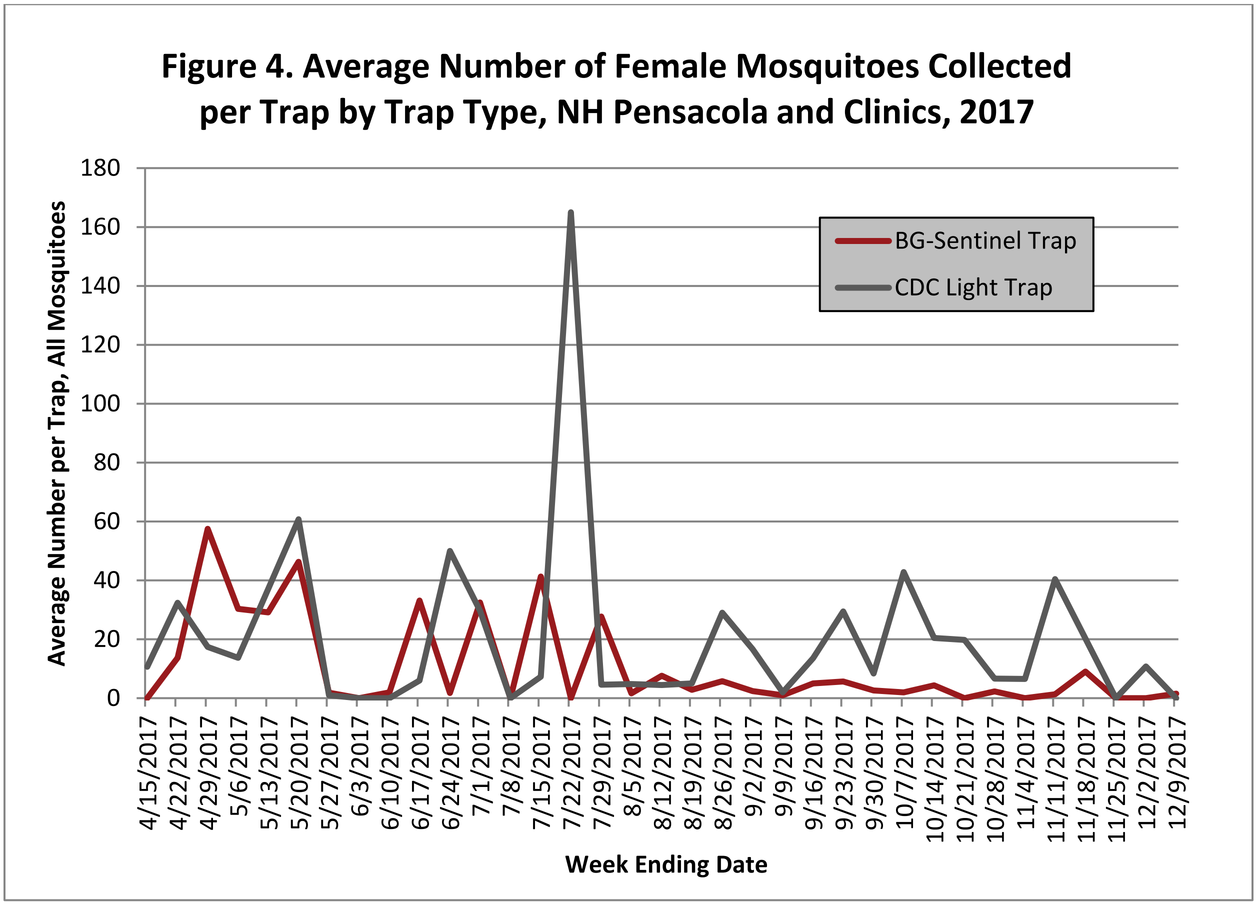


Figure 4 shows trends by trap type, CDC light traps and BG-Sentinel, suggesting differences in mosquito counts between the traps. Using the existing action thresholds, each trap would trigger spraying on different weeks.

Figure 4. Average Number of Female Mosquitoes by Trap at NH Pensacola and Clinics, 2017



Figures 5 and 6 show average *Aedes* and *Culex* mosquito counts by trap type. Again, trends suggest significant differences between the traps, potentially leading to differing public health actions, depending on the trap being used. The two peaks in *Aedes* mosquitoes in May are predominantly from NBHC Panama City traps. Overall, the BG Sentinel trap may be more reliable for capturing of *Aedes* mosquitoes while the CDC light trap appears to be more effective at trapping *Culex* mosquitoes.

Figure 5. Average Number of *Aedes* Female Mosquitoes Captured by Trap Type at NH Pensacola and Clinics, 2017

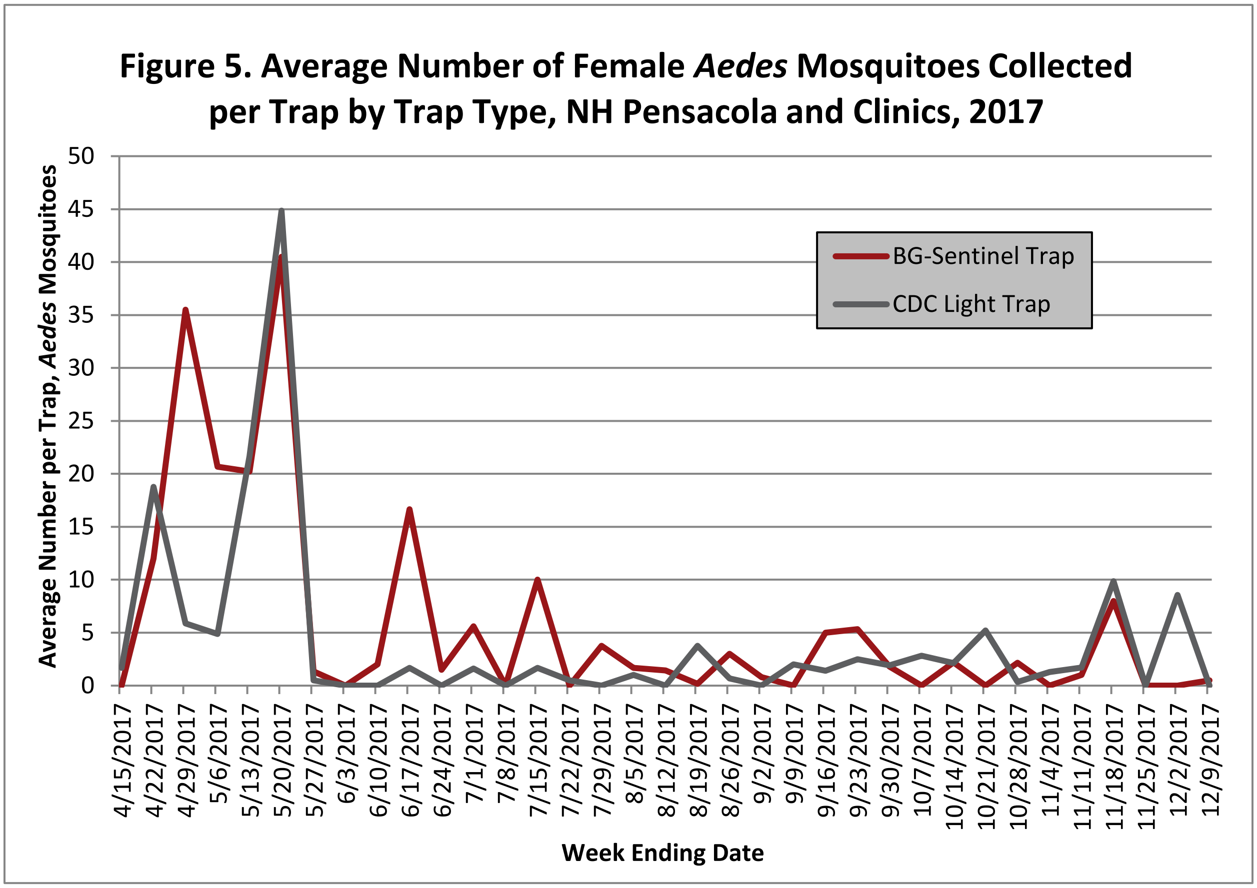
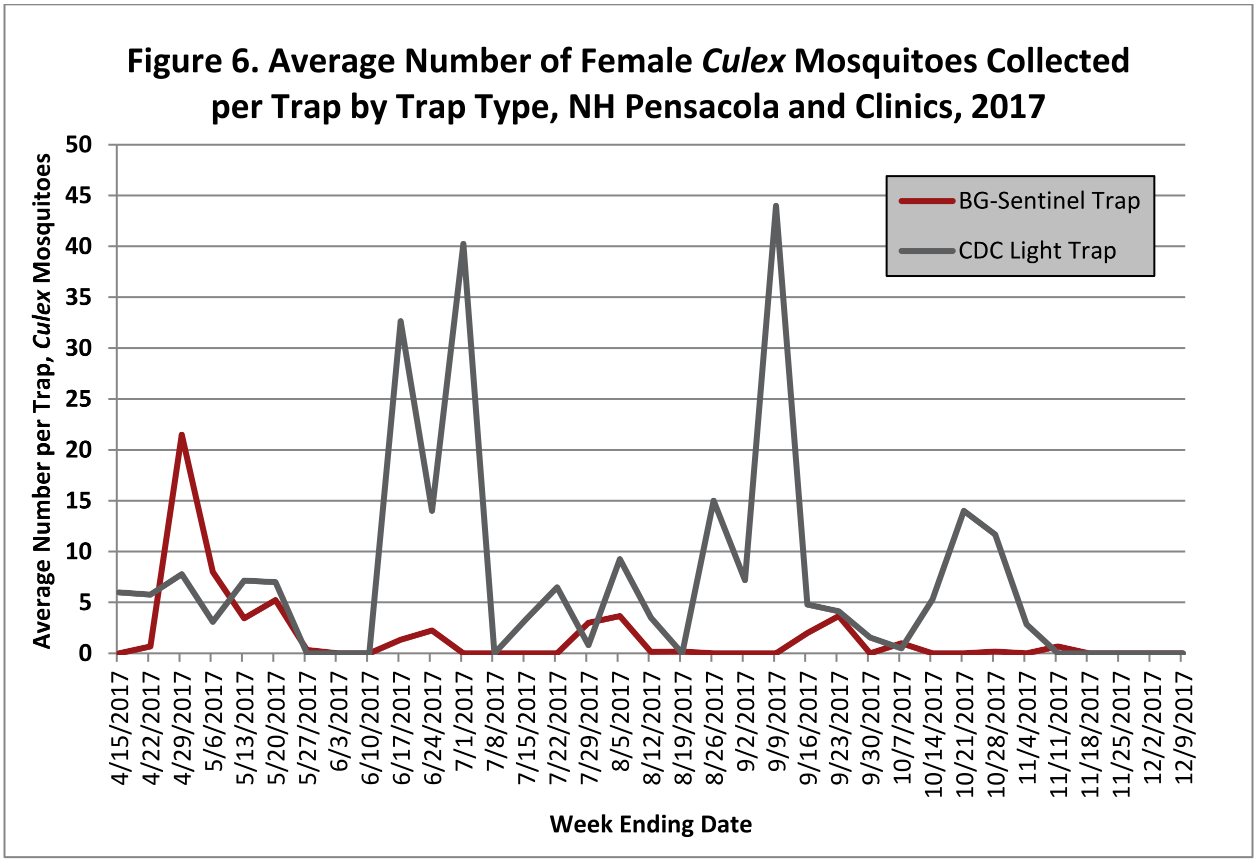


Figure 6. Average Number of *Culex* Female Mosquitoes Captured by Trap Type at NH Pensacola and Clinics, 2017



Of the 5770 female mosquitoes trapped in 2017 at NH Pensacola and its branch clinics, 32% (1833) were trapped by NH Pensacola over the course of 19 trapping weeks (Table 1). An average of seven traps were set per week. Although detailed weather information was not examined for this report, local personnel report there was no trapping during the months of June and July due to a significant amount of rain.

NBHC Panama City trapped for a total of five weeks with 30 traps set during that time. In spite of the low number of surveillance weeks, Panama City was responsible for 31% (n=1791) of all the mosquitoes in this data set. Additionally, this installation had the highest average number of *Aedes* mosquitoes (41 *Aedes*/trap).

NBHC Meridian submitted 21% (n=1217) of the overall mosquitoes collected. They were collected over six trapping weeks with 59 traps set. Average counts remained low in Naval Air Station Meridian though there appeared to be a significant difference between mosquitoes collected in each trap type as with the other locations in this analysis

Only 4% (n=251) of the total mosquitoes trapped were captured by NBHC Gulfport over their six weeks of trapping. A total of 31 traps were used. CDC light trap counts exceeded the BG Sentinel trap counts with an average of 10 mosquitoes per trap versus two mosquitoes per trap respectively.

In spite of only three weeks of trapping with a total of five traps for the year, 10% (n=572) of the mosquitoes trapped in 2017 were captured by NBHC Belle Chasse personnel. The large peak in Figure 3 is attributed to the high number of mosquitoes trapped at Belle Chasse on that date. Additionally, it was the only location that used traps that week.

NBHC Whiting Field performed trapping during 13 weeks of the season using a total of 33 traps. A total of 106 female mosquitoes (2% overall) were trapped in 2017. The average numbers of mosquitoes trapped at this location was low (three female mosquitoes per trap).

Table 1. Distribution of Mosquito Counts by Select Factors, NH Pensacola and Branch Clinics, 2017

				All Female Mosquitoes		All Traps		
MTF	No. of Weeks Traps Set	Average No. of Traps/ Week	% Total Mosquitoes Trapped (n)	BG Sentinel Average No./Week (Range)	CDC Light Average No./Week (Range)	All Female Mosquitoes Average No./Week (Range)	*Aedes* Average No./Week (Range)	*Culex* Average No./Week (Range)
NH Pensacola	19	7	32% (1833)	4 (1,27)	18 (1,210)	14 (1, 210)	3 (1,27)	3 (1, 30)
NHBC Panama City	5	6	31% (1791)	55 (3,151)	62 (1, 257)	60 (3, 257)	41 (2, 106)	10 (1, 37)
NBHC Meridian	6	10	21% (1217)	35 (3, 206)	5 (1, 16)	21 (1, 206)	6 (1, 61)	2 (1, 20)
NBHC Gulfport	6	5	4% (251)	2 (1, 5)	10 (1, 44)	8 (1, 44)	1 (1, 14)	4 (1, 14)
NBHC Belle Chasse	3	2	10% (572)	n/a	114 (36, 165)	114 (36, 165)	0 (0, 1)	112 (36, 163)
NBHC Whiting Field	13	3	2% (106)	3 (1, 17)	n/a	3 (1, 17)	2 (1, 6)	2 (1, 11)

Discussion and Conclusion

NH Pensacola and its branch clinics have implemented a robust mosquito surveillance program over the years with all clinics setting traps on a regular basis and with standardized SOPs to ensure continuity. The addition of BG-Sentinel traps and screening *Aedes* mosquitoes for Zika and other viruses as part of the DoD strategy to prevent Zika virus transmission has the potential to provide additional information about local *Aedes* populations, but the overall operational value of this addition remains to be determined. This analysis does provide an understanding of the challenges faced when implementing new trapping methods for mosquito surveillance, how BG-sentinel traps might be contributing to NH Pensacola disease mitigation, as well as more general challenges in mosquito surveillance and identification. The information herein has contributed to local process improvement efforts and will better inform Navy-wide strategic FHP efforts.

Despite a strong program and standardized SOPs, there remained differences in how mosquito trapping was conducted by location. Ad hoc interviews with local staff suggest that implementation of BG-sentinel traps required additional training as staff were not confident on use of the BG-sentinel traps as part of their overall program. Trap placement can significantly affect trap counts and in turn control action thresholds.

The analysis provides insight into several different areas of the local mosquito surveillance and control programs which can be used to make improvements. As described in the results, average mosquito counts at NH Pensacola remained low suggesting effective implementation of mosquito control measures. NBHC Panama City and NBHC Belle Chasse, however, had a high average count per trap compared to other locations, suggesting a gap in the mosquito spray program. The installations might consider a review of the mosquito control program to determine if any process improvements can be implemented. Additionally, the data suggest that trapping at Gulfport did not begin until the middle of August potentially indicating a breakdown in the MTF's implementation plan. This could have been due a number of different reasons including delays in trap delivery to the installation or delays in training. A review of Gulfport activities will provide information to enable surveillance earlier in the year.

It was noteworthy that only CDC light traps were used at Belle Chasse though BG-Sentinel traps should have been available to all installations in NH Pensacola's geographic area. In contrast, Whiting Field only used BG Sentinel traps; in the future both BG-Sentinel and CDC light traps should be used. When comparing the two types of traps (Figure 4), the CDC light traps appear to be more effective at trapping all mosquito species over time when compared to the BG Sentinel traps; however, differences noted between trap types across the surveillance season may be due to trapping locations and efficacy, weather-related variables, and seasonality of various local mosquito species.

Weather conditions also play a significant role in the use of traps. Often times throughout 2017 traps could not be set due to heavy rainfall. In addition, the BG-Sentinel traps did not have rain covers. Transportation also presented issues as BG-sentinel traps are larger and more expensive than CDC light traps, thus creating the need for planned transportation protocols and available budget to purchase adequate numbers. For one local clinic, lack of priority access to a government vehicle was a hindrance to utilizing BG-Sentinel traps.

It is likely that these challenges were encountered in other installation mosquito surveillance and control programs throughout the Navy and Marine Corps. Navy Marine Corps Public Health Center developed a general *Aedes* mosquito control plan and installation specific Integrated Pest Management Plans were updated to include language for use of BG-Sentinel traps. Entomologists from NECE and Navy Environmental Preventive Medicine Units provided assist visits to Pensacola and other installations in support of trap implementation. However, data suggest implementation of these traps were not as straight forward as once thought. Written SOPs detailing implementation of the new traps would be helpful. Not only would SOPs further support the verbal information provided during assist visits, they would also provide the means for timely program assessment at the local level. Most importantly, SOPs would help ensure more consistent implementation of trapping across installations, making thresholds for further action more reliable.

This analysis did not provide evidence that use of BG-sentinel traps and testing select *Aedes* mosquito species for viruses improved our overall ability to prevent Zika transmission. The BG-sentinel traps did appear to capture more *Aedes* mosquitoes, while the CDC light traps appeared to capture more *Culex* mosquitoes, a general trend noted in many other studies. The difference in trap implementation by location, however, makes it hard to draw a meaningful conclusion. Proper and consistent use of each trap for targeting various mosquito species will provide a better understanding of action threshold limits for a particular region, as action thresholds used to guide control operations at installations in the southeastern U.S. are likely different for locations further north. It is possible that DON's strategy might require implementation of both traps for an effective mosquito surveillance and control program, at least for the foreseeable future. Further data analysis of additional installations, as well as inclusion of additional yearly data in these analyses would provide additional insight.

This analysis did highlight local indicators useful for potential process improvement including the average number of mosquitoes per trap and the number of weeks traps were placed. NH

Pensacola has used this analysis to conduct a thorough process improvement review of their locations to address gaps in mosquito surveillance efforts. We emphasize that mosquito surveillance data for other installations should be analyzed using similar methodologies, as these indicators could be part of an overall program assessment designed to provide preventive medicine programs feedback that will allow for timely process improvement at the local level. Over time, a comprehensive evaluation of this information will be useful to make informed decisions regarding mosquito control and disease risk.

This report highlights how valuable mosquito surveillance data can be in informing local practice as well as DON-wide strategic efforts. As the DON's IPM program adopts a more active vector borne disease surveillance posture (vice a primarily nuisance mosquito surveillance posture) in the U.S., additional installation analyses, as well as routine and ongoing assessments, will be vital in ensuring effective implementation of Installation Pest Management programs.

References

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