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AEDES SURVEILLANCE AND CONTROL PLAN FOR U.S. NAVY AND MARINE CORPS INSTALLATIONS

MOSQUITO VECTORS OF DENGUE, CHIKUNGUNYA, AND ZIKA

(ADAPTED FROM 2014 CHIKUNGUNYA SURVEILLANCE and CONTROL PLAN)

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Contents

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This plan is not meant to be a comprehensive treatment of the subject, nor should it be used to provide diagnosis or treatment of disease.

Preface

The Navy and Marine Corps Public Health Center (NMCPHC), Portsmouth, VA provides guidance for disease vector surveillance and control programs for Navy and Marine Corps installations worldwide. This document is intended as general guidance concerning surveillance and control of *Aedes* spp. mosquitoes - the primary human vectors for dengue, chikungunya virus (CHIKV), and Zika virus. Because each military installation is unique, this guide is meant only to provide general information and act as a template for *Aedes* surveillance and control.

OPNAVINST 6250.4C designates the medical department as having the responsibility of performing inspections and surveys to determine the species, source, location, and density of disease vectors on installations for which they are responsible (Section 4). As referenced in 6250.4C (Subsection 23), the DoD Instruction 4150.07 (Subsection E4.2.1.8) states that pest management records are to be maintained and reported as defined by the designated pest management consultant. Therefore, each installation's medical personnel should conduct ongoing *Aedes* surveillance during the mosquito season appropriate to their region and take preventive and responsive action to reduce disease risk to active duty, government employees, and family member populations.

OPNAVINST 6250.4C also states that the responsibilities for surveillance and control of medically important insects and arthropods will be clearly delineated in the installation's pest management plan (IPMP Section 4). In addition, this instruction requires all Navy and Marine Corps installations to have an Emergency Vector Control Plan (EVCP) for disease vector surveillance and control during disease outbreaks. The EVCP is included as an appendix to the IPMP.

This guide should complement installation pest management plans, including the EVCP, as a way to assess the risk of vector borne diseases, and implement strategies to reduce the risk to personnel assigned to installations. The surveillance program must include identification of the mosquito species present, baseline population density, larval breeding areas, habitation zones (e.g. adult mosquito resting sites), and a method to determine if vector control measures are successful. It is recommended that preventive medicine personnel consult the EVCP, since the plan may already contain information regarding mosquito-borne disease on the installation. If necessary, the EVCP should be modified to include the installation plan for surveying and controlling mosquitoes.

Installations should have a current disease risk assessment (within 3 years). These assessments will determine if and where competent disease vectors are located on installations. An installation can adequately perform a disease risk assessment through coordination with a Navy Environmental Preventive Medicine Unit (NEPMU), Navy Entomology Center of Excellence (NECE), local department of health, or mosquito abatement district. Per OPNAVINST 6250.4C,

it is the responsibility of the military medical department personnel to ensure that proper surveillance data are obtained, whether it is from a public works department, pest management contractor, or local/state public health agencies.

Guidance for establishing mosquito surveillance and/or control programs and other technical assistance can be obtained by contacting Navy entomologists at the Navy Entomology Center of Excellence (NECE) or at the closest Navy Environmental Preventive Medicine Unit located in Norfolk, VA (NEPMU2), San Diego, CA (NEPMU5), Pearl Harbor, HI (NEPMU6) or Rota, Spain (NEPMU7).

1. Purpose

The purpose of this guide is to provide basic knowledge for the surveillance and control of *Aedes* mosquitos on military installations.

This document is not a regulation, but it is intended to assist those individuals responsible for conducting pest surveillance and control during military deployments and installations. This guide will receive periodic review and will be updated to ensure that information presented reflects current technology and guidance.

2. *Aedes* Vectored Diseases Overview

Dengue - Dengue is a mosquito-transmitted disease that is caused by one of four viruses (i.e., DENV 1, DENV 2, DENV 3, and DENV 4). Dengue can be transmitted by both *Aedes albopictus* and *Ae. aegypti*. In the most severe form of infection, dengue hemorrhagic fever, this disease can be fatal. Dengue is not transmitted directly from person to person, but instead must be passed through the bite of an infected mosquito.

Chikungunya - Humans are the primary host for CHIKV, which is transmitted by *Aedes* mosquitoes that live in close proximity to humans. Chikungunya means “that which bends” in the language of southeastern Tanzania, a reference to the painful symptoms of chikungunya fever.

Zika - Zika is a flavivrus with similar symptoms to dengue and CHIKV. Spread of Zika through blood and sexual contact have been reported, however the main mode of transmission is via the bite of an infectious *Aedes aegypti* or *Ae. albopictus* mosquito. At the time of this publication, the Centers for Disease Control and Prevention recommends special precautions be taken for

women who are pregnant, or who are considering becoming pregnant due to a possible connection between Zika and birth defects.

2.1 Vector Biology/ Identification

Aedes mosquitos are the primary vectors for dengue, CHIKV and Zika. The primary species associated with disease transmission are *Aedes aegypti* and *Ae. albopictus.* Mosquitoes are flying insects that develop from aquatic immature stages, from which the winged adults emerge. Only the adult female mosquitoes bite humans to feed on blood. Since there are many genera of mosquitoes, a guide to aid in identifying the genus *Aedes* is provided in Appendix A. Always seek assistance if you are unfamiliar with mosquito identification to ensure you correctly identify those mosquitoes in an area.

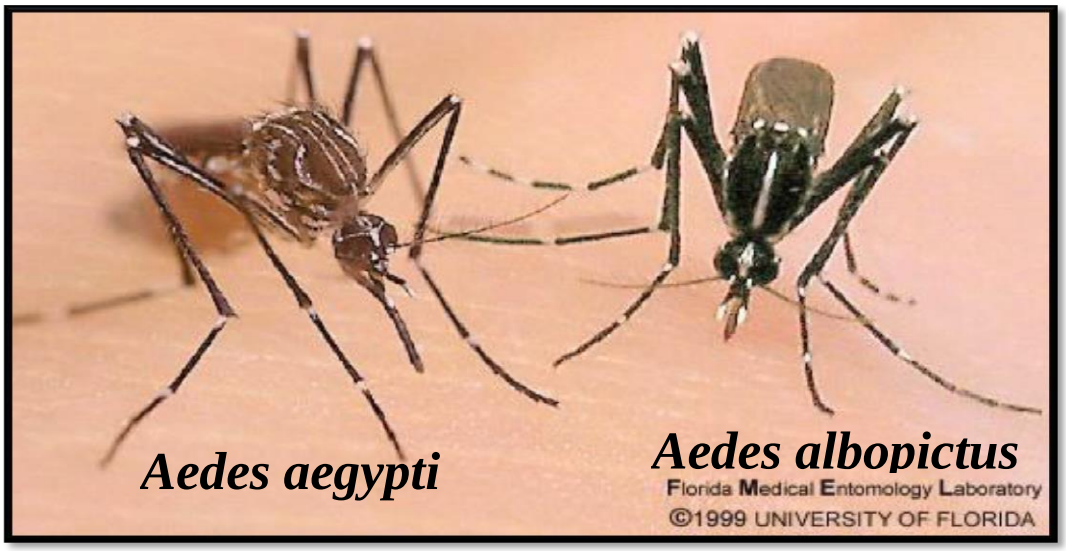


Figure 2. *Aedes aegypti* (left) and *Aedes albopictus* (right) mosquitoes can be distinguished from each other by the presence of a white stripe on the thorax of *Aedes albopictus*.

2.2 Aedes aegypti (yellow fever mosquito)

Aedes aegypti are dark to brown colored mosquitoes with white-banded legs and lyre shaped markings on the top of the thorax (Figure 2). They are sneaky daytime biters that occupy urban areas with or without vegetation. These mosquitoes bite, rest, and lay eggs both indoors and outdoors. They mostly breed inside human-made containers near homes. Although *Ae. aegypti* is native to Africa, travel and transportation of goods has expanded their distribution (Figure 3).

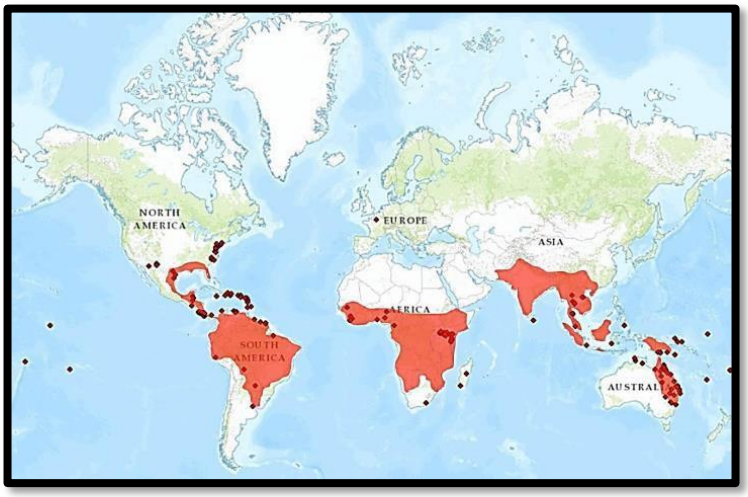


Figure 3. Estimated global distribution of *Ae. aegypti*. Red points designate confirmed collection sites recorded at: http://vectormap.nhm.ku.edu/vectormap/

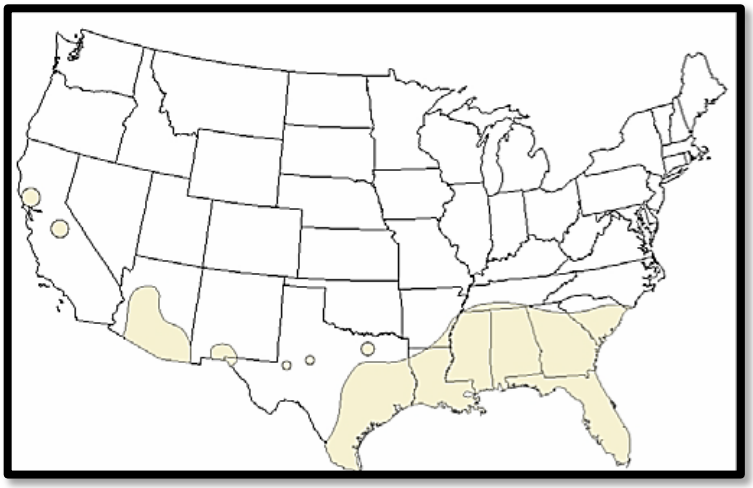


Figure 4. Current known CONUS distribution of *Aedes aegypti.*

2.3 Aedes albopictus (Asian tiger mosquito)

Aedes albopictus are dark colored mosquitoes with white-banded legs and a single silver stripe on the top of the thorax (Figure 2). In contrast to *Ae. aegypti*, they are aggressive daytime biters, mostly associated with thickets and dense vegetation. They are mostly found outdoors, where they breed in tree holes, bamboo internodes, and human-made containers. *Aedes albopictus* is native to tropical and subtropical areas of Southeast Asia, but global travel and trade have expanded their global distribution (Figure 5).

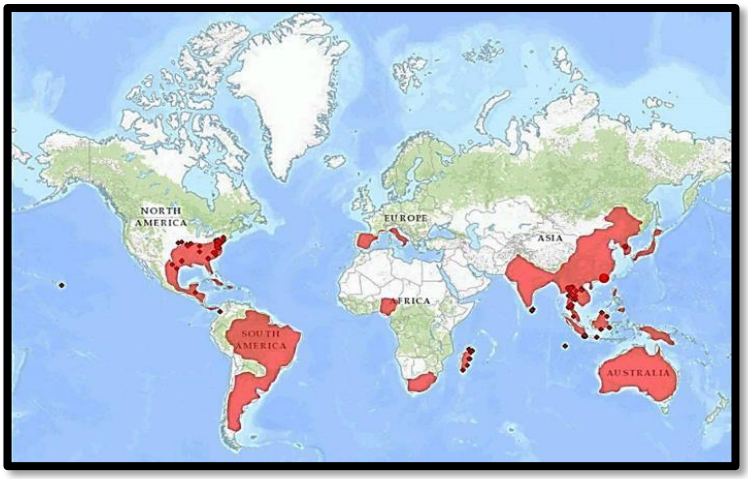


Figure 5. Estimated global distribution of Aedes albopticus. Red points designate confirmed collection sites recorded at http://vectormap.nhm.ku.edu/vectormap/

Aedes albopictus was first documented in CONUS in Texas in 1985. In 1986 *Ae. albopictus* was documented in Jacksonville, Florida. Since then this species of mosquito has rapidly spread throughout the eastern United States (Figure 6).

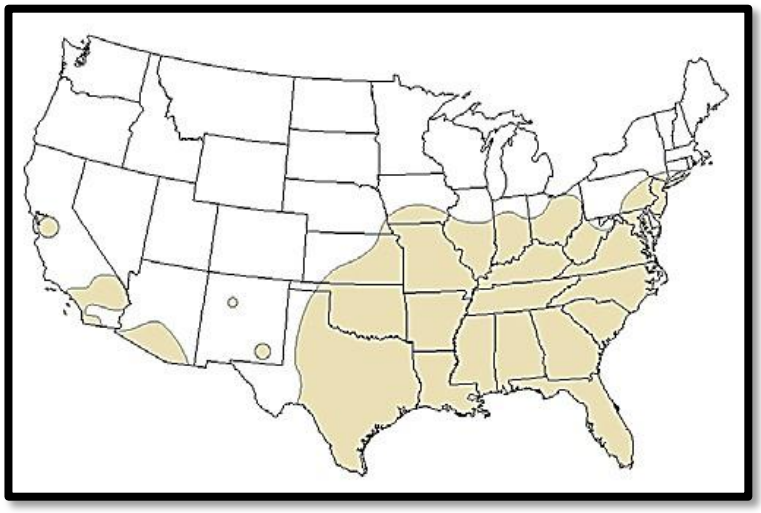


Figure 6. Current known CONUS distribution of *Aedes albopictus*.

3. Vector Surveillance

Surveys must be conducted to determine the population densities of both vectors to aid in determining the risk factors related to disease transmission. Vector surveillance will show where and when to prioritize vector control. Selection of appropriate surveillance strategies are based upon outcome/objective, and should take into consideration time, resources, and infestation levels. Additionally, vector surveillance is required to determine the success of control measures and detect any changes in vector density.

Uniform medical personnel are ultimately responsible for the surveillance of disease vectors on installations. This is typically done via the Preventive Medicine Department of a Branch Medical Clinic or regional Hospital. Some departments do not have the manpower or equipment to conduct vector surveillance or control operations, and these tasks may be contracted out per the IPMP. When the installation contracts out vector surveillance and/or control, information pertaining to the location, species, abundance, and control methods of disease vectors should be shared with the Medical Department in order for military preventive medicine personnel to accurately assess the risk of disease on and around the installation.

Consult your local IPMP or NAVFAC IPM Coordinator to determine the specifics of your installation vector surveillance and control plan. In general, there are three options available to Navy and Marine Corps installations:

- **Local Public Health and/or Mosquito Control Agencies**. If local, county, or state agencies are currently performing surveillance, testing and control measures that **meet or exceed** DoD recommendations, then arrangements may be made with that agency to include the military installation as part of the local agency's operations.
- **Private Contractor**. The installation may have a contract with civilian mosquito/pest control professionals that **meet or exceeds** DoD recommendations.
- **DoD Personnel**. In the absence of civilian support, DoD personnel will provide support for their respective installations.

Global Positioning Systems (GPS) and Geographic Information Systems (GIS) tools should be used whenever possible to keep record of surveyed and/or treated areas, location of traps, and other relevant geographical information that can be referenced. If GPS and GIS tools are not available, a notebook should at least be used to keep detailed records of surveillance efforts. See Appendix B for an example on how to keep surveillance data organized.

Surveillance programs should include the collection of all stages of mosquitoes (using ovitraps, larval surveys, and adult collections), identification of larvae and adults, and mapping and monitoring of larval breeding sites and adult resting sites on the installation. Surveillance on the

installation should occur on a regular basis to ensure new potential larval habitats are documented and removed. During local area outbreaks, surveillance of the mosquito vectors should be conducted weekly.

3.1 Immature mosquito surveillance

Any material, manmade or natural, that may hold water for more than several hours is a suitable habitat for immature mosquito stages (eggs, larvae, and pupae).

In areas where there is regular rainfall, natural and human made containers that can hold water will be of critical importance, since they will fill with water and drastically increase the number of mosquito habitats available.

Some examples of what to look for when targeting mosquito larval habitats are presented in Figure 7. This is not an exhaustive list, as anything that can hold a **tablespoon of water** can be a potential larval habitat for these vectors. Always survey and identify mosquito breeding locations before developing a control program. **Survey containers both inside and outside of homes.** Surveillance of immature mosquitoes can be done by visually inspecting containers for immature mosquitoes and collecting them.

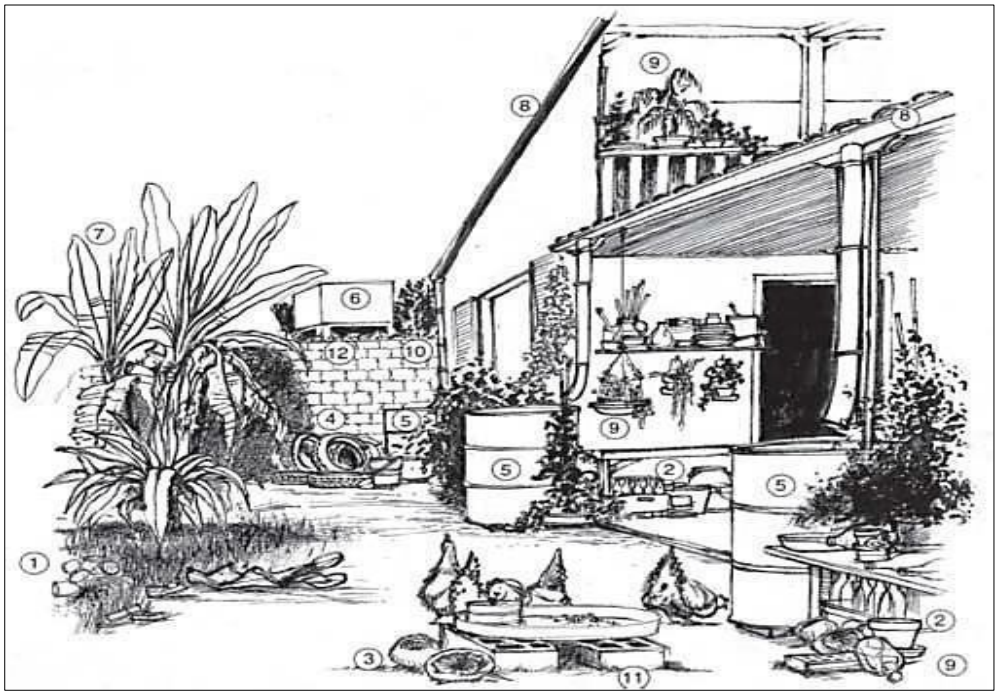


Figure 7. Examples of outdoor breeding sites of *Aedes* spp. (1) discarded cans/plastic containers, (2) bottles, (3) coconut husks, (4) tires, (5) barrels, (6) water storage tanks, (7) bromeliads and axils of banana trees, (8) obstructed roof gutters, (9) plant pot saucers, (10) broken bottles fixed on walls to deter burglars, (11) holes in unused construction blocks, and (12) the upper edge of block walls. From Rozendaal, 1997.

3.1.1 Egg Surveillance

Collecting **eggs** with ovitraps is another effective way to monitor the presence of *Aedes* spp. Ovitraps serve as egg-laying sites to determine the presence or absence of the species (Figure 8). A manufactured ovitrap is available in the DoD stock system (Mosquito Trap-and-Kill, NSN 6840-01-628-4751), and ovitraps can also be constructed with any dark colored container. Simply fill the container partially with water and place a wooden tongue depressor or paper towels along the inside of the cup. Check the tongue depressor and paper towels regularly for the presence of eggs.

Figure 8. Ovitrap

3.1.2 Larval Surveillance

To collect **larvae** a flashlight is often needed to see into large containers or other dark spaces. A large syringe or other suction device can be used to suck up any larvae in containers and natural breeding sites (tree holes, bromeliad axils, crab holes) (Figure 9). In larger containers or bodies of water larval surveillance can be conducted with a larval dipper (NSN 3740-01-454-2341). Water sample bags or another type of storage container can be used if larvae or pupae are being returned to the laboratory. Larval surveillance should continue throughout the mosquito season, since the species composition of an area will often change over time.

Figure 9. Turkey basters can be used to sample water from many narrow openings such as bromeliad axils. In large containers, dippers can collect mosquito larvae.

3.1.3. Larval Indices

The following indices are used in larval surveillance to help make decisions regarding when to begin an *Aedes* vector control program. These indices can signal when and where to begin a control program or when vector suppression was successful. These indices were based on residential areas. Since many structures on a military installation may harbor these vectors, these indices can be applied to all structures/work centers surveyed.

- **House Index (HI):** the percentage of houses infested with larvae and/or pupae. The House Index in mostly used to measure the overall distribution and size of the vector population within the surveillance area. It does not account for how many containers on a property are actually producing larvae. The information gathered from the House Index can demonstrate where the vectors are concentrated and where to focus the control effort. **After effective control operations the HI < 1%. HI = # of positive mosquitoes/total number of houses surveyed.**

- **Container Index:** the percentage of water-holding containers infested with larvae and/or pupae. The Container Index provides information about how many containers in a site are producing vectors. During the collection of these data, surveyors can determine the type of containers that are producing the most vectors, and where the highest concentrations of infested containers are on the installation. **After effective control operations the CI < 1%. CI = # of positive containers/total # of containers surveyed.**

- **Breteau Index:** the number of positive containers per 100 sites surveyed. One site can defined as a structure or an area where containers are present. For example, a site can be a house with containers surrounding it, or it can be a yard with a pile of tires. The Breteau Index establishes a relationship between positive containers and surveyed sites. It is possible to use these data to profile the relative abundance of various container types in the surveillance area (e.g. the number of infested containers per 100 sites). The Breteau Index has also been used to estimate the risk of disease transmission. **There is some risk of disease transmission when BI > 5. Emergency vector control should be implemented when BI > 50. BI = # of positive containers/100 sites surveyed.**

3.2 Adult Mosquito Surveillance

Surveillance of adult *Ae. aegypti* and *Ae. albopictus* is most reliably accomplished by collecting live adults using either a backpack aspirator or a mouth aspirator. The **BG-Sentinel™** and CDC light trap are effective as well, although catches will be lower with the CDC trap. Adult surveillance

should begin when mosquitoes are observed emerging from breeding sites and continue until the first hard frost. If frost does not occur then, adult surveillance should be conducted year round.

3.2.1 Aspirators

Table 2 outlines aspirators available in the DoD stock system for adult surveillance. Aspirators allow for focused surveillance of known mosquito resting sites. The user can capture mosquitoes and then identify them. When collecting with aspirators, use personal protection against mosquito bites, especially in areas with active disease transmission. Because of the risk of infection, landing/biting counts for adult surveillance are discouraged.

Table 2. Available aspirators in DoD stock system

Equipment	NSN
Aspirator, Oral, Entomology Specimen Collection, Model 412	3740-01-474-7402
Aspirator, Insect Backpack, CDC Model 1412,Gel-cell battery	3740-01-503- 5339
Aspirator, 1.5v (2 D-Cell battery) powered, Mechanical Aspirator	3740-00-210- 2368
Collection Bottle Assembly/ Tube, Mechanical Aspirator	3740-01-210- 2371

- **Oral Aspirators** are low-tech collecting devices (Figure 11a). The user provides suction by sucking air through the mouthpiece. The mosquito will be pulled into the base of the tube and prevented from entering the user's mouth by a mesh screen. The mosquito is then transferred to a collection jar when the user blows it out. These are of limited utility for large-scale surveillance because they can only target one mosquito at a time and have a short range due to the suction being provided by a human.
- **Powered aspirators** are very useful tools for collecting adult *Ae. aegypti* and *Ae. albopictus* (Figures 11b,c). For *Ae. aegypti*, use them inside homes and focus on clothing hanging inside and outside closets, dark corners, and covered areas. For *Ae. albopictus*, focus on vegetation surrounding houses or forested parts of known breeding habitats.

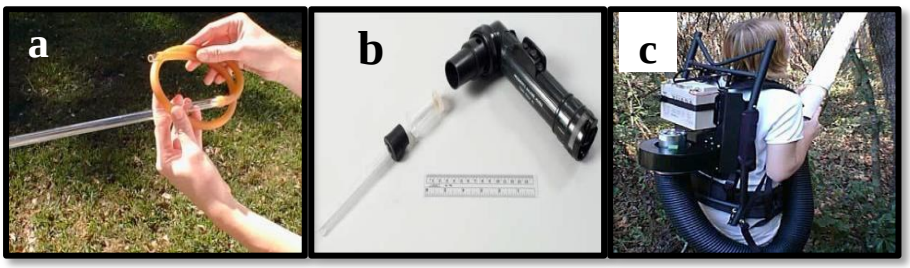


Figure 11a: Oral aspirator (NSN: 3740-01-474-7402), 11b: Hand-held, mechanical aspirator (NSN: 3740-00-210-2368), 11c: CDC backpack aspirator (NSN: 3740-01-503-5339.

3.2.2. Traps

Traps are useful to get an idea of how many adults are in an area. They must be placed near where the mosquitoes are expected to be found, during the periods they are active. *Ae. aegypti* and *Ae. albopictus* are active during the day and so these mosquitoes should be targeted during daytime hours. Two adult mosquito traps are available with NSNs: BG-Sentinel™ trap (BioGents, Regensburg, Germany) (Figure 12) and CDC light trap (Figure 13). The BG-Sentinel™ trap is specifically designed to collect daytime-feeding mosquitoes, and has been found to collect *Ae. aegypti* and *Ae. albopictus* more effectively than the standard CDC light trap. Traps should be baited with CO_2 from dry ice, when available. Also, commercially available lures that can improve a trap's effectiveness have been designed specifically to attract *Ae. aegypti* and *Ae. albopictus.* The BG-Sentinel™ trap requires a lure for effective trapping. Product manuals detail specific setup procedures and instructions for use of each piece of surveillance equipment. Take care when handling the BG-Sentinel™ trap, as some components have durability limitations.

Figure 12. BG-Sentinel™ trap.

Figure 13. The CDC Light Trap.

Table 3. NSNs adult mosquito surveillance traps and required accessories

Equipment	NSN
BG Sentinel™ Trap	3740-01-628-9326
BG-Lure® for BG Sentinel™ Trap (Note: trap will not work without	3740-01-628-9325
Catch Bag for BG Sentinel™ Trap	3740-01-628-9327
Wall charger for BG Sentinel™ Trap	3740-01-628-9324
CDC Light Trap	3740-00-134-9229

3.2.3. Mosquito Identification

To determine whether *Ae. aegypti* and/or *Ae. albopictus* are in the area, collected specimens must be identified. Identification of mosquito larvae can be difficult. However, larvae collected from surveillance can be reared to adults in larval rearing chambers (NSN: 3740-01-454-2345) and identified as adults using keys such as the *Identification and Geographical Distribution of Mosquitoes of North America*, by Darsie and Ward. Adult mosquitoes collected from each CDC light trap or BG-Sentinel™ trap should be separated from other collected insects and sorted by sex. Mosquitoes should be identified to species whenever possible. Entomologists at NECE or the closest NEPMU can provide more detailed assistance for training personnel in mosquito identification.

4. Vector Control

In order to select the most appropriate vector control method or combination of methods, consideration should be given to the resources available for implementation, the cultural context in which control interventions are carried about, feasibility of applying them in a timely manner, and adequacy of coverage. Methods of vector control include source reduction, larviciding with insecticides and/or use of biological agents, and the application of adulticides.

The necessary equipment to mitigate adult and larval *Aedes* spp. can be found in AFPMB Technical Guide 24: Contingency Pest Management Guide. If you do not have a copy of this document, visit: http://www.afpmb.org/sites/default /files/pubs/techguides/tg24.pdf or contact the AFPMB directly.

SURVEILLANCE IS ESSENTIAL in monitoring the success or failure of any control program. Always try to sample larvae and/or adults prior to and after control efforts, thereby revealing any reduction in mosquito numbers. See Appendix C - response levels for guidance on when to initiate mosquito control.

Entomologists at NECE or the NEPMUs can be contacted for technical assistance, consultation, and guidance regarding mosquito surveillance and control on Navy and Marine Corps installations. It is highly recommended that an installation's vector surveillance and control program be developed in consultation with entomologists at NECE, the NEPMUs, or Naval Facilities Engineering Command (NAVFAC).

4.1 Environmental control

The best way to reduce populations of both *Ae. aegypti* and *Ae. albopictus* is through environmental control, also known as **source reduction**, which involves removing or modifying

containers that hold water which prevent immature stages from developing into adults. **Source reduction** should be carried out year-round, regardless of the disease threat level (Appendix C). During mosquito season, conduct larval and pupal surveillance to determine which containers are breeding mosquitoes (refer to previous sections). Environmental control by eliminating breeding sites will involve mobilization of military assets and the direct support of your chain of command.

Since larval mosquitoes are more highly concentrated than the adult stage, a greater number of mosquitoes can be eliminated when targeting larval habitat than when spraying for adults. By finding and eliminating or modifying potential larval sites, mosquito populations can be reduced or eliminated before virus transmission to humans occurs. This method has been largely successful in preventing disease transmission in communities and over large geographic areas, and will be equally effective in reducing the risks on installations.

Source reduction is simple in concept but difficult to put into practice and sustain over long periods of time. You must have the absolute support of your chain of command to develop and conduct a source reduction program. Also, public education and outreach to the service members living on and around the installation will be needed to successfully reduce the populations of disease vectors. See section 9 in this guide for more information on involving the public in vector control. Table 4 provides some guidance on how to handle specific larval sites.

Table 4. Methods to eliminate some common larval breeding sites

Larval Habitats	Empty/ clean regularly	Store under roof	Fill with sand	Throw away/ recycle
Buckets	X	X		X
Discarded containers				X
Flower Pot Saucers	X		X	
Roof Gutters	X			
Tires		X		X
Tree Holes			X	

It may not be feasible to control ALL larval breeding sites in a community. Some containers will produce more mosquitoes than others, and therefore it is important to at least target the most productive containers.

To assist in control measures throughout the mosquito-breeding season, installation preventive medicine personnel should work with the Public Works department to eliminate mosquito-breeding sites, especially those that may be eliminated by filling or draining.

4.2 Larval Chemical Control:

The use of **larvicides** should be complimentary to source reduction, and should be restricted to containers that cannot otherwise be eliminated or managed. It is important to note the limitations of larviciding. Larviciding may not be practical in hard-to-reach areas such as tree holes and leaf axils (e.g. bromeliads) for *Ae. albopictus* and not practical for use in indoor larval habitats in the case of *Ae. aegypti*. Several insecticides are available in the stock system to control immature mosquitoes (Table 4), including microbial derived insecticides such as *Bacillus thuringiensis* var *israelensis* (Bti) briquettes (NSN 6840-01-377-7049) and insect growth regulators such as Methoprene briquettes (NSN 6840-01-424-2495) or liquid (NSN 6840-01-424-2493). Because of the environmental risks and legal limitations when applying pesticides to water, applications should only be conducted by certified pesticide applicators.

No mosquito control plan should rely solely on spraying insecticides in response to mosquito concerns.

Table 5. Insecticides for controlling mosquito larvae

Products	NSN
Insecticide, *Bacillus thuringiensis*, 10%. Summit BTI Briquettes	6840-01-377-7049
Insecticide, *Bacillus thuringiensis*, Vectobac WDG	6840-01-565-8241
Insecticide, Temephos, Abate 4E 2.5-gal	6840-01-424-3132
Insecticide, Methoprene, Altosid XR Briquettes	6840-01-424-2495
Insecticide, Methoprene, Altosid Liquid Larvicide Concentrate	6840-01-424-2493

4.3 Adult Chemical Control

Adult chemical control methods are implemented based on trap surveillance data. Spray (action) threshold information for adult mosquito control is included in the IPMP for each installation. Action thresholds may not be available or applicable in some areas.

Appendix C is a chart that guides individuals on **determining the risk of infection on an installation** and **when to spray** against adults and larvae based on **Breteau Index** values. If a threat level of "Significant" or "Critical" is reached, adulticide space sprays will become necessary, even if action thresholds for the installation are not met. It is important to remember Breteau Index values are generated through larval surveillance not adult surveillance data.

Mosquitoes caught from BG-Sentinel™ and the CDC light trap may also be used to determine spray threshold, however unlike the Breteau Index values, these numbers are based on a nuisance threshold, and do not contribute to determining the risk of an infection on an installation. **When using number of adults to determine adulticide applications, if an average of ≥ 5 *Ae. aegypti* and/or *Ae. albopictus* mosquitoes (males + females) are caught per trap deployed after a sampling period (e.g. weekly), chemical controls should be executed (Farajollahi *et al.* 2012).**

General insecticide applications against *Aedes* vectors should conducted for 3 to 4 consecutive days (timed to coincide with peak activity periods of the target species) to reduce adult mosquito populations. A more aggressive chemical control strategy should begin when an epidemic is occurring (threat level "Critical") in the same geographic region as the installation. During such a scenario, treat where adults are encountered. Insecticide spray operations should be carried out every 2-3 days for 10 days to ensure that the breeding cycles of both *Ae. aegypti* and *Ae. albopictus* are disrupted. Further applications should be made once or twice a week to sustain suppression of the adult population and will need to continue until larval index thresholds are met (WHO 2009).

Aerial insecticide application may be required to treat large areas or when there is a severe epidemic. However, aerial application cannot be implemented unless validated by a Navy Entomologist. Both the inside and outside of structures should be treated, when possible. It is also important to treat possible breeding areas that cannot be removed with residual insecticides to kill adults that visit them to lay eggs (Ritchie *et al*. 2001).

Table 6. List of approved pesticides for contingency operations

Product	NSN
Insecticide, Sumithrin-Piperonyl Butoxide, 10%-10%, (Anvil 10+10 ULV), 2.5 gal box	6840-01-4747751
Insecticide, Sumithrin-Piperonyl Butoxide, 10%-10%, (Anvil 10+10 ULV), 250 gal co.	6840-01-474-7706

Insecticide Pyrethrins, 3% pyrethrins with synergists, liquid, ULV Fog Concentrate, 1gal bottle	6840-01-104-0780
Insecticide, 4%Resmethrin, 12% Piperonyl Butoxide, Scourge, 5-gal can, RESTRICTED USE INSECTICIDE	6840-01-359-8533
Insecticide, Malathion, 96.5%, liquid, Fyfanon ULV, 5 gal can	6840-01-169-1842
Insecticide, Lambda-cyhalothrin, Surrender Pestabs®, 40 tablets	6840-01-431-3357
Insecticide, d-Phenothrin, 2% Aerosol, 12 oz can	6840-01-412-4634

4.3.1. Indoor Residual Spray

Aedes aegypti readily bite people indoors and will rest on wall surfaces after taking a blood meal. Indoor Residual Spray (IRS) is an application method where an insecticide is directly applied to wall surfaces. Mosquitoes that make contact with the insecticide are killed. In addition to directly killing adult *Ae. aegypti,* the insecticide applied to the wall surfaces may act as a repellent and prevent more adult mosquitoes from entering houses. IRS may not be feasible in private residences at CONUS installations, but the principles of IRS can be applied to the outside of homes, near doors, on vegetation, under overhangs, and anywhere else the mosquitoes are found to rest.

In the Contingency Pest Management Guide, the only insecticide recommended for IRS is lambda-cyhalothrin (Product name: Insecticide, lambda-cyhalothrin, Surrender Pestabs®, NSN: 6840-01-431-3357). Strictly follow all guidelines on the insecticide label.

Two types of equipment in the stock system can be used to apply IRS: 1) hand compressed sprayers and 2) backpack sprayers. Table 7 lists all available hand compressed and backpack sprayers in the stock system. For more information on the use of IRS for vector control, please see the NECE publication: **Indoor Residual Sprays for Malaria & Dengue Prevention During Military Operations: A Pocket Guide** available at:
http://www.med.navy.mil/sites/nmcphc/Documents/nece/IRS-Pocket-Guide.pdf

Table 7. List of compressed and backpack sprayers in stock system

Product	NSN
Sprayer, Pesticide, Manually Carried, 1-gallon stainless tank, with pressure gauge. CID A-A- 55748. Flow rate - 0.8 l/min	3740-00-191-3677
Sprayer, Pesticide, Manually Carried, 2-gallon stainless tank with pressure gauge. CID A-A-55748. Flow rate - 0.8 l/min	3740-00-641-4719
Sprayer-Duster, Pesticide, Backpack, STIHL Model SR420 or SR450, gasoline engine driven. Tank size –3.5 gal., 24.6" high X 18.9" wide X 11" deep, 24 lbs. empty wt.	3740-01-463-0147
Sprayer, Pesticide, Manually Carried Hydraulic Backpack sprayer	3740-01-496-9306
Sprayer, Pesticide, Manually Carried Hydraulic Backpack sprayer. Birchmeier, Model Iris	3740-01-543-0676
Sprayer, Pesticide, Manually Carried Compressed Air Backpack Sprayer. Dorendorf (JQSX-12) P/N AQSZ-12	3740-01-561-9663

4.3.2. Thermal Fogging

Indoor and outdoor space spraying with thermal fogs is a component of many dengue control programs around the world. If possible, spray inside and within a 400 to 500 meter radius of structures (WHO 2009). Table 8 lists thermal foggers available in the stock system. For control of sylvatic populations of *Ae. albopictus*, spraying in and around vegetation that serves as harborage will be critical. Due to the amount of **smoke** generated, be certain to coordinate your efforts with all security personnel prior to conducting spray missions.

Table 8. List of thermal foggers available in stock system.

Product	NSN
Fog Generator, Manually Carried, gasoline engine driven, thermal fog, Curtis Dyna Model 2610 Golden Eagle	3740-00-818-6648
Fog Generator, Insecticidal, P/N 58800 21/SUPERHAWK II	3740-01-480-3040

4.3.3. Ultra-Low Volume

The WHO recommends conducting sprays in areas where dengue cases have been identified (WHO 2009). As with thermal fogging, ULV (**cold fogging**) spraying should be conducted within a 400 to 500 meter radius of structures (WHO 2009). Table 9 lists ULV sprayers available in the stock system.

Table 9. ULV sprayers available in the stock system.

Product	NSN
Fogger, Hand Held, gasoline engine driven, ULV, London Aire Colt. PN# 8675	3740-01-456-2622
Fogger, Hand Held, gasoline engine driven, ULV, Clarke P-1	3740-01-456-2623
Fog Generator, Skid Mounted, gasoline engine driven, Grizzly PDS	3740-00-375-9154
Sprayer, Pesticide, Skid Mounted, London Fog M.A.G	3740-01-548-9102
Sprayer, Pesticide, Skid Mounted, Model Pro Mist, ULV	3740-01-076-1341

5. Personal Protection

Mosquito-borne diseases and the injury caused by arthropod bites can be prevented by employing personal protective measures. The military recommends use of the **DoD Insect Repellent System**, a threefold system consisting of a permethrin treated uniform, the application of an insect repellent on exposed skin, and the proper wearing of the uniform (Figure 14). Refer to Table 10 for a list of available insect repellent in the stock system.

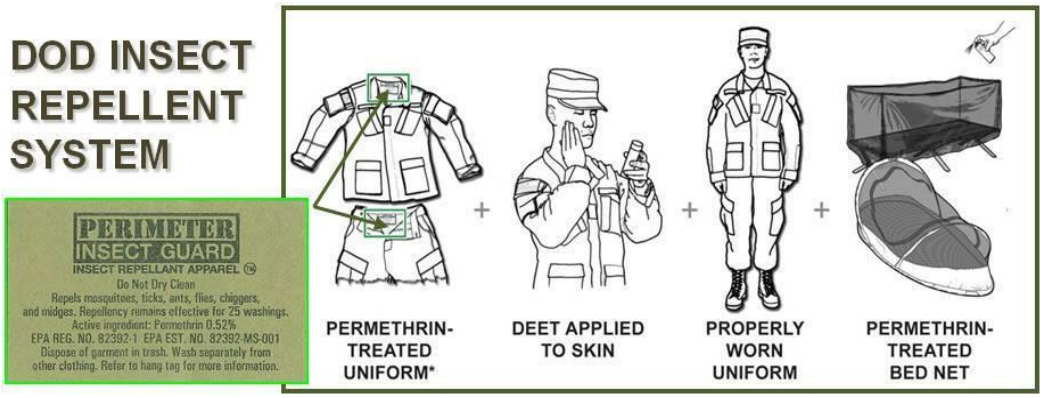


Figure 14. The DoD Insect Repellent System.

5.1 Permethrin treatment

Permethrin treatment of field uniforms with can be accomplished individually using either the **Aerosol Spray Can** (NSN: 6840-01-278-1336) or an **IDA Kit** (NSN: 6840-01-345-0237). Service members can also have a certified applicator treat uniforms using **40% permethrin** (NSN: 6840-01-334-2666) applied with an air compression sprayer.

- Navy Working Uniforms (NWUs) Type I, II, and III are NOT factory treated with permethrin and require manual treatment.
- Marine Corps Combat Utility Uniforms (MCCUUs) Woodland and Desert ARE factory treated with permethrin and CANNOT be retreated per regulation.
- A factsheet on how to check for treated uniforms can be found here: http://www.med.navy.mil/sites/nmcphc/Documents/nece/factsheet-is-your-uniform-protecting-you.pdf

Table 10. Available insect repellents for use on exposed skin.

Product	NSN
3M Ultrathon 33% DEET lotion	6840-01-284-3982
Cutter Backwoods 23% DEET	6840-01-584-8598
Ultra30/LipoDEET 30% lotion	6840-01-584-8393
DEET/SPF15 sunscreen 20% DEET	6840-01-288-2188 (tube) or 6840-01-452-9582 (packet)
20% Picaridin repellent NATRAPEL	6840-01-619-4795

5.2 Proper wear of the uniform

Wearing the uniform properly provides an excellent physical barrier against insect bites. This is accomplished by ensuring that the undershirt is tucked into the pants, and blouse sleeves are rolled down and buttoned. Pants can be secured using blousing straps or can be tucked into the boots. The uniform should be worn loosely so that insects cannot bite through fabric that is tight against the skin.

5.3 Treated pop-up style bed nets

These are also available to protect service members while they sleep [NSNs: 3740-01-516-4415 (green camo) and 3740-01-518-7310 (coyote brown)] (Figure 15). Also, **insect bed nets** (NSN: 7210-00-266- 9736, and similar) can be treated with permethrin (Page 20) to improve protection from biting insects. Be sure to allow the pesticide to dry before the bed net is used.

Figure 15. Green camouflage pop-up style bed net. NSN: 2740-01-516-4415

6. Household Prevention

To further reduce the risk of *Aedes* vectored disease, individual residents living on and nearby Navy and Marine Corps installations must take precautions to reduce the risk of mosquitoes entering their homes. This can be done by ensuring intact insect screens are properly installed on windows and doorways. The use of insect screens will limit the entry of mosquito vectors into the home. Also, ensure rain gutters are cleaned regularly to prevent clogs that will cause the rain gutters to hold water. Any large water storage vessels, such as water catchments, that cannot be removed should be mosquito proofed to reduce the number of larval habitats near the residence.

7. Public Education and Cooperation

Due to the container-breeding nature of the *Aedes* mosquito vectors, it is important to gain active participation from the public for source reduction, personal protection, and household prevention efforts. Information dissemination to the general public, support communities (public health departments, health care providers, veterinary communities, etc.), and other governmental agencies is critical to ensure effective implementation of any vector surveillance and control plan. News bulletins, interviews, web sites, and articles in base newspapers can all be used to inform local military and other DoD personnel about disease risks and precautions. **Factsheets** and **technical guides** can be downloaded from the Armed Forces Pest Management website.

8. Additional Guidance

- Navy and Marine Corps Public Health Center (Zika page): http://www.med.navy.mil/sites/nmcphc/program-and-policy-support/Pages/Zika-virus.aspx
- Navy and Marine Corps Public Health Center (Arboviral infections page): http://www.med.navy.mil/sites/nmcphc/program-and-policy-support/Pages/Chikungunya.aspx
- Armed Forces Pest Management Board: http://www.afpmb.org/
- Centers for Disease Control and Prevention: http://www.cdc.gov/
- Contingency Pest Management Guide. AFPMB Technical Guide 24: http://www.afpmb.org/sites/default/files/pubs/techguides/tg24.pdf
- Guide to Pest Surveillance during Contingency Operations. AFPMB Technical Guide 48: http://www.afpmb.org/sites/default/files/pubs/techguides/TG48/TG48.pdf
- Personal Protective Measures against Insects and other Arthropods. AFPMB Technical Guide 36: http://www.afpmb.org/sites/default/files/pubs/techguides/tg36.pdf
- Ultra Low Volume Dispersal of Insecticides using Ground Equipment. AFPMB Technical Guide 13: http://www.afpmb.org/sites/default/files/pubs/techguides/tg13.pdf
- Walter Reed Biosystematics Unit: http://www.wrbu.org/index.html

9. References

Farajollahi, A., S. P. Healy, I. Unlu, R. Gaugler and D. M. Fonseca. 2012. Effectiveness of ultra- low volume nighttime applications of an adulticide against diurnal *Aedes albopictus*, a critical vector of dengue and chikungunya viruses. PLOS ONE. 7: 1-7.

Ritchie, S. A., B. L. Montgomery, I. D. Walsh, S. A. Long and A. J. Hart. 2001. Efficacy of an aerosol surface spray against container-breeding *Aedes.* Journal of the American Mosquito Control Association. 17: 147-149.

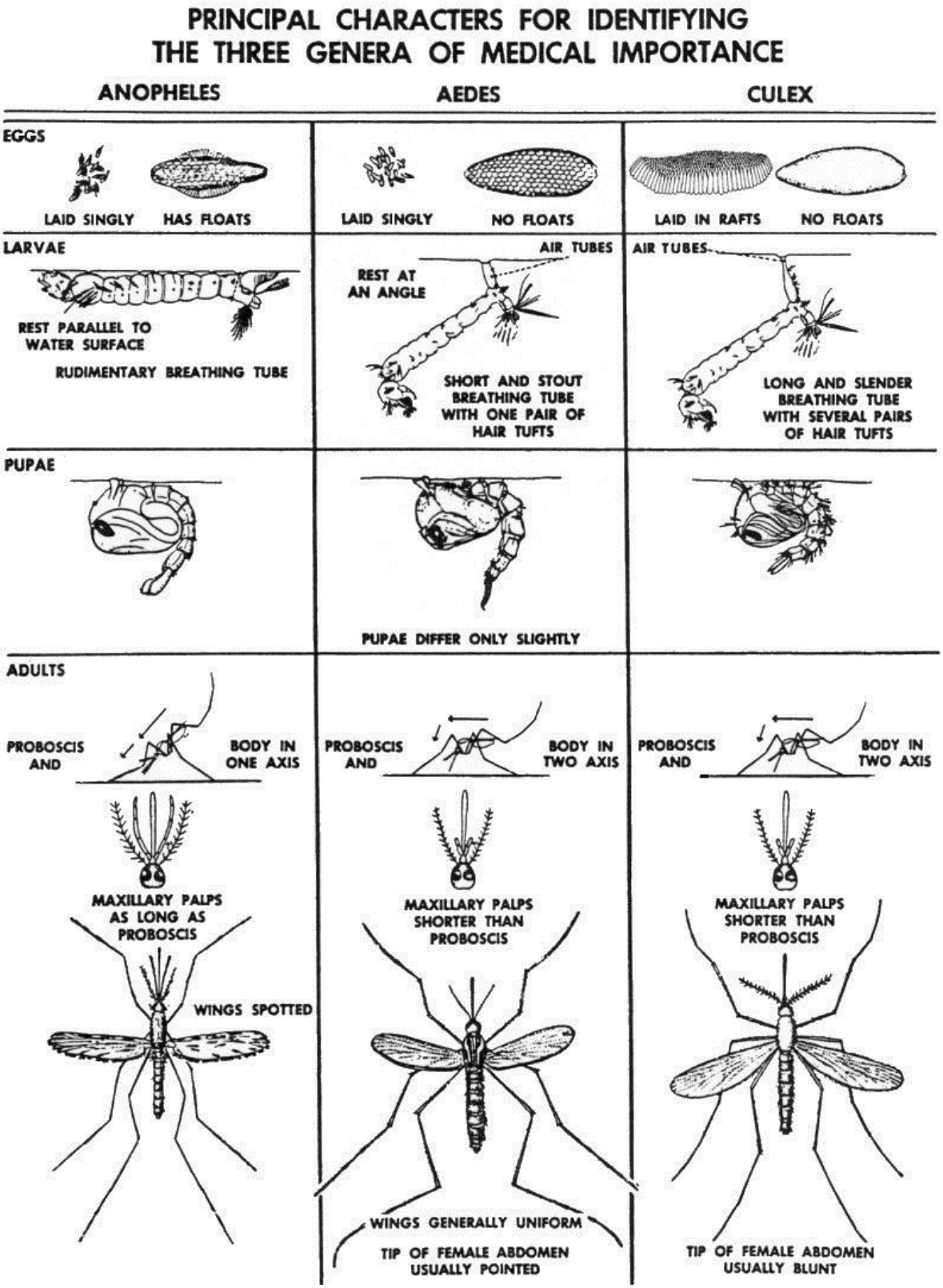
Rozendaal, J. A. 1997. Vector Control: Methods for Use by Individuals and Communities. World Health Organization, Geneva. 412 pp.

WHO. 2009. Dengue, Guidelines for Diagnosis, Treatment and Control. World Health Organization, Geneva. 147 pp.
WHO. 2011. Handbook on Integrated Vector Management. World Health Organization, Geneva.

10. Additional Contact Information

US Navy Entomology Center of Excellence	Jacksonville, FL, USA COM: (904) 542-2424 DSN: (312) 942-2424
Navy Environmental Preventive Medicine Unit 2	Norfolk, VA, USA COM: (757) 953-6600 DSN: (312) 377-6600
Navy Environmental Preventive Medicine Unit 5	San Diego, CA, USA COM: (619) 556-7070 DSN: (312) 526-7070
Navy Environmental Preventive Medicine Unit 6	Pearl Harbor, HI, USA COM: (808) 471-0237 DSN: (315) 471-0237
Navy Environmental Preventive Medicine Unit 7	Rota, Spain DSN: (314) 727-2230
US Naval Facilities Engineering Command ATLANTIC	Norfolk, VA COM: (757) 322-8000 DSN: (312) 262-8000
US Army Public Health Command PHCR-North Entomological Sciences Division	Email: PHCR-NorthESD@amedd.army.mil COM: (800) 222-9698 DSN: (312) 584-4375
USAF School of Aerospace Medicine/PHR Wright-Patterson AFB, OH	Email: Will.Reeves@wpafb.af.mil COM: (937) 938-2716 DSN: (312) 798-2716
US Naval Facilities Engineering Command Southwest	San Diego, CA 619-532-1157

Appendix A. A quick guide for differentiating *Aedes* mosquitoes from other genera.



Appendix B. Example of logbook entry for mosquito surveillance documentation

Date	Collection Time	Method	Location	Eggs/Larval/ Adult	#/Species*	Collector
25-26 Apr '14	0800-1600	BG & CO^2	behind hospital	A	4 *Ae. aegypti*	HM3 Smith
25-26 Apr '14	0800-1600	BG & CO^2	behind hospital	A	7 *Ae. albopictus*	HM3 Smith
25-26 Apr '14	0800-1600	Ovitrap	walking trail pond	E	Eggs Present	HM3 Smith
25-26 Apr '14	0800-1600	Ovitrap	horse stable pond	L	6 *Ae. aegypti*	HM3 Smith
28-29 Apr '14	0800-1600	Ovitrap	behind hospital	L	2 *Ae. aegypti*	HM2 Darwin
28-29 Apr '14	0800-1600	Ovitrap	behind hospital	E/L	1 *Ae. albopictus*	HM2 Darwin
28-29 Apr '14	0800-1600	BG & CO^2	walking trail pond	A	10 *Ae. aegypti*	HM2 Darwin
28-29 Apr '14	0800-1600	BG & CO^2	horse stable pond	A	17 *Ae. aegypti*	HM3 Smith

*For Chikungunya and Zika vector surveillance and control, it is important to be able to identify *Aedes aegypti* and *Aedes albopictus* mosquitoes from trap catches. If unable to determine species, please refer to Section 13 for a list of contacts that may help with mosquito identification.

Appendix C. Vector threat response plan. NOTE: Actions should not rely only on Breteau Index (BI) values.

THREAT	BI VALUE*	ACTIONS
LOW Pre-mosquito season and no reports of disease	<5	1. Establish a response committee 2. Formalize emergency action plan for installation 3. Plan vector surveillance methods and conduct source reduction 4. Stock vector surveillance and control tools 5. Draft public outreach and education materials 6. Establish communication with mosquito control district for continuous updates
MODERATE Mosquito vectors present on installation and surrounding area	5-10	1. Survey larval and adult mosquitoes/ eliminate mosquito habitats and spray for adults when needed 2. Maintain communication with mosquito control district 3. Review/update response plans and IPMP 4. Provide public with necessary information about source reduction, personal protection, and household prevention
SIGNIFICANT Large populations of mosquito vectors and/or reports of imported cases	11-49	1. Intensify larval and adult mosquito surveillance/ eliminate mosquito habitats and use chemical means for larval and adult control when needed 2. Communicate with local mosquito control district about disease threat and response readiness 3. Provide information regarding protective measures and source reduction control method to public 4. Increase visibility of disease threat
CRITICAL High abundance of mosquitoes, disease epidemic/locally acquired disease transmission reported	>50	1. Action by members of response committee 2. Execute emergency action plan 3. Aggressive larval and adult mosquito surveillance 4. Significant source reduction 5. Area-wide spray treatments for adults and larvae 6. Alert the public of disease threat through various forms of media, distribute handouts