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Dengue and Chikungunya Vector Control Pocket Guide

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Foreword

This technical guide (TG) was written to consolidate information and procedures for surveillance and control of mosquitoes that transmit dengue and chikungunya viruses. This TG is not a regulation but provides guidance to those individuals responsible for conducting pest control and surveillance during military deployments. This TG will receive periodic review and will be updated to ensure that information presented reflects current technology and guidance. Individuals using this TG are encouraged to submit comments and suggestions for improvement to the Director, Armed Forces Pest Management Board, US Army Garrison—Forest Glen, 2460 Linden Lane, Bldg #172, Silver Spring, MD 20910-1230: (301) 295-7476; Fax (301) 295-7473.

Contents

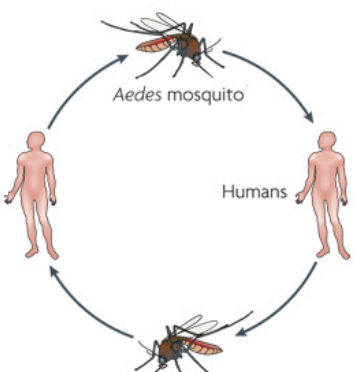
Introduction

This guide is designed to serve as a quick reference for the identification, surveillance, and control of the mosquito species that transmit dengue and chikungunya viruses. The three main components of the guide are 1) disease symptoms and distribution, 2) vector biology, identification, and distribution, and 3) vector surveillance and control. These components are necessary for the planning, implementation, and evaluation of a dengue/chikungunya vector control program.

This guide is not meant to be a comprehensive treatment of the subject, nor should it be used to provide diagnosis or treatment of disease. If you think you or someone else may have either of these diseases, seek medical treatment. See the Additional Guidance, References, and Points of Contact sections to find sources with more detailed information.

Disease Profiles

Both dengue and chikungunya are caused by arboviruses. Arboviruses require an arthropod vector (including insects and ticks) to be transmitted to the host. In the absence of the vector, the pathogen usually cannot be passed to other hosts. Humans are the primary host for both dengue and chikungunya viruses, which are transmitted by mosquitoes that live in close proximity to humans.



From: http://www.nature.com/scitable/topicpage/dengue-transmission-22399758

Dengue

Dengue refers to an infection by any of the four related virus serotypes, DEN-1, DEN-2, DEN-3, and DEN-4. They are transmitted to humans by three mosquito species: *Aedes aegypti*, *Ae. albopictus,* and *Ae. polynesiensis*. Human infection by the virus leads to dengue fever and occasionally dengue hemorrhagic fever.

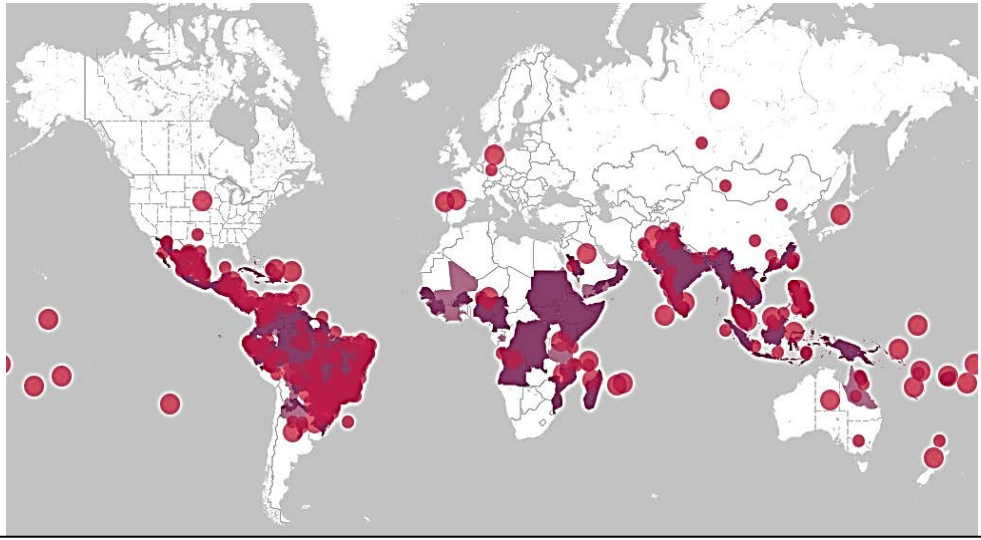
Dengue fever generally results in high fever, headaches, pain behind the eyes, joint and muscle pain, rash, and potentially mild bleeding from the nose and gums.

Dengue hemorrhagic fever (DHF) results from reinfection by a different dengue serotype. DHF begins like dengue fever, but after the fever subsides, blood vessels (mostly capillaries) become "leaky," allowing blood to enter the lining of the abdominal cavity and the space around the lungs, a condition that can be fatal.

Dengue Distribution

Dengue is considered a significant risk to deployed troops by the National Center for Medical Intelligence. The approximate worldwide distribution of dengue virus (as of April 2014) is on page 5. For the most up-to-date information on dengue's distribution visit healthmap.org's interactive dengue map at the following link:

http://www.healthmap.org/dengue/en/



Global distribution of dengue as of April 2014. The shaded countries are endemic areas, the red dots are recently reported cases.

Chikungunya

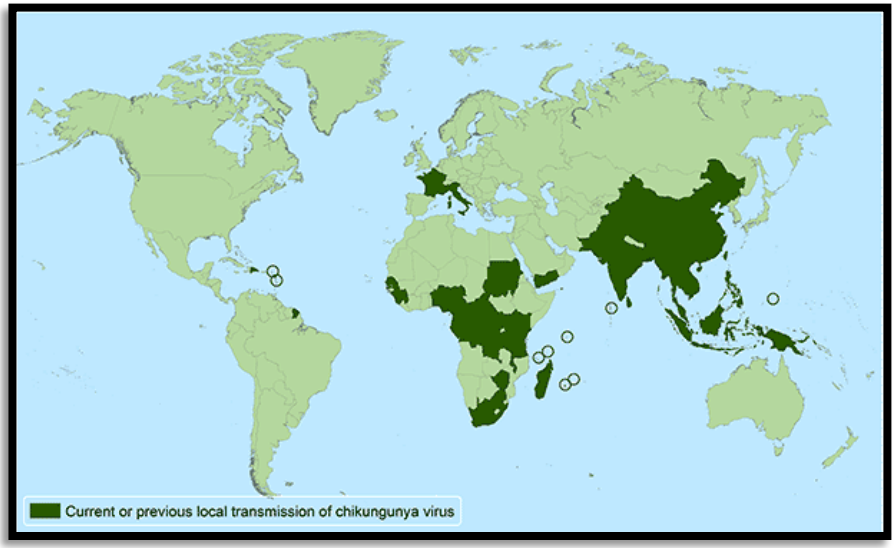
Chikungunya refers to an infection by the chikungunya virus (CHIKV). CHIKV is known to be transmitted by only two mosquito species, *Ae. aegypti* and *Ae. albopictus*. The name means "that which bends" in the language of southeastern Tanzania, and refers to the symptoms of chikungunya fever.

Chikungunya fever (CHIK) symptoms typically include a sudden high fever and severe joint pain. Headache, back pain, muscle pain, nausea, vomiting, arthritis, rash, and conjunctivitis may also occur. Unlike dengue, CHIK is currently thought to be nonfatal.

Chikungunya Distribution

CHIKV was first identified from mosquitoes in Tanzania. Outbreaks historically have occurred in Africa and Asia. In 2007 the virus was found to be spreading in Northern Italy and in December 2013 was found in the Caribbean. A current disease map (April 2014) appears on page 8. Check the Centers for Disease Control and Prevention (CDC) website on CHIKV for updates on distribution:

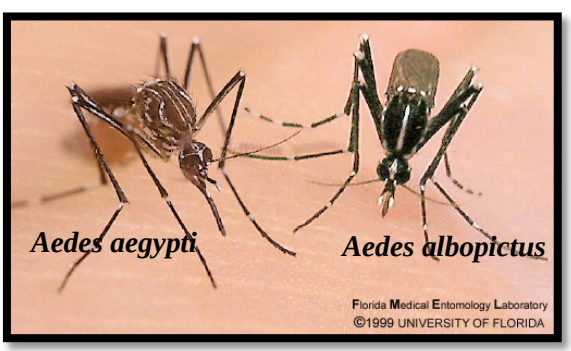
http://www.cdc.gov/chikungunya/geo/index.html

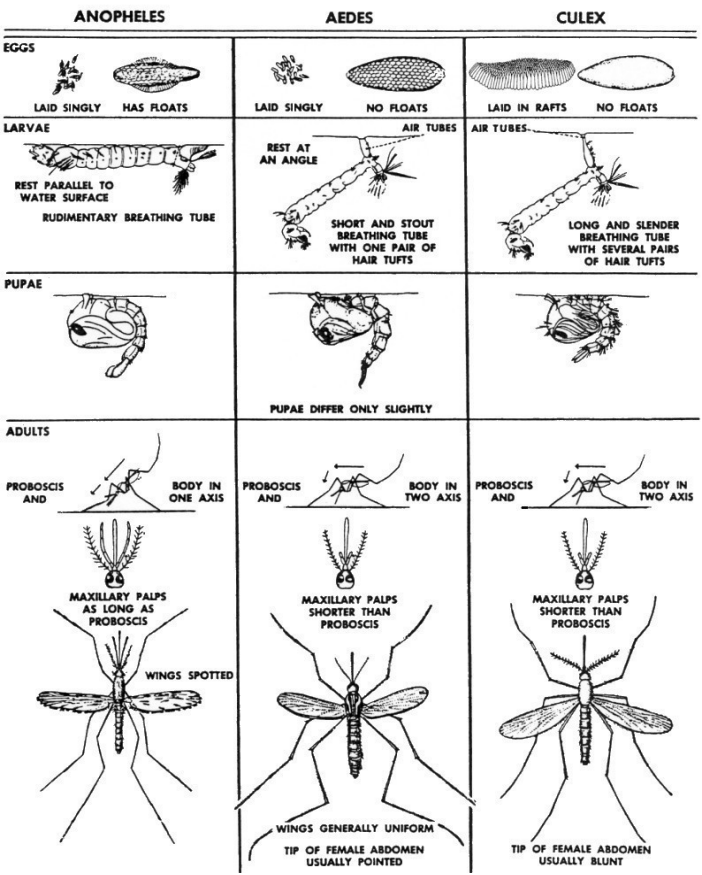


Global distribution of chikungunya as of April 2014.

Vector Biology/Identification

Both dengue and CHIKV are transmitted only by infected female mosquitoes in the genus *Aedes*. 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. There are many genera of mosquitoes; a guide to aid in identifying the genus *Aedes* is provided on page 10. Always seek assistance if you are unfamiliar with mosquito identification to ensure you correctly identify the mosquitoes in an area.





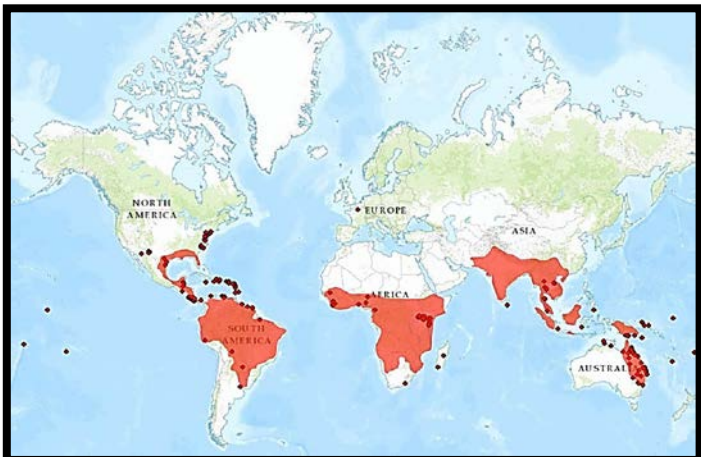
Identifying traits of *Aedes* mosquitoes compared to *Culex* and *Anopheles* mosquitoes.

Aedes aegypti

(yellow fever mosquito)

- Vector of dengue and CHIKV.
- Dark mosquito with guitar- or lyre-shaped markings on the top of the thorax and white-banded legs.
- Sneaky daytime biter.
- Occupies urban areas with or without vegetation.
- Bites, rests, and lays eggs indoors and outdoors.
- Mostly breeds inside human-made containers near homes.
- Responsible for most cases of dengue.

Aedes aegypti Distribution



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

Aedes aegypti Distribution

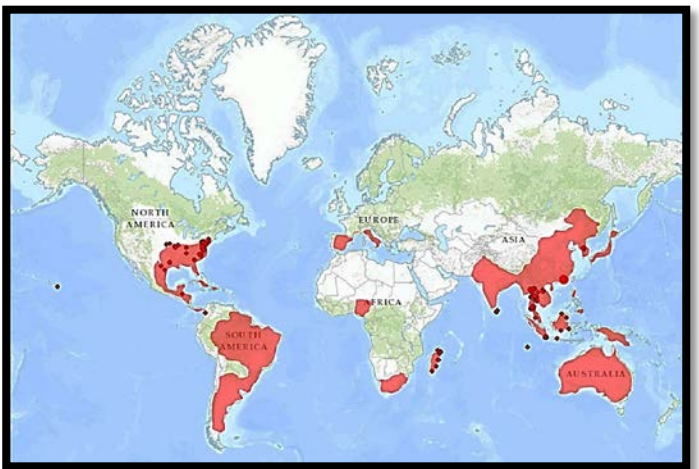
Current known CONUS distribution of *Ae. aegytpi* (CDC).

Aedes albopictus

(Asian tiger mosquito)

- Vector of dengue and CHIKV.
- Dark mosquito with a single silver stripe on the top of the thorax and white-banded legs.
- Aggressive daytime biter.
- Mostly associated with thickets and dense vegetation.
- Mostly found outdoors.
- Breeds in tree holes and bamboo internodes, but will also use human-made containers and rain gutters.

Aedes albopictus Distribution



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

Aedes albopictus Distribution

Current known CONUS distribution of *Ae. albopictus* (CDC).

Aedes polynesiensis

(Polynesian tiger mosquito)

- Vector of dengue, with a very limited distribution.
- Important vector in islands of South Pacific.
- Aggressive late afternoon biter.
- Found around homes.
- Breeds in crab holes, tree holes, and human-made containers.

Aedes polynesiensis Distribution

Austral Islands, Cook Islands, Ellice Islands, Fiji Islands, Hoorn Islands, Marquesas Islands, Pitcairn Island, Samoa Islands, Society Islands, Tokelau Islands, Tuamotu Archipelago

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

Surveillance

Immature Surveillance: Any material, manmade or natural, that holds water for more than several hours could contain mosquito eggs, larvae, or pupae. Examples of such items are tarps, discarded bottles, flower pot saucers, and rain gauges.

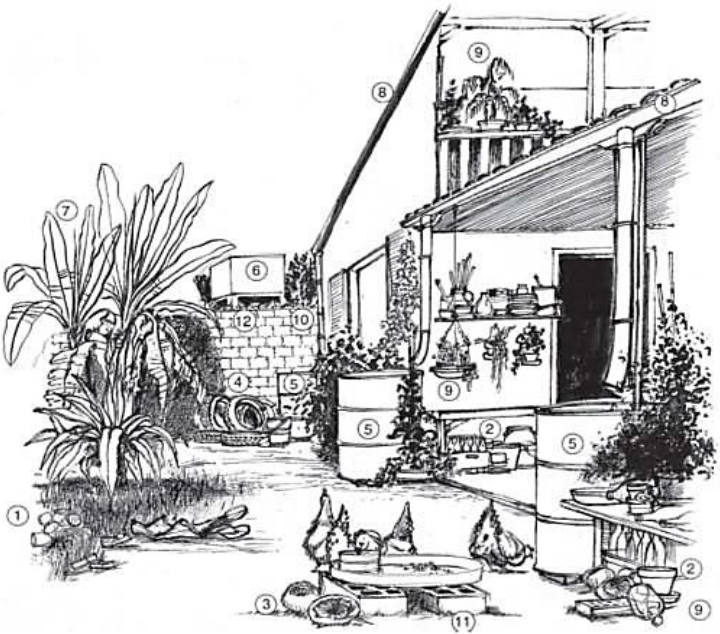
In areas where there is no indoor plumbing and people must store water, the risk of vector mosquitoes being present dramatically increases. Such water storage containers provide suitable, stable habitats for mosquitoes to exploit.

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 larvae are presented here. This is not an exhaustive list, as anything that can hold a tablespoon of water can be a potential larval habitat for these vectors.

Squat toilet and water storage in Thailand.

Outdoor *Pilas* (sinks) in Peru.



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.

Always conduct surveys to identify the main breeding locations prior to developing a control program. **Survey containers both inside and outside of homes.** Surveillance of larvae and pupae can be done by visually inspecting containers for immature mosquitoes and collecting them.

Larval and pupal survey **INSIDE** and **OUTSIDE** homes	**Artificial containers:** Cans, barrels, tires, rain gutters, animal troughs , storm drains **Natural containers:** water-filled axils of bromeliad plants, cut sections of bamboo, tree holes, crab holes, sea shells	Sample a minimum of 10-20% of identified larval habitats

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. Eggs can also be returned to the laboratory and hatched so larvae can be identified.

Ovitrap For general surveillance of eggs. Good for both *Ae. aegypti* and *Ae. albopictus*.	**NSN will soon be assigned.** Easily constructed from black cups or jars. Tongue depressors or filter paper will collect eggs.	Place in full or partial shade near walls, fences, hedges, junk, or tire piles. Inspect at least weekly and replace water.

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). Water sample bags or another type of storage container can be used if larvae or pupae are being returned to the laboratory.

Navy entomologist using a turkey baster to collect larvae from a bromeliad's leaf axil.

Larval Indices: The following indices are used in larval surveillance. These indices can signal when to begin a control program or when vector suppression was successful.

House Index

$$\boldsymbol{HI = \frac{\#\ of\ positive\ houses}{Total\ \#\ of\ houses\ surveyed}}$$

After effective control operations the HI = 0.

Breteau Index

$$\boldsymbol{BI = \frac{\#\ of\ positive\ containers}{100\ houses\ surveyed}}$$

Risk of dengue transmission when BI>5.
Emergency vector control when BI> 50.

Container Index

$$\boldsymbol{CI = \frac{\#\ of\ positive\ containers}{Total\ \#\ of\ containers\ surveyed}}$$

After effective control operations the CI = 0.

Adult 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.

Aspirators: The table below 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 (page 48), especially in areas with active disease transmission. Because of the risk of infection, landing/biting counts for adult surveillance are discouraged.

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

Oral Aspirators are low-tech collecting devices. The user provides suction by sucking air through the mouth piece. 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.

Oral aspirator: NSN 3740-01-474-7402

Powered aspirators are very useful tools for collecting adult *Ae. aegypti* and *Ae. albopictus*. 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.

CDC backpack aspirator: NSN 3740-01-503-5339

Mechanical aspirator: NSN 3740-01-210-2368

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. Traps should be baited with CO2 from dry ice. Also, commercially available lures that can improve a trap's effectiveness have been designed specifically to attract *Ae. aegypti* and *Ae. albopictus.*

Product manuals detail specific setup procedures and instructions for use of each piece of surveillance equipment.

The **BG-Sentinel™** trap (BioGents, Regensburg, Germany) has been found to collect *Ae. aegypti* and *Ae. albopictus* more effectively than the standard CDC light trap. The trap and the lures are available for purchase from Bioquip at

http://www.bioquip.com/search/DispProduct.asp?pid=2880

BG-Sentinel™ Trap Used for general surveillance of adults. Good for both *Ae. aegypti* & *Ae. albopictus*.	**No NSN.** Requires D-cell batteries. Use of BG lure is strongly recommended.	Place in areas inside or outside where you suspect adults to occur.

The **CDC Light Trap** may collect *Ae. aegypti* and *Ae. albopictus*, but in low numbers.

CDC Trap Used for general surveillance of adults. Will collect both *Ae. aegypti* & *Ae. albopictus*.	**NSN: 3740-00-134-9229** Requires D-cell batteries. Use of a lure (chemical or dry ice) is strongly recommended.	Place in areas inside or outside where you suspect adults to occur.

Control

An important way to both prevent and control dengue transmission is to eliminate the breeding sites of *Ae. aegypti* and *Ae. albopictus* and/or kill larvae and adult mosquitoes. Environmental control by eliminating breeding sites will involve mobilization of military assets and the direct support of your chain of command.

The necessary equipment to kill adult and larval *Aedes* 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.

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 and disposing of containers that hold water that may allow immature stages to develop. By using this method, dengue transmission has been successfully prevented in communities and over large geographic areas. Conduct larval and pupal surveillance to determine which containers are breeding mosquitoes.

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. The table below provides some guidance on how to handle specific larval sites:

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

Larvicides: Insecticides listed in the Contingency Pest Management Guide for controlling mosquito larvae appear in the table below. These insecticides are effective at killing larvae, but applying them is time consuming and labor intensive because individual larval habitats must be located and treated.

Strictly adhere to all directions on the insecticide label. **DO NOT APPLY TO DRINKING WATER!**

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

Adulticides: The WHO recommends adulticiding for dengue control during epidemics (WHO 2009), although there is little evidence that adulticiding is an effective long-term dengue control strategy (Esu et al. 2010).

Control measures should be carried out every 7 to 10 days to ensure that the breeding cycles of both *Ae. aegypti* and *Ae. albopictus* are disrupted (WHO 2009).

Control measures should be carried out both inside and outside of structures. It is also important to treat possible breeding areas, such as tires, with residual insecticides (Ritchie et al. 2001).

The list of insecticides available in the Contingency Pest Management Guide is found on page 43 of this guide.

Approved Pesticides for Contingency Operations

Product	NSN
Insecticide, Sumithrin-Piperonyl Butoxide, 10%-10%, (Anvil 10+10 **ULV**), 2.5 gal box	6840-01-474-7751
Insecticide, Sumithrin-Piperonyl Butoxide, 10%-10%, (Anvil 10+10 **ULV**), 250 gal container	6840-01-474-7706
Insecticide Pyrethrins, 3% pyrethrins with synergists, liquid, **ULV** Fog Concentrate, 1 gal 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

Indoor Residual Spray: *Ae. aegypti* readily bites 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.

In the Contingency Pest Management Guide, the only insecticide recommended for IRS is lambda-cyhalothrin. Strictly follow all guidelines on the insecticide label.

Product	NSN
Insecticide, lambda-cyhalothrin, Surrender Pestabs®	6840-01-431-3357

Two types of equipment in the stock system can be used to apply IRS: 1) hand compressed sprayers and 2) backpack sprayers. The table below lists all available hand compressed and backpack sprayers in the 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, gasoline engine driven. Tank size –3.5 gal., 24.6" high X 18.9" wide X 11" deep, 24 lbs empty	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

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 500m radius of structures (WHO 2009).

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.

Product	NSN
Fog Generator, Manually Carried, gasoline engine driven, thermal fog, Curtis Dyna Model 2610 Golden Eagle	3740-00-818-6648
Fogger, Hand Held, gasoline engine driven, ULV, Clarke P-1	3740-01-456-2623
Fog Generator, Insecticidal, P/N 58800-21/SUPERHAWK II	3740-01-480-3040

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 500m radius of structures (WHO 2009). Below is a list of ULV sprayers available in the stock system. See the insecticide list on page 43 of this guide for ULV insecticides.

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 MAG	3740-01-548-9102
Sprayer, Pesticide, Skid Mounted, Model Pro Mist, ULV	3740-01-076-1341

Personal Protection

Diseases such as dengue and chikungunya, and the injury caused by insect 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.

Permethrin on Uniform

DEET on Exposed Skin

Properly Worn Uniform

The treatment of field uniforms with **permethrin** 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.

Several **DEET-based** repellents for use on exposed skin are currently available. They include 3M Ultrathon 33% DEET lotion (NSN: 6840-01-284-3982); Cutter Backwoods 23% DEET spray (NSN: 6840-01-584-8598); Ultra30/LipoDEET 30% lotion (NSN: 6840-01-584-8393); and DEET/SPF15 sunscreen 20% DEET [NSNs: 6840-01-288-2188 (tube) and 6840-01-452- 9582 (packets)]. Also available is the 20% **Picaridin** repellent NATRAPEL (NSN: 6840-01-619-4795) for those preferring not to use DEET.

Proper wear of the uniform 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.

Treated pop-up style bed nets are also available to protect service members while they sleep [NSNs: 3740-01-516-4415 (green camo) and 3740-01-518-7310 (coyote brown)].

Green camo pop-up style bed net
NSN: 3740-01-516-4415

Also, insect bed nets (NSN: 7210-00-266-9736, and similar) can be treated with **permethrin** (page 44) to improve protection from biting insects. Be sure to allow the pesticide to dry before the bed net is used.

Additional Guidance

The World Health Organization recently published an extensive set of guidelines for dengue control. Comprehensive information on surveillance and control of dengue vectors can be found in the following references:

WHO. 2009. *Dengue, Guidelines for Diagnosis, Treatment and Control*. World Health Organization, Geneva. 147pp.

CDC, 2011. *Preparedness and Response for Chikungunya Virus Introduction in the Americas.* Centers for Disease Control and Prevention. Washington, D.C. 149pp.

Contingency Pest Management Guide. AFPMB Technical Guide 24.

Guide to Pest Surveillance during Contingency Operations. AFPMB Technical Guide 43.

Personal Protective Measures against Insects and other Arthropods. AFPMB Technical Guide 36.

Ultra Low Volume Dispersal of Insecticides using Ground Equipment. AFPMB Technical Guide 13.

Websites:

Armed Forces Pest Management Board: http://www.afpmb.org/

Centers for Disease Control and Prevention: http://www.cdc.gov/

Walter Reed Biosystematics Unit: http://www.wrbu.org/index.html

World Health Organization: http://www.who.int/en/

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Points of Contact

Contingency Liaison Officer
Armed Forces Pest Management Board
Email: http://www.afpmb.org/contact
COM: 301-295-7476
DSN: (312) 295-7476

US Navy Entomology Center of Excellence
E-mail: NECE-FleetSupport@med.navy.mil
COM: 904-542-2424
DSN: (312) 942-2424

US Army Public Health Command
PHCR-North Entomological Sciences Division
E-mail: PHCR-NorthESD@amedd.army.mil
COM: 301-677-3466
DSN: (312) 622-3466

USAF School of Aerospace Medicine/PHR
Wright-Patterson AFB, OH
E-mail: Will.Reeves@us.af.mil
COM: 937-938-4129
DSN: (312) 798-4129

Center for Medical, Agricultural & Veterinary Entomology E-mail: Dan.Kline@ars.usda.gov
Voice: (352)374-5933 Fax: (352) 374-5922