

**Armed Forces Pest Management Board  
Technical Guide No. 47**

January 27, 2012

**Dengue and Chikungunya  
Vector Control  
Pocket Guide**



Published and Distributed by the  
Armed Forces Pest Management Board  
Information Services Division  
US Army Garrison—Forest Glen  
2460 Linden Lane, Bldg #172  
Silver Spring, MD 20910-1230

Office of the Deputy Under Secretary of Defense  
For Installations and Environment

## **Acknowledgements**

This Armed Forces Pest Management Board (AFPMB) Technical Guide (TG) was written by LCDR Craig Stoops and LT Anthony Hanley of the U.S. Navy Entomology Center of Excellence, Dr. Gary Clark, USDA-ARS Center for Medical, Agricultural and Veterinary Entomology, and Dr. Graham White, AFPMB.

## **Disclaimer**

Any mention of specific proprietary products, trade names, or manufacturers does not constitute a recommendation or an official endorsement of these products by the Department of Defense but is intended for illustration and information purposes only. Neither should the absence of an item necessarily be interpreted as DoD disapproval. Information or inquiries concerning any equipment or items should be sent through Command Pest Management Professionals or Applied Biologists to the Armed Forces Pest Management Board Medical Entomology Committee for evaluation.

## **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 focuses on mosquitoes that transmit dengue but also makes reference to chikungunya and yellow fever because the pathogens that cause these diseases may be transmitted by the same mosquito species. Thus, control of dengue vectors will also control the spread of these diseases. 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.

## Table of Contents

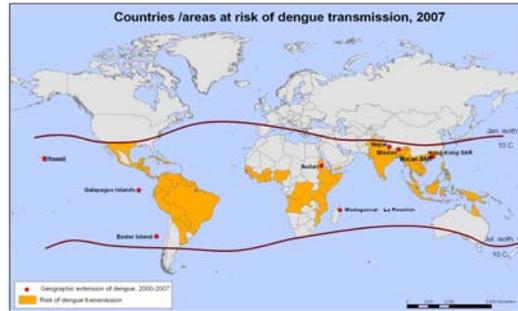
1. Introduction.....	4
2. Identification/Biology.....	7
3. Surveillance.....	10
4. Control.....	20
5. Personal Protection.....	29
6. Additional Guidance.....	31
7. References .....	32
8. Points of Contact.....	33

## **1. Introduction**

This guide is designed to serve as a quick reference for the identification, surveillance, and control of mosquito species that transmit dengue and chikungunya viruses. The three main components of the guide are biology/identification, surveillance, and control. These components are necessary in the planning, conduct and evaluation of a dengue vector control program.

This guide is not a comprehensive treatment of the subject. Please see the Additional Guidance, References, and Points of Contact sections for in-depth information on specific subjects introduced in this guide.

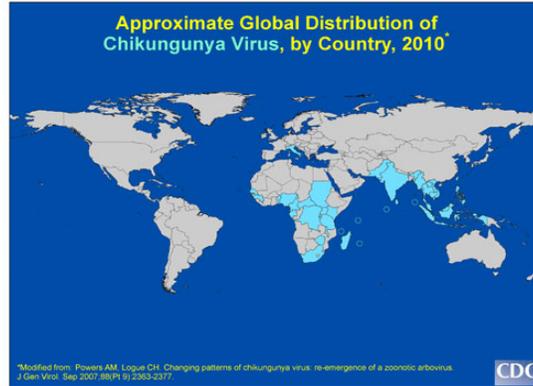
Dengue is considered a significant risk to deployed troops by the National Center for Medical Intelligence. The approximate worldwide distribution of dengue viruses is shown below.



Estimated worldwide dengue distribution. Dengue range minimum 10°C isotherm, north and south of the tropics. Orange-shaded countries are areas where dengue risk is well known.

*Aedes aegypti*, *Ae. albopictus* and *Ae. polynesiensis* are three mosquito species that are vectors of dengue. *Aedes aegypti* accounts for >95% of all cases worldwide. During deployments, all three species must be considered important vectors, and control measures must be put into place to protect troop health.

Chikungunya is another arboviral disease transmitted to humans by the bite of infective mosquitoes. Chikungunya virus has caused human epidemics in many areas of Africa and Asia, and most recently in a limited area of Europe (CDC 2008). Both *Ae. aegypti* and *Ae. albopictus* are vectors of chikungunya, and this virus is of special concern due to the recent resurgence and spread of these mosquito species.



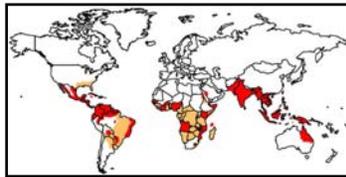
Estimated distribution of chikungunya virus.

## 2. Identification/Biology



*Aedes aegypti*

- Small black and white mosquito with markings that look like a guitar on the thorax.
- Daytime biter.
- Vector of dengue and chikungunya viruses.



CDC map showing dengue outbreaks in red (for year 2000) and wider distribution of the vector *Aedes aegypti* in yellow. Distribution: pantropical, Old and New World tropics, Pacific islands.



***Aedes albopictus***

- Small black and white mosquito with single white stripe on thorax.
- Daytime biter.
- Vector of dengue and chikungunya viruses.



Global distribution of *Aedes albopictus*:  
pantropical, Old and New World tropics, Pacific islands.

	Anophelines		Culicines	
	<i>Anopheles</i>	<i>Aedes</i>	<i>Culex</i>	
Eggs	 with floats, laid singly on water	 no floats, laid singly on dry/damp surface	 no floats, laid in rafts on water	
Larva	no air tube  rest parallel to water surface, head rotated 180° when feeding	one tuft on short stout air tube  rest at angle to surface, head not rotated	several tufts on slender air tube  rest at angle to surface, head not rotated	
Adult	 resting position	 resting position	 resting position	

Mosquitoes are flying insects that develop from aquatic immature stages, from which adults emerge. Adult female mosquitoes take blood meals to nourish their eggs.

### 3. Surveillance

**Immature Stages:** 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, plastic sheeting, and other materials used as covers.

In areas where there is no indoor plumbing and people must store water, either collected from a pump or during rains, the risk of vector mosquitoes being present increases dramatically. Such water storage containers provide suitable, stable habitats for mosquitoes to exploit. Water storage basins used by domesticated animals may also serve as mosquito breeding sites.

In areas where there is regular rainfall, natural and man-made containers that hold water will be of critical importance, exponentially increasing the number of mosquito habitats available.



Indoor water storage (*Bak mandi*)  
in Jakarta, Indonesia.



Outdoor *pilas* (sinks) in Peru.



Some examples of outdoor breeding places of *Aedes* spp. Breeding occurs in (1) discarded cans and plastic containers, (2) bottles, (3) coconut husks, (4) old tires, (5) drums and 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 as a precaution against burglars, (11) holes in unused construction blocks, and (12) the upper edge of block walls. From Rozendaal, 1997.

Conduct surveys to identify main breeding locations and to develop a control program. **Survey containers both inside and outside homes.** Surveillance of larvae and pupae can be done by visually inspecting containers for these stages and collecting them.



<p>Larval and pupal survey INSIDE and OUTSIDE homes</p>	<p><b>Artificial containers:</b> Cans, barrels (left photo), tires, rain gutters, animal troughs , storm drains (right photo) <b>Natural containers:</b> water-filled axils of bromeliad plants, cut sections of bamboo, tree holes</p>	<p>Sample a minimum of 10-20% of habitats identified</p>
---	---	--

Equipment necessary includes a flashlight, syringe or other suction device, and water sample bags or another type of storage

container if larvae or pupae are being returned to the laboratory.

**Larvae:** The table below summarizes the common indices used in larval surveillance. These indices can signal when to control or when control has been achieved.

House Index	$\text{HI} = \frac{\text{\# of Positive Houses}}{\text{Total \# of Houses Surveyed}}$	After effective control operations the HI = 0.
Breteau Index	$\text{BI} = \frac{\text{\# of Positive Containers}}{100 \text{ Houses Surveyed}}$	Risk of dengue transmission when BI > 5. Emergency vector control when BI > 100.
Container Index	$\text{CI} = \frac{\text{\# of Positive Containers}}{\text{Total \# of Containers Surveyed}}$	After effective control operations the CI = 0.



Collecting eggs using ovitraps is an effective way to monitor populations of *Aedes* spp. Ovitrap, which serve as egg-laying sites, allow presence or absence of species to be determined. Eggs can also be returned to the laboratory and hatched so larvae can be reared for identification.

<p>Ovitrap Used for general surveillance of eggs. Good for both <i>Ae. aegypti</i> and <i>Ae. albopictus</i>.</p>	<p>No NSN. Ovitrap are easily constructed from black cups or jars. Tongue depressors or filter paper will collect eggs.</p>	<p>Place in areas in full or partial shade near walls, fences, hedges, junk or tire piles.  Inspect at least weekly and replace water.</p>
---	---	--

**Adult Stages:** 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.

The table below outlines the equipment available to conduct adult surveillance.

Equipment	NSN
Aspirator, 1.5v (2 D-Cell battery) powered, Mechanical Aspirator	6640-01-210-2368
Collection Bottle Assembly/ Tube, Mechanical Aspirator	6640-01-210-2371
Aspirator, Insect Backpack, CDC Model 1412, Gel-cell battery	6640-01-503-5339
Aspirator, Oral, Entomology Specimen Collection, Model 412	6649-01-474-7402

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 6640-01-503-5339



Prokopack aspirator  
(<http://www.futurity.org/health-medicine/mosquito-surveillance-on-the-cheap/>).  
No NSN available.  
Use extension pole to access ceilings and other hard-to-reach areas.

Aspirators for collecting adult mosquitoes.



The BG-Sentinel™ trap (<http://www.mueckenfall.en.de/>) has been found to collect *Ae. aegypti* and *Ae. albopictus* more effectively than the standard CDC light trap.

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



The CDC Light Trap has been found to collect *Ae. aegypti* and *Ae. albopictus*, but in low numbers.

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

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

#### 4. 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 or 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 [www.afpmb.org](http://www.afpmb.org) or contact the AFPMB directly to obtain one.

**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**, removing and disposing of containers that hold water allowing immature stages to develop. Using this method, dengue has been successfully prevented in communities and over large geographic areas. Checking for the presence of mosquito larvae and pupae will tell you which containers are breeding mosquitoes.

The idea is very simple but difficult to put into practice and sustain over long periods of time without the necessary support. You must have the absolute support of your chain of command to develop and conduct a source reduction program.

During humanitarian missions, if you plan on designing and carrying out a source reduction program as part of Integrated Vector Management (WHO 2011), efforts must be coordinated with local, regional and national health authorities to ensure local compliance.

**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 are very time consuming and labor intensive because individual larval habitats must be located.

Strictly adhere to all directions on the insecticide label.

NOMENCLATURE	NSN
Insecticide, <i>Bacillus thuringiensis</i> , 10%, Bactimos Briquets, <b>DO NOT USE IN DRINKING WATER</b>	6840-01-377-7049
Insecticide, <i>Bacillus thuringiensis</i> , Vectobac Wettable DG, <b>DO NOT USE IN DRINKING WATER</b>	6840-01-565-8241
Insecticide, Temephos, Abate 4E, 2.5-gal, <b>DO NOT USE IN DRINKING WATER</b>	6840-01-424-3132
Insecticide, Methoprene, Altosid XR Briquettes, <b>DO NOT USE IN DRINKING WATER</b>	6840-01-424-2495
Insecticide, Methoprene, Altosid SR 20 Liquid Larvicide, <b>DO NOT USE IN DRINKING WATER</b>	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 24 of this guide.

NOMENCLATURE	NSN
Insecticide, d-Phenothrin-Piperonyl Butoxide (10%-10%), Anvil 10+10 ULV, (2) 2.5-gal co/BX	6840-01-474-7751
Insecticide, d-Phenothrin-Piperonyl Butoxide, (10%-10%), Anvil 10+10 ULV, 250 gal mini-bulk container	6840-01-474-7706
Insecticide Pyrethrins, 3% pyrethrins with synergists, liquid, ULV Fog Concentrate, 1-gal can	6840-01-104-0780
Insecticide, Resmethrin 4%+12% Piperonyl Butoxide, Scourge, 5-gal can, RESTRICTED USE INSECTICIDE	6840-01-359-8533
Insecticide, Malathion, 96.5%, liquid, Fyfanon ULV, 5 GL can	6840-01-169-1842
Insecticide, Lambda-cyhalothrin, Surrender Pestabs®, 40 tablets/bottle	6840-01-431-3357
Insecticide, d-Phenothrin, 2% Aerosol, 12 oz can	6840-01-412-4634

**Indoor Residual Spray:** *Aedes 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 contacting 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 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.

Nomenclature	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.

Nomenclature	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 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 P/N AQSZ-12	3740-01-561-9663

**Thermal Fogging:** Indoor and outdoor space spraying using thermal fogs is a component of many dengue control programs around the world. If possible, spray inside and within a 400m 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.

The Golden Eagle is currently the only hand held thermal fogger available in the stock system. See the insecticide list on page 24 of this guide for insecticides used for thermal fogging.

NOMENCLATURE	NSN
Fog Generator, Manually Carried, gasoline engine driven, thermal fog, Curtis Dyna Model 2610 Golden Eagle.	3740-00-818-6648

**Ultra Low Volume:** The WHO recommends conducting spraying in areas where dengue cases have been identified (WHO 2009). As with thermal fogging, ULV (COLD FOGGING) spraying should be conducted within a 400 - 500m radius of structures (WHO 2009). Below is a list of ULV sprayers available in the stock system. See the insecticide list on page 24 of this guide for ULV insecticides.

NOMENCLATURE	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	3740-01-463-0147
Sprayer, Pesticide, Skid Mounted, London Fog ULV XKE Gas Sprayer	3740-01-496-9306
Sprayer, Pesticide, Skid Mounted, Model Pro Mist, ULV	3740-01-543-0676

## **5. Personal Protection**

Diseases such as dengue and chikungunya, and 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 comprising a permethrin-treated uniform, application of an insect repellent on exposed skin, and proper wearing of the 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), a controlled release formulation; DEET/SPF15 sunscreen 20% DEET [NSNs: 6840-01-288-2188 (tube) and 6840-01-452-9582 (packets)]; and camouflage face paint 30% DEET (NSN: 6840-01-493-7334).

Proper wearing 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)].

## 6. 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.

*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.

## 7. References

- CDC. 2008. *Chikungunya Fact Sheet*. Centers for Disease Control and Prevention, United States.
- Esu, E., A. Lenhart, L. Smith and O. Horstick. 2010. Effectiveness of peridomestic space spraying with insecticide on dengue transmission; systematic review. *Tropical Medicine & International Health* 15(5): 619-631.
- 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. (in press).

## 8. Points of Contact

Contingency Liaison Officer  
Armed Forces Pest Management Board  
Email: [afpmb-webmaster@osd.mil](mailto:afpmb-webmaster@osd.mil)  
COM: 301-295-7476  
DSN: (312) 295-7476

US Navy Entomology Center of Excellence  
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](mailto: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@wpafb.af.mil](mailto:Will.Reeves@wpafb.af.mil)  
COM: 937-938-4129  
DSN: (312) 798-4129

Mosquito and Fly Research Unit  
Center for Medical, Agricultural & Veterinary Entomology  
E-mail: [Dan.Kline@ars.usda.gov](mailto:Dan.Kline@ars.usda.gov)  
Voice: (352)374-5933  
Fax: (352) 374-5922