
بسم الله الرحمن الرحيم

Ministry of Health and Medical Education (Iran)

QAZVIN UNIVERSITY OF MEDICAL SCIENCES

Biology، Ecology of the Vectors, their Roles in Transmission, Prevention and Control of Dengue Fever

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PHD of medical Entomology & vector control ,Jul 2024

Iranian Mosquitoes

Domain: **Eukarya**
Kingdom: **Animalia**
Phylum: **Arthropoda**
Class: **Insecta**
Order: **Diptera**
Family: **Culicidae**
Genus: **Aedes**
Species: ***Aedes aegypti***

Genus *Aedes* & *Ochlerotatus*

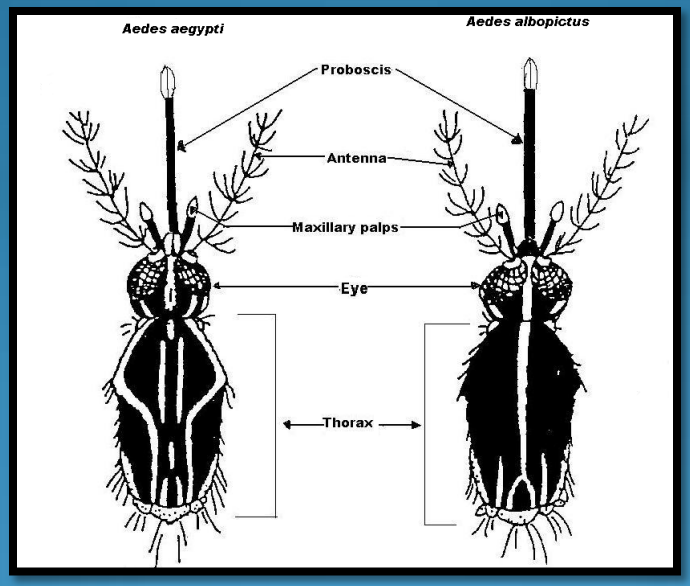
Ae.vittatus
Ae.vexans
Oc.echinus
Oc.detritus
Oc.leucomelas
Oc.flavescens
Oc.caballus
Oc.pulcritarsis pulcritarsis
Oc.pulcritarsis asiaticus
Oc.caspius s.l.
Oc.geniculatus

- **Iran (73 species, 8 genus)**

Aedes aegypti & Ae.albopictus



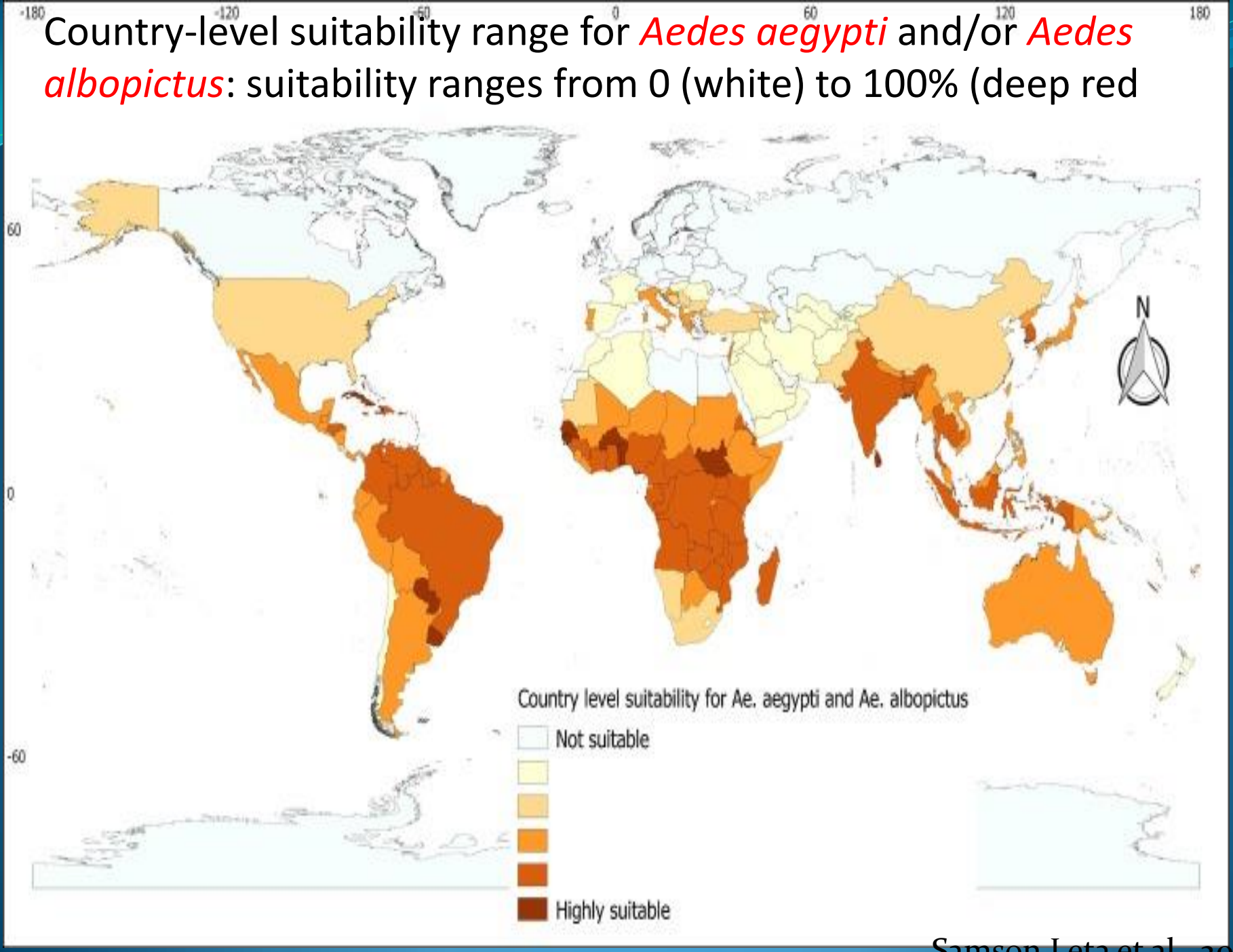




Thorax of adult female *Aedes mosquito*
(modified from WHO, 1995)

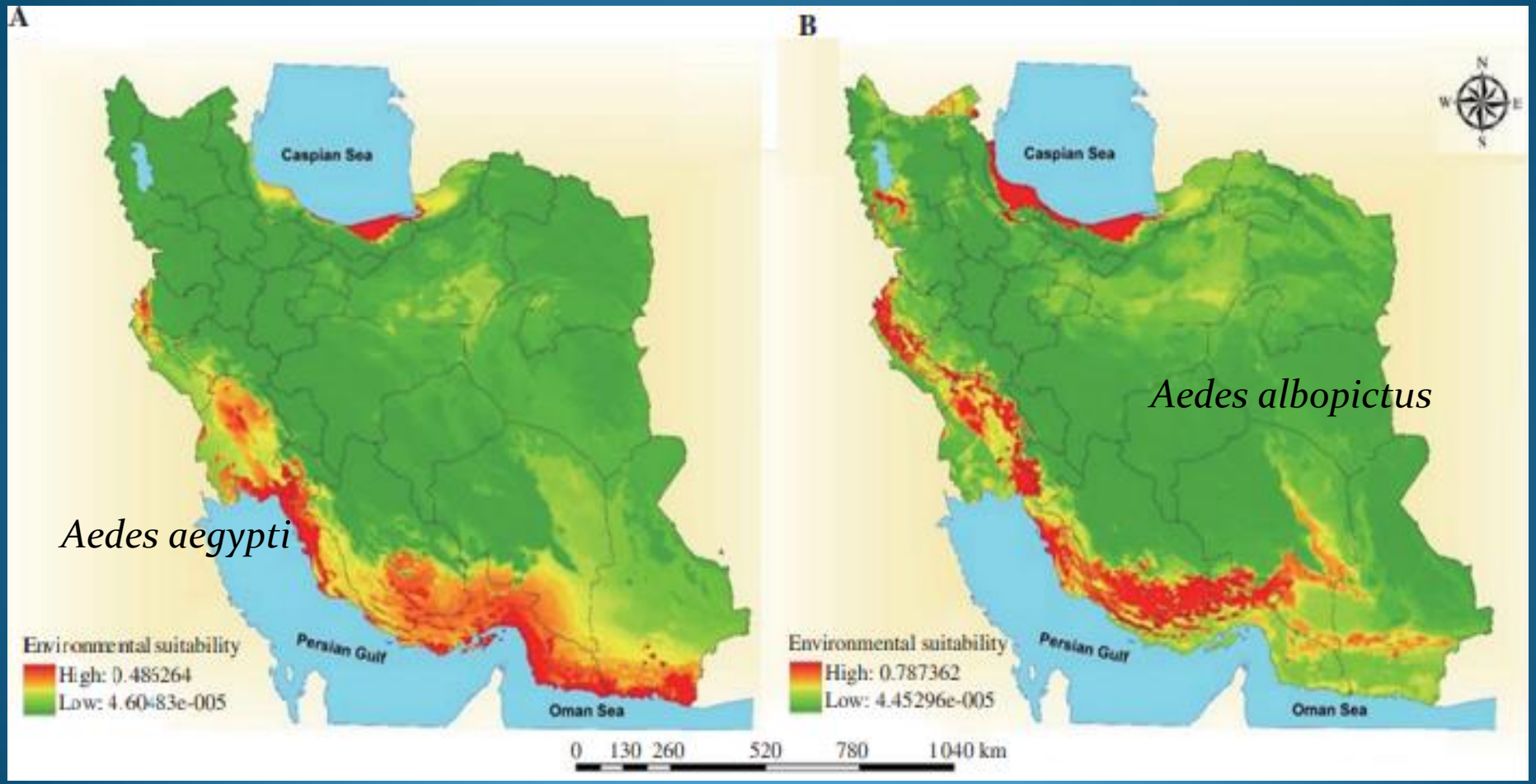
Invasive Mosquito Species

Country-level suitability range for *Aedes aegypti* and/or *Aedes albopictus*: suitability ranges from 0 (white) to 100% (deep red



Samson Leta et al , 2018

Modelling the probability of presence of *Aedes aegypti* and *Aedes albopictus* in Iran until 2070



Mohammad Mehdi Sedaghat et al./ Asian Pacific Journal of Tropical Medicine 2023; 16(1): 16-25

Entry of Aedes Invasive Mosquitoes to Iran

- *Aedes aegypti* and *Aedes albopictus* has been reported in Bushehr, Hormozgan, Sistan & Baluchestan provinces
- *Aedes albopictus* has been reported in Gilan provinces

These species are efficient vectors of Zika, dengue, chikungunya , yellow fever and Other potential diseases

Invasive Mosquito Species

An invasive mosquito that replaces a resident species via competition or apparent competition may alter disease transmission if it is either a more or less efficient disease vector.

– Risks

- Threat to biodiversity
  - – Outcompetition / replacement native fauna
  - – Increase ubiquitous species
- Threat to human and/or animal health
  - – Biting nuisance
  - – Transmission of arboviral diseases

Dengue Vectors (*Aedes aegypti* and *albopictus*) in Iran

الف – سناریو اول: آیدس اجیپتی و آیدس البوپیکتوس استقرار نیافته اند

- اجرای هوشمند و هدفمند برنامه های مراقبت در مبادی ورودی که از پیش تعریف شده باشند (برای مثال بنادر دریایی ، فرودگاه ها ، مسیرهای اصلی حمل ونقل زمینی در ارتباط با کشورهای آلوده و یا مناطقی که لاستیک های وارداتی به آنجا حمل می شوند) و در سایر نقاط پرخطر (برای مثال مناطقی که انتقال محلی بطور مشکوک یا قطعی گزارش شده باشد و یا سابقه حضور یکی از دو گونه ناقل در آن مناطق موجود باشد) جهت تعیین ورود یا استقرار احتمالی پشه های ناقل.
- ارزیابی کیفیت و اثر بخشی اقدامات حذف ناقل.

ب – سناریو دوم: استقرار محدود محلی آیدس اجیپتی و آیدس البوپیکتوس (مراحل ابتدایی استقرار که به مناطق کوچکی محدود باشد)

- سنجش استقرار و محدوده جغرافیایی از طریق برنامه تشدید مراقبت در مناطق کولونیزه شده و اطراف آنها.
- ارزیابی کیفیت و اثر بخشی اقدامات حذف ناقل.

ج – سناریو سوم: استقرار گسترده آئدس اجیپتی و آئدس البوپیکتوس

- ارزیابی دینامیزم جمعیت پشه ناقل (توزیع، اکولوژی لارو، فراوانی جمعیت و روند فصلی)
- ارزیابی به صرفه بودن و اثر بخشی برنامه های کنترل ناقل

Qazvin in Scenario I

Transmition:

- The full life cycle of dengue fever virus involves the role of mosquito as a transmitter (or vector) and humans as the main victim and source of infection.

- **Vectors:**

  Aedes aegypti

  Aedes albopictus

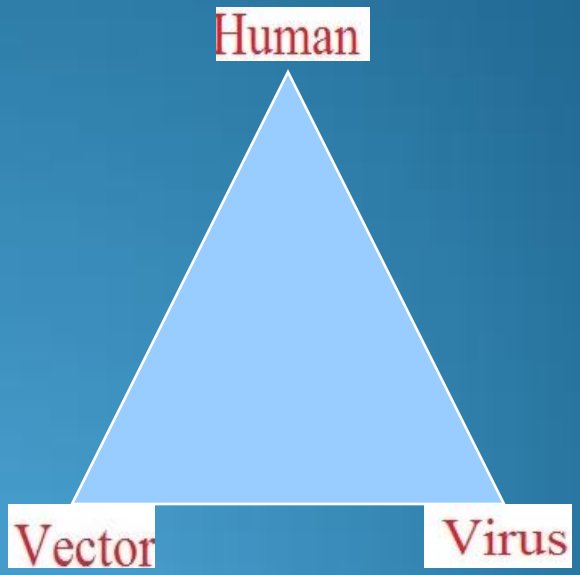
- **Vertebrate reservoir**

  Humans

  Some monkeys

In low level transmission :

Mosquitoes by transovarial transmission



The vectors:

Aedes aegypti
Aedes albopictus

Aedes polynesiensis
Aedes scutellaris
Aedes hensilli
Aedes furcifer
Aedes luteocephalus

*LIFE CYCLE (10-12 days)

Adult
-Maxillary pulps shorter than probosis
-Wings uniformly grayish black
-Body and legs are black with distinctive white patches throughout
-Thorax has markings



Eggs
- Black and oval in shape
- Laid singly above water surfaces of containers
- Without float
- Viability: 6 months to 1 year due to the presence of chorion



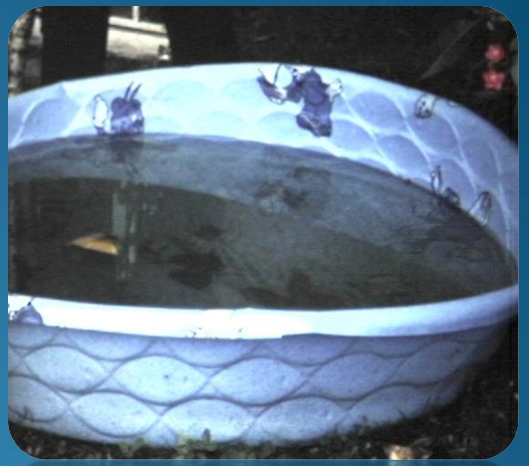
Pupa
-Non-feeding stage
-Breeding trumpet is long, slender with narrow opening

Larva:
- Feeding stage
- Breeds in clean and non-polluted water
- Short and stout siphon with one pair of hair tuft
- Rests at an angle to the water surface

Aedes aegypti & *Ae. albopictus* Breeding Sites














10 29 02

Potential Breeding Grounds







Potential Breeding Grounds







Potential Breeding Grounds









Potential Breeding Grounds







Potential Breeding Grounds















Bamboo pole holders



Air-con trays

Potential breeding sites

Water valve chambers



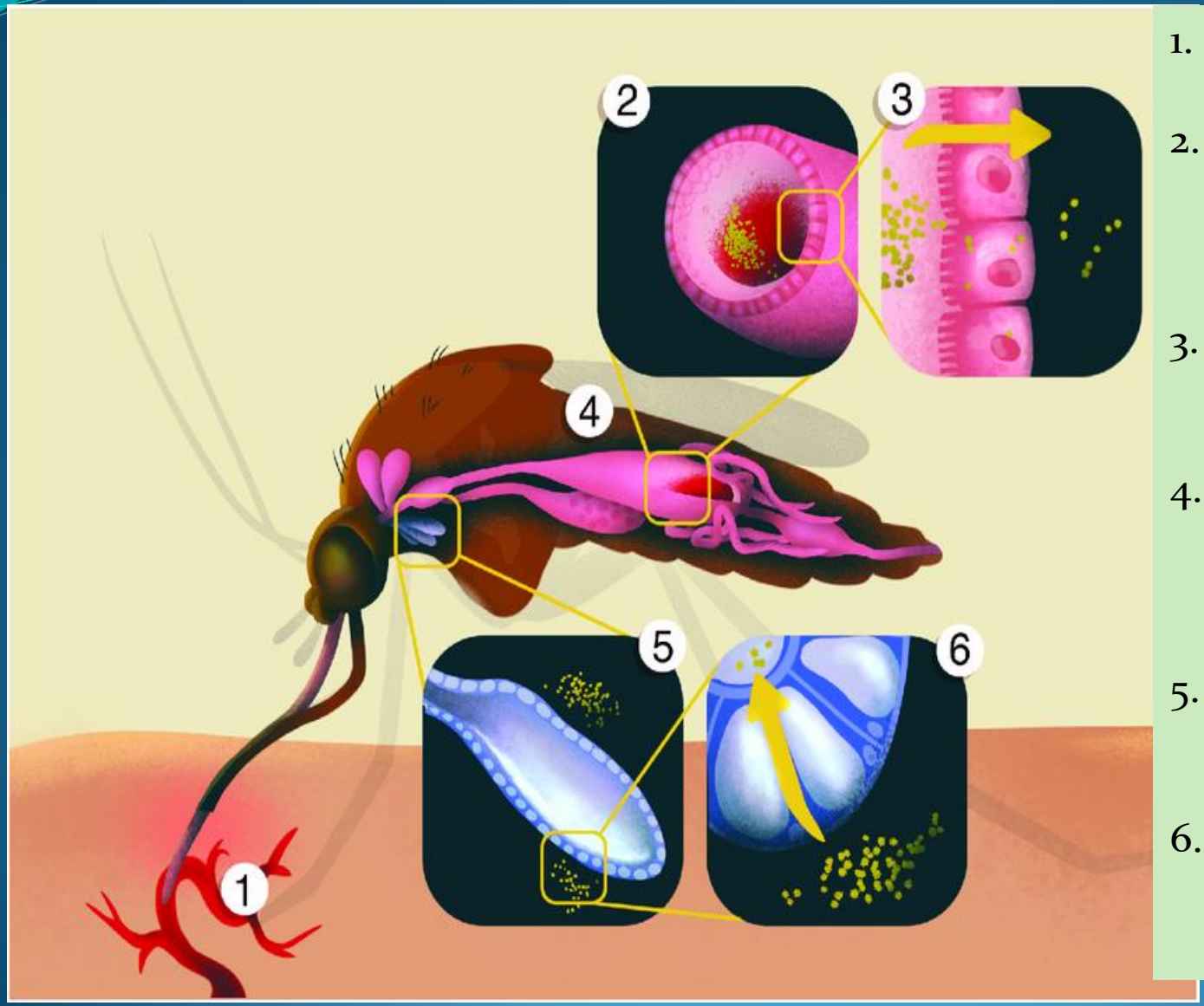


Drains



Brackish water development habitats of Aedes larvae in Sri Lanka. The photographs show the brackish water collections
containing larvae in: A & B - disused boats; C & E: abandoned wells; D & F: discarded food and beverage containers.
doi:10.1371/journal.pntd.0001369.g003

successful transmission of an arbovirus by a mosquito



1. Virus ingested from a viremic host.
2. Virus deposited in the posterior section of the mesenteron (midgut).
3. replicates in the epithelial cells of the mesenteron.
4. The virus infects other tissues, such as fat bodies or neural tissue,.
5. The virus then infects the cells of the salivary glands.
6. The virus released another vertebrate host

disseminate infection to the salivary glands

size of the virus inoculum

product Of viral titer

quantity of blood meal taken by the insect

influences the probability the vector will subsequently disseminate infection to the salivary glands

viremia peaks

In all dengue infections, viremia peaks shortly after the onset of fever. For those individuals who develop severe disease and are at risk of death, peak viremia has occurred before the onset of incapacitating symptoms and signs when they are ambulatory and fully exposed to mosquitoes.



Mosquitoes Bite Some People More Than Others (signals to M)

- Blood Type : Type O: Asian tiger mosquito, Type AB: Anopheles gambiae.
- Carbon Dioxide: distance of 5 to 15 meters (attracted to head)
- Body Heat (fever & exercise, …)
- Sweat: attracted to lactic acid, ammonia, and other compounds emitted
- Skin Bacteria : ankles and feet especially ripe for bacterial growth

civilians and soldiers and increased numbers of susceptible individuals in endemic areas

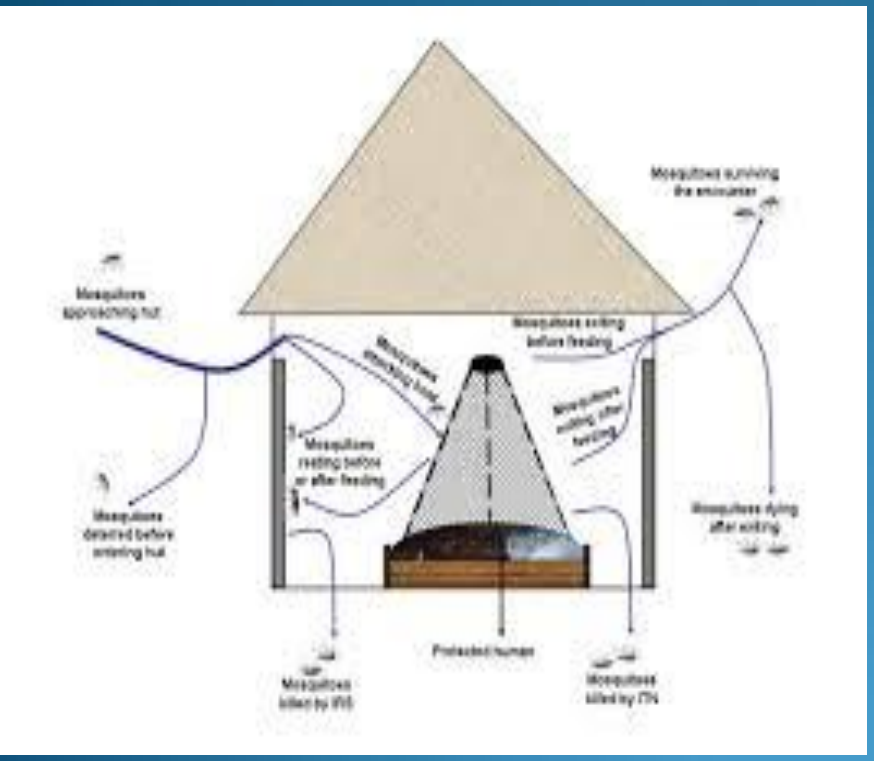
Threshold Viremia Required to Infect Mosquitoes

The threshold of viremia in humans required to infect mosquitoes has not been measured accurately. In natural infections, virus titers in humans rise as high as 10^8 and In monkeys, dengue viremia was as high as 10^6 MID_{50}

Mosquito Infectious Doses (MID_{50}) per ml.



Experience over the past 20 years has shown ITNs to be a promising intervention for reducing the risk of malaria infection in areas of both stable and unstable.





Insecticide-Treated Mosquito Nets (ITNs) - PMI

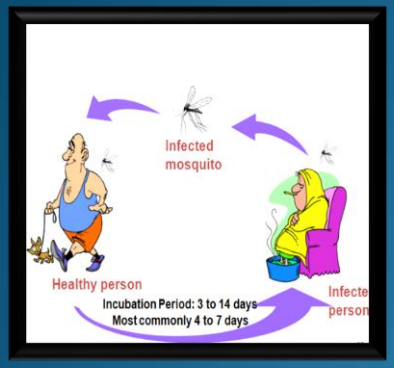


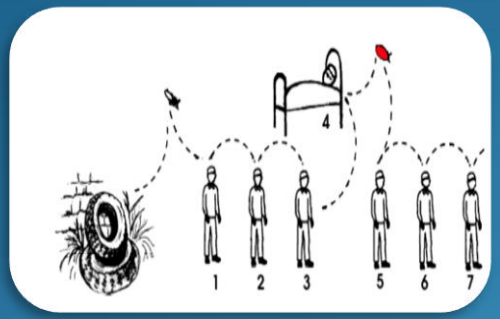
- ***Aedes albopictus***
  - Native to Southeast Asia
  - Peri-domestic, associated with thickets.
  - Breed and bite outdoors
  - Aggressive bitter
  - Also breed in natural containers
  - Biting Peak : before dusk
  - Bites humans and available domestic and wild vertebrates.



- ***Aedes aegypti***
  - Imported from Africa
  - Domesticated, occupies urban areas with or without vegetation.
  - Breed and bite indoors
  - Sneaky biter.
  - Only breed in artificial containers
  - Biting peak : morning.
  - High preference for human blood.

Household Transmission





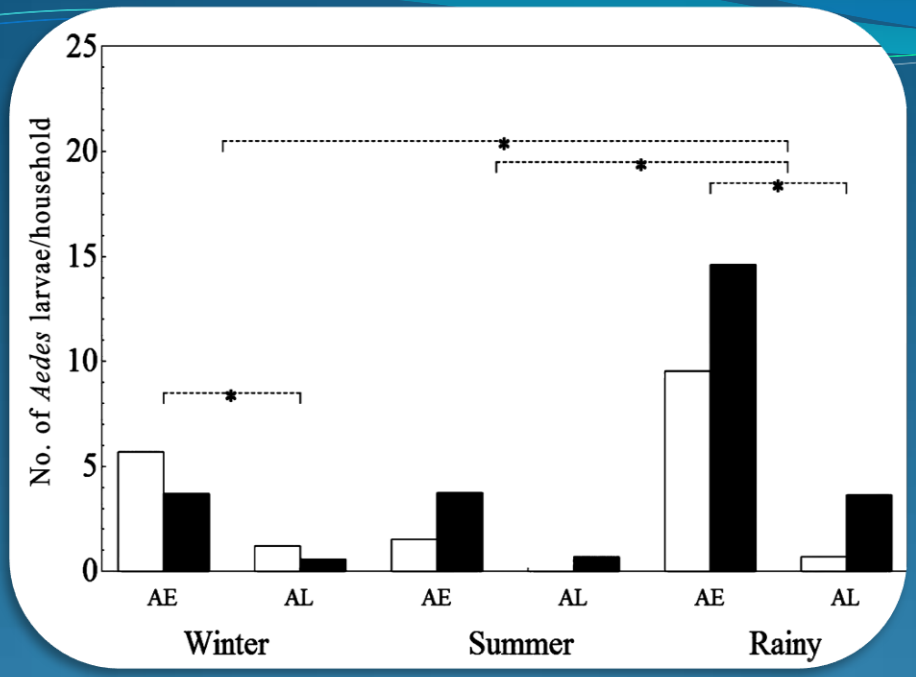
Once an infective mosquito enters a house or a member of a household becomes infected, the probability of multiple infections in the household increases and may result in clusters of dengue infections

In a Chinese household,
29 of 30 members were infected



Following an increase in dengue cases in children residing in Bangkok, epidemic waves appeared outside the capital progressively, moving away at a speed of 148 km per month

- Females bite during the day ,rarely at night and preferably inside dwellings. They bite humans, mammals ,birds ,batrachians or reptiles , depending on host presence
- Females readily enter dwellings dusk and night but also be found biting during daytime outside houses in shaded areas.
- Adults in forested areas ,rural villages, peri-urban ecosystems, in tropical as well as in temperate regions.
- Lay around 300-345 eggs per female
- The phase of aquatic development varies between 7-20 days depending on temperature and food abundance



Number of *Ae. aegypti (AE) and Ae. albopictus (AL) larvae* per household in urban (□) and rural (■) areas in winter, summer and rainy seasons at Sisaket, Thailand from January to December 2010. Horizontal lines indicate the statistical differences between the means.

Dynamic of transmission

1- Environmental factors

2 - Host pathogen interactions

3- Population immunological factors

4- Climate directly: biology of vectors, their abundance, distribution

vector susceptibility and epidemic

In general, *Ae.aegypti* is less susceptible to infection by DENS' than *Ae.albopictus*

However, susceptibility of the mosquito vector and transmission dynamics are also influenced by the strain of infecting virus (Anderson and Rico liesse, 2006; lIanley et al., 2008).

Effects of virus on mosquito:

-Mosquito infected mosquito infected with DEN virus

- Mosquito infected with DEN virus has shorter life-span
- Take longer to feed



- According to WHO study, incubation period of DEN virus from 12 days at 30 centigrade to 7 days at 32-35 centigrade in *Ae. aegypti*.

- Most transmission of DEN in 28˚C

Effect of Temperature

adult survival.

extrinsic incubation & reproduce quickly



gonotrophic cycle

lowest daily temperature

Effect of Rainfall

increase in adult survival

feeding activity



positive correlation between rainfall and vector abundance

Vector Surveillance and Control

Prevention is the Best Medicine

- No specific chemotherapy for DEN/DSS.
- No vaccine (existence 4 serotypes makes it complicated)
- No drug to prevent DEN
- Vector control (combination of environmental sanitation, chemical control)

Environmental Sanitation

- Knowledge of oviposition behavior can help identify breeding sites & monitor populations.
- In areas without adequate piped water supplies, fresh water in containers, provide larval habitats.
- Best way, to provide piped water supply
- Health education efforts can encourage people to protect water supplies.
- Work closely with community workers and leaders to obtain their active participation in waste containers
- Covering, emptying and cleaning of domestic water storage containers on a weekly basis.
- Cemeteries in urban areas, vases for flowers, Frequent emptying of water filled containers, Education of cemetery staff and visitors

Global Strategy For Dengue Prevention & Control:

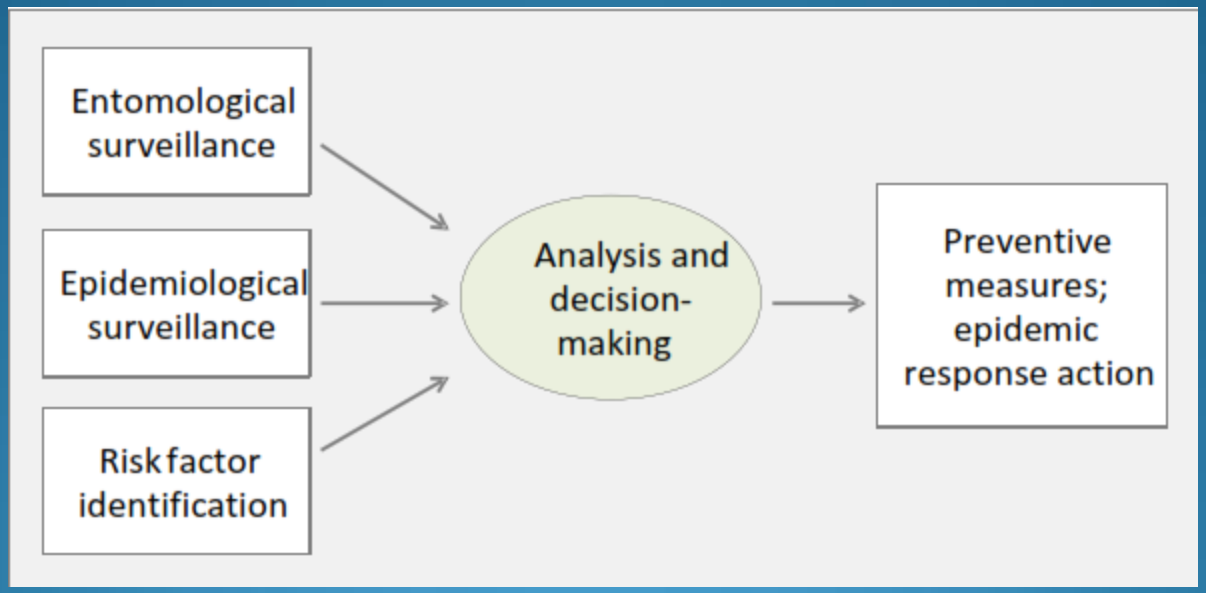
- **Goal And Objectives**

  - The goal of the global strategy is to reduce the burden of dengue.

    Its specific objectives are:

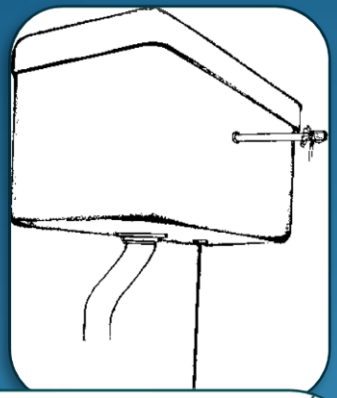
    - ✓ To reduce dengue mortality by at least 50% by 2020
    - ✓ To reduce dengue morbidity by at least 25% by 2020
    - ✓ To estimate the true burden of the disease by 2015

The role of surveillance data in the planning of measures for disease prevention or epidemic response action in countries where *Aedes mosquitoes have become established*



Environmental Control





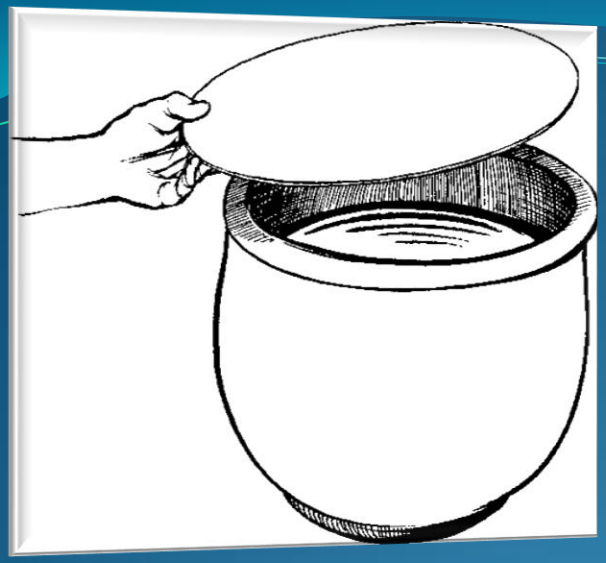


Toilet bowls, floor traps and overflow pipes should be made mosquito-proof.





Dispose of rubbish safely through the organized collection system or by burying it.



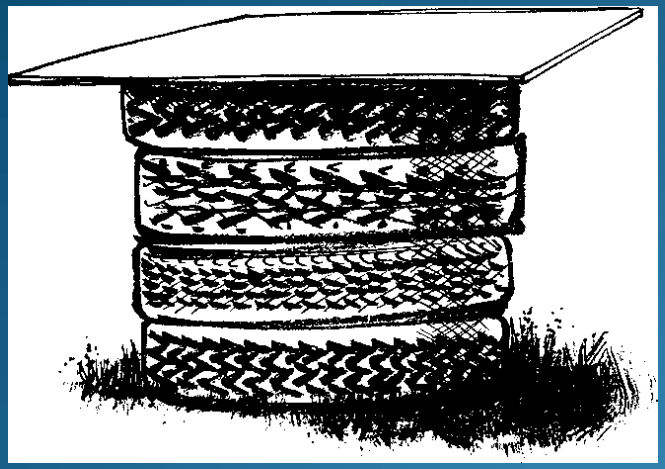
Cover open jars with a tight-fitting lid.



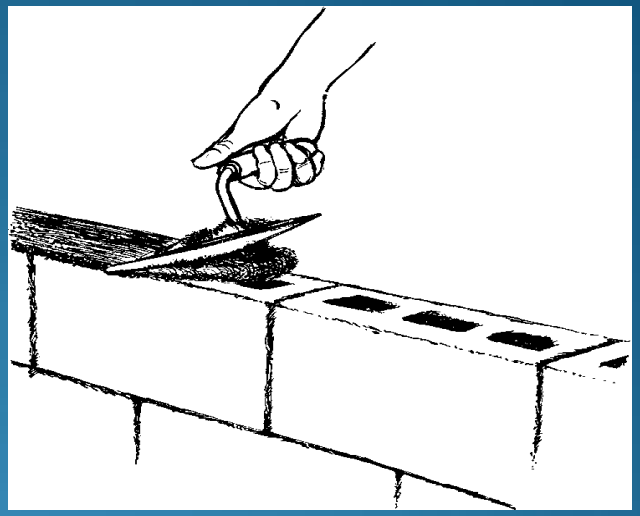
Cover barrels and drums with cloth or netting.



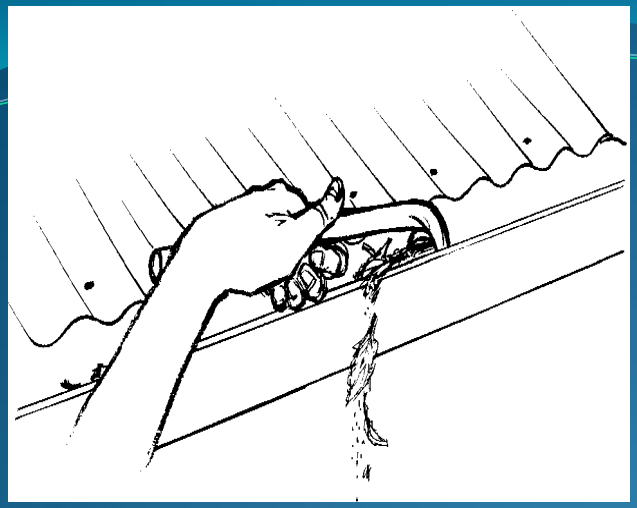
A fixed cover incorporating a sieve.



Store tyres under a cover.



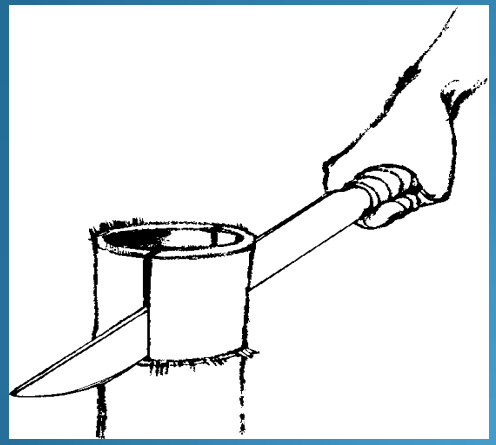
Fill holes in construction blocks with cement or sand



Clean gutters regularly.



Fill tree holes with sand or concrete.



Cut down bamboo stumps to the node.

Human Behavioral Control

- Frequently (once in 2-3 days) empty all water storage containers

- Cover tanks by LLINs to prevent mosquitoes breeding in fresh water









before







after





before





After



Remove larval habitat breeding





Prevention during pregnancy

- ✓ Use mosquito repellents with up to 50% DEET, Picaridin, IR3535 or Oil of Lemon Eucalyptus during pregnancy.

- ✓ Dress in loose cotton clothing that covers your arms and legs

Babies between 4-12 months of age are at higher risk for severe dengue

- Cover cribs, strollers and baby carriers with mosquito netting at all times
- For babies over 2 months of age, use repellents with up to 30% DEET, picaridin or IR3535
- Do not use repellents on babies less than 2 months of age
- Dress your baby in loose cotton clothing that covers arms and legs







- Although insecticide space-spraying is recommended for vector control in epidemics, its efficacy in other situations has not been well documented.







A sensitive, safe, low cost and easy to use tool is suitable for continuous egg-collection at a number of fixed sampling stations in order to monitor reproductively active populations. This can be accomplished with an ovitrap model consisting of a black plastic cup baited with 2 L of grass infusion (or water supplemented with alfalfa pellets) treated with a Bti-based product and containing three 5 × 15 cm wooden paddles, as oviposition substrates (Regis et al. 2008). Besides being a potent, safe and long lasting larvicide specially under shade (Regis et al. 2001, Araújo et al. 2007, MeloSantos et al. 2009),

Bti seems to act as an oviposition stimulant (Santos et al. 2003, Stoops 2005), giving increased efficiency to the trap, which can safely remain in the field for up to two months showing an egg-collection capacity of over 7.000 eggs/trap-month (Regis et al. 2008). An egg counting computer-assisted system (Mello et al. 2008) allows operational advantages over the optical microscopic counting system. It is less time-consuming and data records are directly transferred to a geographical database.

Chemical Control

- Residual house spraying is rarely used against *Aedes* mosquitoes, because of outdoor habitats or rest indoors on unsprayed objects such as clothes, or curtains.

First report of field evolved resistance to agrochemicals in dengue mosquito, *Aedes albopictus* (Diptera: Culicidae), from Pakistan

Hafiz Azhar Ali Khan[1*], Waseem Akram[2*], Khurram Shehzad[3] and Essam A Shaalan[4]

Abstract

Background: Agrochemicals have been widely used in Pakistan for several years. This exposes mosquito populations, particularly those present around agricultural settings, to an intense selection pressure for insecticide resistance. The aim of the present study was to investigate the toxicity of representative agrochemicals against various populations of *Aedes albopictus* (Skuse) collected from three different regions from 2008-2010.

Results: For organophosphates and pyrethroids, the resistance ratios compared with susceptible Lab-PK were in the range of 157-266 fold for chlorpyrifos, 24-52 fold for profenofos, 41-71 fold for triazofos, and 15-26 fold for cypermethrin, 15-53 fold for deltamethrin and 21-58 fold for lambdacyhalothrin. The resistance ratios for carbamates and new insecticides were in the range of 13-22 fold for methomyl, 24-30 fold for thiodicarb, and 41-101 fold for indoxacarb, 14-27 fold for emamectin benzoate and 23-50 fold for spinosad. Pair wise comparisons of the log LC_{50s} of insecticides revealed correlation among several insecticides, suggesting a possible cross resistance mechanism. Moreover, resistance remained stable across 3 years, suggesting field selection for general fitness had also taken place for various populations of *Ae. albopictus*.

Conclusion: Moderate to high level of resistance to agrochemicals in Pakistani field populations of *Ae. albopictus* is reported here first time. The geographic extent of resistance is unknown but, if widespread, may lead to problems in future vector control.

Background

Dengue fever and dengue hemorrhagic fever (DF/DHF) are vector borne diseases of public health concerns in tropical and subtropical parts of the world [1], affecting millions of people annually [2]. The incidence of DF and DHF has increased cyclically in Pakistan since the first recognized outbreak in 1994 with *Ae. albopictus* (Skuse) as the core mosquito vector in this respect [3]. Currently, controlling this vector with insecticidal habitat spraying remains an important option to minimize the incidence of dengue fever [4], resulting in resurgence and development of insecticidal resistance.

Insecticide resistance has become a limiting factor in the use of these compounds in chemical control of many insect pests. The exploration of more efficient toxic chemicals and other control tactics are necessary with the increasing world population and preservation of species diversity [5]. Frequent use of chemicals, such as pesticides, coupled with monoculture crops on a large scale, has generated pesticide resistance in insect pests, resurgence and difficulties in pest management [6]. By 2007, intensive use of pesticides had resulted in at least 553 arthropod species resistant to one or more classes of insecticides (organochlorines, organophosphates, carbamates and pyrethroids) [7]. Of these, 60 percent are agricultural pests and the remaining 40 percent are pests of medical importance [8]. Resistance in medical pests or disease vectors is a serious threat to the control of vector-borne diseases, owing to the fact of insecticide-based strategies such as insecticide treated nets, indoor residual spraying, insecticide treatment of

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Full list of author information is available at the end of the article

- Resistance of *Ae. albopictus* larvae to Temephos (China, Pakistan, Malaysia, Thailand, Caribbean islands and Brazil, Italy and Greece)

- Resistance to DDT and Pyrethroids
  (China, Pakistan, Malaysia, Thailand, Cameron)

Mosquito density required for transmission.

The minimum density of *Ae.aegypti* that permits transmission of dengue viruses has long been a topic of fierce debate.

For example, a house index of 5 was selected as the target for control of urban yellow fever in Quito, Ecuador

In Singapore, where vector density had been held to a house index of less than 1 for many years, dengue infections continued to occur over a long period.

Aedes aegypti , Aedes albopictus

- **In anticipation of , or during epidemics of DEN or YF, application of space spraying ,destruction of breeding sites and larviciding. (WHOPES)**
- **IRS for control of *Aedes aegypti*.**
- ***Ae.albopictus* , vegetation, residual treatment of plants**
- **Insecticide resistance in *Aedes aegypti* and *Ae. albopictus***

Larviciding

- **Water storage containers, Methoprene , Pyriproxyfen ,Temephos , Bti , in drinking water at dosages against *Ae.aegypti.***

- **In septic tanks and soak-away pits, polystyrene beads can be applied.**

Temephos

Not exceeding 1 mg of active ingredient at per liter (1 ppm)

Methoprene

Pyriproxyfen Not exceeding 0.01 mg (ai) per liter (0.01 ppm) and Bti

Application procedures

- Hand-operated compression sprayers for liquid insecticides to large breeding places
- A syringe or pipette for indoor flower vases
- Granule by hand to confined breeding sites
- Containers of drinking water: 1 gr of 1% temephos granules for 10 liter

Treatment cycle:

- Mosquito species , seasonality of transmission, rainfall patterns, type of breeding sites, affect the treatment cycle.
- 2-3 treatments per year . In periods of rainfall might be sufficient.
- Insecticides except : Organochlorines e.g. Carbamate, Organophosphate and Pyrethroid can be used to treat large accumulations of discarded containers.

Space treatment

- In early stage of an epidemic, emergency space spraying as source reduction (ULV). Deltamethrin
- Doors and windows should be open during space spraying
- Target areas, where people congregate, e.g. high density housing
- Schools, hospitals , areas where cases of disease with high vector densities (up to 400 m) from houses
- Cold aerosols or thermal fogs including:

Primophos-methyl
Cyfluthrin
Cypermethrin
Delthamethrin

- **Thermal fogs, 10-15 l/ha**
  ULV droplets size (15-25 um) at a rate of o.5-2 l/ha.

- **If affected are more than 1000 ha, aerial cold fog application is used.**

- **Space spray should correspond to acting of *Ae. aegypti* or *Ae. albopictus* in the morning or afternoon.**

Treatment cycle

- **Space treatment, every 2-3 days for 10 days**

- **Further application : once or twice a week**

Biological control

- **Fish e.g. *Poecilia* spp, Copopeda (Cyclopoidea) in Argentina, Bti**

Health Education ,Pamphlet , Radio ,TV. , News paper, Magazines , Workshops, Seminar, Talks , Film, Exhibition , Slogan on Radio and TV. Call Health authorities , when you detect unusual number of mosquitoes.

Health Education + Law Enforcement

“An ounce of Prevention is better than a Pound of Cure”

Integrated Control

- **Both environmental control methods & insecticides**
- **The program requires monitoring of adult and larval population densities and ecology of the vector species**
- **Vector control is effective when applied in the early stages of a potential outbreak, but fails to achieve the desired result when it is introduced at a later period.**



Comments by WHO

- Network on Entomological Surveillance of Dengue fever
- Establishment of the dengue working group
- There are bad news on mosquitoes in they world., allocation at least an entomological position in each county (almost 430).
- Engaging field staff in designing and operationalizing. entomological surveillance
- A better knowledge of the local characteristic s and risk factors for dengue transmission this fundamental to the design of vector control strategies.
- Training courses for public health entomology and vector control personnel.
- Alternative strategies for training doctors and nurses, e.g., distance learning.
- Raise awareness among ministerial decision-makers, program managers at various levels of the health system.


Every thing begins in the field
and ends in the field

Thank You

