Dengue control and dengue mosquito research: An overview

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Dengue

- Often referred to as ‘break-bone fever’
- Caused by a *Flavivirus* with 4 serotypes (DEN-1, DEN-2, DEN-3, DEN-4)
  - No cross-protective immunity
- Transmitted by the *Aedes aegypti* (and *Aedes albopictus*) mosquito
- Most dangerous manifestation: dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS)
  - Most often kills children

Dengue: Transmission

- Transmitted primarily by the *Aedes aegypti* mosquito
  - Bites most often at dawn and dusk
  - ‘container-breeder’
  - Also primary vector of yellow fever
- In some parts of Asia, *Aedes albopictus* is also a vector
  - Prefers more ‘natural’ breeding sites such as tree holes

Dengue Risk Factors

- Local presence of dengue virus, *Aedes aegypti* mosquito vector and a susceptible human population
- Poor water and sanitation
  - Water storage in open containers
  - Trash accumulation
- ‘Open’ houses
- More common in urban/periurban areas

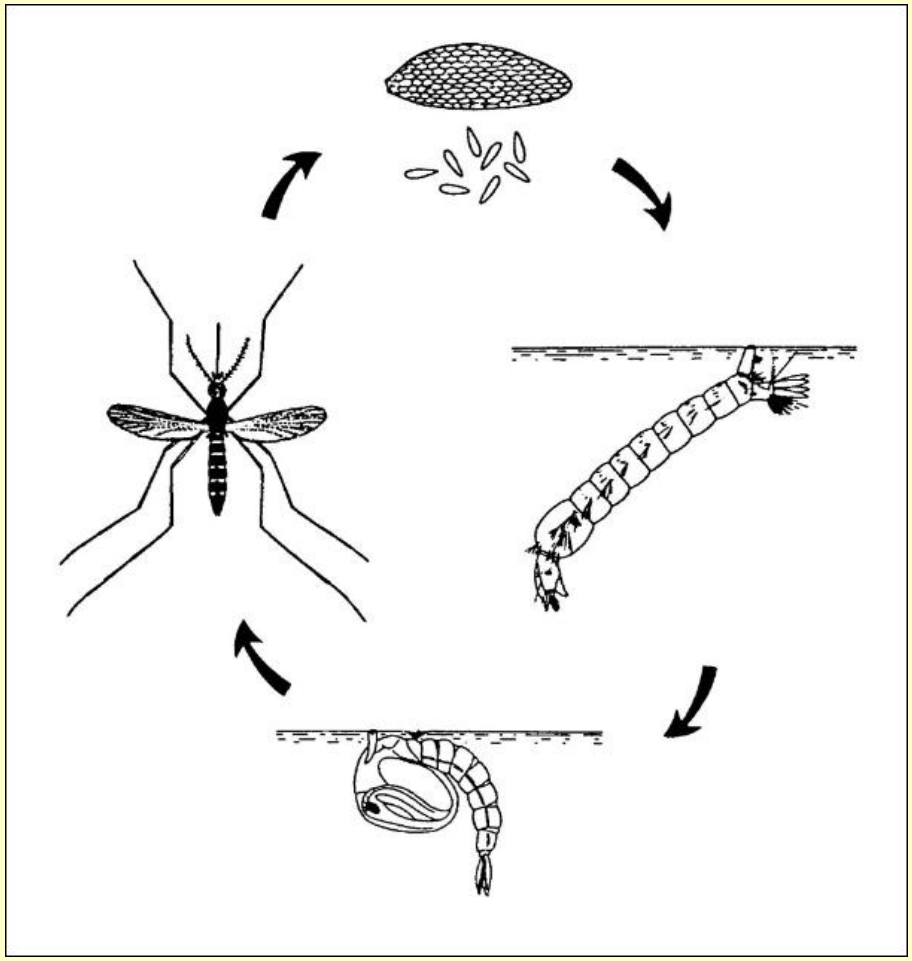
Dengue Control and Prevention

- Currently, vector control is the only way to prevent and control dengue
  - No vaccine
  - No therapeutic medications

Dengue Control and Prevention

- Goal: To control the vector population, so that it is kept below the threshold level necessary for dengue transmission
  - Control is focused almost exclusively on the immature stages of the mosquito

Aedes aegypti life cycle



Dengue Control and Prevention: 4 ‘traditional’ methods

1. Community education and container clean-up
   - Require behaviour modification on the part of the human population
   - Promoted widely by health authorities

2. Application of chemical larvicides and insect growth regulators to water storage containers
   – Abate (temephos)
   – Bti (*Bacillus thuringiensis* var. *israelensis* endotoxin)
   – Pyriproxyfen (Sumilarv®) mock juvenile hormone

Dengue Control and Prevention: 4 ‘traditional’ methods

3. ‘Biological’ solutions:
   - Addition of small fish or copepods to water storage containers

4. Spraying of insecticides to kill adult mosquitoes
   - Outdoor space spraying→ not effective
   - Indoor space spraying → likely effective; especially with residual insecticides

Community education and container clean-up

- Human population instructed on how to keep their water containers free from *Aedes* mosquitoes
  - Proper rubbish disposal
  - Storing containers face-down when not in use
  - Using lids or chemical treatments for intentionally stored water
- Can sometimes work in reducing breeding sites in the short-term, but are usually not sustained

Larvicides: Abate (temephos)

- Organophosphate insecticide
- Most commonly added to household water storage containers in sachets
- Kill existing larvae and prevent future larvae from developing

- Disadvantages:
  - Water looks cloudy
  - Disagreeable taste
  - Limited efficacy

Bti

- *Bacillus thuringiensis* var. *israelensis* endotoxin
- Kills mosquito larvae and is non-toxic to other beneficial organisms
- New long-lasting formulations can endure for 3 months

- Disadvantages:
  - Still introducing something into people's water
  - Limited efficacy
  - Expensive

Larvivorous fish and copepods

- Larvivorous fish prey on mosquito larvae
  - More common in Asia where people keep decorative fish in pots
- Predatory copepods (*Mesocyclops spp*.)
  - Naturally occurring in areas with *Aedes* mosquitoes
  - Success in Vietnam (Nam *et al*. 2005; Kay & Nam 2005)

Insect growth regulators

- Synthetic analogues of insect juvenile hormone
- Prevent the development of larvae into pupae
- Pyriproxyfen
  - Effective at extremely low doses
  - Long-lasting, slow release formulation
  - Mosquitoes can transfer it themselves to other breeding sites
  - Doesn’t alter the look or taste of drinking water

Spraying for adults

- Highly visible but notoriously ineffective due to *Aedes* resting behaviour
- Can sometimes be useful in very focused applications
  - eg: in a defined radius around the home of a person with dengue
- Indoor residual spraying

(IRS) may be effective

Drawbacks of the ‘traditional’ methods

- Resistance of human population to having substances introduced into their water (cloudy water, disagreeable taste)
- Reapplication necessary at regular intervals
  - Incurs regular material and labour costs
- Questionable efficacy

ITMs for dengue control and prevention: a new strategy

- ITMs: Insecticide Treated Materials
  - Insecticide treated curtains

  - Insecticide treated water storage container covers

ITMs: Targeting adult mosquitoes

- Immature control
  - Only affects adult densities
    - But factors other than this can influence dengue transmission, such as mosquito behaviour and survival
- Adult control
  - Still affects mosquito densities
  - Offers the additional benefit of decreased life expectancy
    - Fewer mosquitoes live long enough to become infective

Dengue vector surveillance

- Currently, the only way to control dengue disease is to control dengue vectors
  - How do we determine if vector levels are low enough so that there is no dengue transmission risk?
    - The short answer: We really don’t know!

Stegomyia indices

- Used as a measure of dengue transmission risk
- House Index (HI): % of houses positive for aquatic stages of *A. aegypti*
- Container Index (CI): % of containers positive for aquatic stages of *A. aegypti*
- Breteau Index (BI): number of positive containers per 100 houses

Thresholds for transmission

- WHO recommends that HI or BI $\geq$5 is indicative of yellow fever transmission risk
  - This threshold estimate is also used for dengue control
    - Despite the fact that dengue and yellow fever have completely different etiologies!

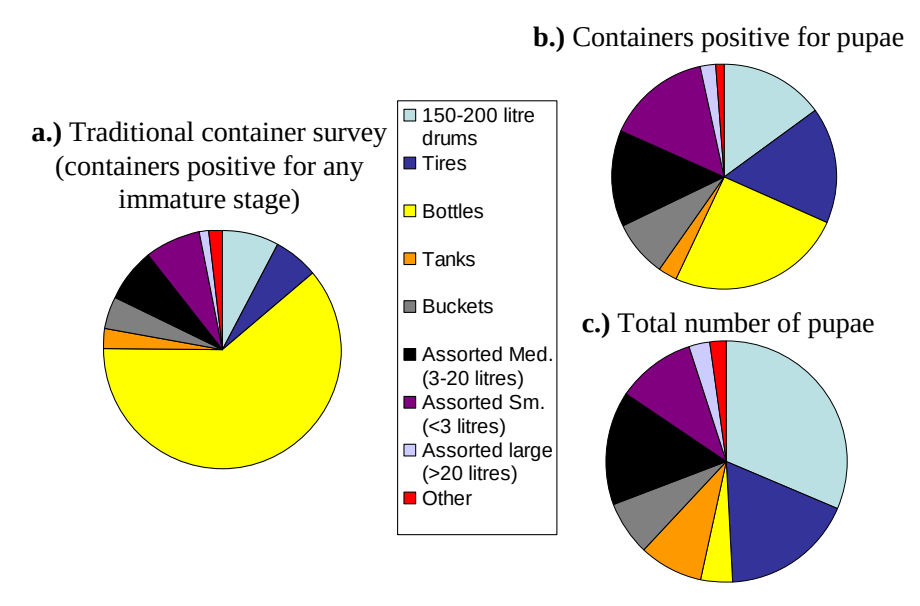
- Better estimates of dengue transmission risk may be achieved through pupal indices

Pupal indices

- The number of pupae may best approximate the number of adults
  - Pupae per person index
  - Pupae per hectare
- Intervening in the containers that produce the greatest number of pupae may be the most efficient approach to vector control

Uniqueness of pupal data

- Pupal data demonstrate the relative importance of containers differently (Lenhart *et al*. 2006)



- Pupae per person (or hectare) may correlate best with dengue transmission risk

Adult indices

- Difficult to measure
  - Most adult traps are not effective at catching *A. aegypti*
  - Backpack aspirator catches are labour intensive and provide limited information

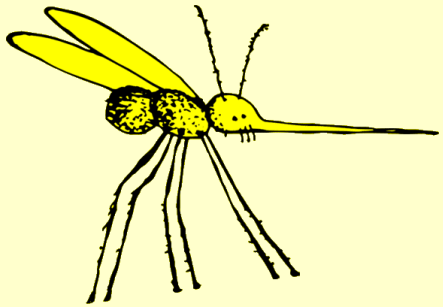
  - Landing catches are not permitted in most places due to ethical constraints

Current dengue vector control research agenda

- ITMs:
  - Continuing to build the body of evidence for their entomological efficacy (multiple current studies)
  - Linking ITM use to serotype-specific dengue transmission dynamics (LSTM)
  - Cost-effectiveness and cost-efficacy studies
  - WHO policy recommendations forthcoming
- Targeted container interventions
  - Based on pupal productivity
  - First round of research: *Annals of Tropical Medicine and Parasitology*, 2006, Vol. 100, Supplement 1

Conclusions

- Many unknowns remain regarding how dengue vector infestations ultimately translate into dengue transmission risk
- Many challenges to effective control exist, and ‘one size does NOT fit all’
  - Preferred breeding containers vary
  - Behavioural and cultural factors can influence dengue vector breeding and acceptance of control strategies
- As dengue continues to increase as a public health problem, novel tools and strategies will be needed for effective control
  - Possibilities of integrating the control of dengue with other diseases



Questions?