Bio Factsheet

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Mosquitoes vs. Mosquitoes: Fighting Dengue Fever

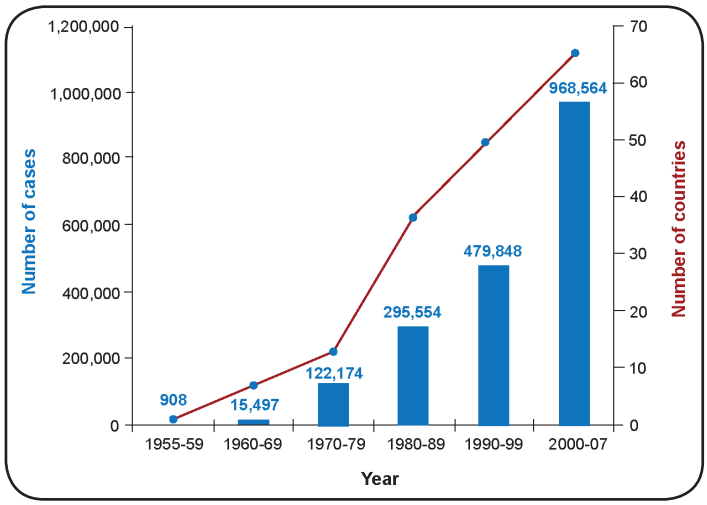
This Factsheet:

- Outlines the cause and symptoms of dengue fever
- Describes how the disease is transmitted
- Describes the life cycle of the mosquito vector
- Outlines the ways in which mosquitoes can be controlled
- Describes how genetically modified mosquitoes can reduce the spread of dengue fever
- Explains how mosquitoes are genetically modified
- Lists the advantages of using GM mosquitoes to control the disease
- Examines some of the ethical issues of genetic modification

Introduction

Dengue fever is a **viral** disease. The virus is spread by mosquitoes. Dengue fever is common in tropical and subtropical areas of the world. In some countries, the disease is **endemic**. This means it is always present in the population. Approximately 50% of the world's population live under the threat of dengue fever. The best way to prevent catching it is to avoid mosquitoes.

Figure 1 The average annual number of dengue fever cases reported to the World Health Organisation together with the average annual number of countries reporting dengue



Dengue Fever

The first case of dengue fever was confirmed by Benjamin Rush in 1789. He called the disease 'break bone fever'. This is because people suffering from the disease have severe muscle and joint pain. Dengue is a **haemorrhagic** disease. This means the virus damages blood vessels and causes bleeding from the nose, gums and under the skin.

Symptoms of Dengue Fever

A person who contracts the dengue virus will have flu-like symptoms including:

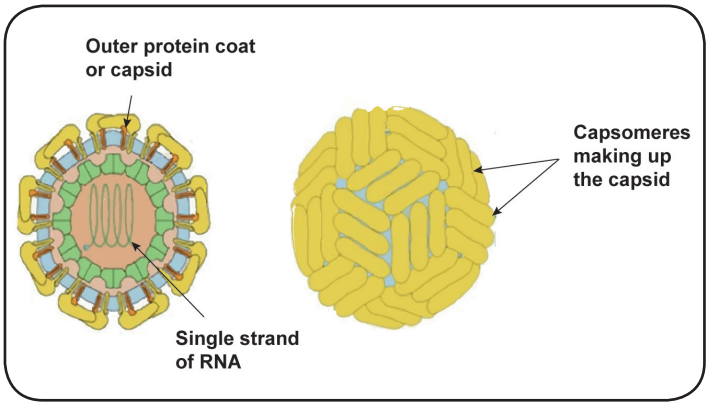
- High fever
- Muscle and joint aches
- Severe headaches
- Nausea and vomiting

There is no specific treatment for dengue fever. However, if the disease is detected early, proper medical treatment can be given. This will decrease the death rate to under 1%. There is a **vaccine** against dengue. The vaccine is only given to people in areas where dengue is common. If the vaccine is given to people who have not previously been infected with the virus, it can increase their chances of contracting dengue.

The Dengue Virus

The dengue virus is a spherical structure. The **virion**, or infectious particle, contains a single strand of **RNA** inside a protein coat. The protein coat or **capsid** is made of units called **capsomeres**.

Figure 2 The internal and external structure of the dengue fever virion



Exam Hint: *A virion is an infectious particle. It has a protein coat inside which is a strand of nucleic acid (either DNA or RNA). The virion is really the vector stage of the virus. Viruses cannot carry out any metabolic processes. They are difficult to classify as living or non-living. Viruses are only active once they are inside a living cell. The host cell reads the instructions on the viral nucleic acid and makes more viral particles.*

Transmission of Dengue Fever

The disease is carried from person to person by a mosquito. The female mosquito can then transmit the virus when she bites a human. The female mosquito feeds on blood. She needs the nutrients in blood to help her eggs develop.

There are two different mosquitoes that transmit the dengue virus:

Aedes aegypti is the primary **vector**.

- This mosquito lives in urban areas
- It is a day-time feeder
- The female feeds on blood; the male does not bite
- The eggs are laid in any containers of water – these could be puddles, swimming pools or flowerpots
- The female bites many people during one feeding period

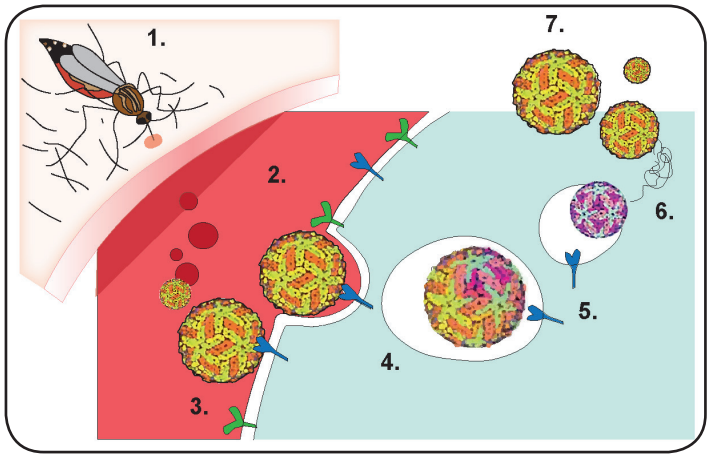
Aedes albopictus is a secondary vector.

- This mosquito is widespread in Asia and has spread to North America and Europe
- It has been able to adapt rapidly to the cooler temperatures found in Europe
- The mosquito can survive the cooler climates because it can hibernate

Exam Hint: *The mosquito is a vector or carrier. The mosquito does not cause dengue fever. An infected mosquito transfers the dengue virus from one human to the next. It is the virus that causes the disease in humans. Mosquitoes are not affected by the virus.*

Exam Hint: *A primary vector is the main carrier of the pathogen. A secondary vector also carries the pathogen but would not maintain a disease if the primary vector was wiped out.*

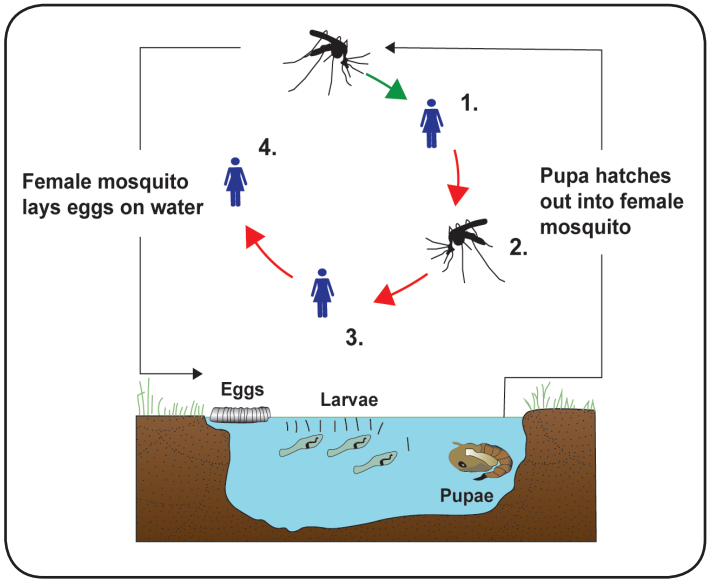
Figure 3 How the female mosquito transmits the dengue virus into a human host



1. Female mosquito taking a blood meal from a human.
2. Viral particles enter the blood from the mosquito's salivary glands.
3. Virus attaches to **receptors** on cell surface membrane.
4. Virus enters the cell in an **endocytotic vesicle**.
5. Viral membrane and vesicle membrane fuse.
6. Viral RNA is released into cytoplasm.
7. Human cell creates more viral particles which are released by **exocytosis**.

Life Cycle of the Mosquito

Figure 4 The life cycle of the *Aedes* mosquito and the transmission of the dengue virus



1. Mosquito bites a person infected with the dengue virus.
2. Dengue virus moves to mosquito's salivary glands.
3. Healthy person is bitten by mosquito and the virus is injected into their blood.
4. The person develops dengue fever.

Controlling Dengue Fever

The best method of preventing dengue fever is to control the mosquito **vector**. This can be done by:

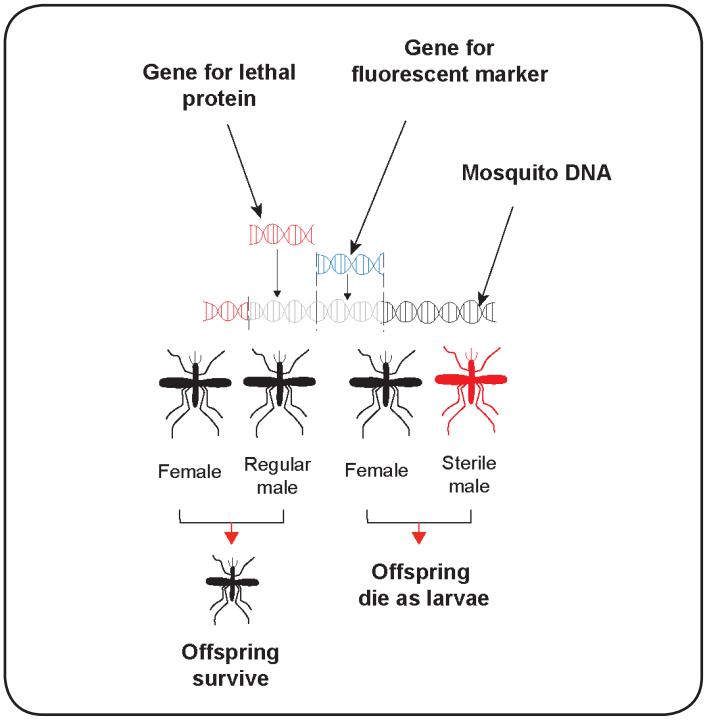
- Preventing mosquitoes from laying their eggs on water by covering or draining any water storage containers
- Using insecticides or larvicides to kill the insects or their larvae
- Covering exposed skin, particularly when the insects are active
- Sleeping under mosquito nets
- Using genetically modified insects to target the wild type

Genetic Modification of Mosquitoes

In Brazil, trials using genetically modified mosquitoes have resulted in a huge drop in the number of cases of dengue fever.

Scientists have **genetically modified** male *Aedes* mosquitoes using a technique called RIDL (Release of Insects carrying a Dominant Lethal). A gene coding for a **lethal** protein is injected into the eggs of the *Aedes* mosquitoes. Another gene for a fluorescent marker is also injected into the eggs. The eggs that have taken up the gene will glow. This helps scientists identify those eggs with the lethal gene.

Figure 5 How the modified mosquitoes are engineered



Male mosquitoes which hatch out produce huge quantities of the lethal protein. This protein kills them. However, if these males are fed an **antibiotic** called **tetracycline**, they do not die.

The modified male mosquitoes are then used to control the wild population.

The process works as follows:

- Adult mosquitoes which carry the lethal gene are mated
- The eggs are collected
- The eggs hatch into larvae
- The larvae are given the antibiotic tetracycline – this antibiotic inactivates the lethal gene
- The larvae develop into pupae
- The male pupae are separated from the female pupae
- The GM male adults hatch in the laboratory
- These males are released into the environment and mate with the wild females
- The GM males continue to produce the lethal protein and die shortly after mating (this is because they no longer have tetracycline)
- Any fertile eggs that hatch should inherit the lethal gene
- The mosquitoes that hatch out will produce the protein and die before reaching adulthood

For the process to work, huge numbers of genetically modified mosquitoes have to be released. This is so they can outcompete the wild ones.

Advantages of Using Genetically Modified Mosquitoes

The trials using the GM mosquitoes in Brazil have shown a 91% drop in the number of cases of dengue fever. However, there are other advantages to using this GM technique:

- **A reduction in the use of insecticides**. Many insecticides harm the environment. Insecticides kill off useful insects. This will affect other species of birds and mammals which eat the insects.
- **Insecticide resistance has built up in the *Aedes* mosquito**. Insects rapidly develop resistance to **pesticides**. This means the chemicals have no effect on the insect. Insecticide resistance has no effect on GM mosquitoes.
- **Each release of GM mosquitoes lasts for one generation only**. There is no long-lasting population of these mosquitoes.

Ethical Issues

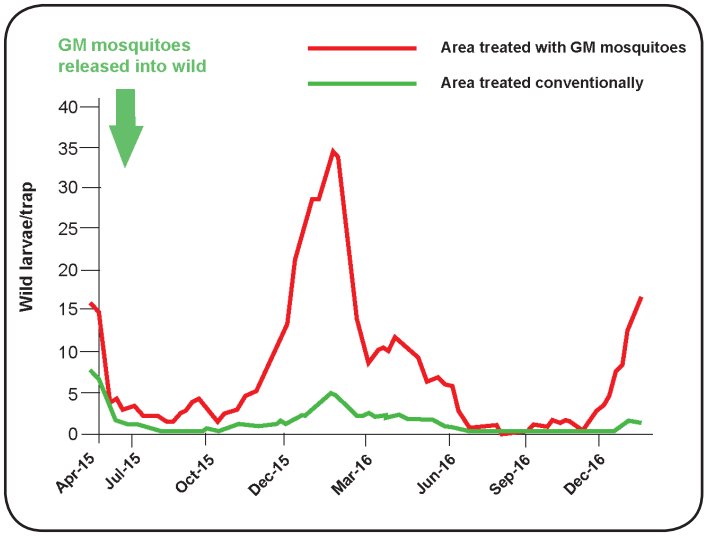
Evidence from the trials of genetically modified mosquitoes shows that this method could be very successful in reducing dengue fever. However, there are many people who do not trust genetically modified organisms. They fear that a superbug may develop which would cause environmental chaos.

The GM mosquitoes were developed by a profit-making company. The involvement of such companies has raised questions as to how much money they will make from the GM technique.

To be successful the production of billions of mosquitoes will be necessary. These have to be produced in laboratories and so the strategy could be very expensive.

Questions

1. Dengue fever is endemic in Brazil. The graph shows the number of mosquito larvae that were trapped every four weeks in two different areas of Brazil. The green line shows the number of mosquitos trapped after genetically modified mosquitoes were released. The red line shows an area where mosquitoes were killed using traditional methods.



a. What does endemic mean?

b. List the symptoms of dengue fever.

c. What traditional methods are used to kill mosquitoes?

d. Describe the effect of releasing the GM mosquitoes into the test area.

e. Explain how genetic modification of the mosquitoes is carried out.

2. Choose the correct word from the list below to fill in the gaps in the table.

An antibiotic used in the production of GM mosquitoes	
A fever that causes bleeding from mouth, gums and nose	
A chemical used to destroy an immature stage of the mosquito life cycle	
An issue where there is no obvious right or wrong answer	
An organism that carries infectious agents	
A non-living pathogen	
The process a cell uses to take in substances from outside	

endocytosis exocytosis virus tetracycline larvicide ethical vector haemorrhagic pesticide

Answers

1. a. a disease that is always present in the population.
   b. fever, headache, joint and muscle pain, bleeding from mouth, gums and nose.
   c. spraying with insecticide, draining water in containers
   d. The release of the GM mosquitoes reduced the number of mosquitoes quite significantly.
   e. A lethal gene is injected into mosquito eggs.
   Males carrying this gene are separated from the females.
   The males are kept alive by giving them tetracycline.
   Millions of males carrying the gene are released into the wild.
   The males mate with wild females and pass on the lethal gene.
   The modified males die shortly after mating.
   Any mosquitoes that inherit the lethal gene also die.

2.

An antibiotic used in the production of GM mosquitoes	tetracycline
A fever that causes bleeding from mouth, gums and nose	haemorrhagic
A chemical used to destroy an immature stage of the mosquito life cycle	larvicide
An issue where there is no obvious right or wrong answer	ethical
An organism that carries infectious agents	vector
A non-living pathogen	virus
The process a cell uses to take in substances from outside	endocytosis

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