

Integrated Vector Management

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What is a vector borne disease

- Disease that results from an infection transmitted to humans and other animals by blood-feeding arthropods, such as mosquitoes, ticks, and fleas.

Disease carrying insects of medically importance

Mosquitoes

Mosquitoes, by far the most important of the disease vectors, number over 3,000 species worldwide. Only the female mosquito can transmit disease because only she, and not the male, has the knife-like mouthparts needed to extract blood from her victims. She needs the blood meal to provide protein for egg formation.

AKA: *Mossies, Nippers, Skeeters*

Diseases vectored: Malaria, Yellow Fever, Dengue Fever, West Nile virus, Rift Valley Fever, Chikungunya, Japanese Encephalitis, Venezuelan Equine Encephalitis, Murray Valley Encephalitis

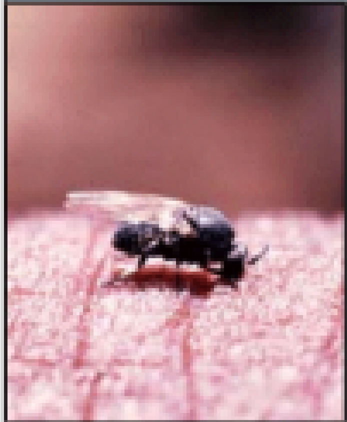
Sand Flies

Closely related to mosquitoes, sand flies are blood-feeders and breed in caves, rodent burrows, manure piles and other dark places that retain humidity and are rich in organic matter. They are weak fliers, tending to move from host to host in short "hopping" flights. Their bodies are so small (3 mm) they are hard to detect until after they begin biting. Their bite generates intense discomfort for several days.

AKA: *Punkies, Black Gnats, No-see-ums, Biting Midges, Chitras,*

Diseases vectored: Leishmaniasis, Sand Fly Fever

Black Flies



Black flies are yet another relative of mosquitoes that are specialized for breeding in running water from small trickles to large rivers. Unlike mosquitoes, black flies feed by slashing through the skin, and they never feed indoors. They can attack in such large numbers that their salivary fluids alone can cause a person to become ill, causing a condition called "black fly fever." They also vector a nematode that can live in the human body for up to fifteen years destroying tissue in internal organs, most notably in the eye thereby causing blindness.

AKA: *Buffalo Gnat, Turkey Gnat, White Socks*

Diseases vectored: River Blindness/Onchocerciasis, Black Fly Fever

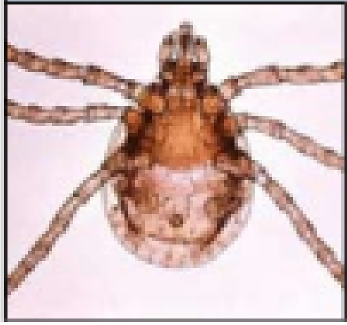
Kissing Bugs

Triatomines are large insects with nocturnal habits. They are typically found in structures with thatched roofs that offer hiding places during the daytime. They are called "kissing bugs" due to their predilection for feeding on the soft skin of people's faces, including lips. Although these can be large insects, their bites are generally painless. After feeding on the victim's blood this insect releases its infected feces near the bite wound. The victim by scratching the bite causes the infection to enter its body.

AKA: *Conenose bugs, Assassin Bugs, Benchuca, Vinchuca, Chipo, Pito, Chupanca, Barbeiro*

Diseases vectored: Chagas

Ticks



Ticks in general have a much longer life cycle than a mosquito. Hard ticks feed only a few times during their lifespan, which tends to limit their odds of acquiring an infection. Nevertheless, the longevity and host selectivity of hard ticks allows them to be relatively efficient vectors. Soft ticks are long-lived nest and burrow dwellers. Like mosquitoes they can feed many times during their lifespan.

Diseases vectored: Tick-borne Encephalitis, Lyme Disease, Tick-borne Relapsing Fever

Characteristics of Vector-Borne Diseases

- High disease transmissibility.
- Explosive, unpredictable spread of disease.
- Resilient to control and prevention because of vector’s small size and sheer numbers.
- Larger range vs diseases that require direct contact.

Integrated Vector Management (IVM)

- Integrated Vector Management is a decision-making process for the management of vector populations, so as to reduce or interrupt transmission of vector-borne diseases (WHO, 2008).

- An IVM-based process should be cost-effective, should have indicators for monitoring efficacy with respect to impact on vector populations and disease transmission.

Rationale

- Driving forces behind a growing interest in IVM include the need to overcome challenges experienced with conventional single-intervention approaches to vector control as well as recent opportunities for promoting multi-sectoral approaches to human health.

Why do we need IVM?

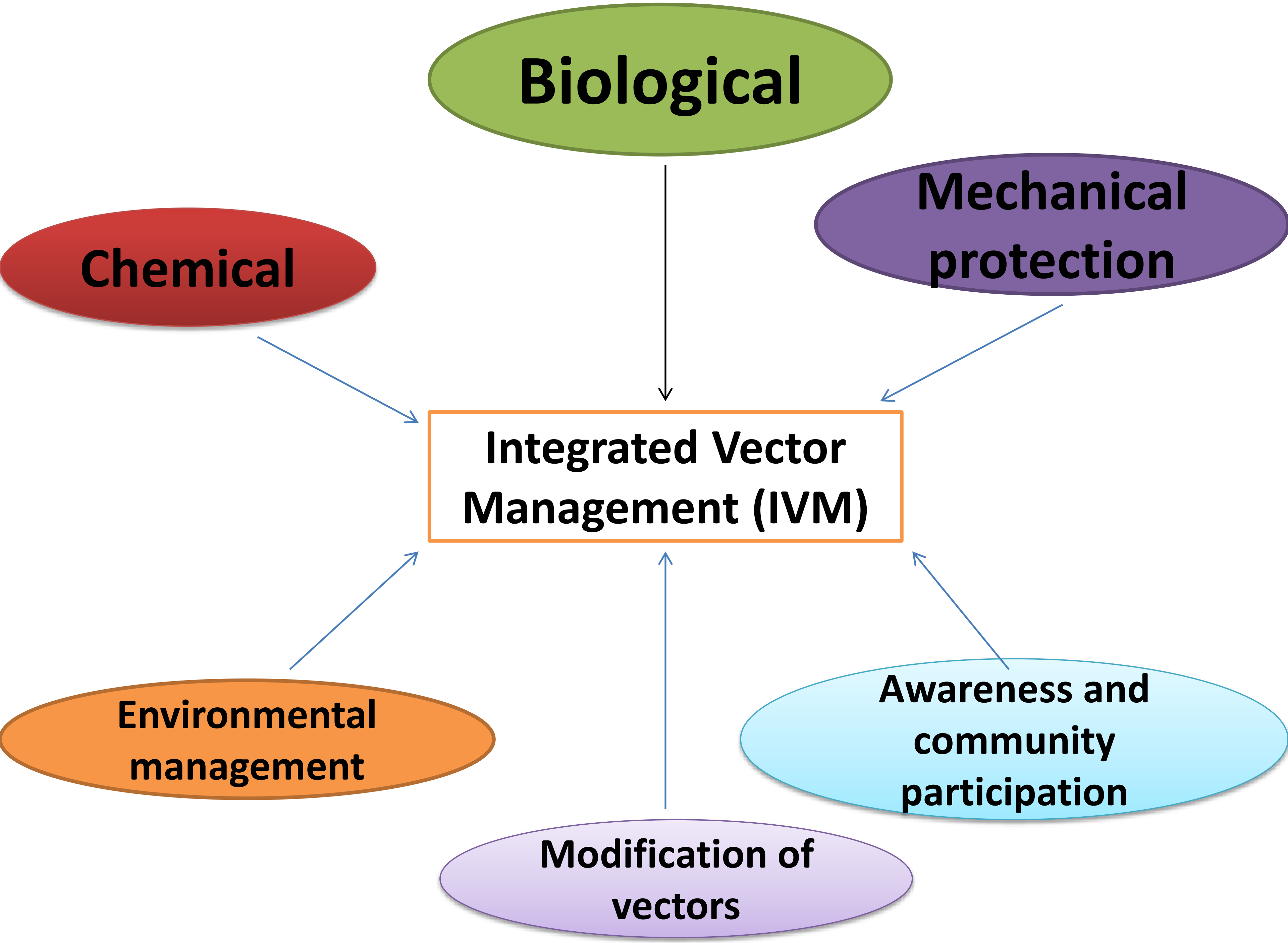
- Vector-borne infectious diseases, such as lymphatic filariasis, Japanese encephalitis, dengue fever are still exist in the country.
- There is an increase in dengue cases during last two decades in the country.
- The WHO warns of rapid rise in vector borne diseases.

Key elements of an IVM strategy

N°	Element	Description
1.	Advocacy, social mobilization and legislation	Promotion and embedding of IVM principles in designing policies in all relevant agencies, organizations and civil society; establishment or strengthening of regulatory and legislative controls for public health; empowerment of communities
2.	Collaboration within the health sector and with other sectors	Consideration of all options for collaboration within and between public and private sectors; application of the principles of subsidiarity in planning and decision-making; strengthening channels of communication among policy-makers, vector-borne disease programme managers and other IVM partners
3.	Integrated approach	Ensure rational use of available resources by addressing several diseases, integrating non-chemical and chemical vector control methods and integrating with other disease control methods
4.	Evidence-based decision--making	Adaptation of strategies and interventions to local ecology, epidemiology and resources, guided by operational research and subject to routine monitoring and evaluation
5.	Capacity-building	Provision of the essential material infrastructure, financial resources and human resources at national and local level to manage IVM strategies on the basis of a situational analysis

[a] Source: Global strategic framework for integrated vector management (*8*).

Components of IVM

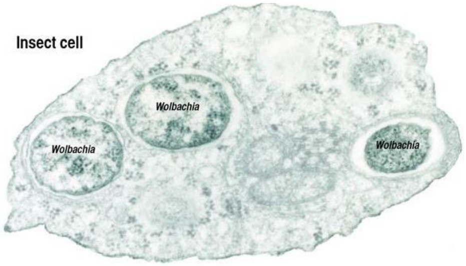

Biological
Chemical
Mechanical protection
Integrated Vector Management (IVM)
Environmental management
Modification of vectors
Awareness and community participation

Use of biological control agents

Toxorhynchites

Larvivorous fish

Copepods



Wolbachia

Larvivorous fish

- For mosquito control, larvivorous fish, have been used successfully as biological control agents in water jars, drains and other large containers.

- Therefore, larvivirous fish species can be used as an effective, eco-friendly controlling measure.

Danio rerio

Copepods

- Cyclopoid copepods are tiny crustaceans live in fresh water habitats.

- Most of them are predators of first instar mosquito larvae and more effective for biological control than other predatory invertebrates, because it is so common for cyclopoids to be numerically abundant.

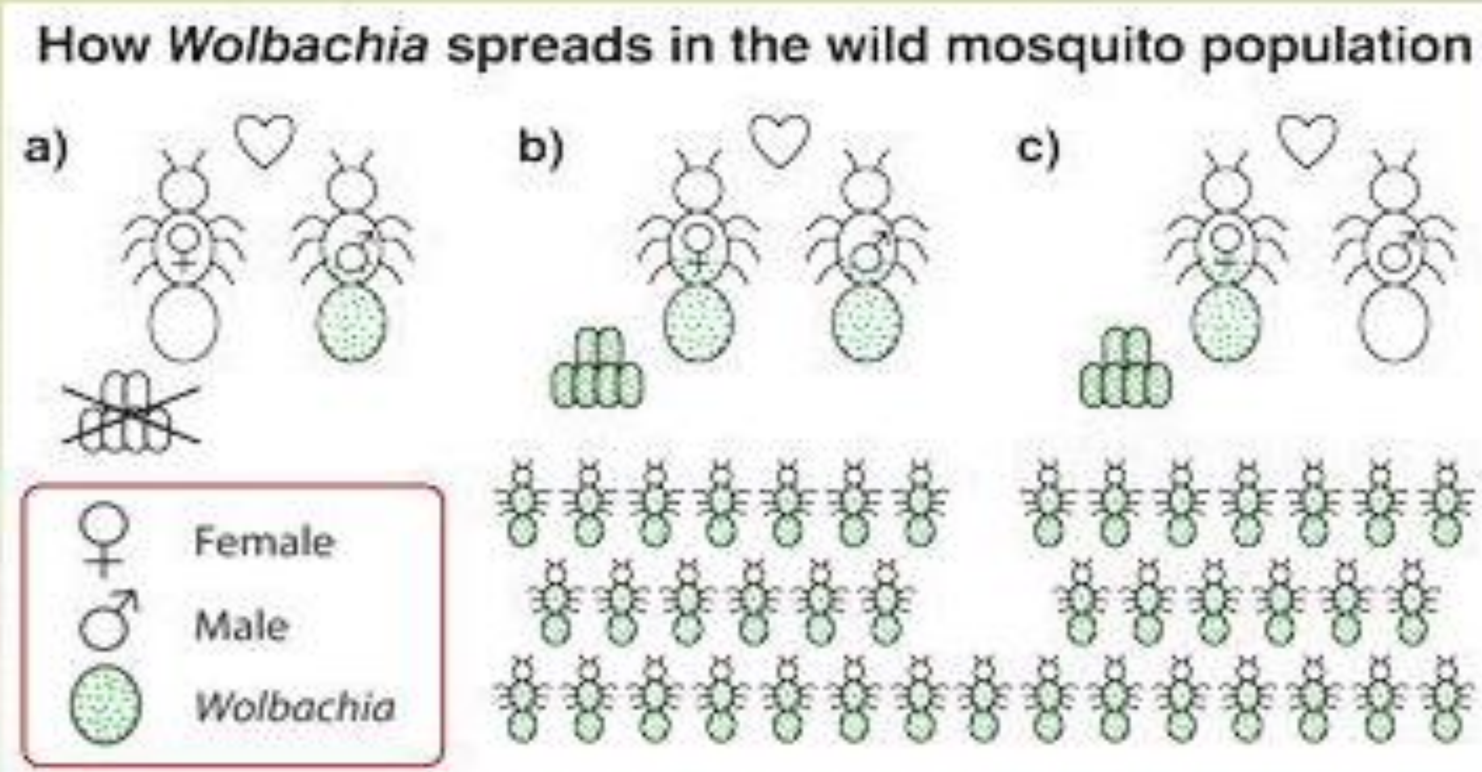
Wolbachia (Bacteria) strains

- *Wolbachia,* an obligate intracellular bacterium that lives inside insects and is transmitted vertically from mother to offspring.

- Alternatively, releasing males harboring a different *Wolbachia* strain from that present in a wild population will also produce reproductive incompatibilities.

- When the strain *Wolbachia* is released via females, it will not only block pathogen spread via the action of cytoplasmic incompatibility, but also reduce the insect lifespan.

HOW *WOLBACHIA* SPREADS IN INSECT POPULATIONS



The diagram above explains **Cytoplasmic Incompatibility** and how by releasing a limited number of mosquitoes with *Wolbachia* to breed with wild type mosquitoes, over a small number of generations, will result in all the mosquitoes having *Wolbachia*.

Biological larviciding

- The use of bacteria against mosquito larvae or pupae (e.g. *Baccillus thuringiensis*).

- *Baccillus thuringiensis* **israelensis** (***Bti***) is a group of bacteria used as biological control agents for larvae stages of certain Dipterans.

- *Bti* produces toxins which are effective in killing various species of mosquitoes.

2. Biolarvicides

- Bacteria for the control of mosquito larvae. Bacillus thuringiensis H 14 and Bacillus sphaericus.
- Available as wettable powder and granules which contain bacteria, spores and toxic crystals.
- Safe to environment , human being and animals but are expensive.

Bacillus thuringiensis H 14

- Gram positive, spore forming bacteria which is specifically acts against mosquito larvae.
- Produces endotoxin which after ingestion causes gut paralysis & leakage of contents into body cavity leading to death.

Use of chemical control agents

Indoor Residual Spraying (IRS)

- Timely application of long-lasting chemical insecticides on the walls and ceilings of houses in order to kill the adult vectors that land on these surfaces.

Chemical larvicides

- The release of chemicals on water bodies and surfaces to kill larvae and pupae of insect vectors.

Temephos: is highly active against mosquito larvae and other aquatic insects, while it has low toxicity for fish, birds, mammals and humans. It is also recommended for vector larvae control in drinking water.

Fenthion: quickly kills larvae and has a long residual effect. However, fenthion has a high toxicity for humans, birds and mammals, so it should not be used in drinking-water supplies for humans or animals.

Malathion: is used primarily as a residual spray against adult vector species, but it also kills vector larvae in breeding sites in sprayed areas.

Insect growth regulators

- ***Methoprene***, an insect growth regulator, is considered to be safe for use in drinking water by the WHO.

- Methoprene is often applied using briquettes, which release the chemical slowly over a period of up to four months in stagnant water, but in flowing water this period of time is reduced.

- An advantage of methoprene briquettes is that if the breeding site dries up, the briquettes remain effective until it is flooded again.

- Leaf axils of economically valuable crops such as pineapple are of the best breeding habitats for dengue mosquitoes.

- Pyriproxyfen is an insect growth regulator, which inhibit the normal development of mosquitoes.

- It has a high margin of safety for mammals.

Modification of vectors by Sterile Insect Technology (SIT) and other genetic engineering techniques

Use of irradiation method to produce sterile male mosquitoes

- Male insects are exposed to Gamma-irradiation or sterilizing chemicals, causing large scale random damage to the insect chromosomes or dominant lethal mutation in the sperm.

- These males are then released in far larger numbers that occur in the wild females, and viable offspring are rarely produced after mating.

- With ongoing release of these males, the population reduces to low levels or is completely eliminated.

Development of dengue virus resistance in genetically modified *Aedes aegypti* : Engineering RNA interference-based resistance

- RNA molecules inhibit gene expression, typically by causing the destruction of specific mRNA molecules.

- Genetic modification of dengue virus vector *Ae. aegypti* will be undertaken towards the development of RNA interference-based resistance to dengue virus type 2 in genetically modified *Ae. aegypti*.

- A key principal in this control strategy is the expression of an effector gene in the *Ae. aegypti* that inhibits viral replication.

- Effector gene : Gene that expresses an inverted-repeat (IR) RNA derived from the premembrane protein coding region of the dengue-2 RNA genome.

- The *Ae. aegypti* carboxypeptidase A promoter is used to express the IR RNA in midgut epithelial cells of *Ae. aegypti*.

Feasibility of using Genetically Modified dengue mosquitoes to suppress vector population

(Release of Insects carrying a Dominant Lethal genetic system- RIDL)

- The RIDL approach is similar to the sterile insect technique.

- The difference is use of genetics to stop the insects from reproducing.

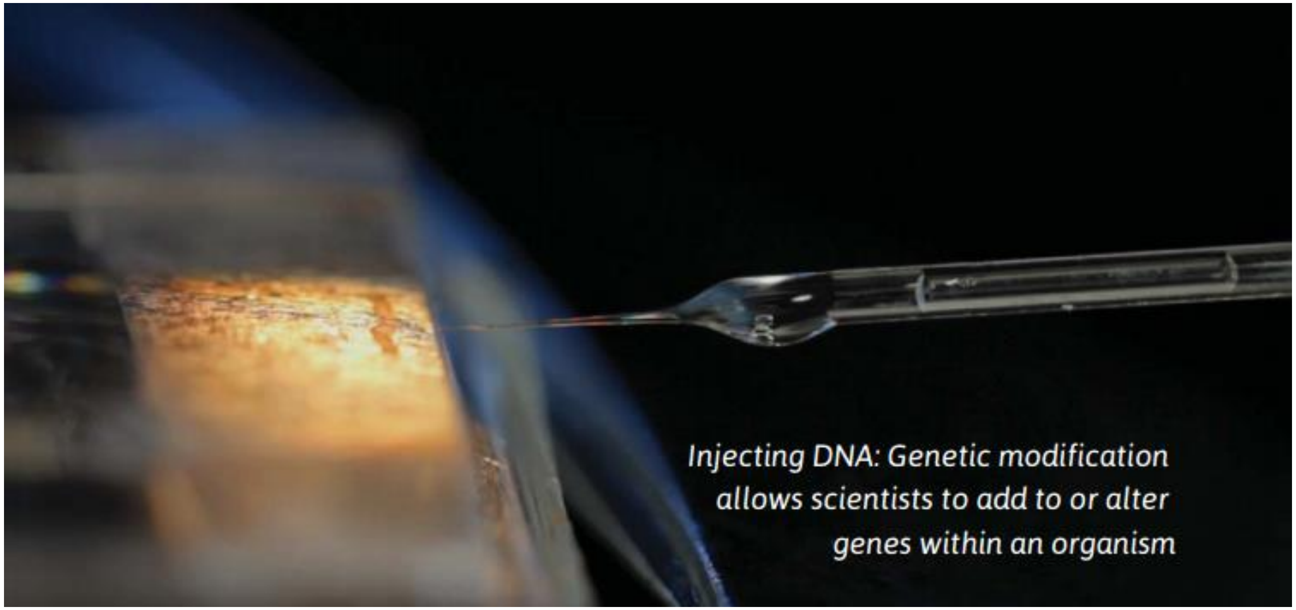
- This technique modifies mosquitoes by adding a leathal gene which produces a protein (tTA) that stops their cells from functioning normally.

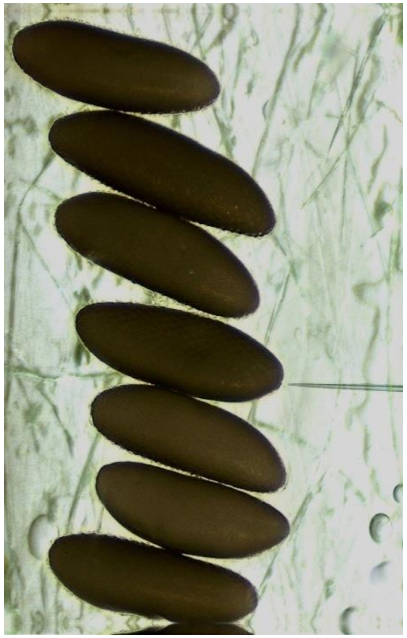
- This protein acts as a switch that controls the activity of other genes.

- It can interact with other proteins which are needed for controlling genes in the cell, and in this way it stops the cell from turning on other genes which are essential for it to survive.

- All this means that the modified mosquitoes become very sick, and die before reaching adulthood.

Microinjection



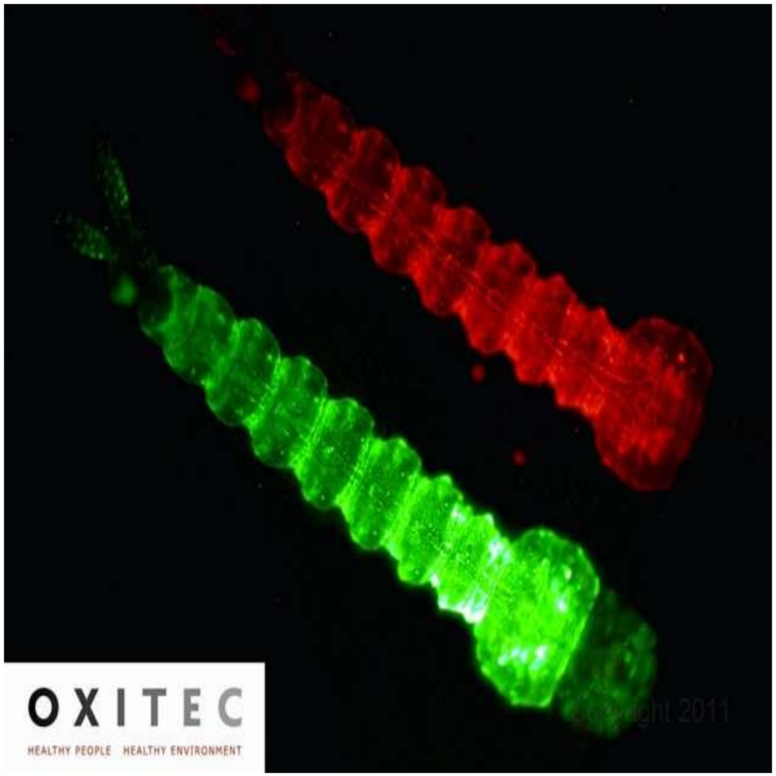


Source: http://www.oxitec.com/wpcms/wp-content/uploads/Oxitec_Dengue-Mosquitos-Genes_V1-4D-information-pack2.pdf

If the gene kills them, how does that make them sterile?

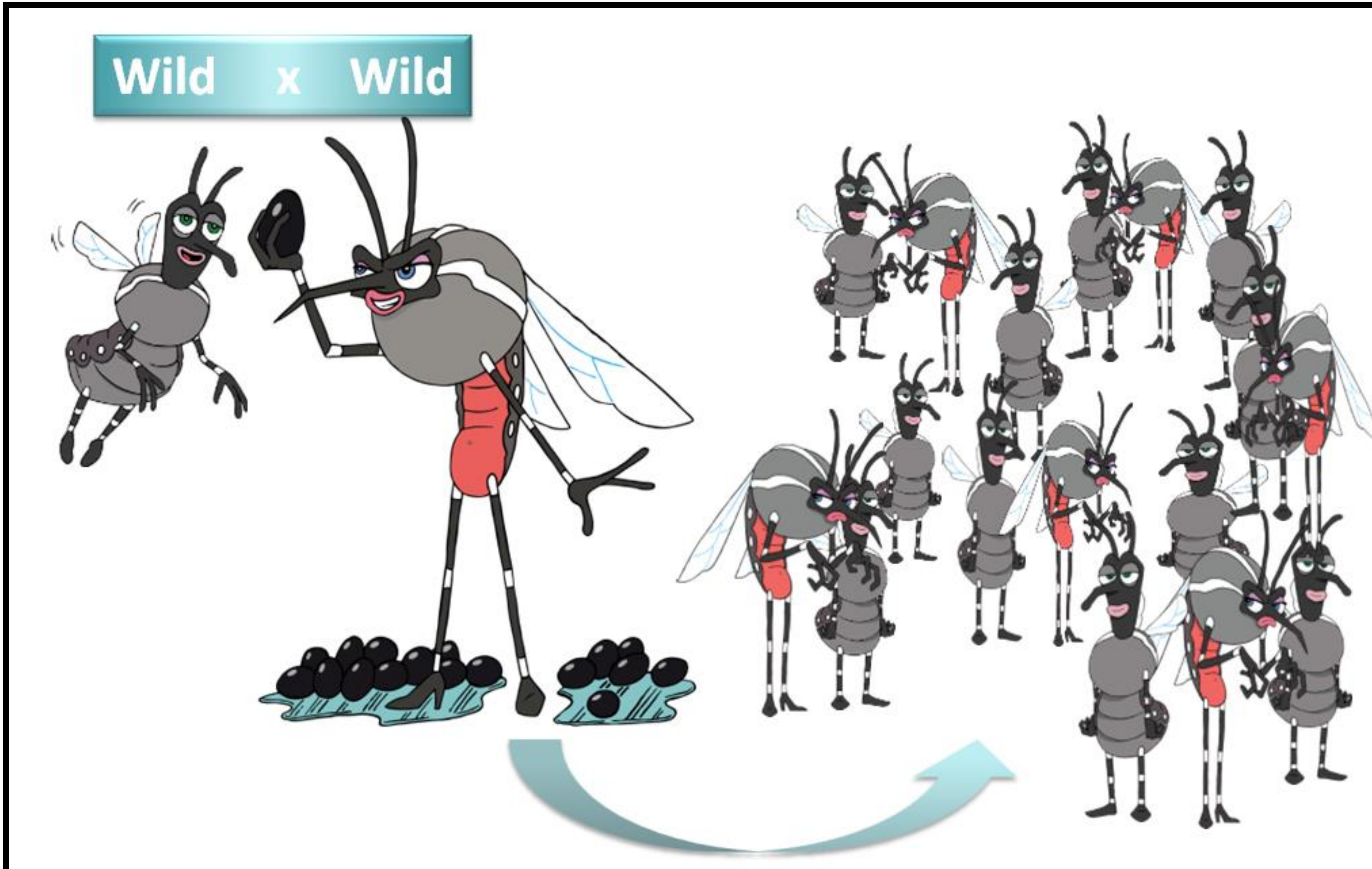
- When the mosquitoes are reared in the presence of tetracycline, it stops the **tTA** from working - in effect, it acts like an antidote.

How to identify the transgenic mosquitoes.

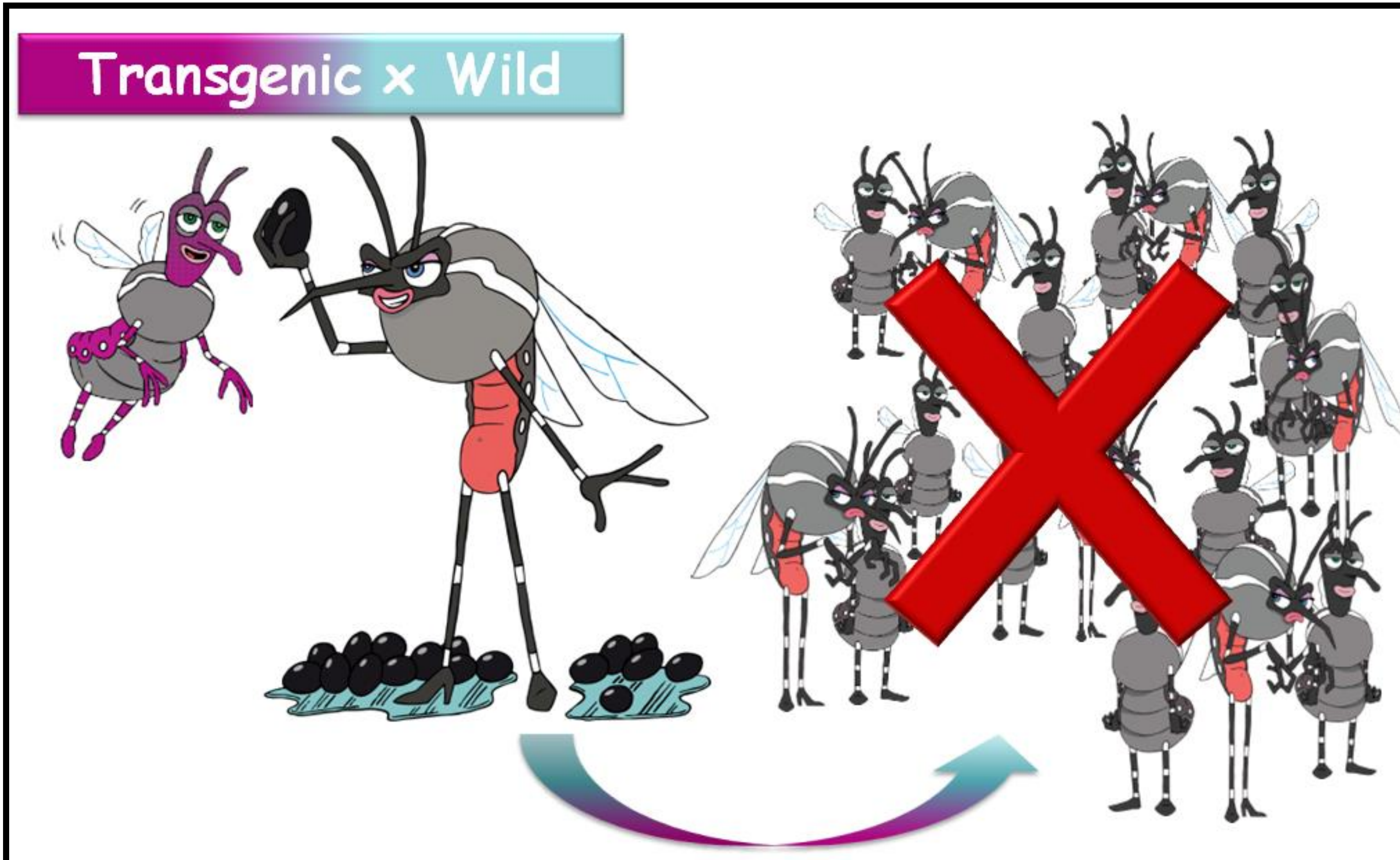


Repressible lethal trait, and fluorescent marker gene, introduced into the germline through embryonic injection of DNA.

Natural population



Transgenic population



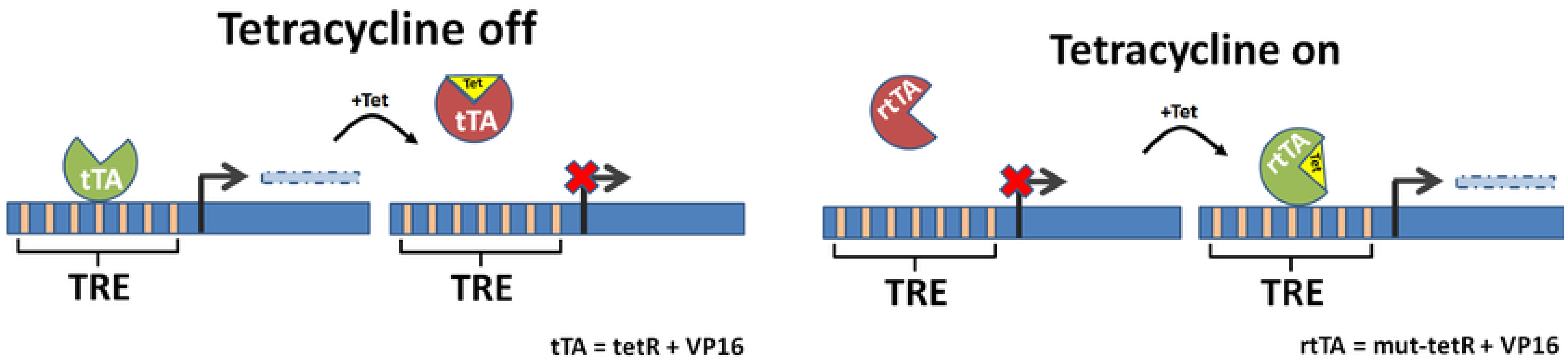
Limitations

- “Rebound” effect could be more serious if a technology is used that becomes less effective over time.
- There is no assurance of 100% mortality in the offspring.
- Not effective at reducing high density populations of insects.
- Genetical incompatibility and behavioral changes in the local population.

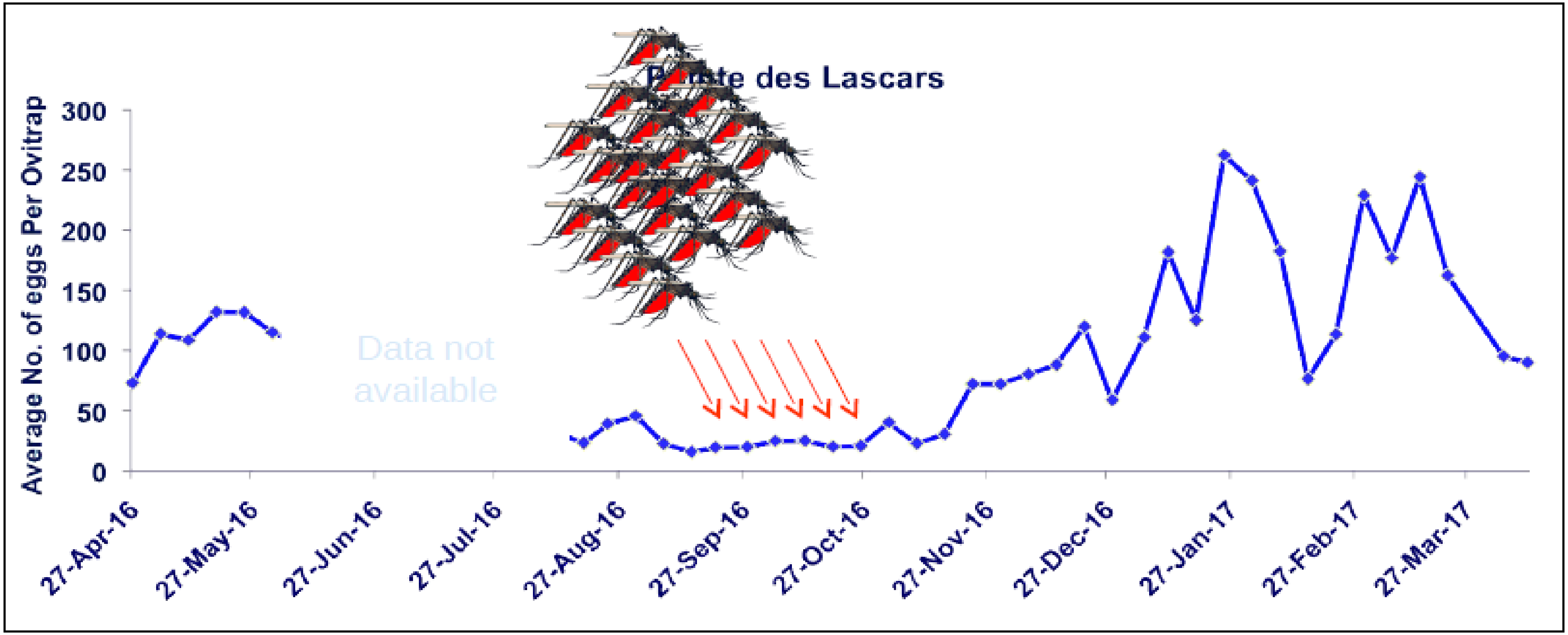
- No sufficient published information to demonstrate that surviving GM females do not pose risk to the public health.

- The fluorescence marker in the GM insects begins to disappear especially in hot weather. Therefore, open release and monitoring trials may be in adequately monitored.

- In Herpes Simplex Virus (HSV), there is a transcriptional activation domain called **Virion protein 16 (VP16).**
- The C terminator of the VP16 has fused with Tetracycline repressor gene (tetR).



Releasing modified vectors



Physical/ mechanical protection

Long Lasting Insecticidal Nets (LLINs)

- The use of long lasting insecticide treated nets (LLIN) is one of the most effective ways to prevent malaria.

- This prevents bites from disease-baring insects.

- LLINs have a double effect, working as a physical barrier preventing the mosquitoes from reaching their pray, but also as a chemical barrier: the insecticide repels the mosquitoes or kills them when they enter into contact with the net.

Other Insecticide-Impregnated Materials

- Use of insecticide-impregnated clothing, coverings (blankets), door and window blinds, etc to prevent human-vector contact and bites.

Environmental management trough community participation

- Environmental management through community participation can be performed using
  - Modification of the natural environment to reduce breeding habitats
  - Modification of human habitats or behaviors to reduce biting incidence
  - Waste management through community mobilization to reduce breeding places

Benefits of IVM:

- Improves management of insecticides and effective mitigation of potential negative health and environmental impacts of vector control interventions.

- Provides a sound basis for management of insecticide resistance in disease vectors.

- Enhances inter-sectoral accountability, leading to responsible actions among a wider range of stakeholders.

- Provides a framework to sustain and maximize the impact of vector control interventions.

- Maximizes the utilization of available resources.

Challenges

- Developing resistance to insecticides by the vector species.
- Drug resistance by pathogens.
- Changes in the virus serotypes.
- Knowledge and attitudes of general public.
- Improper implementation on interated vector controlling programs.
- Poor monitoring of such programs.

THANK YOU