ILM Wolbachia technology
A sustainable approach to mosquito suppression and elimination

Institut Louis Malardé, Tahiti, French Polynesia

Collaborating partners

Context

Aedes mosquitoes (principally *Ae. aegypti, Ae. polynesiensis, and Ae. albopictus*) severely affect the health and well-being of Pacific island communities by transmitting infectious diseases such as lymphatic filariasis, dengue and chikungunya (Fig. 1). Widely distributed across the Pacific, these vector species are also a major source of nuisance affecting local tourism, and the sustainability of Pacific island economies. *Ae. polynesiensis* is an exophilic, day biting mosquito which uses a wide range of domestic and natural larval containers (e.g. rat-chewed coconuts), making classical control impractical, expensive and short lasting.

Wolbachia, a unique mosquito control technology

To improve mosquito control, Institut Louis Malardé (ILM) recently developed and field validated an integrated approach combining innovative mosquito surveillance and control. Our approach which does not rely on the use of insecticides, resulted in the **complete elimination** of the mosquito *Aedes aegypti* on a private atoll (ca. 21 ha) in the Tuamotu archipelago, French Polynesia. Most recently, ILM conducted an unprecedented suppression trial in the Society islands, French Polynesia. This pilot study investigated the efficacy of the incompatible insect technique (IIT) to suppress a naturally isolated mosquito population. Our operation resulted in the **successful suppression** of an isolated mosquito population (*Aedes polynesiensis*) at The Brando, a luxury hotel (ca. 1 sq. km) operating on the private atoll of Tetiaroa, North of Tahiti. This operation relied in part on the release of ILM *Wolbachia* incompatible males mosquitoes that seek, mate and sterilize mosquito females. Sustained, weekly releases of incompatible males (Fig. 2) resulted in the complete and lasting suppression of the mosquito nuisance. Thanks to ILM's intervention, mosquito nuisance has disappeared. The hotel no longer sprays insecticides, which is good for its guests, its employees, and for the environment (Fig. 3). Stemming from this success, our vision is to eliminate mosquitoes vectors of diseases from the Society Islands and beyond over the next decade.

Figure 1 : A blood-feeding *Aedes aegypti* female. This species and the polynesian tiger mosquito (*Ae. polynesiensis*) can both transmit diseases like dengue, Zika, or chikungunya.

How does the ILM technology work?

Our technology uses a bacterium called *Wolbachia*, which occurs naturally in insects. Our incompatible mosquitoes, which contain *Wolbachia*, are mass-produced at our mosquito facility in Tahiti. Females which bite, bloodfeed and can potentially transmit diseases are systematically removed using a mechanical sorter. Once sorted, incompatible males are packaged and transported as airfreight in a standard cooler for subsequent release in infested areas. Once released, incompatible male mosquitoes will seek and mate with females of their own species, making this technology species-specific and therefore safe for humans and the environment. Mosquito females only mate once so they are sterile for life. Without viable offsprings, the mosquito population rapidly crashes.

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Figure 2 : Principal lab and field steps of ILM technology for mosquito elimination: (A) mass-production of incompatible mosquitoes, (B) removal of mosquito female pupae using mechanical sorter, (C) packaging of male pupae, (D) transport of incompatible males in standard cooler, (E) preparing for male release, (F) adult males inside buckets ready for release, (G) ILM scientist Dr. H. Bossin and his staff inspecting mosquito traps, and (H) release of incompatible male mosquitoes

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Figure 3 : (A) actor Johnny Depp and (B) president Barack Obama releasing incompatible male mosquitoes with ILM mosquito team at the Tetiaroa research station. Guests at The Brando enjoy the mosquito free environment achieved by ILM with its unique mosquito surveillance and control strategy.

Are male mosquitoes not a source of nuisance?

No. Unlike females, male mosquitoes don't bite, they dont bloodfeed, and hence they can not transmit diseases.

What is *Wolbachia*?

Wolbachia are naturally occurring symbiotic bacteria that live only inside insect cells. Scientists estimate that it is one of the most common bacteria on the planet, occurring naturally in up to 60% of all insect species, including bees, butterflies, dragonflies and many mosquito species. While common in insects, *Wolbachia* is not infectious and cannot be transmitted to people, pets or any warm blooded animals.

Does the technology include genetic modification?

No. The *Wolbachia* infection is 100% natural. We replaced the *Wolbachia* already present in the polynesian tiger mosquito by another *Wolbachia* strain naturally occurring in a different mosquito species.

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How efficient is the ILM technology?
Very efficient, our operations in the field demonstrate that mosquito populations including the polynesian tiger mosquito can be efficiently suppressed and ultimately eliminated using ILM integrated approach.

Why do incompatible male mosquitoes need to be released for a relatively long period of time?
While mosquito females only live 2-3 weeks, their eggs (measuring less than 0.5 mm) can survive for many months. Even after the biting nuisance is gone, mosquito eggs are still present which can be a temporary source for re-infestation. The sustained release of sterilizing males is thus required until all mosquito eggs on the motu disappear (which can take over a year depending on weather conditions), This is to make sure females arising from these eggs are properly sterilized and don't contribute to motu re-infestation.

Once elimination is achieved, how long will it last?
Aedes mosquitoes are relatively poor flyers, During the course of its short life, a mosquito female typically won't fly more than a 150 m away from its breeding site. Moreover, *Aedes* mosquitoes tend not to venture across open areas like a lagoon. They also stay put under windy conditions. Once a mosquito population is successfully eliminated from an island, it will not easily come back unless re-introduced by humans (e.g. boat or airplane transfers). Because, mosquitoes on the main island are abundant, biosecurity measures combined with regular motu inspections need to be enforced to reduce the risk of re-infestation.

Why conventional mosquito control methods don't work in the long run?
Typical mosquito control methods too often rely on insecticide spraying which is harmful for the environment and rapidly selects for mosquitoes that are resistant. Moreover, mosquitoes like the polynesian tiger mosquito develop in natural water-holding containers like rat-chewed coconuts, tree holes, or even crab-burrows which makes classical intervention impractical and inefficient.

What makes the polynesian tiger mosquito so difficult to control?
The polynesian tiger mosquito, *Ae. polynesiensis,* is an outdoor, day biting mosquito that is native from the Pacific. Its larvae develop in a wide range of domestic and natural containers (e.g. rat-chewed coconuts), making classical mosquito control impractical, expensive and short lasting.

Regulatory aspects
ILM operates in the framework of French Polynesia Council of Ministers Decree CM1392 (Oct. 17th 2007) which allows the experimental use of incompatible male mosquitoes.

ILM mosquito projects in the media
- « Bacteria could be key to freeing South Pacific of mosquitoes » Nature News 1st August 2017 (writer Emma Marris)
- « Génétique ou rayons X: les nouvelles armes contre les moustiques » L'Express magazine, 15 July 2017 (writer Stéphanie Benz)
- « Sur le fil du Zika » documentary, Canal+ Outre mer (first aired on 28 juin 2017)
- "Moustiques stérilisants: l'arme biologique contre les virus" news report, Polynésie 1ère evening news (16 mars 2017)
- « Polynésie, un écosystème sous haute surveillance », magazine Sur les Routes de la Science, Ushuaia TV (9 avril 2017), ICI Explora, and Universcience.TV.
- Tahiti Pacifique, Mars 2017 « Lutte anti vectorielle : lâchers massifs de moustiques modifiés sur Tahiti ? », n° 350

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- Tahiti Infos, 25 janvier 2017 « Un moustique stérile pour lutter contre la dengue, le zika et le chikungunya »
- France Ô, « Zika en Polynésie, les prémices d'une pandémie » documentaire diffusé le 4 janvier 2017 dans le magazine "Investigations"
- National Geographic, "Mosquitoes May Meet Their End Thanks to Marlon Brando", 21 octobre 2016
- Tahiti Infos, 27 avril 2016, «Un nouveau laboratoire pour produire des moustiques stériles »
- Polynésie 1ère, journal télévisé du 23 mars 2016 « Lutte anti moustiques : l'institut Malardé en passe de gagner la guerre ! »
- Tahiti Infos, 23 mars 2016 « L'expérience des moustiques stériles à Tetiaroa est concluante »
- StatNews, 3 mars 2016, « Mosquitoes don't bug rich tourists on Marlon Brando's island. Here's why that matters »
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