

PUBLIC ENEMY THE M



NUMBER ONE SQUITO

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Mosquitoes and global warming

The recent surge in dengue fever, Zika virus, chikungunya and yellow fever correlates with the proliferation of mosquitoes in affected countries. This escalation is likely due to global warming which increases the breeding habitat for mosquitoes.¹ Admittedly, there are other diseases and medical problems associated with climate change, but we shall confine our discussion to mosquito-borne diseases. Are we to take the blame for our failure to curb global warming? Certainly 16-year-old Greta Thunberg, in her speech to the United Nations in September 2019, thinks so.² Yes, I'm afraid that the older generation, through our inaction, must bear much of the responsibility for climate change and the ensuing increased incidence of associated diseases.

Mosquito-borne diseases are the number-one killers

Mosquito-borne diseases infect about 300 million and kill about half a million people each year. Mosquitoes are therefore considered the greatest vector-borne infectious killers in the world.^{3,4} Malaria remains the biggest scourge, but thanks to concerted efforts of the World Health Organization (WHO) and the Bill and Melinda Gates Foundation, its incidence is starting to fall. Worldwide, malaria infected 219 million people and claimed 435,000 lives in 2017.⁵ In

comparison, dengue was estimated to cause 60 million symptomatic cases and was responsible for 13,600 deaths worldwide in 2013.⁶

The Singapore experience

The WHO declared Singapore malaria-free in 1982,⁷ and the only new cases of malaria seen in Singapore since were brought in by travellers who contracted the disease overseas. In contrast, Singapore has seen other mosquito-borne diseases. In 2016, Zika was first diagnosed in a total of 255 patients. It fell to 67 cases in 2017 and only one case in 2018. However, dengue fever has surged in 2019 to infect over 15,998 people and has caused 20 deaths.⁸ This is rapidly approaching the 2016 levels where 13,085 cases of dengue were reported.

The enemy

Sun Tzu (544 BC – 496 BC), in his book *The Art of War*, wrote about the importance of "knowing your enemy". Therefore, we need to know a bit more about our enemy – the mosquito.

Mosquitoes first appeared on earth some 100 million years ago, as evidenced by their fossilised remains embedded in amber found in Myanmar.⁹ Today, the mosquito population totals 110 trillion.¹⁰ There are 3,500 species of mosquitoes, but the ones that mostly concern us are the anopheles and culex species which transmit malaria. In South East Asia, we are most worried about *aedes aegypti* and *aedes albopictus* which are responsible for dengue, Zika, and chikungunya fever.¹¹

How the mosquito has made a significant impact throughout human history is well documented in the 2019 book, *The Mosquito: A Human History of Our Deadliest Predator* by Timothy Winegard.¹² It is highly recommended.

Adult mosquitoes have a length that ranges from 3 to 6 mm and they weigh about 5 mg. Female mosquitoes flap their wings around 500 beats per second, while males flap slightly faster at 600

beats per second. They can fly at a speed of 2.4 km per hour and their flight range is usually less than 50 metres. Their life cycle is about eight to ten days, and the female lays between 50 to 200 eggs per clutch. The lifespan of the female mosquito is 42 to 56 days, while the male mosquito's lifespan is a mere ten days.¹³

Only female mosquitoes bite their hosts and thereby transmit diseases. The most common species that cause human diseases are the anopheles, aedes and culex. In South East Asia, only the anopheles and aedes mosquitoes cause a significant public health problem. The anopheles mosquito is slightly yellowish in colour, and the aedes has black and white stripes. The anopheles mosquito's resting position is 45 degrees whereas the aedes is parallel to the surface. The anopheles mosquito carries malaria, while the aedes mosquito transmits dengue, Zika and chikungunya; in other countries, the aedes mosquitoes carry yellow fever, West Nile Fever and eastern equine encephalitis.¹¹

Who do mosquitoes prefer to bite?

Mosquitoes are attracted to carbon dioxide¹⁴ and warm, sweaty skin.¹⁵ Therefore, people who have been exercising become delicious targets. However, the myth that mosquitoes prefer to bite people wearing dark clothing¹⁶ or have blood type O has now been refuted¹⁷. Whew!

Stratagems to battle mosquitoes

Those of you who have cared for cancer patients will be familiar with the multipronged approach that we sometimes have to adopt when combating an elusive enemy, combining surgery, radiotherapy, chemotherapy and immunotherapy. The mosquito is a similarly wily adversary, hence its reputation as public enemy number one. We have several options and combinations to choose from though some have been more effective than others.

Table 1. Mosquito-bourne diseases (2013-2018)

World ranking	Disease	No. of reported cases in one year	Deaths in one year
1	Malaria	219,000,000	435,000
2	Dengue	60,000,000	13,600
3	Chikungunya	1,300,000	190
4	Zika	500,000	-
5	Yellow Fever	200,000	30,000
TOTAL		300,000,000	500,000

Table 2. Differences between anopheles and aedes mosquitoes

Mosquito	Anopheles	Aedes
Color	Yellowish	Black and white patches
Resting position	45° to surface	Parallel to surface
Diseases caused	Malaria	Dengue, Zika, Chikungunya

Failed tactics

But first, let me dismiss a few failed or controversial manoeuvres to eliminating mosquitoes. Ultrasound, unfortunately, does not repel mosquitoes.¹⁸ Zapping mosquitoes with electricity, sadly, also has very limited effects.¹⁹ Apart from a few proven sprays and creams, many either do not work or have too many side effects. For example, lemon eucalyptus oil (not to be confused with oil of lemon eucalyptus [OLE]) does not work, nor do several products that contain peppermint oil or diluted citronella.²⁰ Here are some of the more effective strategies.

Insecticides

DDT: The irony of current environmentalists' accusation that we caused the rise in mosquitoes by failing to tackle global warming, is that the existence of these protesters was a result of our attempts to annihilate the mosquito. Dichlorodiphenyltrichloroethane, or DDT, was first synthesised in 1874, but its insecticidal action was only discovered in 1939. DDT was used by the allies during World War II to control malaria and typhus in Europe and the Pacific Islands. By October 1945, DDT was available for public sale in the US as an agricultural and household pesticide. In 1962, Rachel Carson published her seminal book, *Silent Spring*, which catalogued the environmental and health impacts of DDT. The book claimed that DDT caused cancer and threatened wildlife, especially birds. This led to the environmental movement and huge public outcry, resulting in the banning of DDT in the US in 1972, followed by the 2001

Stockholm Convention on Persistent Organic Pollutants, which proposed a worldwide elimination or restriction on the production and use of persistent organic pollutants. By the time DDT was banned, the mosquito had already become resistant to it.²¹

Malathion: You may have been using malathion to treat head lice. It is an organophosphate used by farmers on vegetable crops to kill a wide variety of insects. They can also be used in a 5% solution to fog an infested area. In the recommended dose, this pesticide is considered safe for humans and wildlife.²²

Permethrin: Some of us have used permethrin to treat scabies and head lice. It is a synthetic insecticide with a structure belonging to the pyrethroid family, which resembles the natural insecticide found in chrysanthemum flowers. It is mixed with oil or water and sprayed as a mist. It is not harmful to people and animals, but because it is toxic to fish and bees, it is banned in North America and Nordic countries. This is the insecticide that is used for fogging and applied to mosquito nets.²³

Mosquito repellents

Unlike insecticides, repellents do not kill but merely repel. The chemicals act as a deterrent so that mosquitoes dare not come near.

DEET: Of all the insect repellents, diethyltoluamide, or DEET, is considered the gold standard and one of the most effective. It is applied onto the skin or clothing and deters a whole range of insects, including mosquitoes, ticks, fleas and many other biting insects.²⁴

Picaridin: Also known as icaridin, picaridin is an excellent insect repellent and is now considered on a par with DEET. It is also sprayed onto the skin and some claim that it causes less dermal irritation compared to DEET.²⁰

OLE: OLE should not be confused with lemon eucalyptus oil. Although the names are similar, their chemicals and actions are very different. OLE is an oil extracted from the gum eucalyptus tree, which is native to Australia. The extracted chemical contains citronella and can be effective as an insect repellent.²⁵

Drainage of stagnant water

Mosquitoes lay their eggs in stagnant water, without which they cannot propagate. Culex and anopheles mosquitoes do not care what sort of water they lay their eggs in, as long as it is stagnant. Larvae of anopheles mosquitoes have not only been found in fresh clean water, but also in polluted water, saltwater marshes, mangrove swamps, rice fields, pools of water found in rubber tyres, tin cans and leaf-filled drains.²⁶

Aedes mosquitoes, on the other hand, are quite finicky. They prefer water that contains certain chemicals associated with a particular microbial stew, while rebuffing water that contains chemicals or bacteria inhospitable to their future larvae. Regardless of the type of stagnant water, one method of reducing the mosquito population is to deprive them of their obstetric wards and delivery suites. The problem is that in the tropics, heavy rains come sporadically and there will always be temporary puddles of water on roads, gardens, rooftops, discarded plastic containers, flowerpots, etc. The time between the hatching of the egg, and the emergence of the adult mosquito ready to fly off, is eight to ten days. This means that we cannot allow pools of water to remain undrained for just over one week.

Another way of approaching stagnant water is to use sonic waves. This is good when you cannot discard stagnant water. Applied to stagnant water, the sound waves can cause mosquito larvae to rupture, and an example of its use could be at a wastewater treatment tank of a worksite.²⁷

Wolbachia

An exciting new way of tackling mosquitoes and the diseases they carry is currently being tried out in many countries, including Singapore.

Wolbachia is a gram-negative bacterium belonging to the rickettsia family. It infects a variety of insects, including mosquitoes, spiders, mites and filaria parasites. It inhibits the replication of dengue, Zika, chikungunya and West Nile viruses inside the adult aedes mosquitoes. It can also increase the anopheles mosquito's resistance to Plasmodium falciparum malaria. Curiously, when a male aedes mosquito infected with Wolbachia impregnates a female, the latter's eggs cannot hatch. In contrast, when a female mosquito already infected with Wolbachia is impregnated by a male who also has Wolbachia, the eggs are fine and hatch normally.^{28,29}

Singapore is now conducting its Phase 4 trial of releasing male aedes mosquitoes infected with Wolbachia bacteria into selected neighbourhoods. The bacteria were injected into individual mosquito eggs, resulting in the hatching of both male and female infected mosquitoes. They were then allowed to mate and propagate in purpose-built enclosures, resulting in the laying of more Wolbachia bacteria-infected eggs and rendering further injections into individual eggs unnecessary. When the larvae hatch out of these eggs, they are carefully tracked because they soon transform into pupae. The male pupae are smaller than the females and can therefore be separated from the opposite sex. Large numbers of infected male mosquitoes have been released to date. When they mate with uninfected females living in those areas of Singapore, the females become infected with Wolbachia, which renders them less able to contract dengue, Zika, chikungunya and other viruses. Moreover, the eggs they lay cannot hatch. Using this method, the mosquito population has already declined by 90% in the trial areas in Singapore.³⁰

Global warming

The other way to tackle the rise in the mosquito population is to tackle global warming. This includes reducing the use of fossil fuels, stopping deforestation, putting out forest fires promptly, reducing intensive farming, reducing overconsumption, proper waste disposal, growing more green plants, becoming more efficient in our use of energy (eg, using solar and tidal energy) and using renewable energy sources.³¹ We have most of the answers to prevent the deleterious effects of climate change, but we have been rather slow in doing anything.

Final buzz

Global warming is responsible for many medical problems, including spreading mosquito-borne diseases. Tackling the mosquito problem requires a multifaceted approach. We hope that the recent novel approach of releasing male aedes mosquitoes infected with the Wolbachia bacterium can reduce the mosquito population. In combination with all the other existing techniques, our ultimate goal is to annihilate the mosquito.

Combating global warming is more challenging than we have realised. Most people are apathetic or lazy, and they just pass the buck to the politicians.

Sorry, Greta Thunberg, we have been rather inert. Yes, we do sincerely support you and will certainly try our best to give your generation a brighter future. Please give us a little more time! ♦

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