Abstract

Vector-borne diseases are a major threat to human health. Millions of people die every year from viruses and parasites carried by mosquitoes. These viruses and parasites cause different diseases. How can we control these diseases? One way is called biocontrol. This uses natural enemies of mosquitoes to control the population. Human infections are limited as a result. We wanted to try a different method. Bacteria can be used to keep mosquitoes from easily passing on diseases. A town in Australia had a lot of dengue outbreaks. We gave bacteria to the local Australian mosquitos and then released them to reproduce with wild mosquitos. Soon, most mosquitos in the area carried the bacteria. Now there are way fewer human dengue cases!

Introduction

You may already know what the deadliest animal in the world is. It’s not sharks or spiders – it’s mosquitos. Mosquitoes can carry viruses and parasites that cause illness. Vector-borne diseases like malaria, dengue, and Zika are difficult to prevent. Millions of people die every year because they don’t have enough vaccines or medicine.

There are different ways to control the mosquito population. Insecticides are chemicals that can be helpful but can also be toxic to the environment. Biocontrol is another option. This involves using predators that feed on mosquito larvae. But we wanted to try something a bit different. What if we use another natural enemy to mosquito populations: bacteria?

Wolbachia are natural bacteria found in many types of insects. The Aedes aegypti is a type of mosquito that carries diseases like Zika, dengue, and yellow fever. This mosquito is less able to pass on the disease when Wolbachia is present. Why is this happening? Wolbachia bacteria boost the mosquito’s immune system. The bacteria also compete against viruses for important resources in the mosquito’s cells. Competition makes life tough for viruses. Wolbachia is safe for human health and the environment. We felt comfortable using this bacteria to test how much less disease the mosquitoes would pass on.

Methods

First, we had to raise mosquitoes with Wolbachia. We used a tiny needle to give the bacteria to the mosquitos. Then, we looked after the mosquitos for several generations. We divided them into two groups: one to reproduce in the lab and one to release.
We released mosquitoes with *Wolbachia* in Townsville, a small city in Australia. We did this in a series of four stages. We predicted that the mosquitoes with *Wolbachia* would reproduce with wild mosquitoes. Over time, we thought most of the insects would carry the bacteria (See Figure 1.)

After that, we regularly collected information about two things:

1. The number of mosquitoes carrying *Wolbachia*. We trapped mosquitoes in the area where we had released the ones that carried *Wolbachia*. We performed tests to see if the bacteria were present in the insects.
2. The number of dengue cases among people in the area between January 2000 and October 2018. We got this information from the Queensland Health Communicable Diseases Branch.

When male mosquitoes with *Wolbachia* mate with wild female mosquitoes without *Wolbachia*, those females will lay eggs but they won’t hatch.

When male mosquitoes with *Wolbachia* mate with females with *Wolbachia*, all of their offspring will carry *Wolbachia*.

When female mosquitoes with *Wolbachia* mate with males without *Wolbachia*, only the female offspring will carry *Wolbachia*.

**Figure 1:** This diagram explains how *Wolbachia* can be passed from parent to offspring in the mosquito population.

*Source: World Mosquito Program*
Results

We found that the bacteria quickly spread through the mosquito population in the area where we released the insects (Figure 2). As the percentage of Wolbachia-carrying mosquitoes went up, the number of human dengue cases went down (Figure 3). Even if a person carried dengue into the town from an outside location, the virus wasn't spread by the local mosquito population.

Figure 2:
Percentage of Wolbachia-carrying mosquitoes over time in Hermit Park, one of the areas where we released them. The yellow shading shows the release times. The green line shows the percent of mosquitoes carrying the bacteria.

Figure 3:
Dengue cases in the area between 2000 and 2018. The top graph shows dengue cases that people caught within the town. The bottom graph shows the dengue cases brought in from somewhere else. The green shading represents the spread of Wolbachia-carrying mosquitoes.

Look at the graph showing dengue cases caught within the town. How did the number of cases change after the release of Wolbachia-carrying mosquitoes?

How much time did it take for the percentage of mosquitoes carrying Wolbachia to reach 80%?
Discussion

Our method showed promising results. Wolbachia quickly spread among the mosquitoes in almost all areas of release. It only took a few months for the bacteria-carrying mosquitoes to rise above 80% of the population. This means the insects don’t need our help in multiplying Wolbachia.

Does our success in spreading Wolbachia among mosquitoes relate to dengue cases? Yes, we can see a clear relationship between the number of Wolbachia-carrying mosquitoes going up and the number of human dengue cases going down.

This area has had some serious dengue outbreaks since 2001. But most of the cases caught within the area were in places where we didn’t release our mosquitoes.

Also, the number of dengue cases from outside locations hasn’t gone down in the same way over the years. This is more evidence that the bacteria worked.

Conclusion

Governments and health organizations are trying various ways to control vector-borne diseases. Even so, the best prevention against these diseases is to avoid mosquito bites. After all, a mosquito can’t infect you if it doesn’t take a bite!

- Use insect repellents.
- Wear long sleeves and trousers.
- Be careful during the day, not only in the evening. Some mosquitoes (like the Aedes aegypti we mentioned before) bite during the daytime!

Glossary of Key Terms

**Biocontrol (or biological control)** – Keeping the numbers of an unwanted creature (like mosquitoes) under control using a natural enemy such as a predator, parasite, etc.

**Dengue** – A disease caused by a virus that mosquitoes carry. It causes fever and very bad joint and muscle pains. Sometimes it causes death, especially in children under 5.

**Larva** – An active form of an insect that is not yet an adult. The singular is larva and the plural is larvae. (This term is used for some other animals as well.)

**Offspring** – The result when animals or plants reproduce. The offspring of dogs are puppies and the offspring of people are children.

**Outbreak** – When there is a sudden rise in the number of something negative, like cases of a disease.

**Release** – Let go, set free.

**Repellent** – A chemical or natural substance that makes insects prefer not to get close or bite.

**Reproduce** – To make one or more new individuals of the same species. Animals reproduce sexually: a male animal mates with a female animal to produce offspring. Bacteria reproduce asexually by splitting into two identical copies.

**Vector-borne disease** – Diseases caused by viruses or parasites that insects (such as mosquitoes or some flies) and ticks carry to people.
Greenflies, also called aphids, are insects that can harm many plants people like to grow. If you use an insecticide to kill greenflies, what kind of control is this? And what about if you use wasps that feed on greenflies? Which do you think is less harmful to the environment?

After we released the *Wolbachia*-carrying mosquitoes, what happened with *Wolbachia* in their offspring?

What effects do *Wolbachia* have on mosquitoes?

What effect did we see on dengue cases in the area where we released *Wolbachia*-carrying mosquitoes?

What are some vector-borne diseases control strategies mentioned in the article?

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**REFERENCES**

