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Eradicating mosquitoes via GM

Mosquitoes are responsible for deadly diseases such as malaria, dengue fever and yellow fever. So news that scientists have created genetically modified (GM) mosquitoes that contain self-destruct or fligh-blocking genes must be great news, right? Not necessarily……

This Factsheet:

- Explains how scientists have created self-destructing and flightless GM mosquitoes
- Discusses the possible wider ecological effects and ethical issues of GM mosquitoes

Mosquitoes act as a vector for malaria, which kills 1 million people, mostly children in sub-Saharan Africa and dengue fever, which kills 20,000 people a year. Two teams of scientists have now created genetically-modified mosquitoes which, they believe may be the solution to all our mosquito problems….

1. "Lethal genes"

Scientists based in Oxford inserted a "lethal gene" into male mosquitoes (*Aedes aegypti*) (Fig.1) which caused them to need the antibiotic tetracycline to develop beyond larval stage.

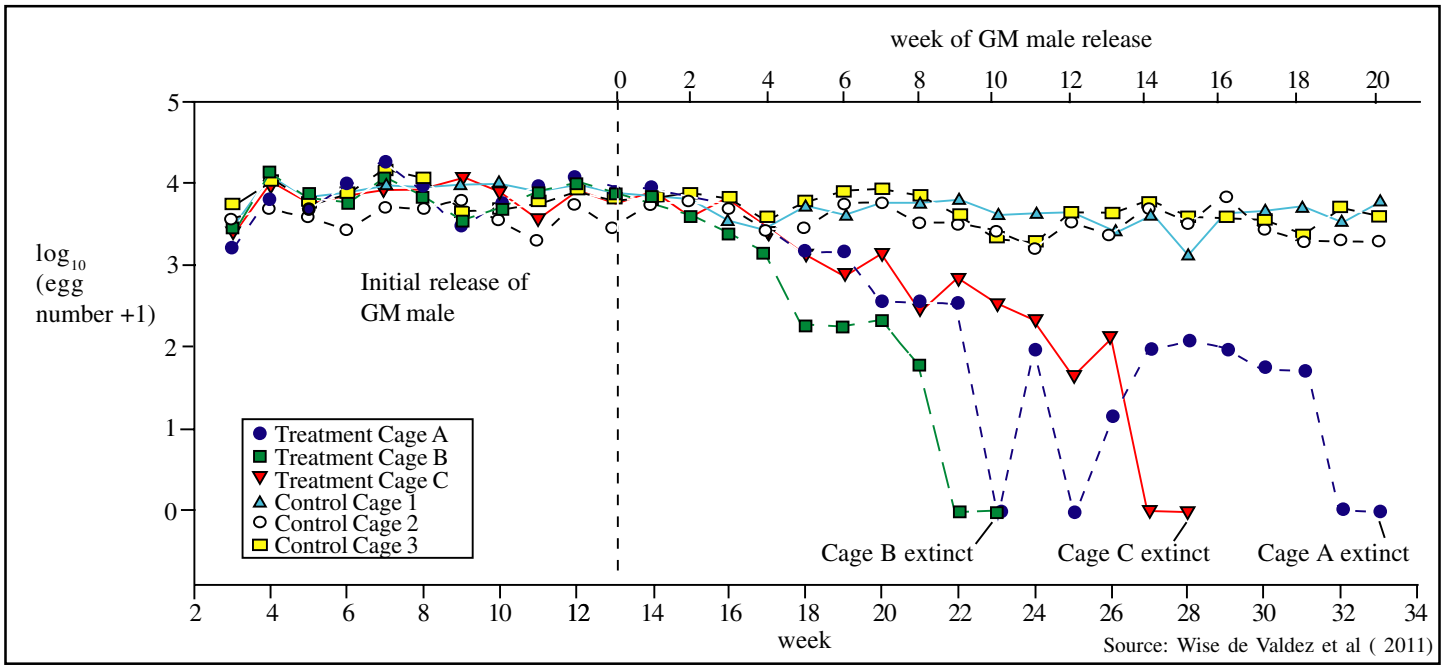
Fig. 1 ***Aedes aegypti***

The GM males were fed tetracycline in the lab and in a scientific trial the GM males were then released on the Caribbean island of Grand Cayman and mated with wild females. The females then laid eggs as normal but the resulting larvae were also then dependent upon tetracycline which, being unavailable, resulted in their death, along with death of all the GM males. 3.3 million GM mosquitoes were released over a period of 6 months and by that time the population of wild mosquitoes fell by 80%.

2. Genes that block flight muscles

Scientists in California have inserted genes into male A. aegypti mosquitoes which were then released to mate with females in a controlled laboratory situation. The resulting female offspring contain the altered genes are were unable to fly and soon died (Fig.2).

Fig.2 Results of lab trial of flight-blocking genes



The next step is to repeat the procedure in an outdoor trial and the hope is that it will cause the female population to crash.

Creating flightless GM mosquitoes

1. Scientists insert altered DNA into fertilized mosquito eggs.
2. In order to be passed on to future generations the DNA must enter the reproductive cells. A marker gene in the DNA makes the carrier larvae glow under fluorescent light.
3. Scientists provide the mosquitoes with an antidote to block the effect of the inserted genes, then crossbreed the carriers to produce millions of eggs.
4. The DNA sequence destroys the flight muscles of females that are then unable fly, feed or bite.

The males develop normally and are released to mate with wild females. Their offspring repeat the cycle.

Typical Exam Question

Scientists developing GM mosquitoes wanted to be able to track the spread of the mosquitoes when they were released. To do this they also inserted a gene from sea coral that controls fluorescence in the sea coral. This gene then conferred fluorescence upon the mosquitoes.

(a) Explain why the gene for fluorescence is expressed in the same way in coral and mosquitoes (2)

(b) What steps are required, within the mosquito cells, for the sea coral gene to be expressed? (2)

Markscheme

(a) Genetic code is universal;
codons in mRNA code for the same amino acids in all species;
(b) DNA is transcribed into mRNA (in the nucleus);
then translated;
in the cytoplasm/at the ribosome into a polypeptide/protein;

Ecological implications

Previous attempts to control A. aegypti involved pesticides, male sterilisation and education programmes to try to persuade people not to leave even tiny amounts of standing water in or around their homes.

Insecticides are expensive, manufactured using finite fossil fuels, may stimulate insictidide resistance and can have harmful effects on humans and other non-target insects e.g. pollinators.

The difficulty with male sterilisation is identifying the level of radiation that makes the males infertile but not so weakened that they become unattractive to females. Scientists succeeded in identifying the correct level of radiation for fruit flies but failed with mosquitoes. Education programmes largely failed.

But the use of GM in this way has its critics.

1. Effect on food chains

One potential problem with the GM approach is the effect on food chains. If scientists succeed in more or less wiping out mosquito populations, what will the effects be on species that interact with them? Little is known about the species that feed on mosquitoes. Previous attempts to eradicate disease-spreading insects have merely led to population booms of competing vector species. In the case of malaria, successful campaigns to reduce the populations of one sub-species of Anopheles has merely triggered a population explosion of a competing sub-species.

2. Gene transfer

There is also the concern that the lethal or flight-blocking genes might be passed to other species with totally unforeseen consequences.

3. If GM mosquitoes survive?

Some scientists believe that the outdoor trial in Grand Cayman was very risky, arguing that no GM procedure will ever be 100% successful. We simply do not know what the implications would be if a GM female mosquito survived to mate repeatedly.

4. Ethical implications

Some scientists argue that it is unethical for humans to make a species extinct. On the other hand, it could be argued that it is unethical not to use the technique if it saves just one person dying from dengue fever.

Another concern is that local inhabitants do not have to be consulted before transgenic organisms are released into the environment. Many people have serious reservations about the use of any GM organism.

The Oxford-based scientists are now working on a GM *Anopheles* mosquito, the genus that acts as a vector for malaria…..

References:

Wise de Valdez M.R, Nimmo D, Betz J, Gong.H. F, James A.A, Alphey L, Black IV W.C **Genetic elimination of dengue vector mosquitoes**. Proc. Nat. Acad. Sci. 22 March 2011 4772-4775

Practice Questions

1. (a) What is a transgenic organism? (2)
   (b) Describe one way in which transgenic mosquitoes might be used to try to reduce the incidence of diseases such as malaria and dengue fever (3)
2. (a) Explain the conditions necessary for the vector of the malarial parasite Plasmodium to complete its life cycle (3).
   (b) Outline 3 techniques used to try take to break the life cycle of the mosquito (3).
   (c) DDT is a non-biodegradable insecticide that has been used in many countries to control mosquitoes. Explain how this use of DDT may have affected other organisms (3)

Markscheme

1. (a) organism whose DNA/ genotype / genome / genetic code has been altered;
artificially/ by gene technology/ genetic engineering;
transgenic organism contains foreign/recombinant DNA;
(b) gene inserted into mosquito DNA;
produces toxin/damages larvae or adult;
ref to sterility/flight blocking/metabolic disruption;
targets/reduces population of female mosquitoes;
2. (a) high rainfall/good water supply;
water is needed for breeding;
stagnant water needed for larvae / pupae;
larvae / pupae hang from water surface / breathe air;
warm enough for mosquito to survive;
(b) drainage/remove standing water;
destroys breeding grounds;
oil on surface of water; larvae / pupae suffocate;
insecticides; kills adults;
introduce guppies/ fish; eat larvae / pupae;
(c) kill other/beneficial/non-target species;
DDT is non-specific/broad spectrum;
may harm top predators/organisms high in food chain;
through biomagnification;
ref to less food supply for mosquito predators;

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This Factsheet was researched and written by Kevin Byrne.
Curriculum Press, Bank House, 105 King Street, Wellington, Shropshire, TF1 1NU.