Ethical dilemma: Should we get rid of mosquitoes?

Because of the **pathogens** they **carry**, **mosquitoes** are responsible for **more human deaths** every year **than any other animal**, including other humans. But very few of the 3,500 mosquito **species** actually **transmit deadly diseases to** humans. So what if we could **get rid of** the most **lethal** mosquitoes? Over the last two decades, scientists have begun **conducting experiments** using engineered technologies called "gene drives" that could **theoretically** do just that. So, should we?

To begin **grappling with** this question, we have to **get a sense of** how the technology works. In the usual process of **inheritance**, the **genomes** of each parent **recombine randomly**. So their **offspring** end up with the DNA that's a rough 50/50 mix **from their parents**. But gene drives **thwart** this process and **ensure** they're **passed on**. Gene drives are **found in nature** but, using new **gene-editing** technology, scientists have also begun **engineering** them **in contained labs**.

For example, in a 2018 study, researchers **injected** a gene drive **into** mosquito **eggs** that made females **sterile** when they had **two copies of** the **modified gene**. Such a **modification** would usually **disappear** quickly. But it **spread**. The **modified** mosquitoes **passed** the gene drive **onto** some of their **offspring**. The gene drive, which they **inherited** on one **chromosome**, **copied itself onto** the other chromosome in the offspring's **sperm** and **egg cells**, ensuring it was **passed on to** their offspring, **regardless of** which chromosome they **received**. This process **repeated** as all males that **carried the gene** and all females that **had one copy of it**, continued **reproducing**, spreading the gene drive. As they did, they **produced more females** that had two copies of the gene— and would, therefore, **sterile**. With a near 100% **inheritance rate**, the gene **spread through the population** and within 12 **generations** almost all females were **sterile**, and the populations **crashed**. In 2020, the same team **achieved a similar result** with a gene drive that made populations **male-only**.

Gene drives have **proven** powerful in the **lab**. So, **implementing** them **in the wild** is a big decision— one that's being **considered** because of how the fight against **mosquito-borne diseases** is going. Existing **mosquito control measures**, like **insecticide-treated** bed nets, helped **reduce the number of deaths** from malaria, the **deadliest** mosquito-borne disease, between 2000 and 2019. But **fatalities** have

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begun rising again. Many mosquitoes have developed **insecticide resistance**— and insecticides **kill more than just** mosquitoes. In addition to the first-ever **malaria vaccine**, approved in October of 2021, many see **promise** in gene drives.

Experts are researching what it would look like to **specifically target** the **deadliest** mosquito populations with this technology. Like Anopheles gambiae, for instance: the species **overwhelmingly** responsible for **spreading malaria** in Equatorial Africa, which experiences the vast majority of **mosquito-related fatalities**. The idea is that, when a gene-drive-affected population of Anopheles gambiae **drops low enough**, it would **break** the malaria **transmission cycle**.
But before gene drive mosquitoes are actually **released into the wild**, some big questions need answers. Like, could gene drives **cross into** and **cause the collapse** of **non-target species**? It doesn't seem that many mosquito species **interbreed**, making this **unlikely**, but scientists are **conducting research** to be **certain**. And how might a mosquito population's collapse **affect ecosystems**? One team is **examining** the **feces** and stomach **contents** of **insectivores** in Ghana to **gauge the role** of Anopheles gambiae in local **food webs**. And researchers are **investigating** whether **suppressing** populations could make other insects more **vulnerable** or leave a **niche** open that a **harmful** species could **occupy**. Scientists are also exploring **alternatives to** population collapse, like gene drives that instead make mosquitoes **resistant** to the malaria **parasite**. And others are developing **countermeasures** to **reverse** the effects of gene drives if needed.

Meanwhile, some people have called for gene drive research to **halt** out of concern for the **possible consequences**. This raises another question: who should decide whether to **release gene drives**? It's essential that **communities**, scientists, **regulators**, and governments of the countries **most affected by** mosquito-borne diseases be highly **involved** in the research and **decision-making processes**. Conversations are **currently underway** at all levels to **establish** a **system** to **manage** this new area of research— and the **ethical** questions it **carries**.

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