Can Gene Drives help Eliminate Vector-borne Diseases?

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What is a Gene Drive?

“any genetic element that is able to bias its own inheritance among offspring”
What is a Gene Drive?....cont’d

Mendelian Inheritance

Gene Drive Inheritance

Can transform an entire population in a few generations
How does a Gene Drive Work?
Gene Drive Systems Occurring in Nature

- Sex chromosome drive
- Transposable Elements
- Homing-based Gene Drive Elements
- Killer-rescue (e.g. MEDEA)
- Underdominance
- Cytoplasmic incompatibility (e.g. Wolbachia)

Current Applications of Gene Drives

• Speculatively….many options:
• Most actively researched:
  1) Control of Invasive Alien Species
  2) Control of Vector-borne Diseases
Burden of Vector-borne Diseases

80% of the world’s population is at risk of one or more vector-borne disease

17% of the global burden of communicable diseases is due to vector-borne diseases

Over 700,000 deaths are caused by vector-borne diseases annually

Global Vector Control Response 2017-2030
Global Distribution of Vector-borne Diseases

Dahmana, H. and Mediannikov, O. (2020)
Vector Control Tools

Wilson, A.L. Et al. (2020)
Malaria Vector Control, 2000~15

Bhatt, S. et al., 2015
(Partially) Successful Vector Control

- Screens
- Bed nets
- Indoor Residual Spraying
- Fumigation
- Habitat Removal
- Insecticide Resistance

- Only active against those mosquitoes that bite indoors, at night
- Difficult to access all types of vector habitats
- Lack of specificity – ecosystem damage
- Toxicity

Toxicity

Indoor Residual Spraying

Habitat Removal

Bed nets

Screens
What Makes Mosquitoes Good Vectors?

FACTORS:

- Host feeding behaviour
  (human biting preference?)

- Vector susceptibility
  (immunity to parasite?)

- Vector longevity
  (sufficient time for parasite to develop?)

- Vector density
  (high reproductive rate?)

- Habitat preference
  (frequency of contact with human host?)
  (preference for man-made habitats?)

Courtesy: Nolan, T.
Mosquitoes' ability to transmit malaria is genetically determined….cont’d
Genetic Control – Using Insects to do the Work

Population suppression
Elimination or reduction of a wild vector population

Population replacement/modification
Replace a pathogen-susceptible vector population with pathogen-resistant insects
Questions Arising with Gene Drives

• Resistance

• Ecological and Biodiversity Effects

• Containment

• Community and Regulatory Acceptance
The phased pathway to deployment

- Large indoor cage
- Large outdoor cage
- Laboratory studies
- Small-scale isolated releases
- Small-scale open releases
- Large-scale open releases
- Post-implementation surveillance

Who works on Gene Drive Mosquitoes in Africa?
Gene Drives have great potential for control of Vector-borne Diseases