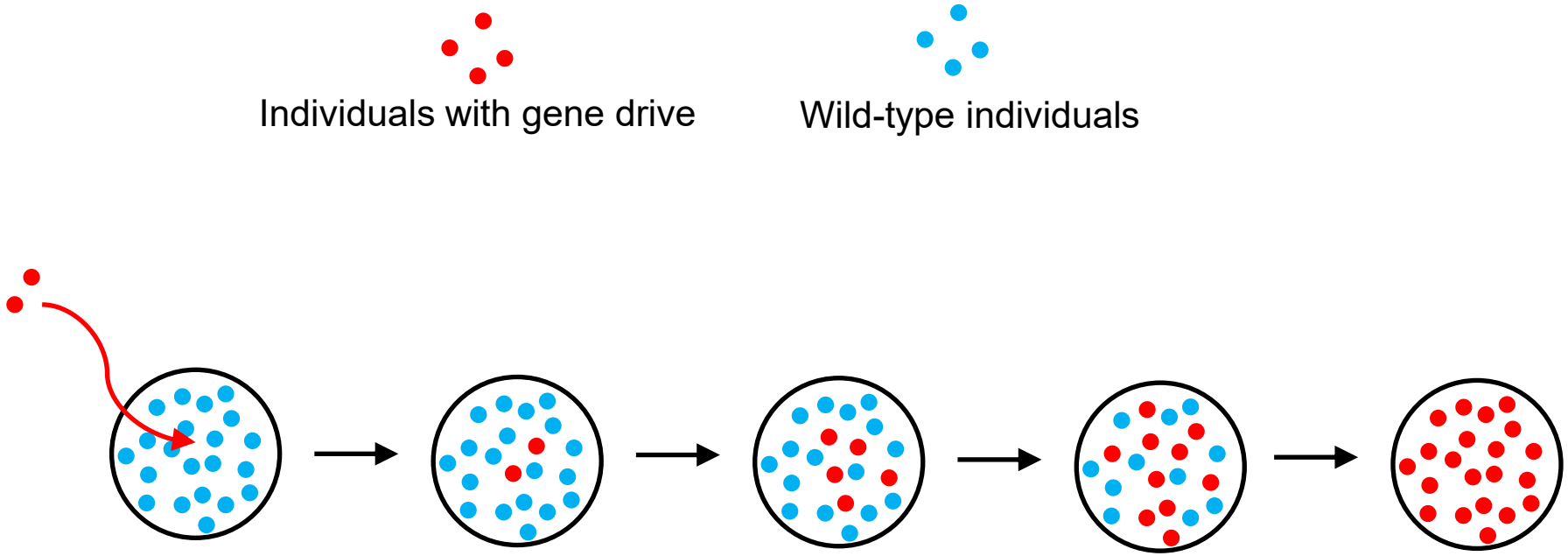
Introduction to gene drive technologies and potential applications

Jackson Champer

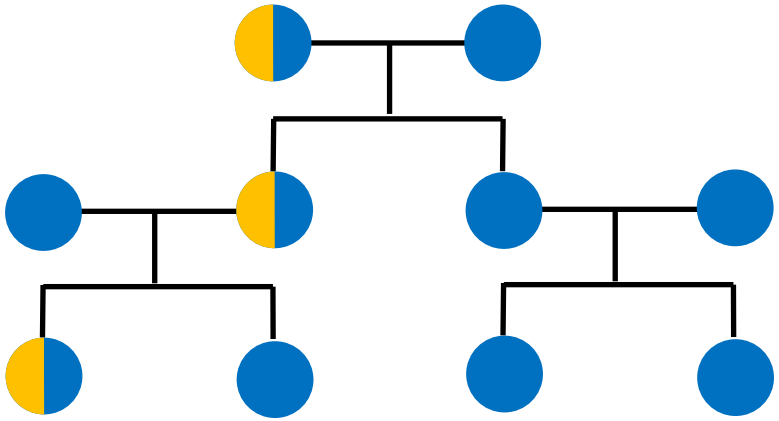
Spread of a Gene Drive



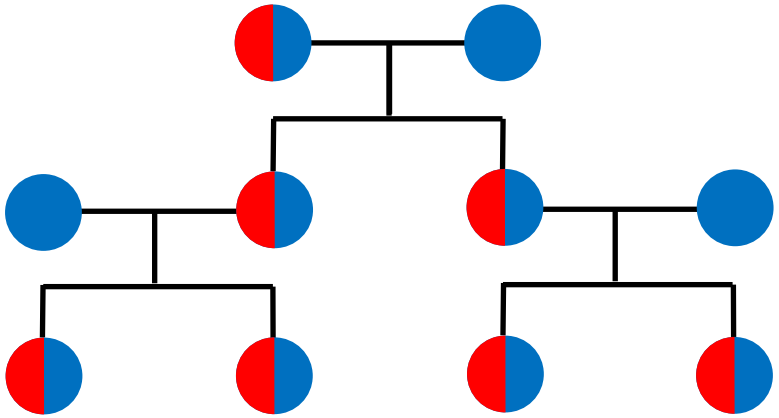
The gene drive spreads through the population over several generations

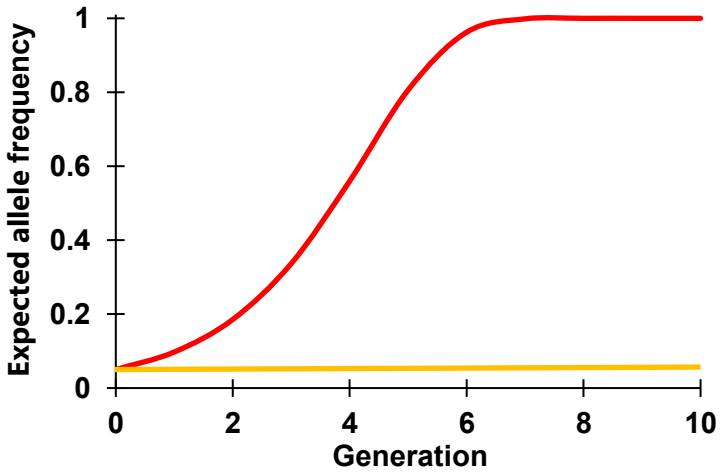
Gene Drive

Normal Inheritance



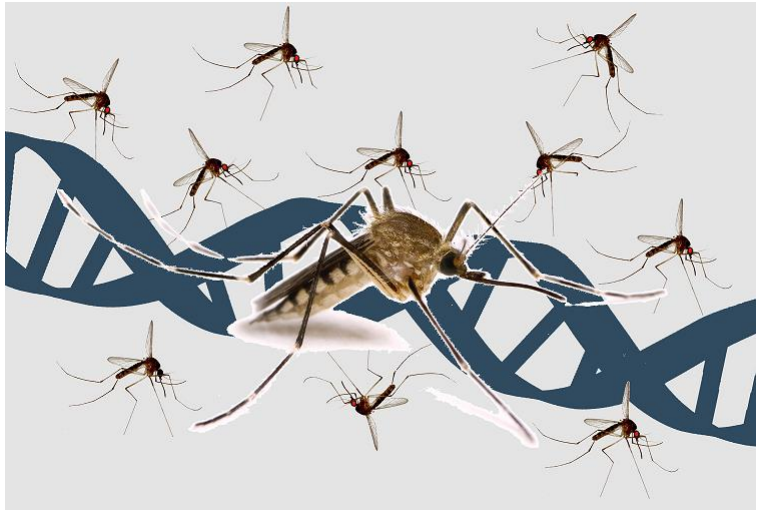
Gene Drive Inheritance





Gene Drive Types

- Modification



- Suppression

Applications

Anopheles gambiae
(malaria)

Aedes aegypti
(dengue, zika, chikungunya
several others)

Culex quinquefasciatus
(West Nile virus, avian malaria, others)

Applications

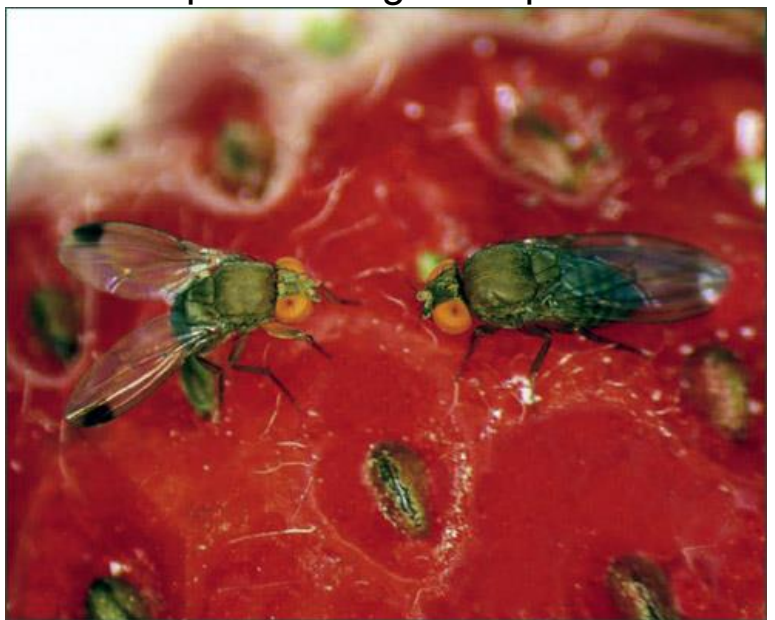
Alligator Gar

Redroot pigweed

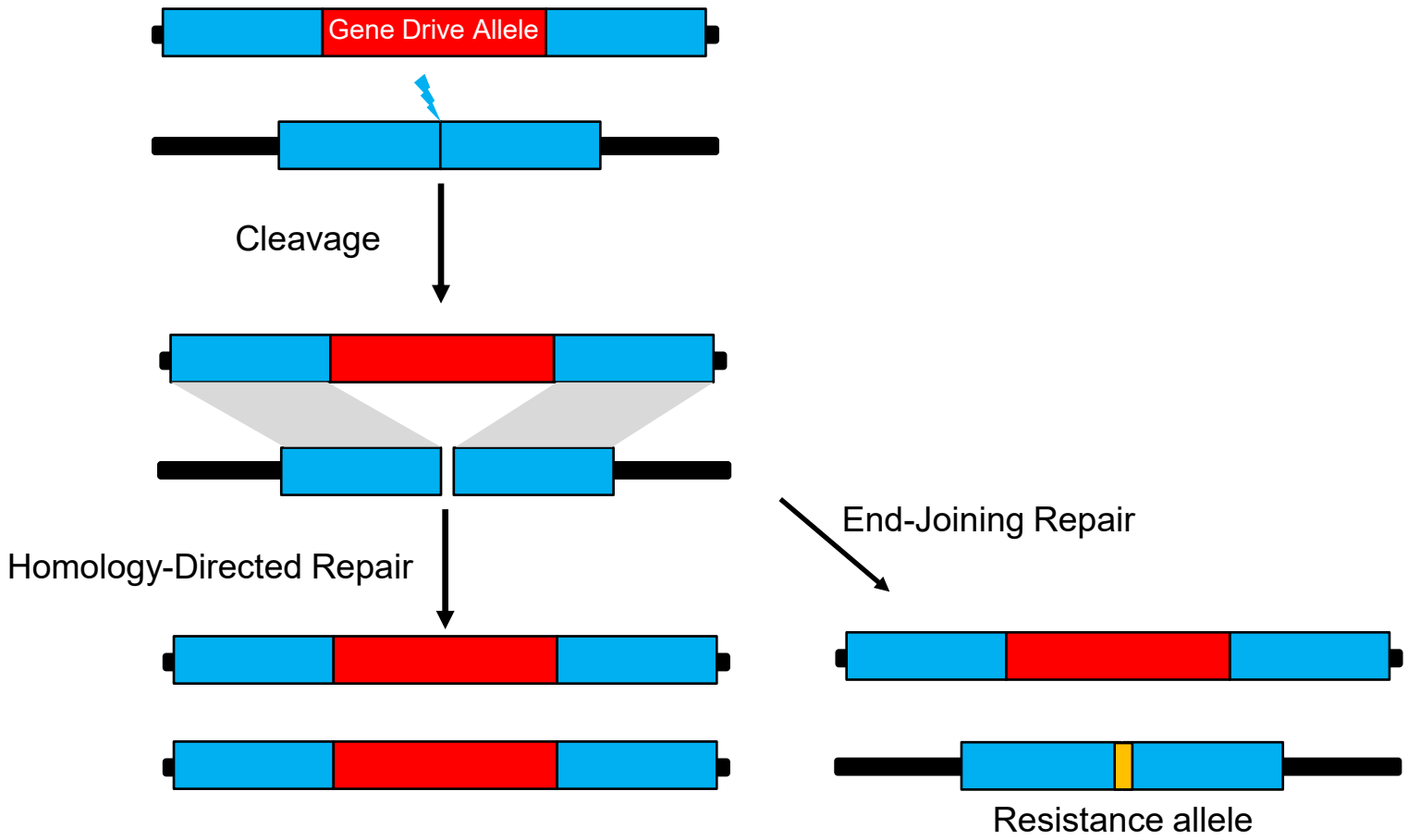
Cane toads

Rats

Spotted-wing drosophila

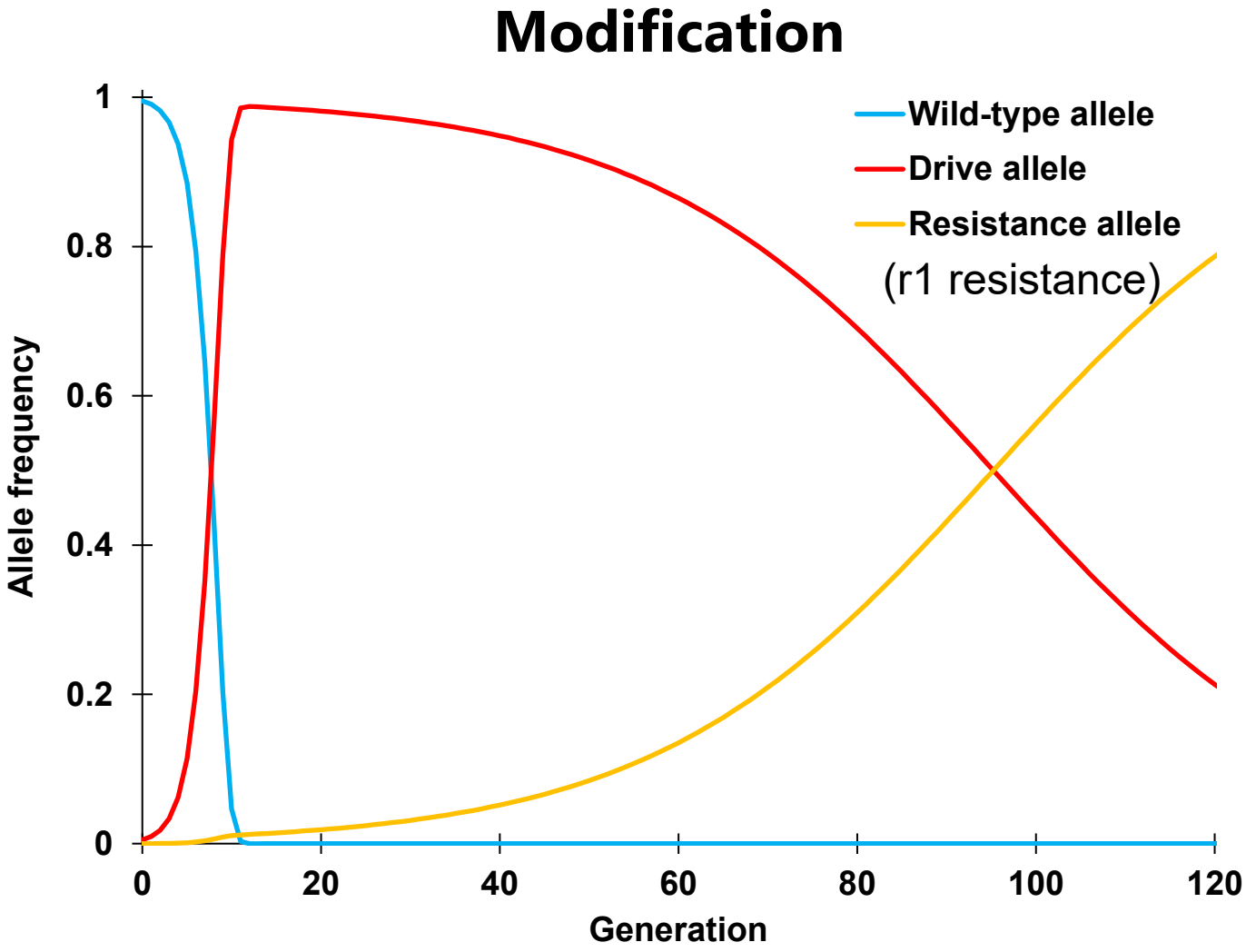


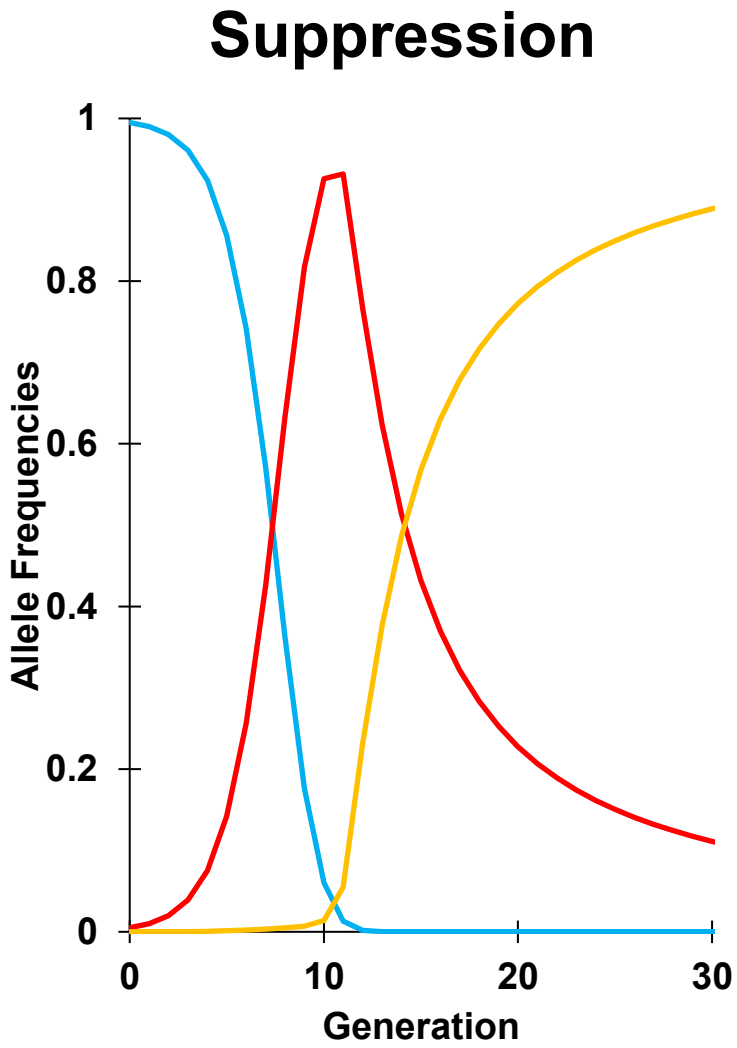
Homing Drive



Champer J, Reeves R, Oh SY, Liu C, Liu J, Clark AG, Messer PW. Novel CRISPR/Cas9 gene drive constructs reveal insights into mechanisms of resistance allele formation and drive efficiency in genetically diverse populations. *PLOS Genetics*, 2017.

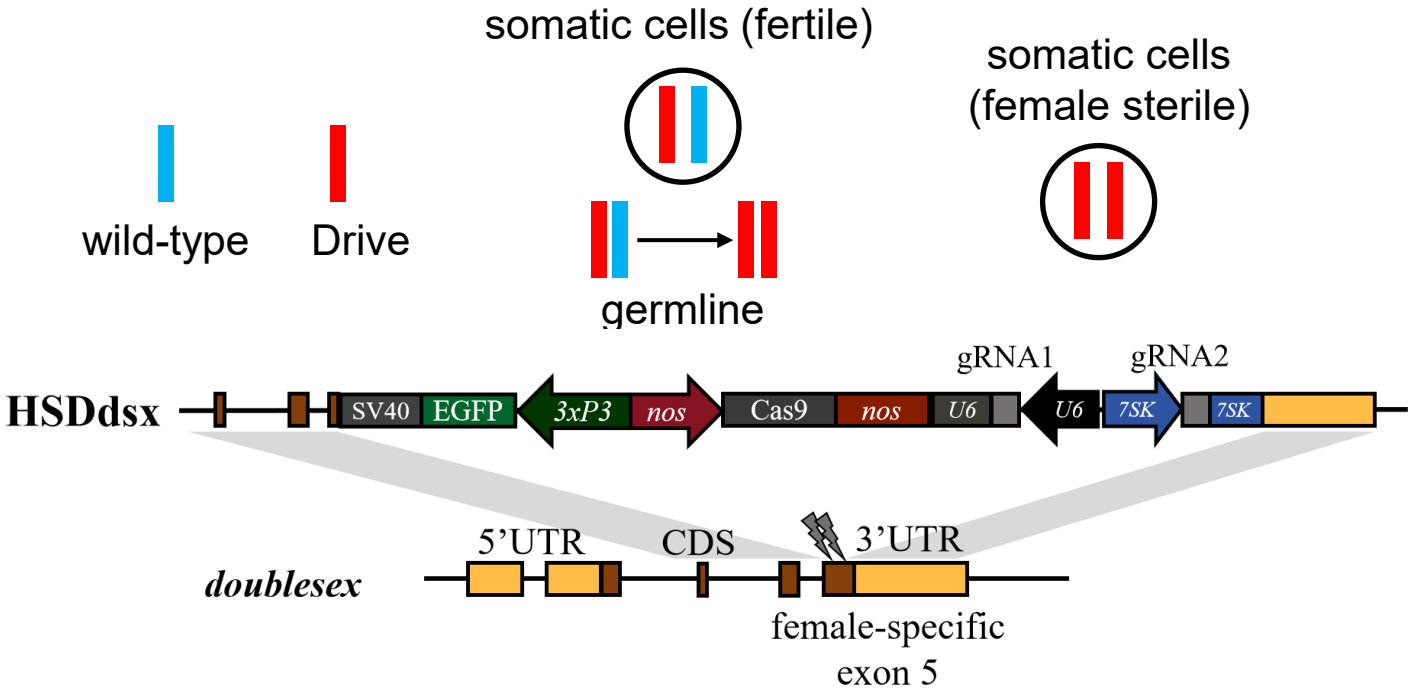
Resistance

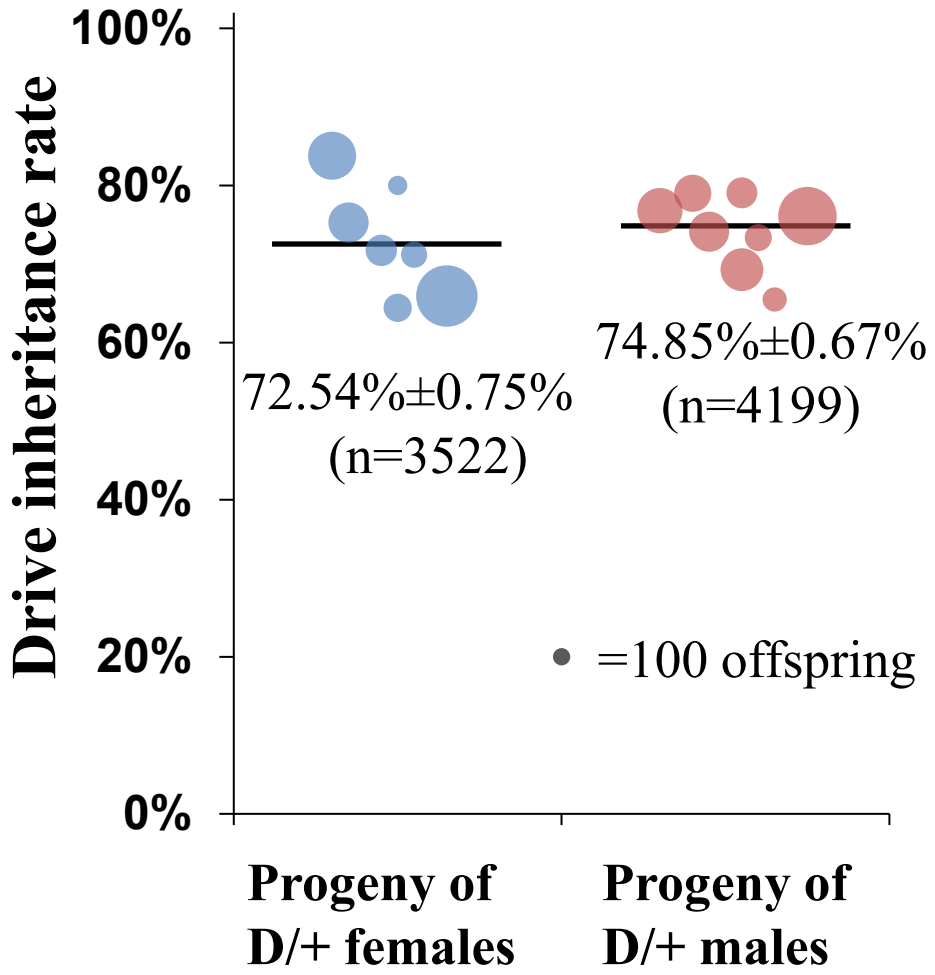

Modification
Wild-type allele
Drive allele
Resistance allele
(r1 resistance)
Allele frequency
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
Generation


Suppression
Allele Frequencies
1
0.8
0.6
0.4
0.2
0
0
10
20
30
Generation

Suppression Experiment

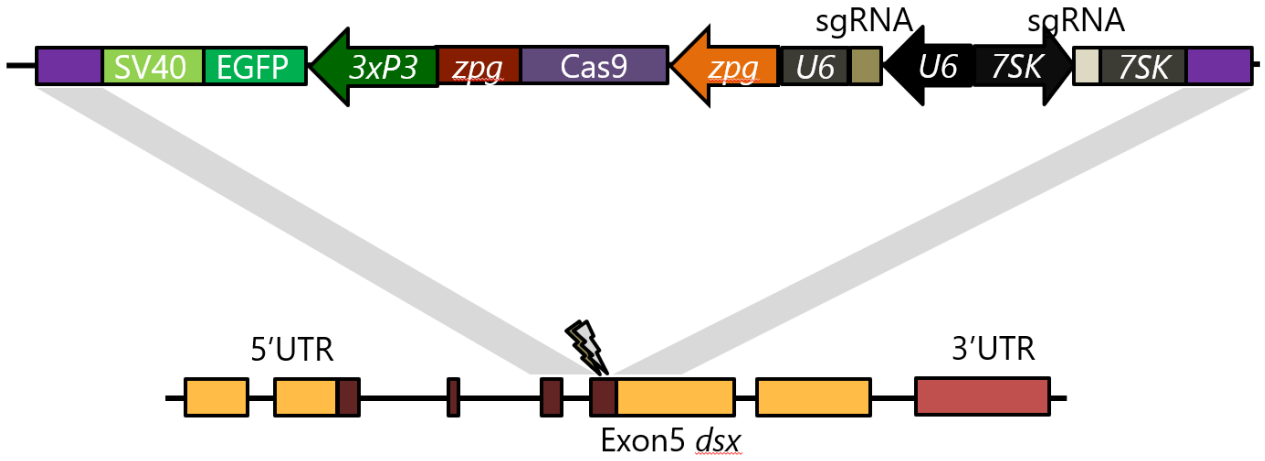
- Target an essential but haplosufficient female fertility gene.

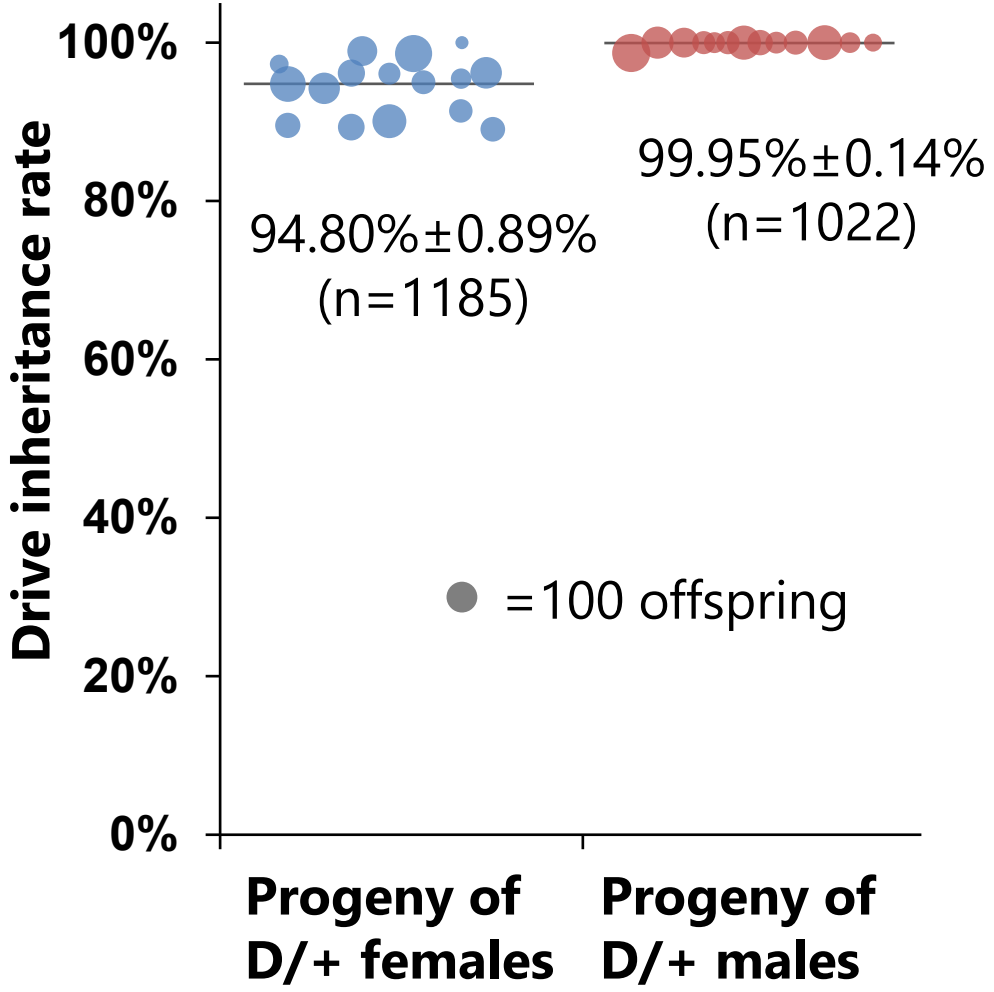




Xu X, Chen J, Wang Y, Liu Y, Zhang Y, Yang J, Yang X, He Z, Champer J. Gene drive-based population suppression in the malaria vector *Anopheles stephensi*. *Nature Communications*, 2025.

Improved *Anopheles stephensi* Suppression





- Cage trials (including larval fitness) and other fitness assessment underway...

Examples for Agricultural Pests

Spotted wing drosophila

Medfly

Diamondback moth

CRISPR/Cas9-based split homing gene drive targeting *doublesex* for population suppression of the global fruit pest *Drosophila suzukii*

Amarish K. Yadav[a], Cole Butler[b], Akihiko Yamamoto[a], Anandrao A. Patil[a,1], Alun L. Lloyd[b], and Maxwell J. Scott[a,2]

Article

https://doi.org/10.1038/s41467-023-44399-1

Gene drive and genetic sex conversion in the global agricultural pest *Ceratitis capitata*

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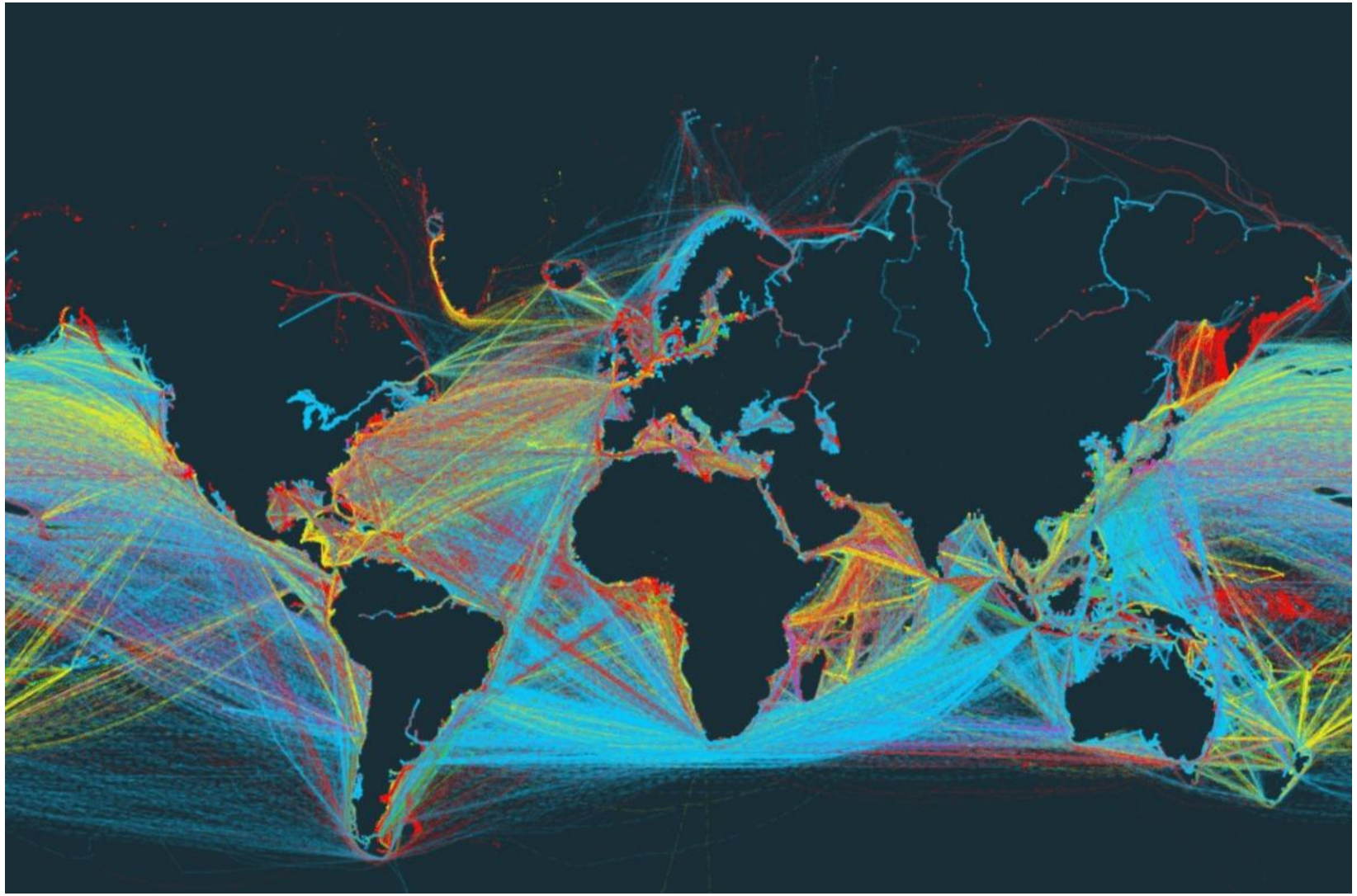
Angela Meccariello[1], Shibo Hou[1], Serafima Davydova[1], James Daniel Fawcett[1], Alexandra Siddall[2], Philip T. Leftwich[2], Flavia Krsticevic[3], Philippos Aris Papathanos[3] & Nikolai Windbichler[1]

RESEARCH ARTICLE

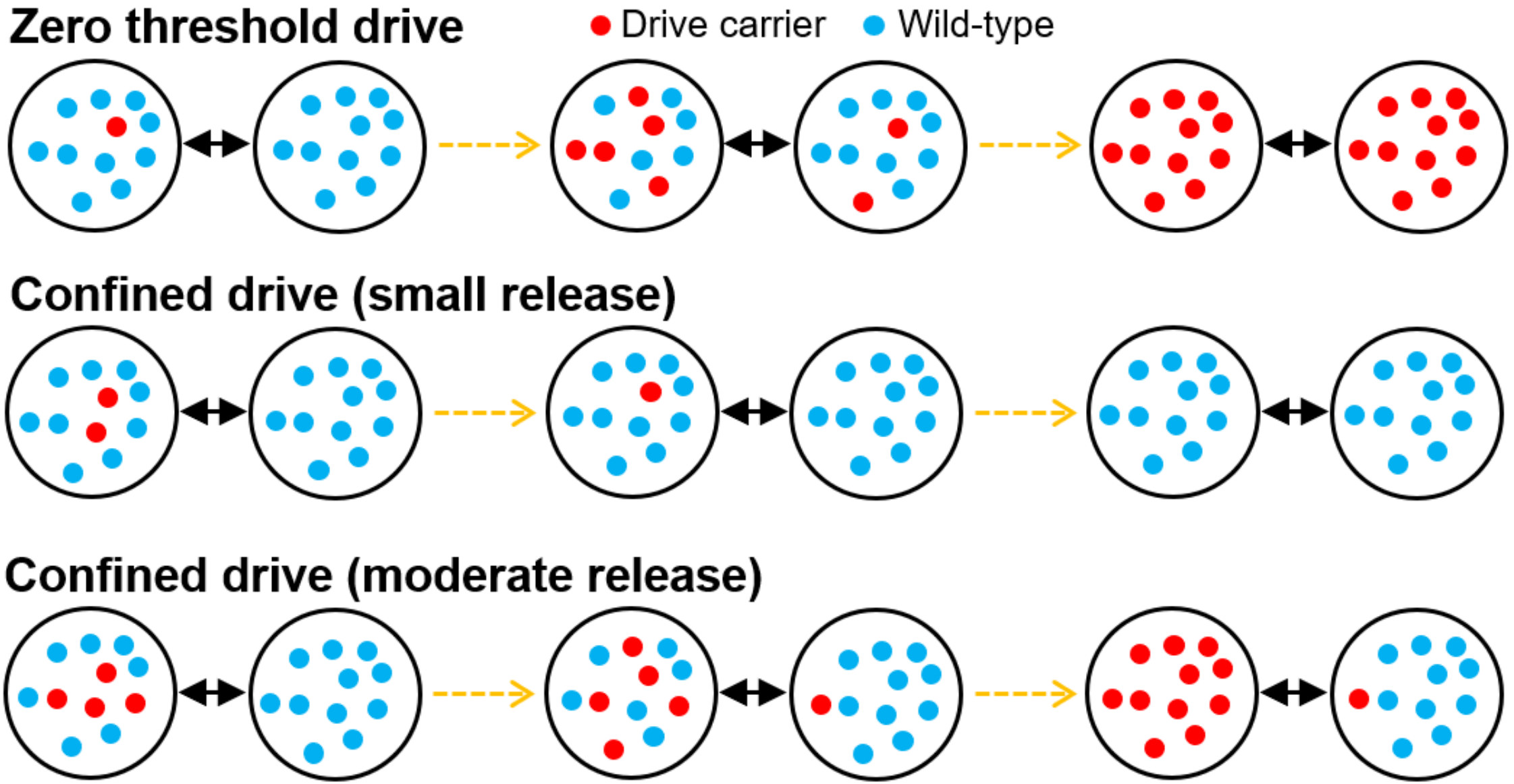
Toward a CRISPR-Cas9-Based Gene Drive in the Diamondback Moth *Plutella xylostella*

Xuejiao Xu,[1,2,†] Tim Harvey-Samuel,[3,†] Hamid Anees Siddiqui,[4] Joshua Xin De Ang,[3] Michelle Ellis Anderson,[3] Christine M. Reitmayer,[3] Erica Lovett,[3] Philip T. Leftwich,[5] Minsheng You,[1,*] and Luke Alphey[1,3,*]

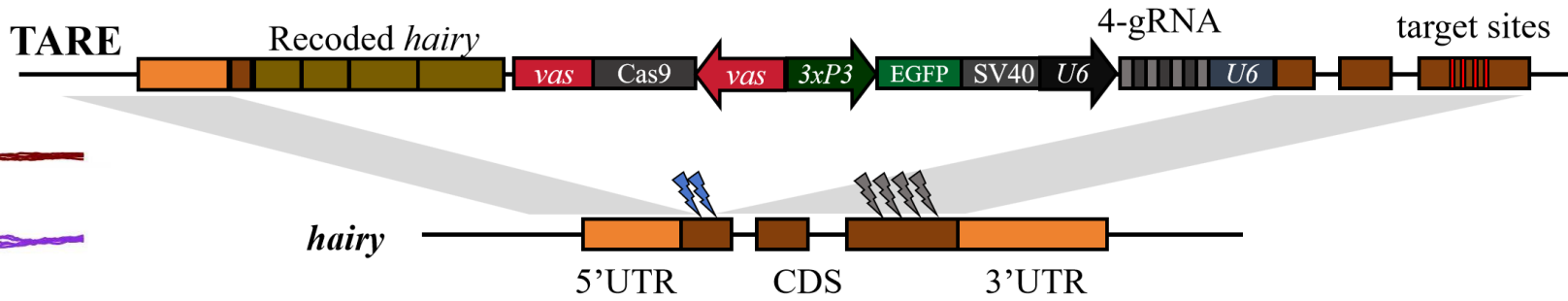
Need for Confined Drive

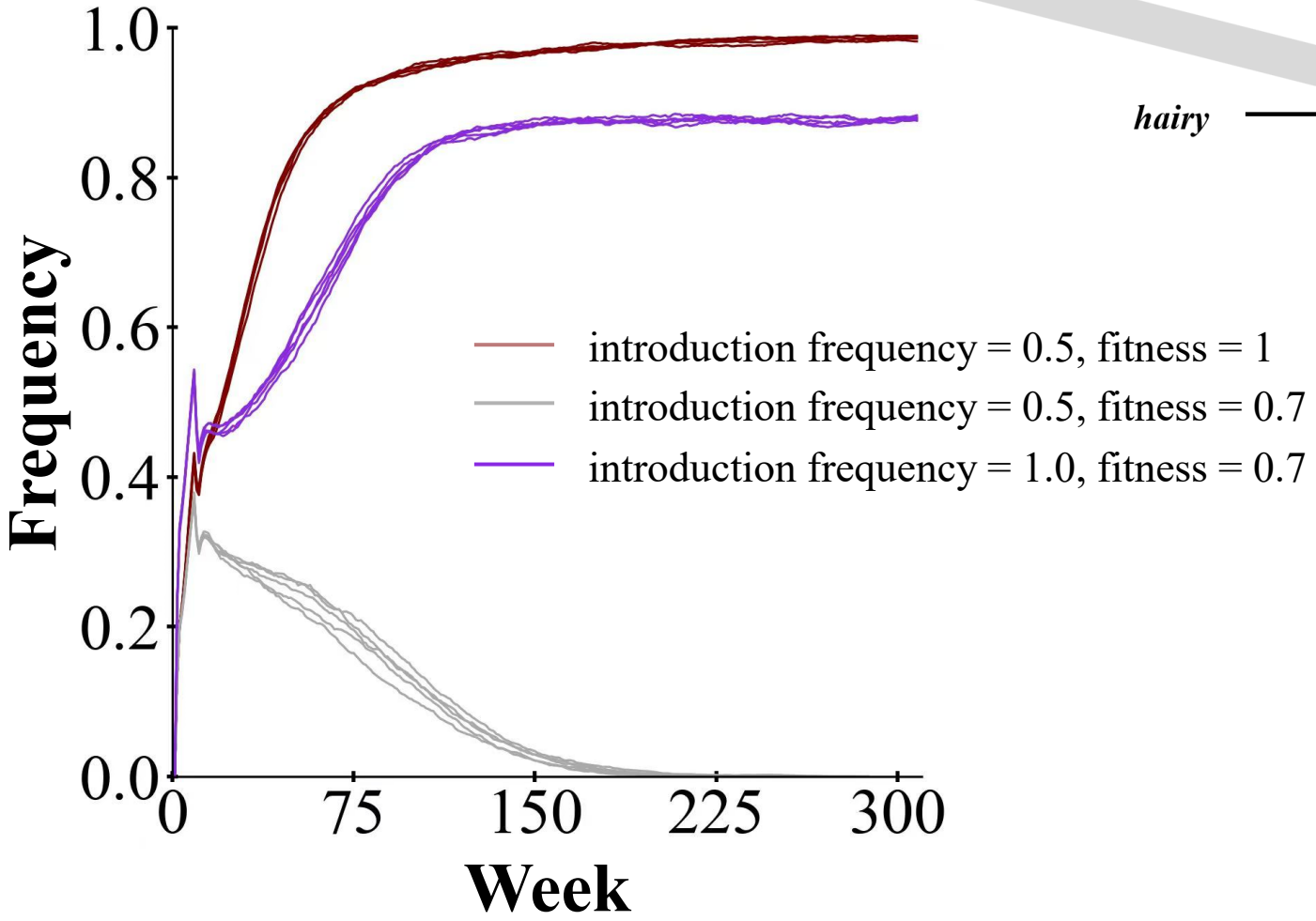


Confinement



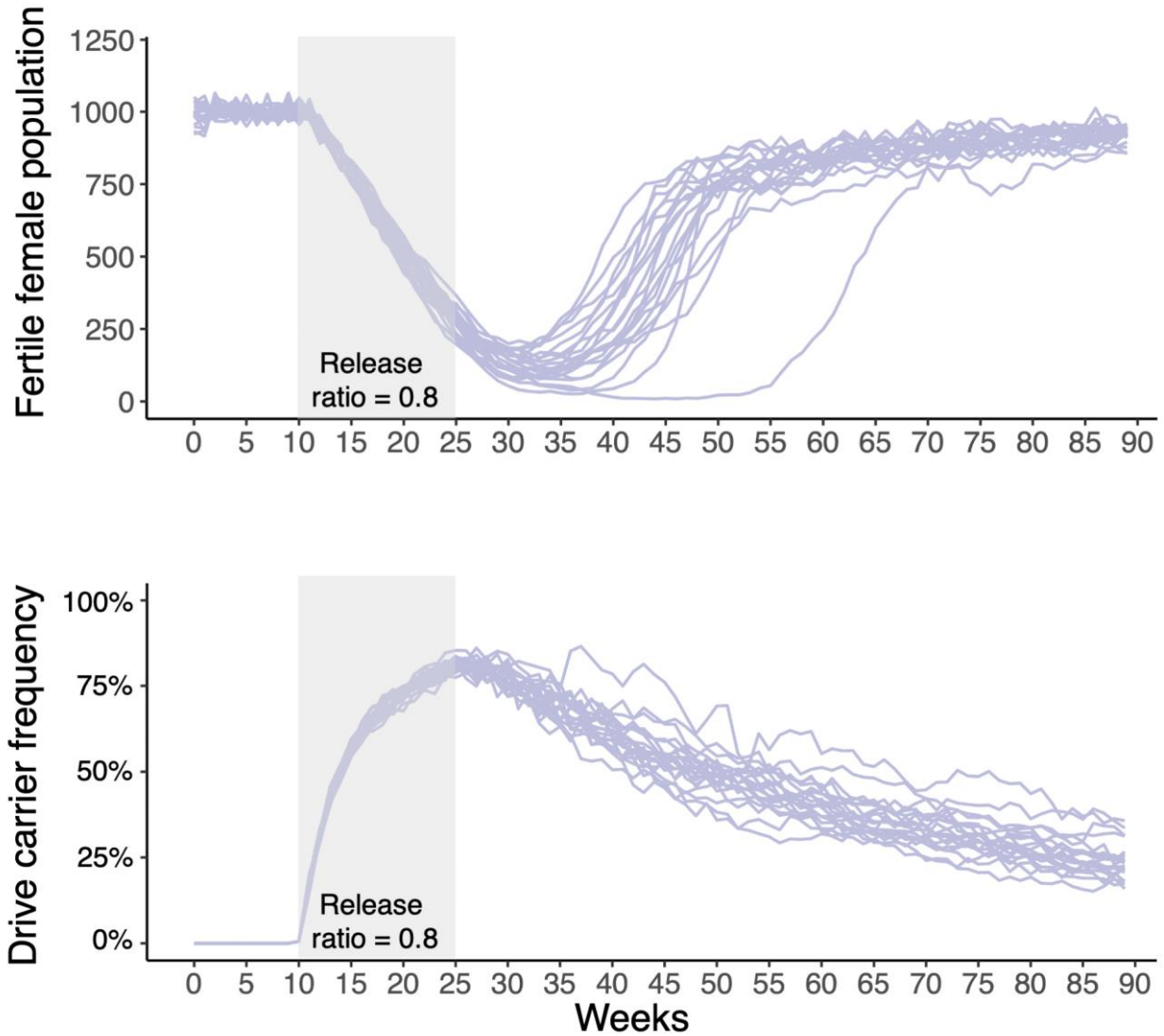
Anopheles stephensi TARE





- Improved version under construction…

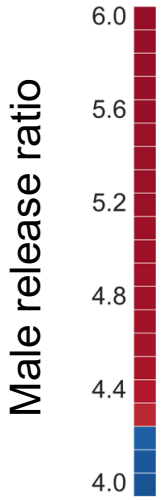
Self-Limiting Suppression



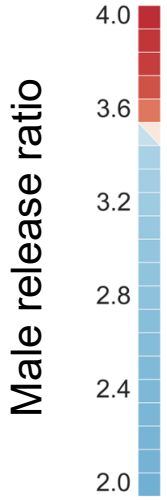
Chen W, Guo J, Liu Y, Champer J. Population suppression by release of insects carrying a dominant sterile homing gene drive targeting *doublesex* in *Drosophila*. *Nature Communications*, 2024.

Improved Self-Limiting Suppression

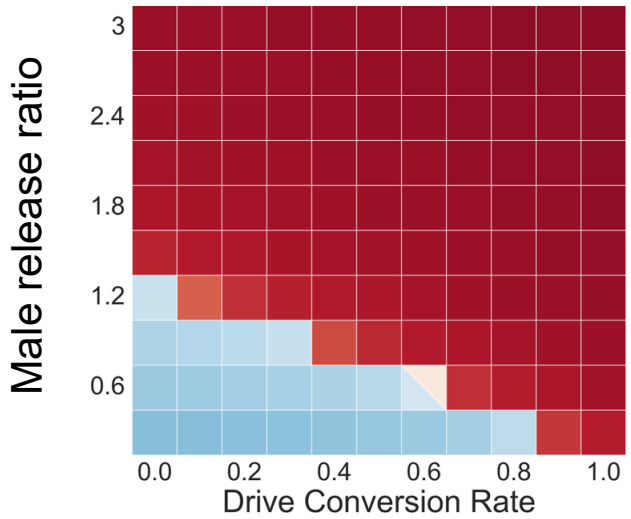
Sterile Insect Technique (SIT)

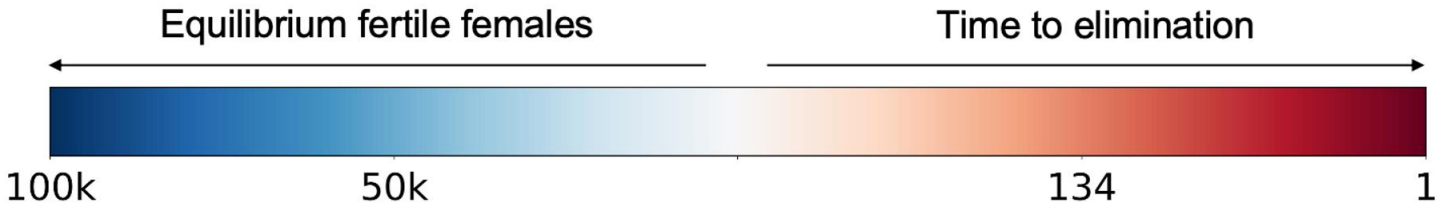


female-specific Release of insects carrying dominant lethal genes (fsRIDL)



Release of insects with dominant drives (RIDD)





Han Y, Champer J. A comparative assessment of self-limiting genetic control strategies for population suppression. *Molecular Biology and Evolution*, 2025.

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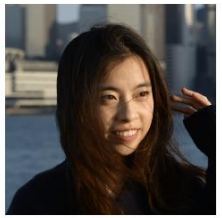
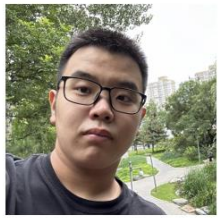

Weizhe Chen


Xinyue Zhang


Ruobing Feng


Yingke Wu


Yue Han


Jinyu Zhu

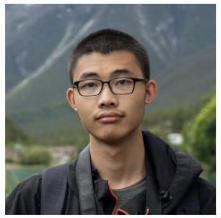

Jialiang Guo


Yunchen Xia


Xinyi Wang


Xiaozhen Yang


Jiahe Li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Xiaohan Xie


Peixin Wu


Chengwei Shi


Ziye Wang


Andrea Tan


Xinyue Lu


Emma Yao


Jingtian Liang

Not Pictured

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- Yuna Cho

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