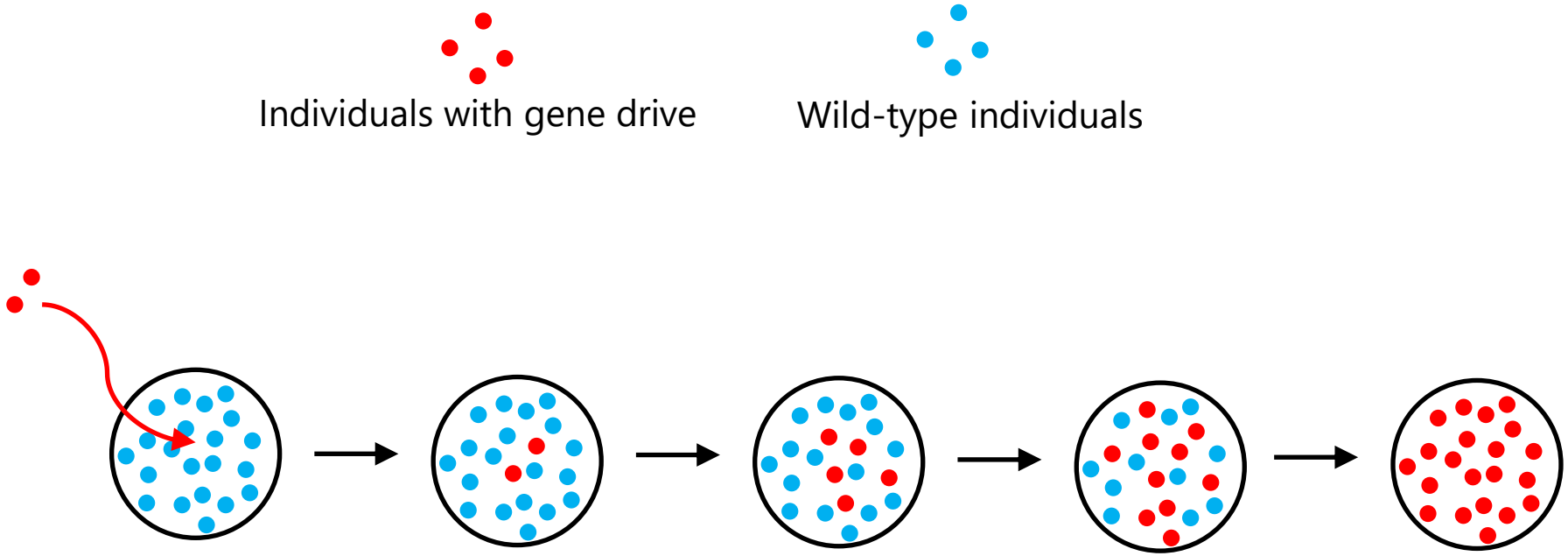
Progress in *Anopheles stephensi* gene drives

Jackson Champer



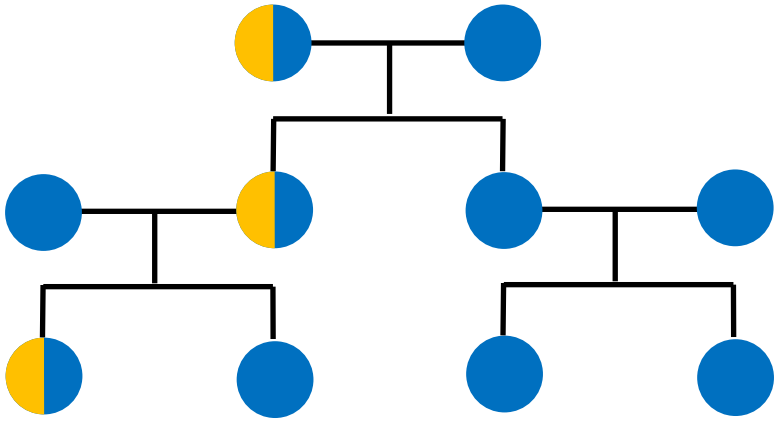
Spread of a Gene Drive



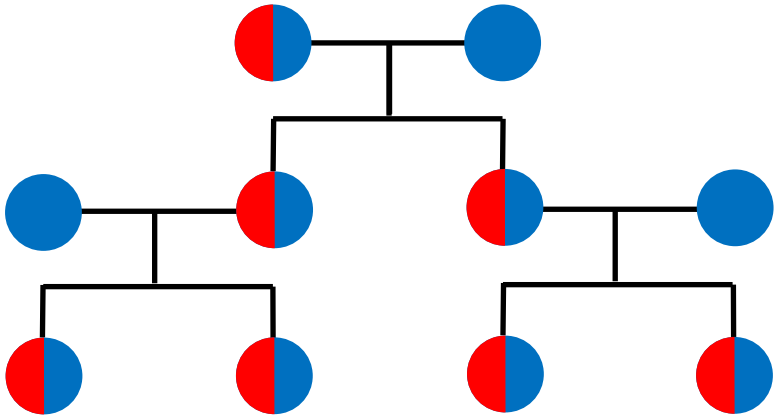
The gene drive spreads through the population over several generations

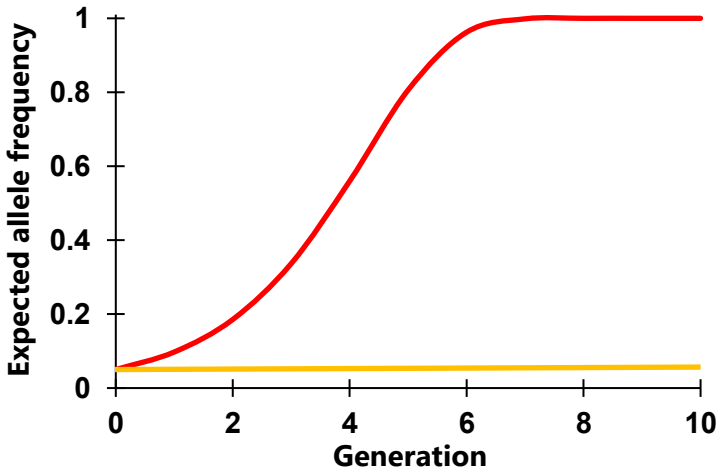
Gene Drive

Normal Inheritance



Gene Drive Inheritance





Gene Drive Type

- Modification



- Suppression



Applications

Anopheles gambiae
(malaria)



Aedes aegypti
(dengue, zika, several others)



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



Applications



Suckermouth catfish



Brown tree snake



Cane toad

Rat



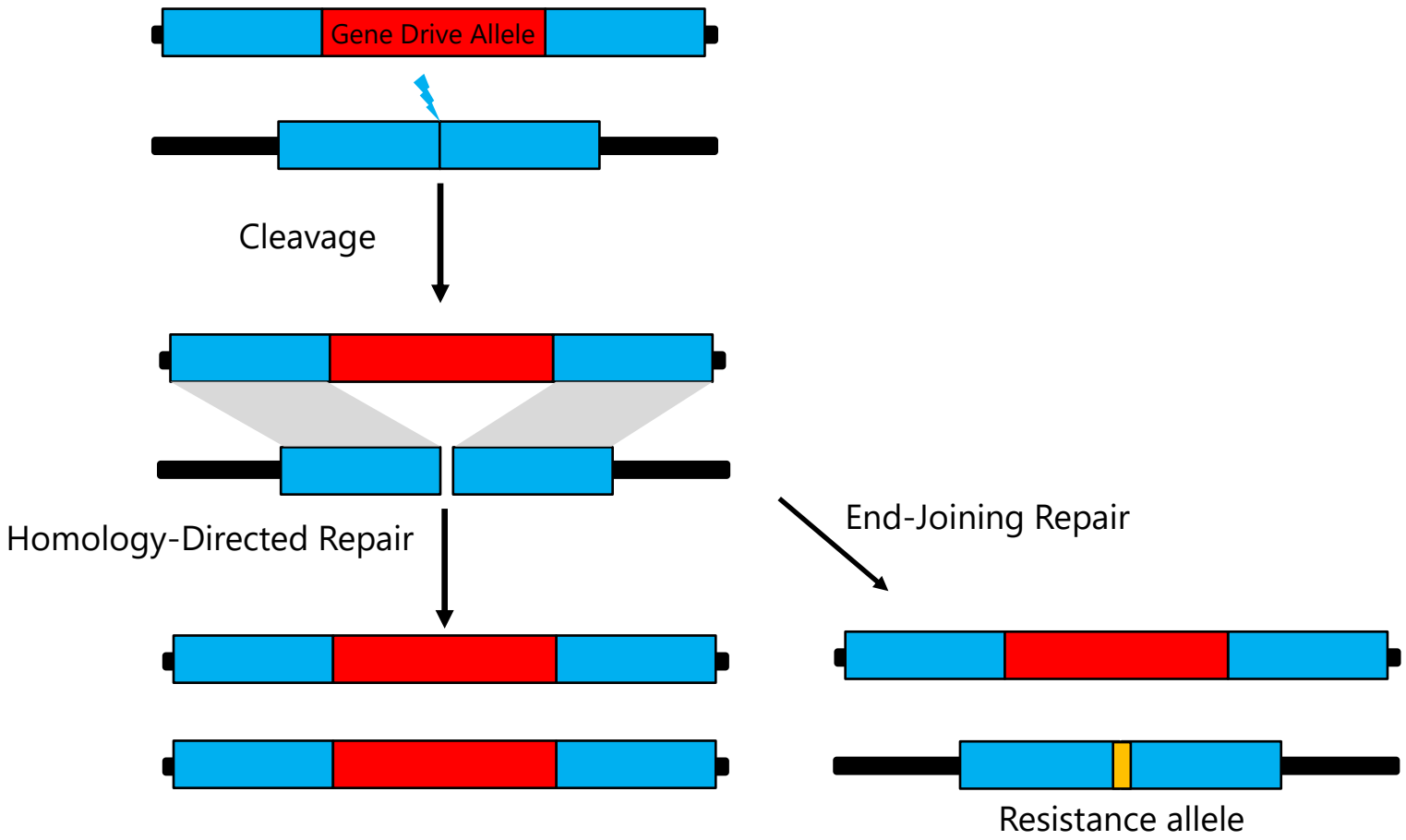
Redroot pigweed



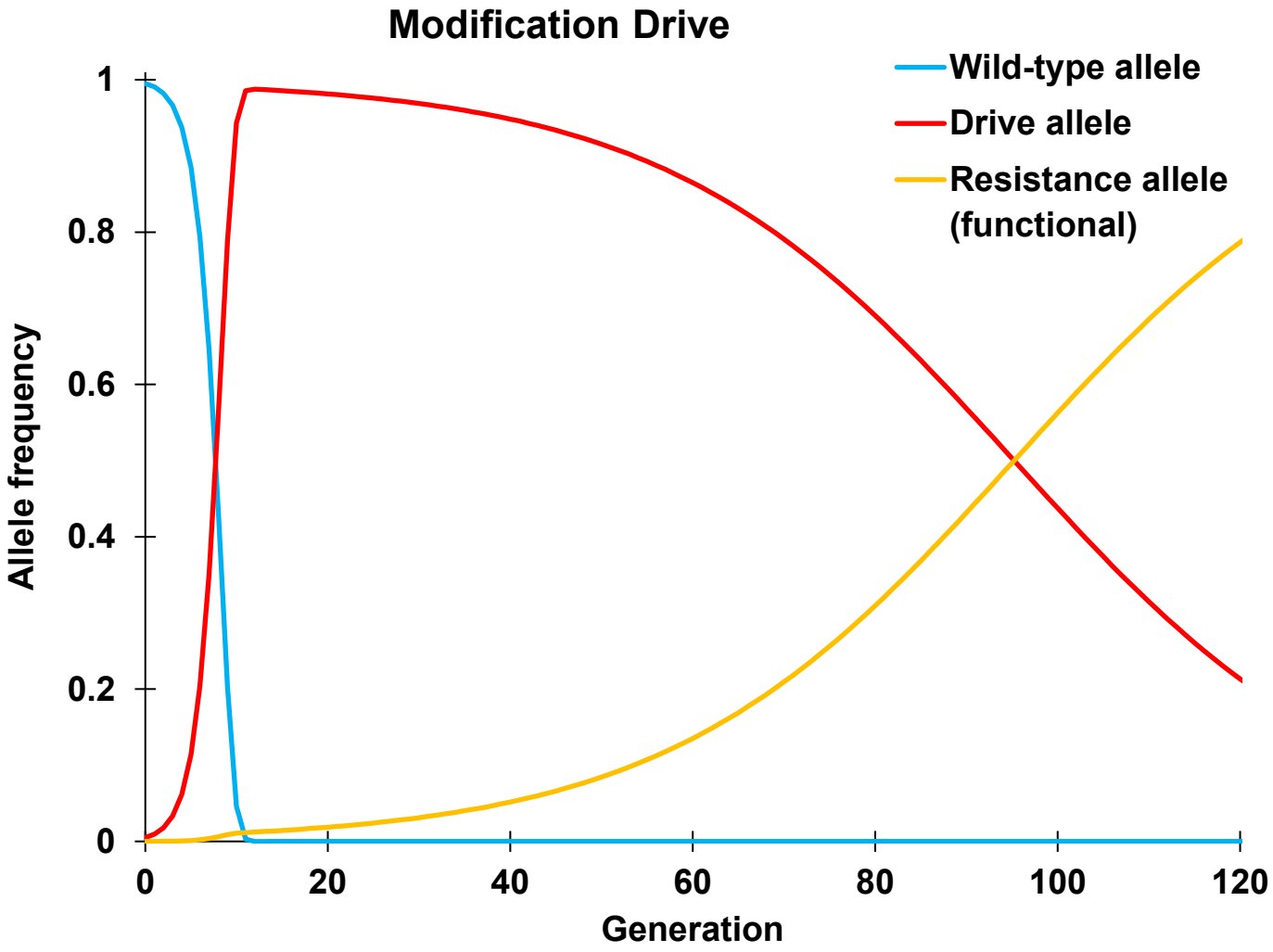
Spotted-wing drosophila

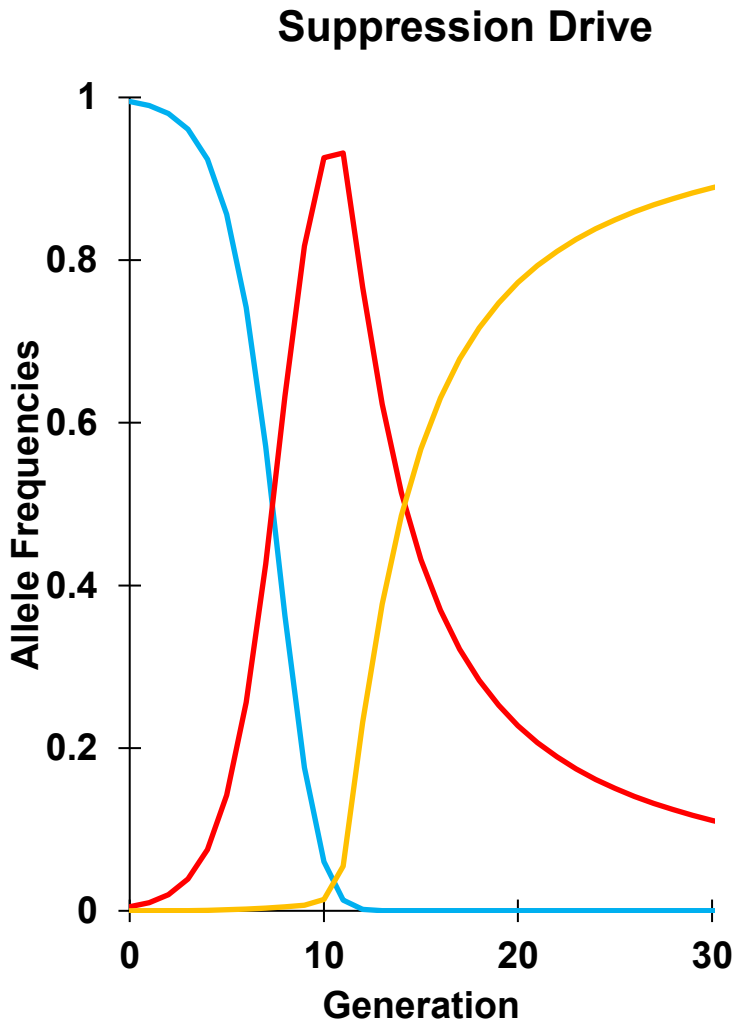


Homing Drive

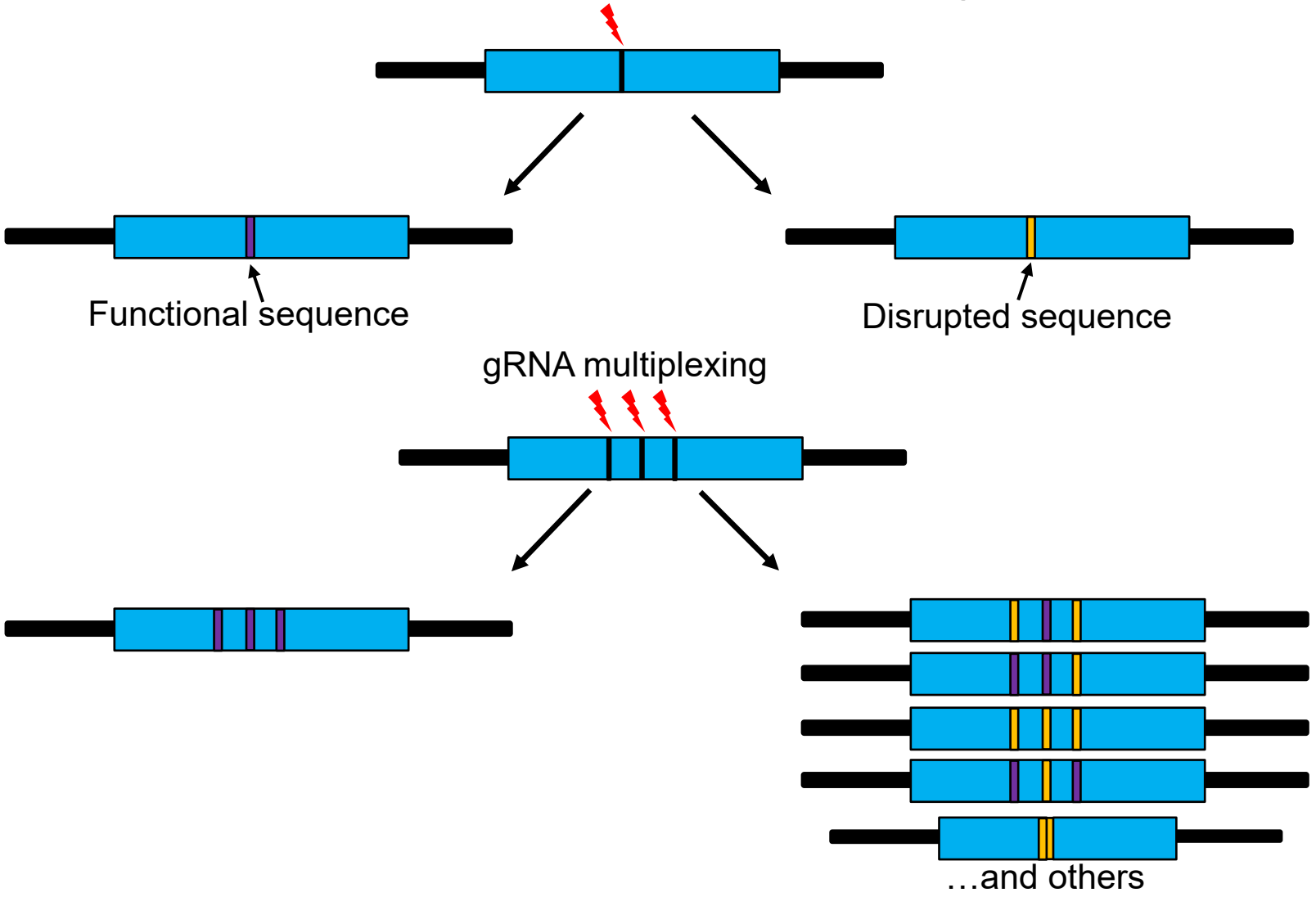


Resistance


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


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

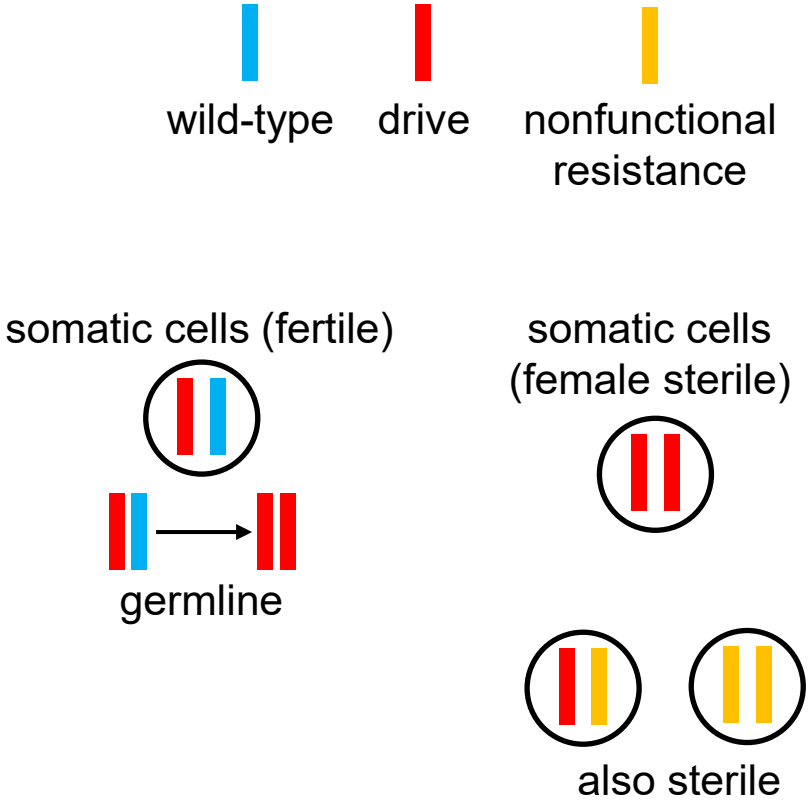
Resistance Allele Types

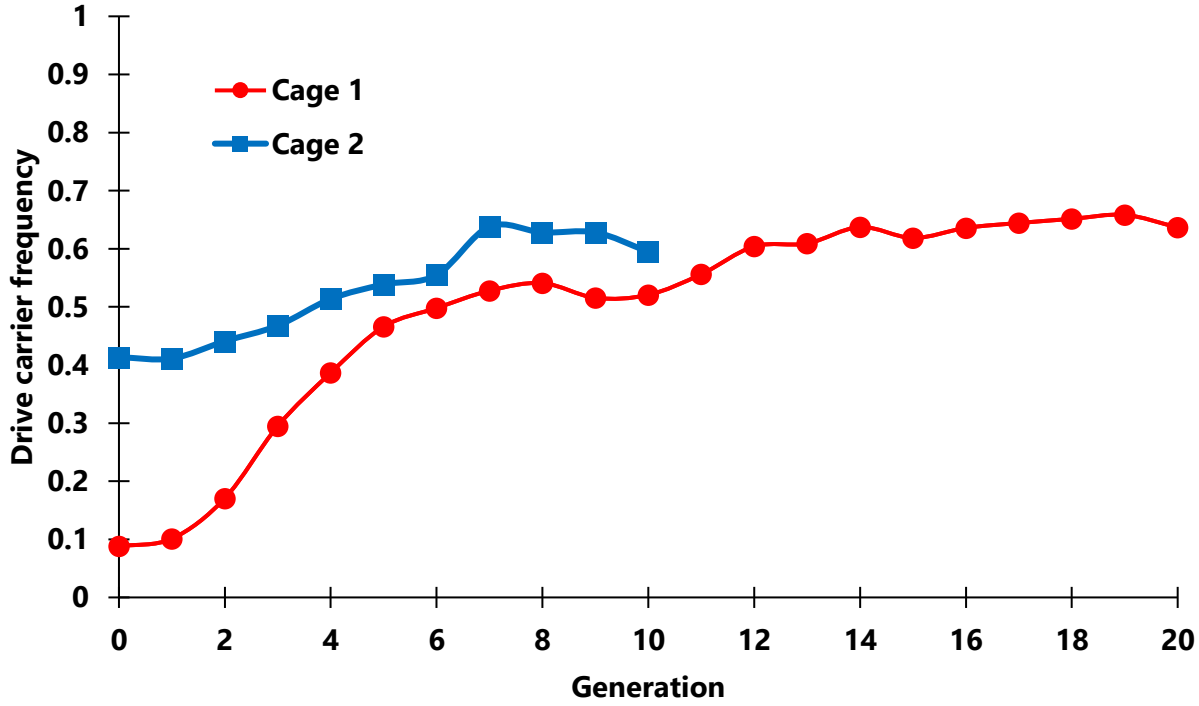


Champer J*+, Liu J+, Oh SY, Reeves R, Luthra L, Oakes N, Clark AG, Messer PW*. Reducing resistance allele formation in CRISPR/Cas9 gene drive. *PNAS*, 2018.
Champer SE, Liu C, Oh SY, Wen Z, Clark AG, Messer PW, Champer J*. Computational and experimental performance of CRISPR homing gene drive strategies with multiplexed gRNAs. *Sci Adv*, 2020.

Suppression Drive

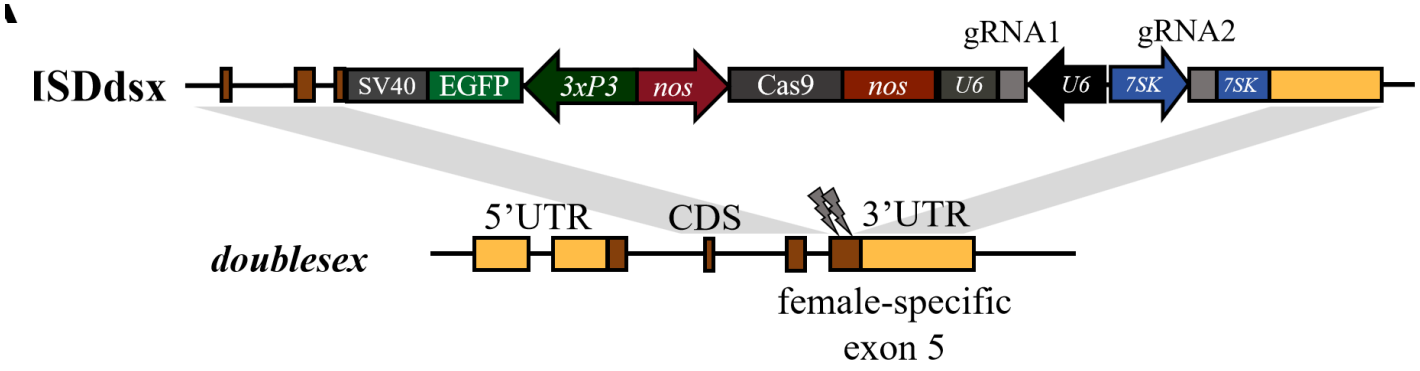
- Target an essential but haplosufficient female fertility gene.



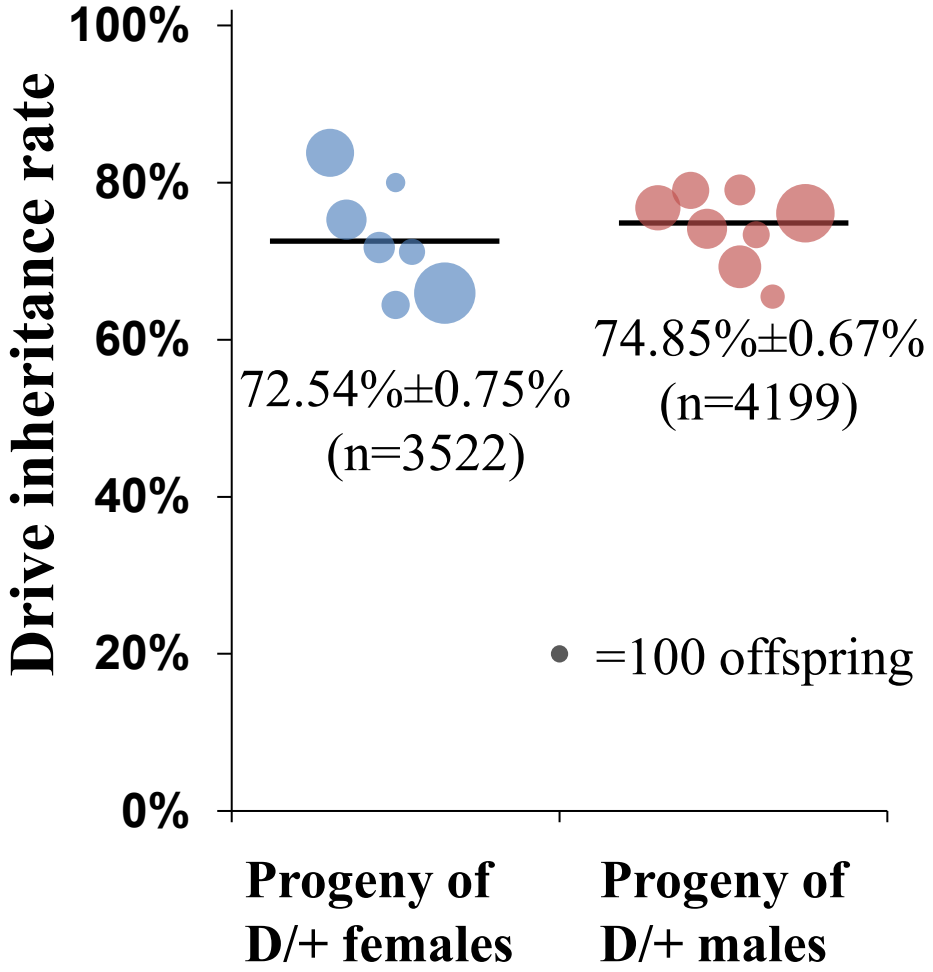


Yang E, Metzloff M, Langmüller AM, Clark AG, Messer PW, Champer J*. A homing suppression gene drive with multiplexed gRNAs maintains high drive conversion efficiency and avoids functional resistance alleles. *G3*, 2022.

Anopheles stephensi Suppression

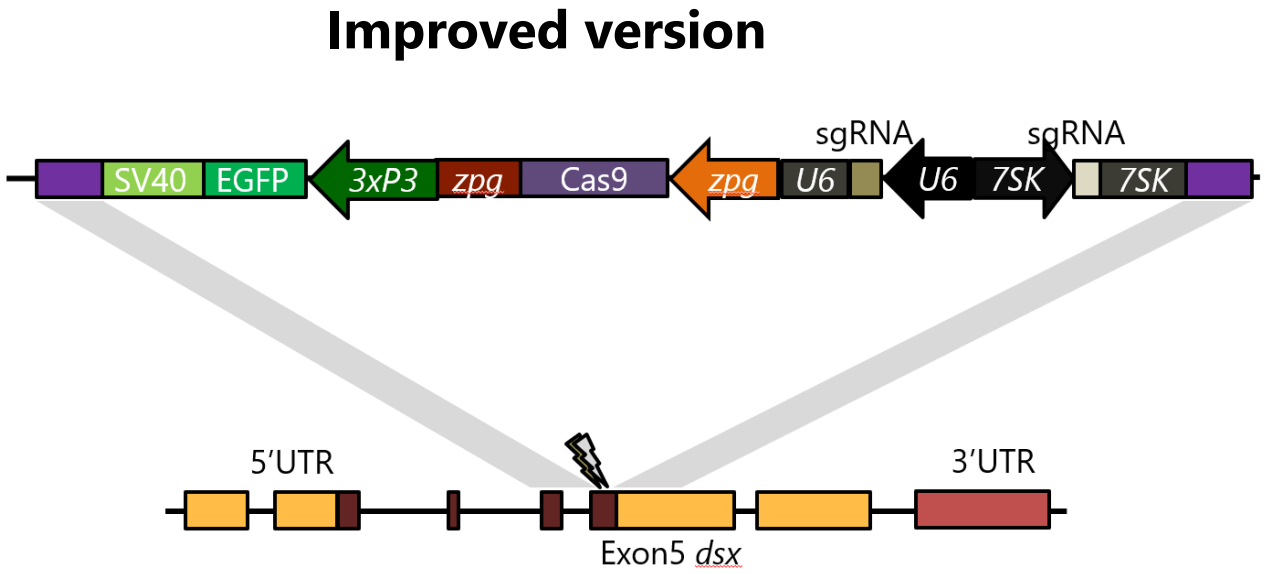


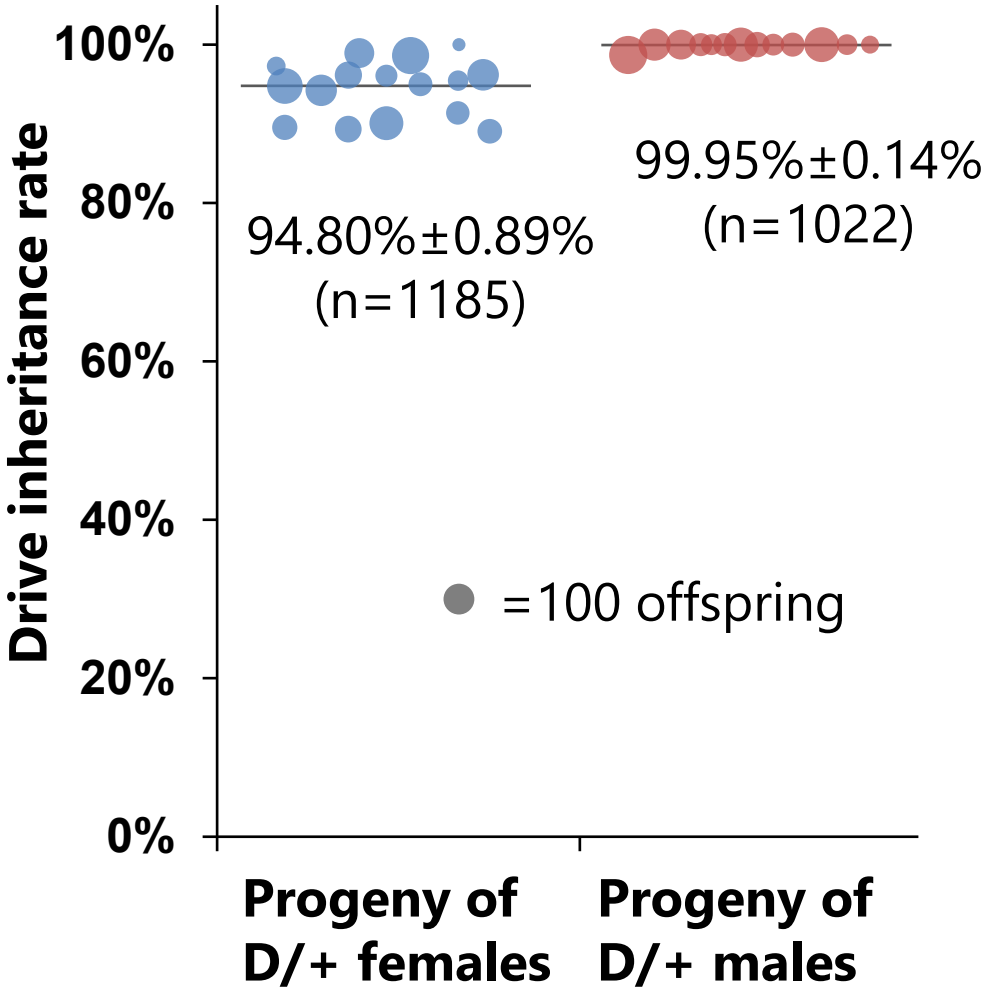




Xu X, Chen J, Wang Y, Liu Y, Zhang Y, Yang J, Yang X, He Z, Champer J. Gene drive-based population suppression in the malaria vector *Anopheles stephensi*. *Nature Communications*, 2025.

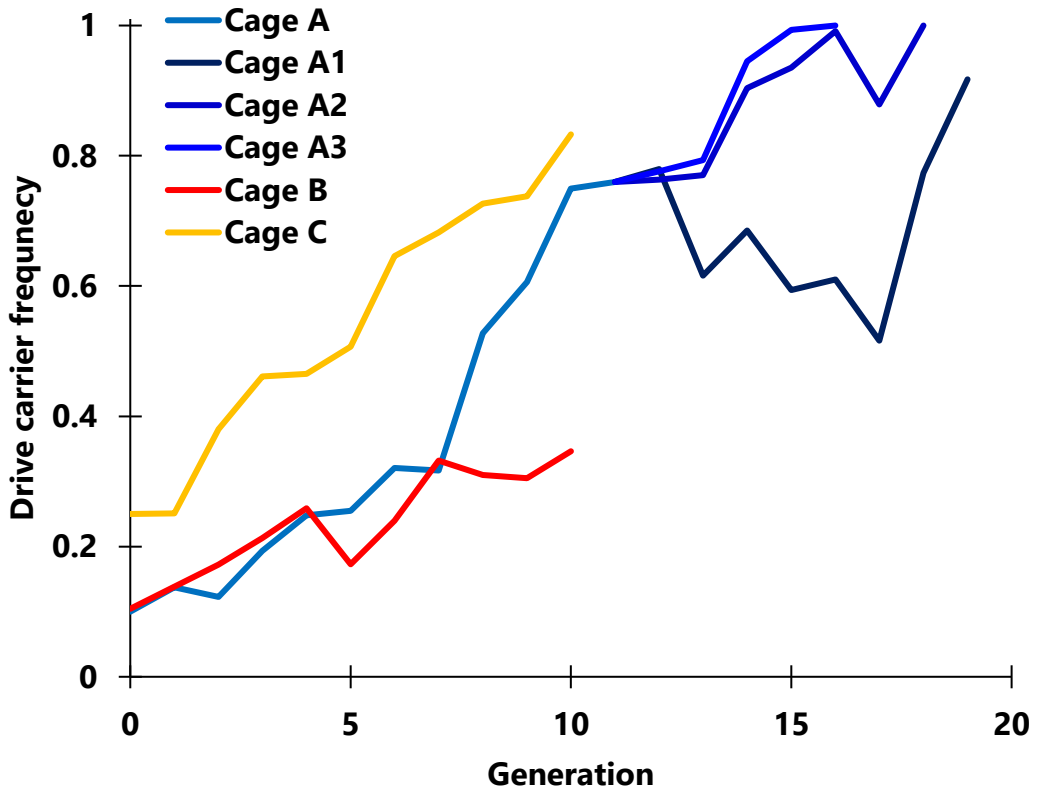
Improved *Anopheles stephensi* Suppression

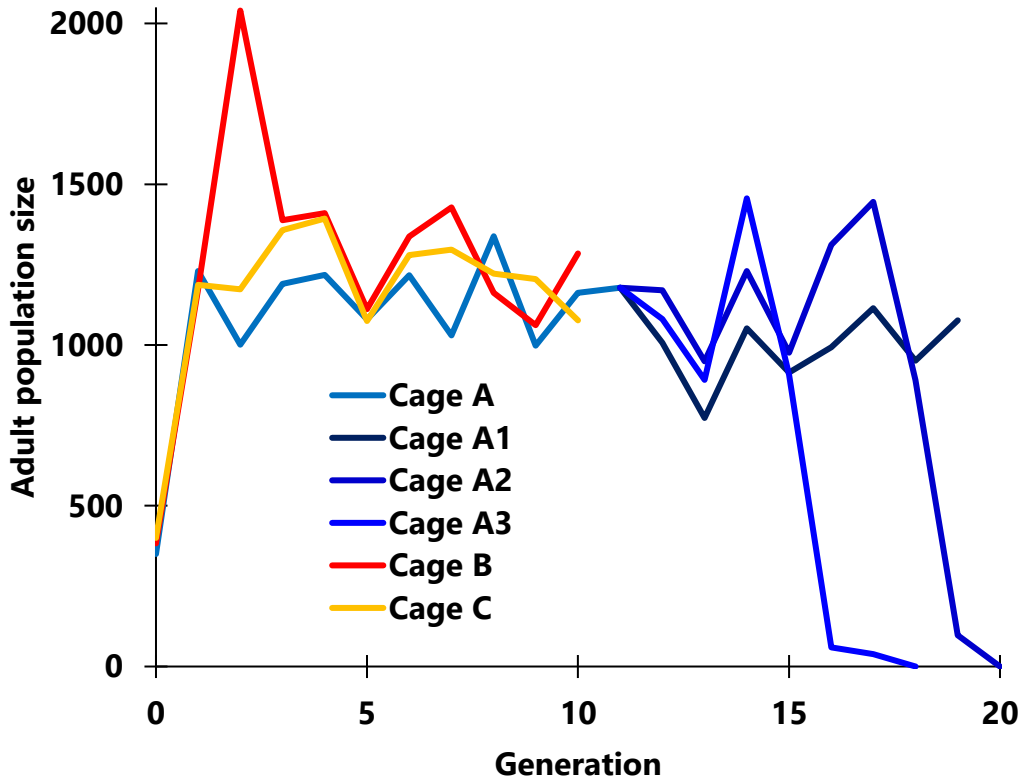




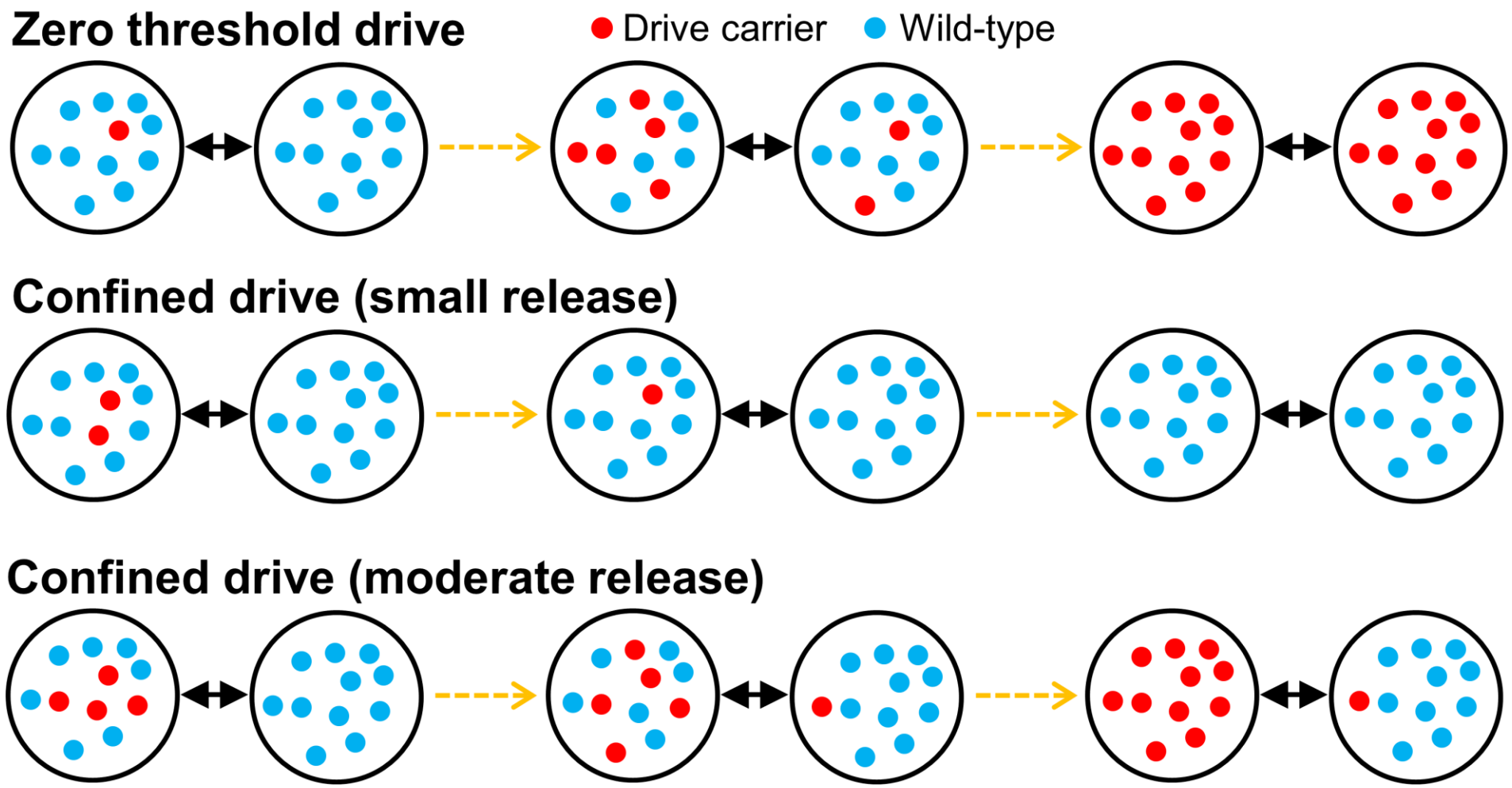
- Male homozygotes remain sterile.

Improved *Anopheles stephensi* Suppression

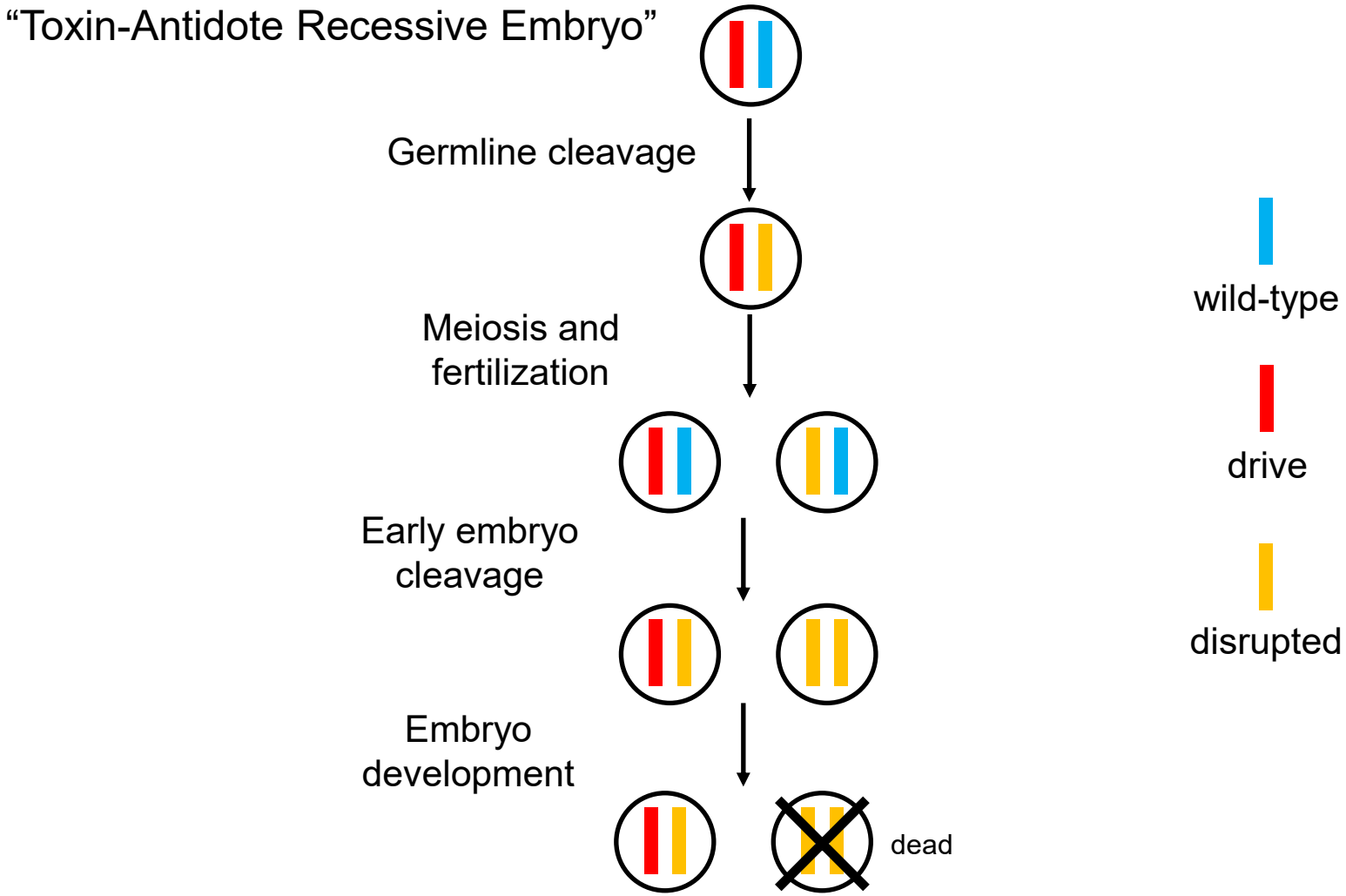




Confinement

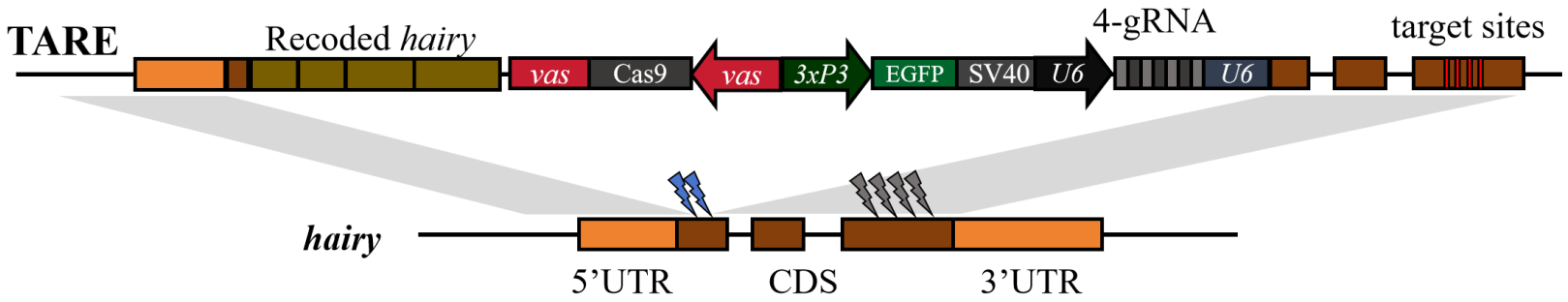


TARE Drive

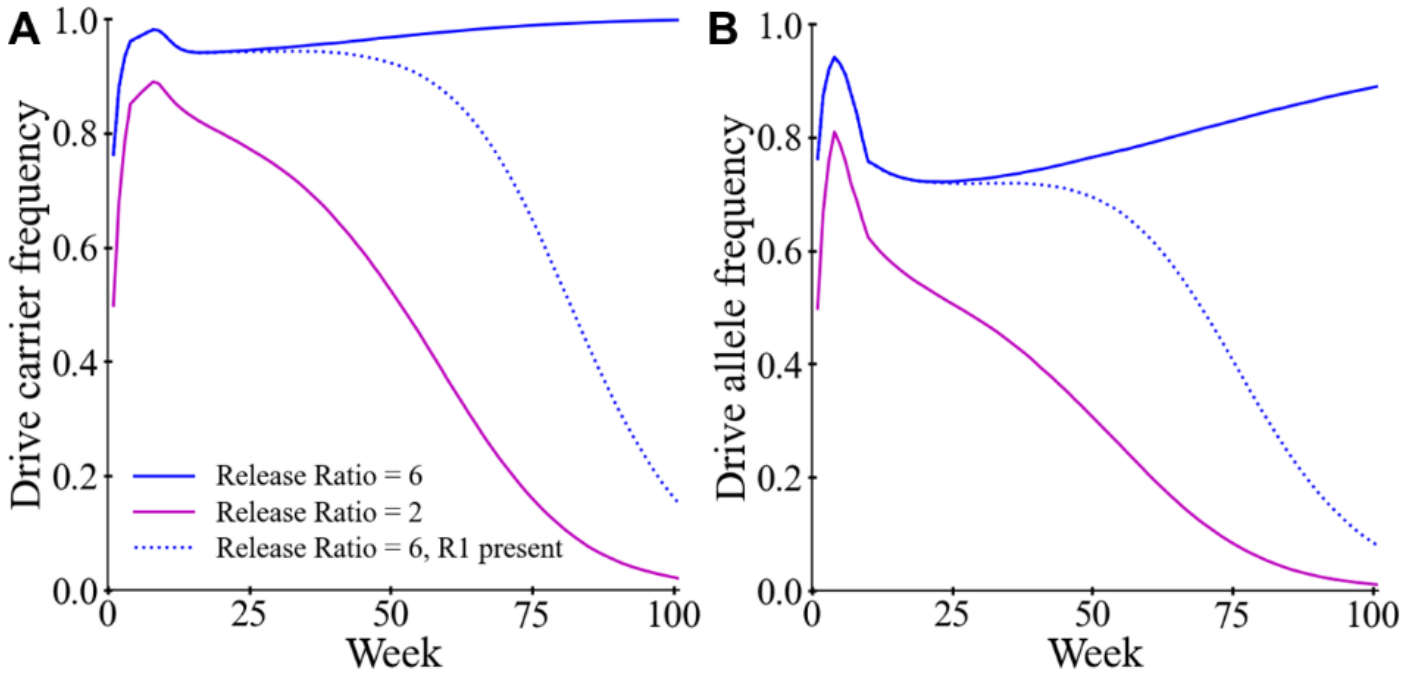


Champer J*, Lee YL, Yang E, Liu C, Clark AG, Messer PW*. A toxin-antidote CRISPR gene drive system for regional population modification. *Nat Commu*, 2020.
Champer J*, Kim I, Champer SE, Clark AG, Messer PW. Performance analysis of novel toxin-antidote CRISPR gene drive systems. *BMC Biol*, 2020.

Anopheles stephensi TARE

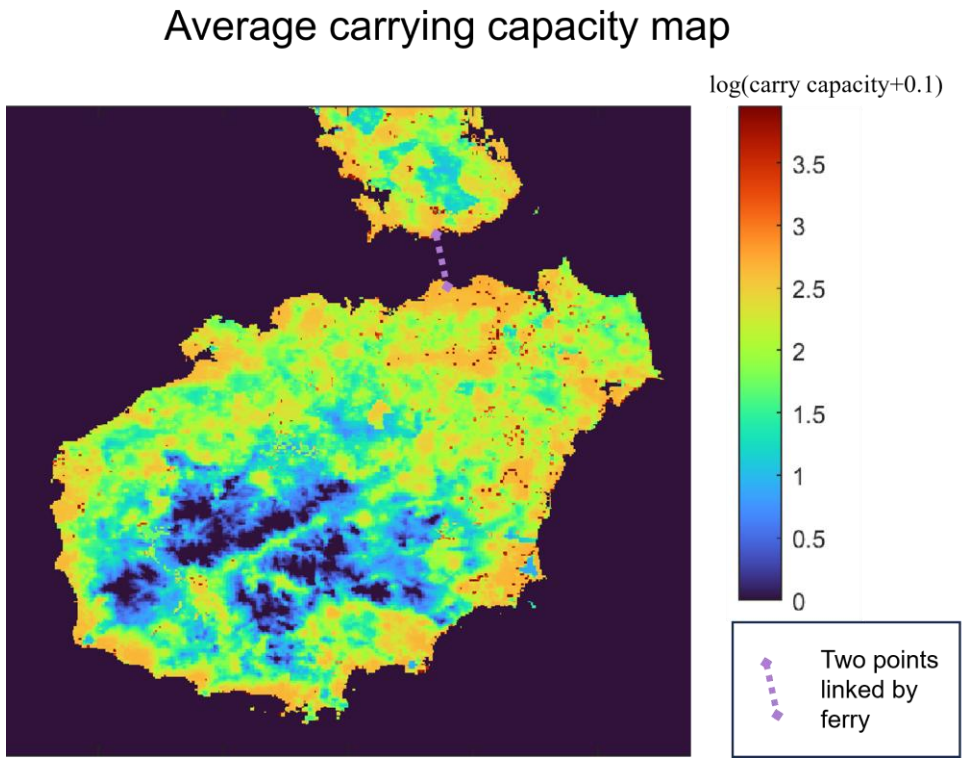


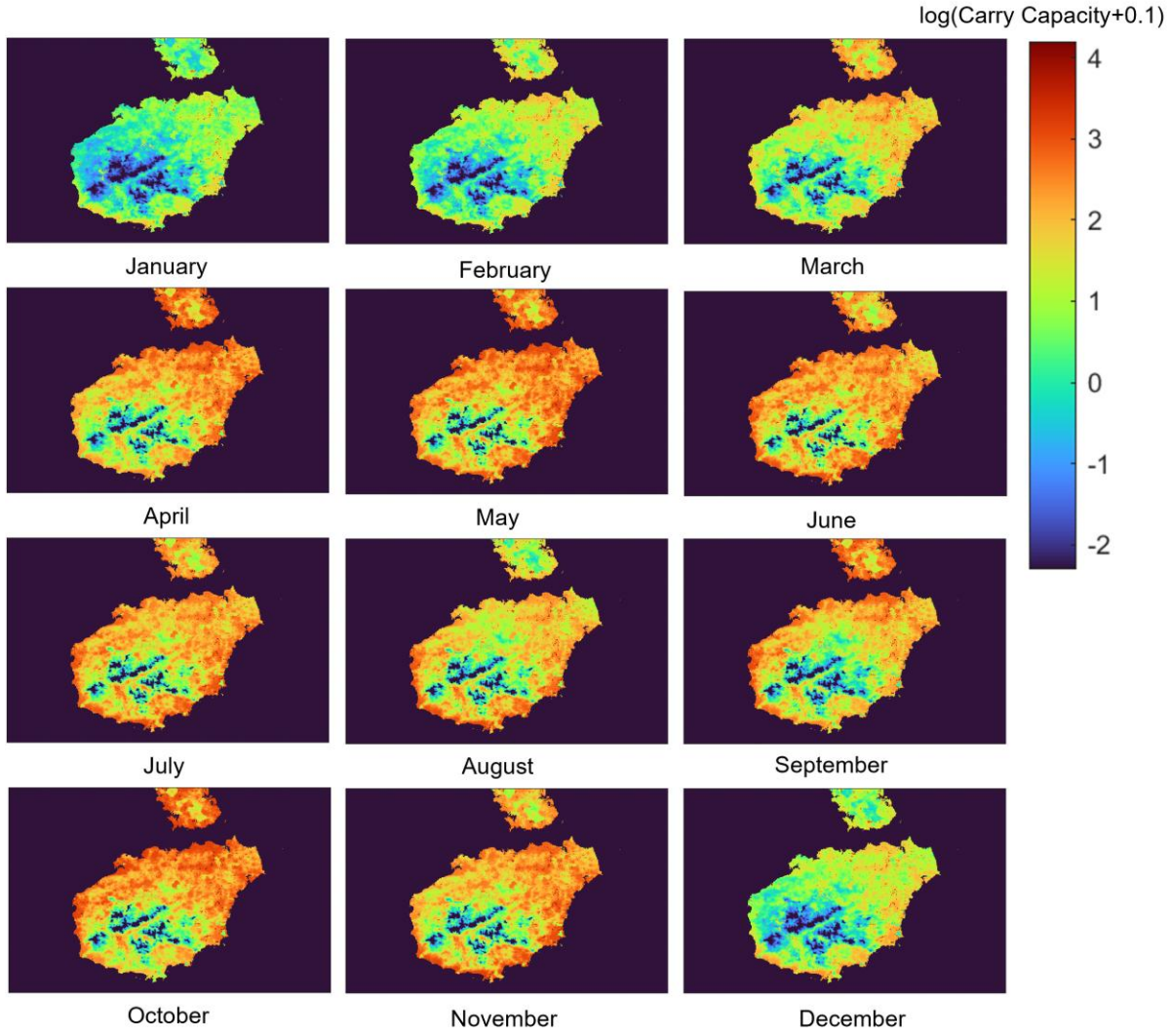




Xu X*, Liu Y, Jia X, Yang J, Xia Y, Chen J, Champer J*. A confined gene drive for population modification in the malaria vector *Anopheles stephensi*. *bioRxiv*, April 2026.

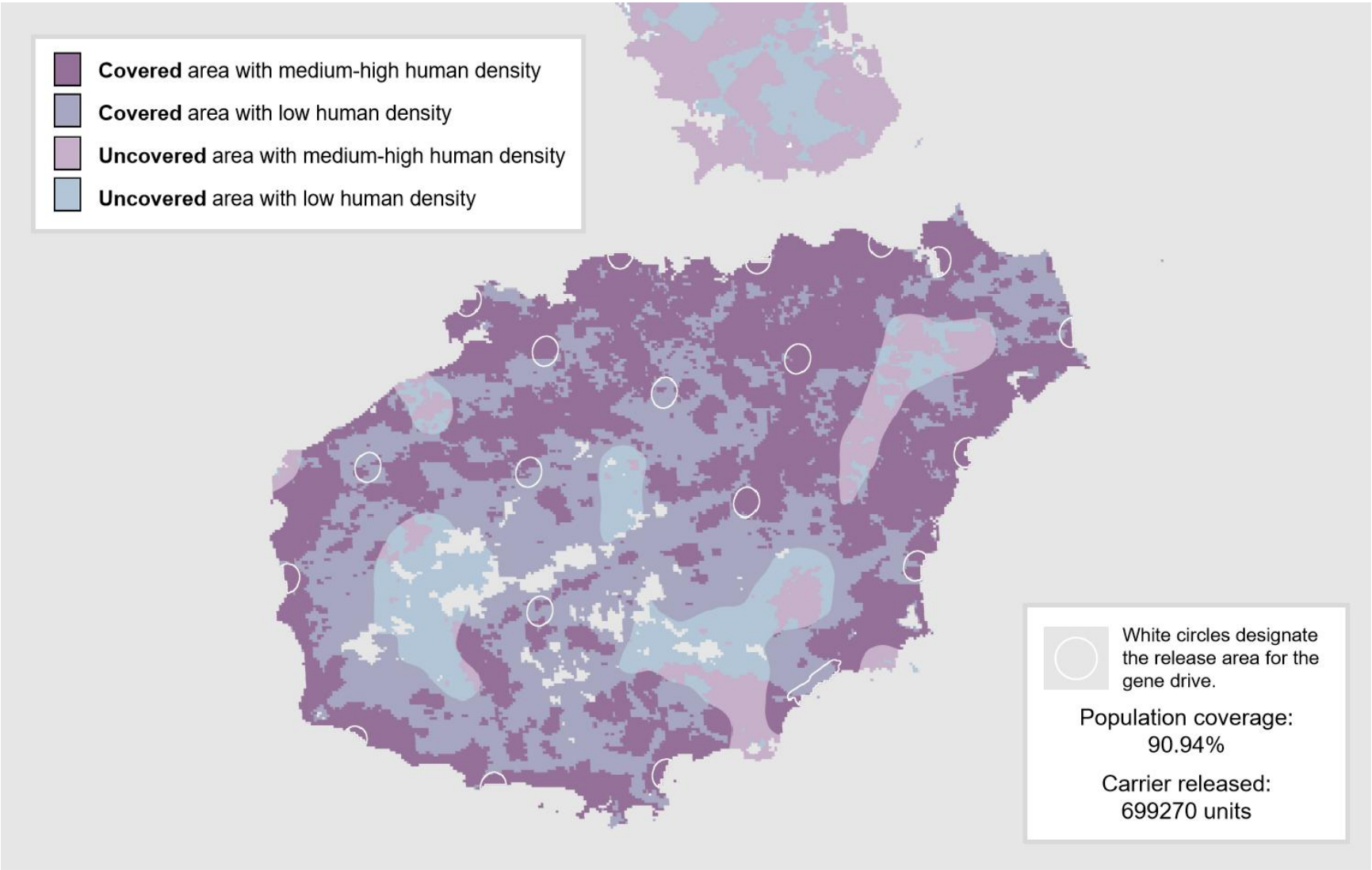
Hainan Island in Hexes





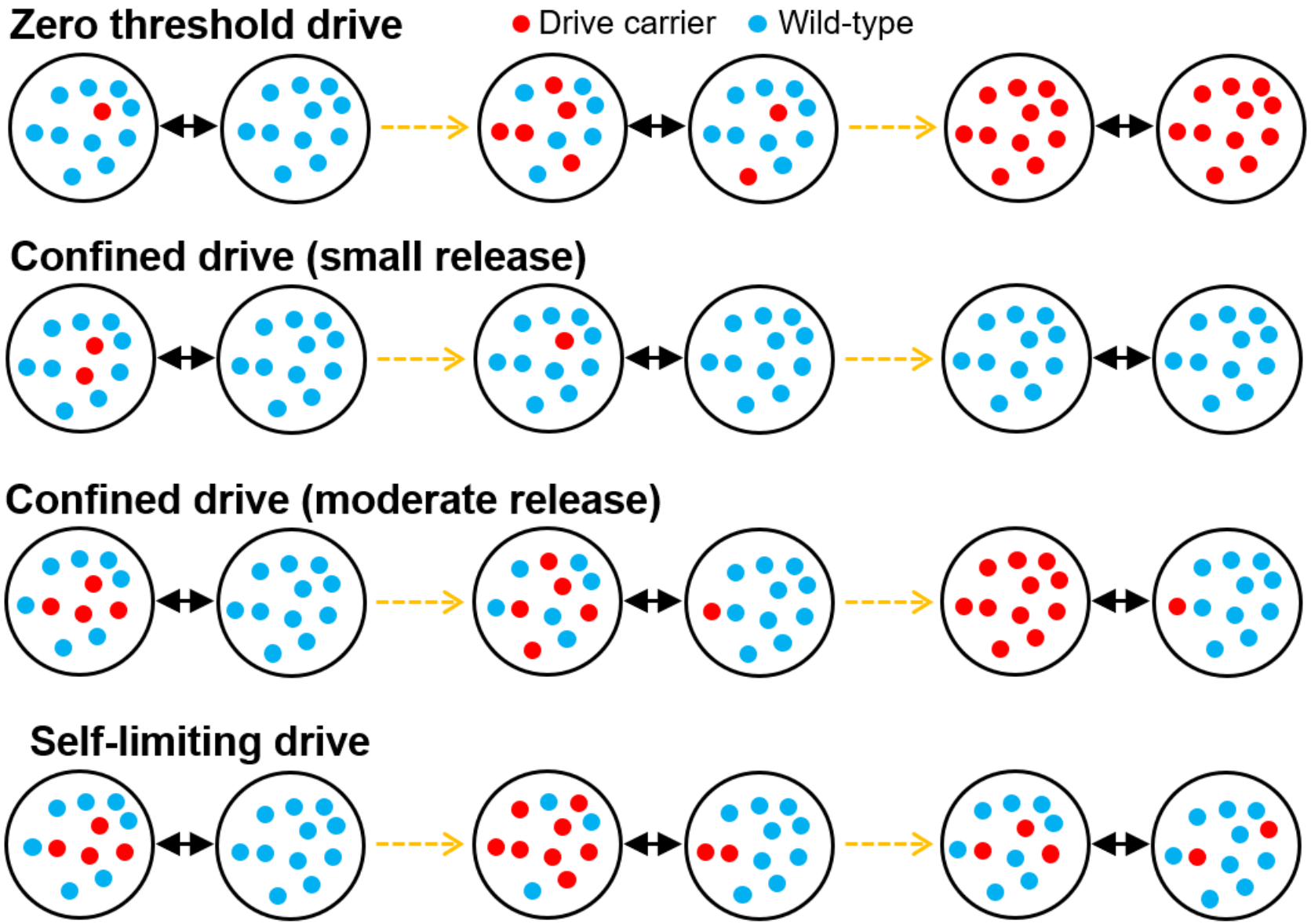
Li J+, Shi C+, Champer J*. Comparative assessment of gene drive release patterns and spread with a hex-based model for large-scale simulations. *bioRxiv*, July 2026.

Optimal TARE Releases

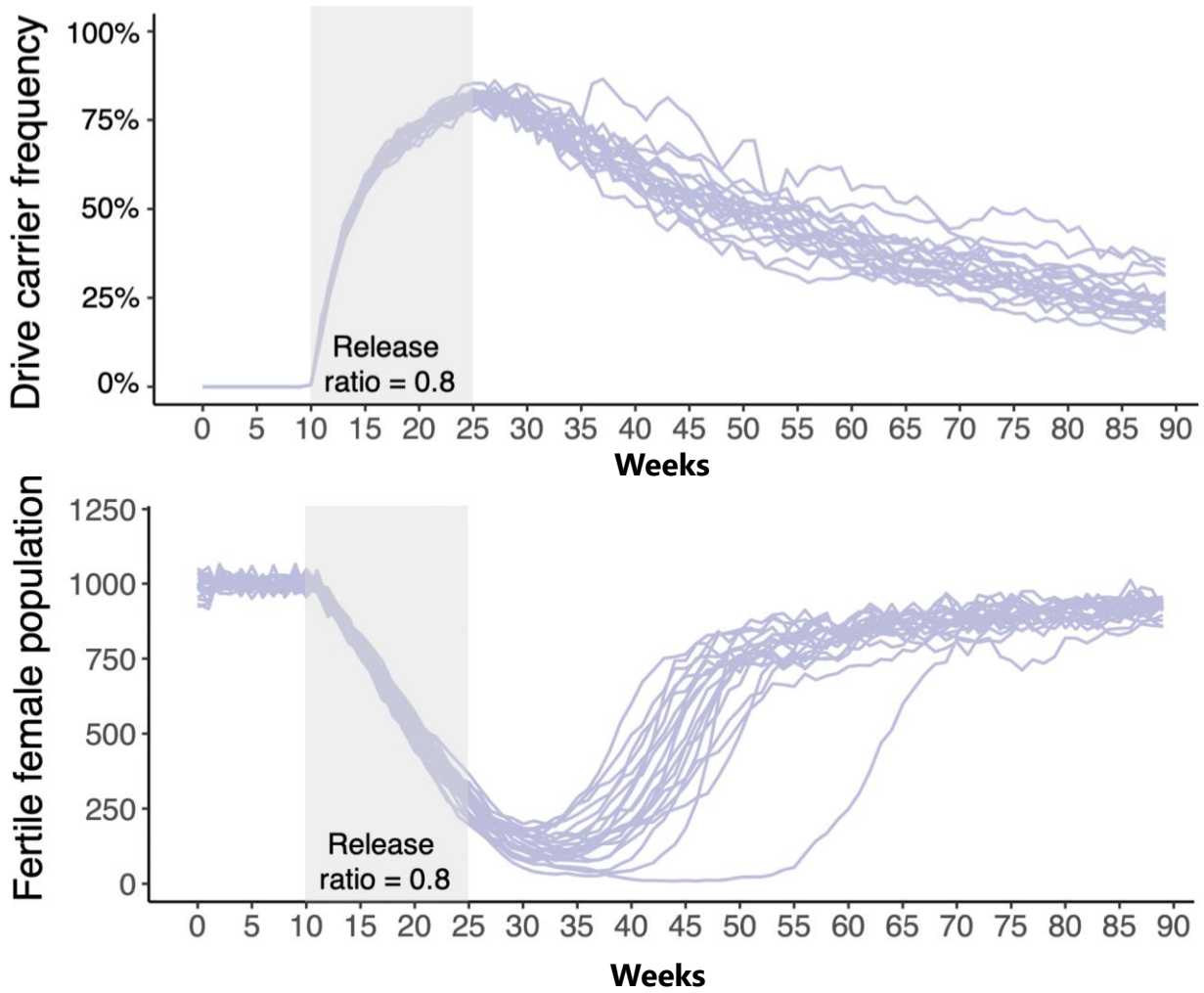


Li J+, Shi C+, Champer J*. Comparative assessment of gene drive release patterns and spread with a hex-based model for large-scale simulations. *bioRxiv*, July 2026.

Confinement

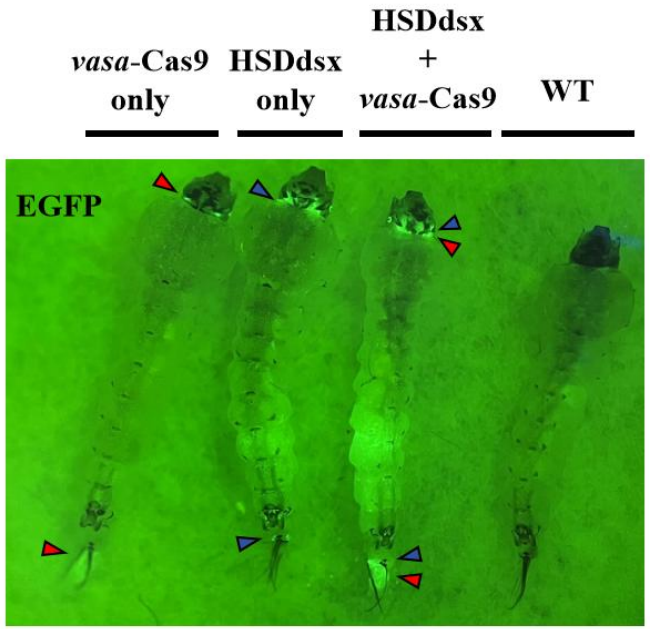


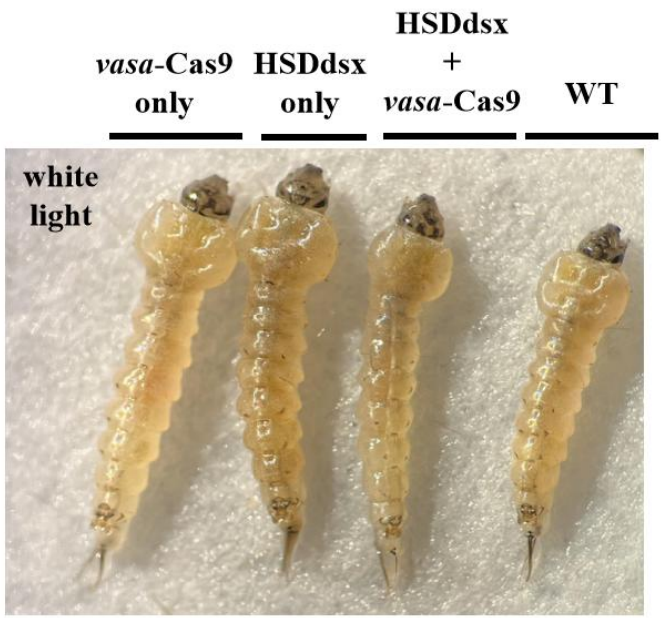
Self-Limiting Suppression

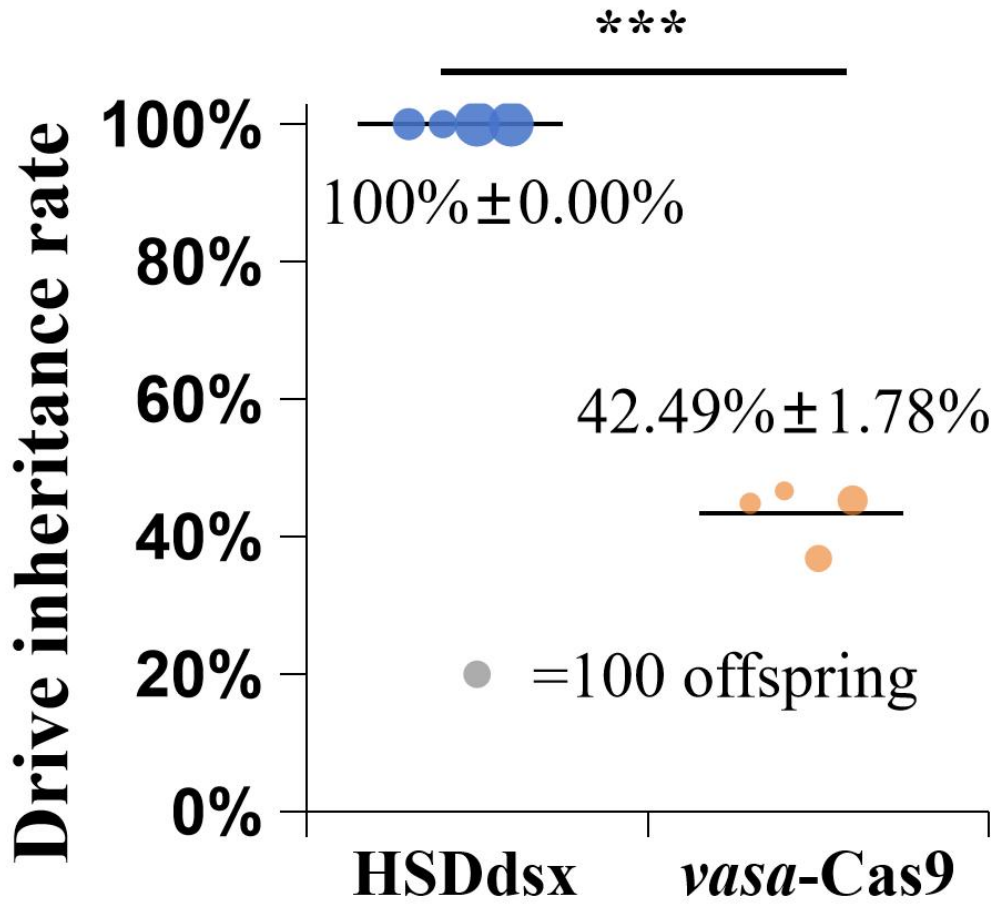


Chen W, Guo J, Liu Y, Champer J*. Population suppression by release of insects carrying a dominant sterile homing gene drive targeting *doublesex* in *Drosophila*. *Nature Communications*, 2024.

Anopheles stephensi Suppression







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.

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