



Invasive alien species: Why is gene drive being considered?

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Invasive species in Australia



Fox



Rabbit



Feral Cat



Cane Toad

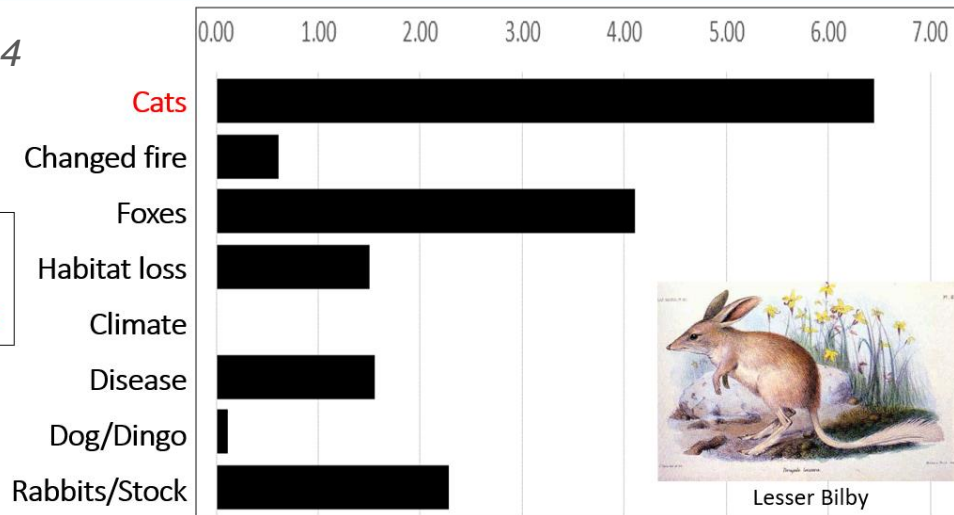


Carp

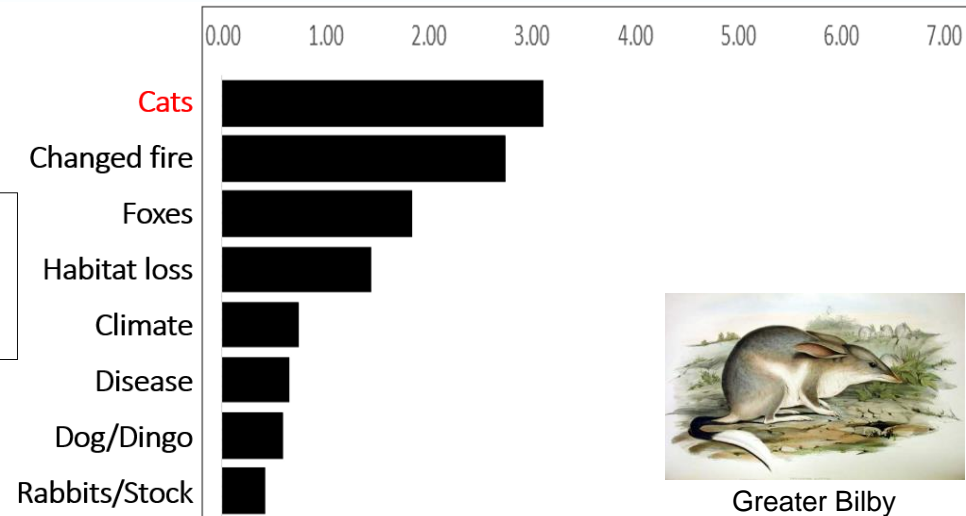
Threats to endemic fauna in Australia

Source:
Woinarski et al. 2014

Threats to
extinct
mammals



Threats to
extant
mammals



316,000,000

Number of birds killed by feral cats in Australia each year

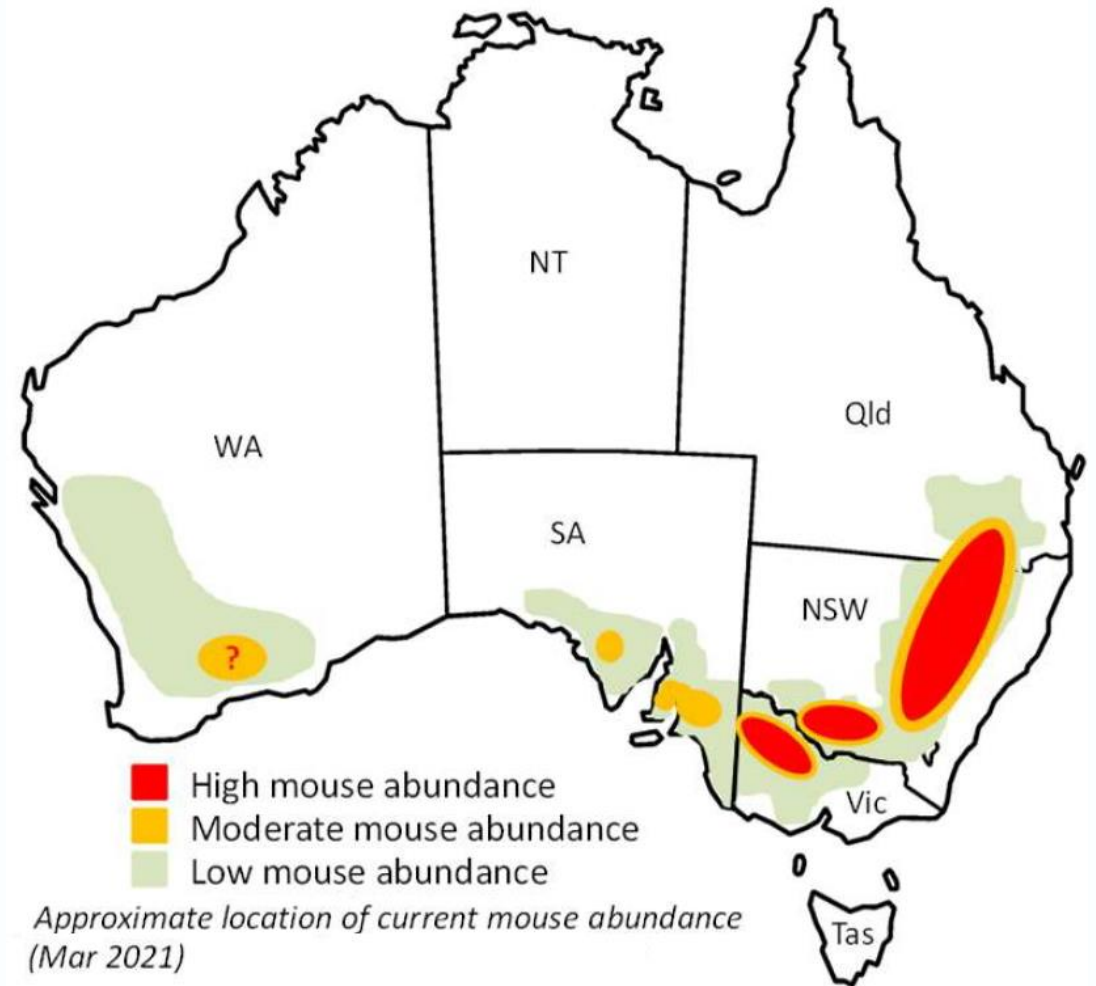
596,000,000

Number of reptiles killed by feral cats in Australia each year

Chemical control



Mouse Plagues



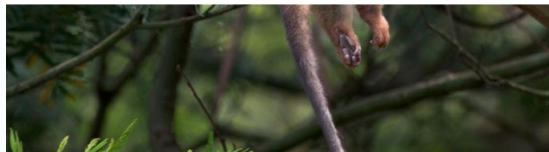
Chemical control



Eastern
Quoll

Australia news

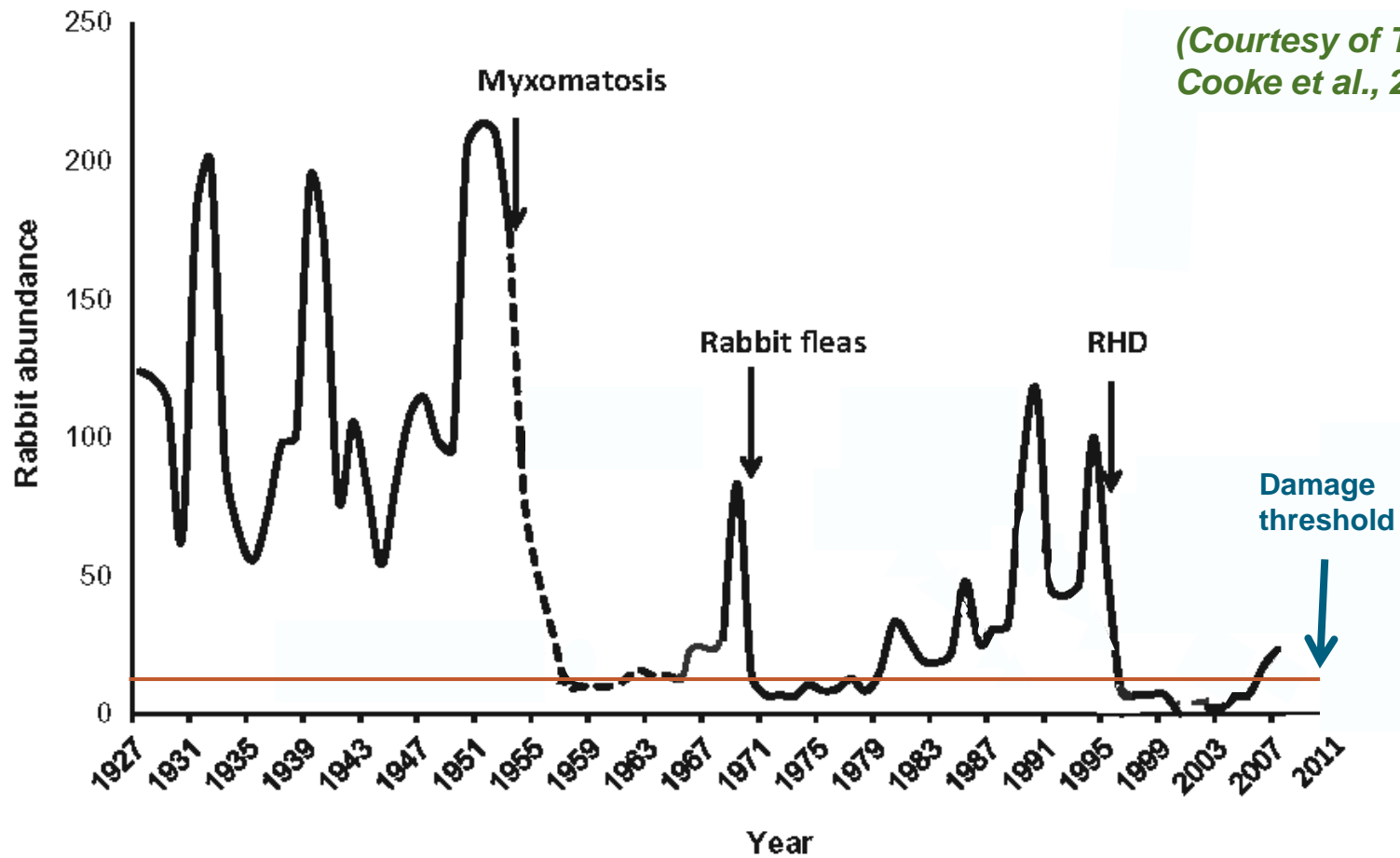
NSW plan to use 'napalm' poison to control mouse plague rejected over fears for wildlife



Powerful Owl



Biological control

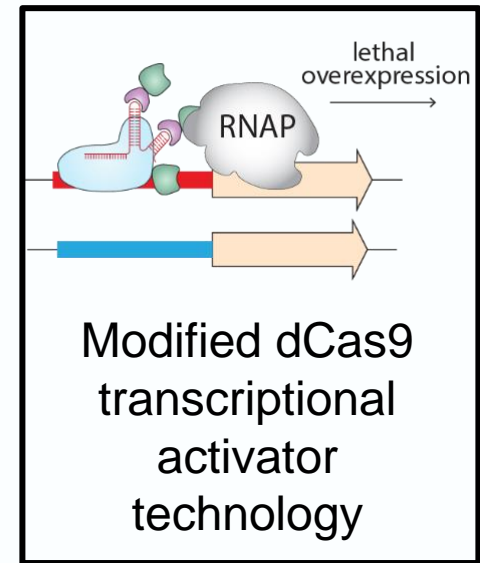
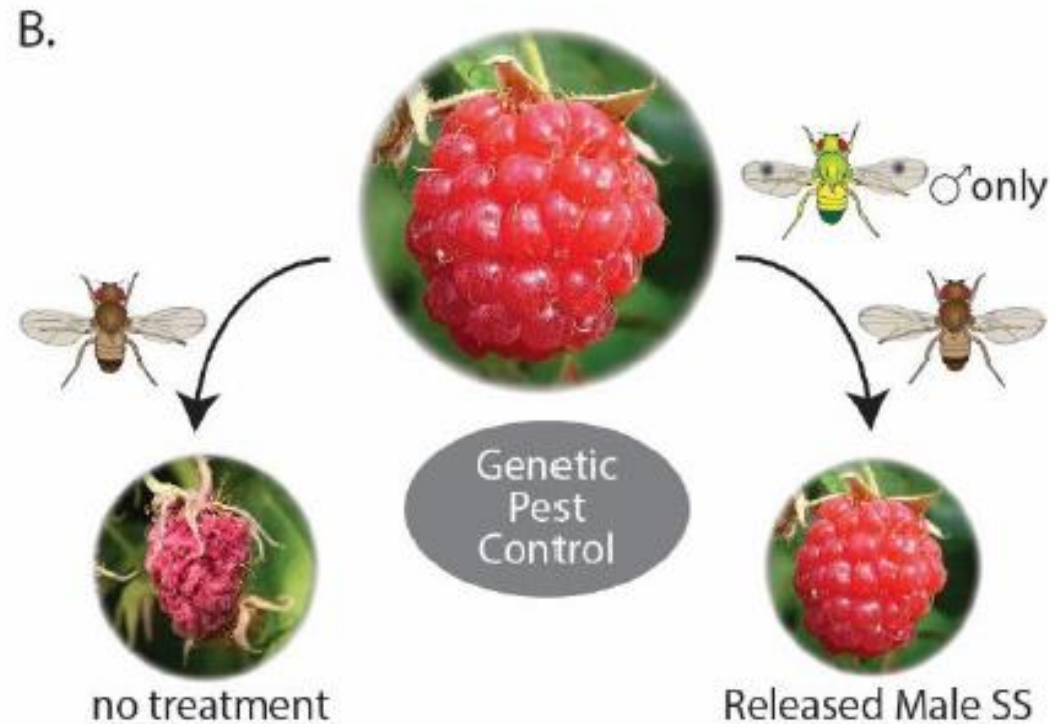
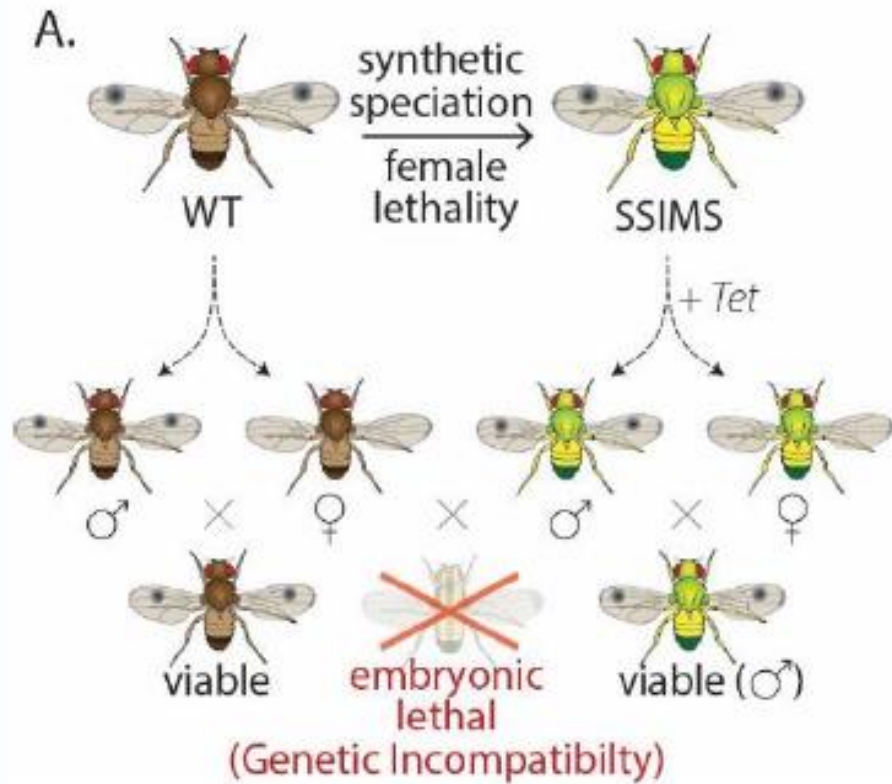


(Courtesy of Tanja Strive, modified from Cooke et al., 2013, Aust Econ Hist Rev)

Genetic control

Courtesy of Maciej Maselko
(see Maselko et al. Nature Comms 11: 1-7)

Self-selecting incompatible male system



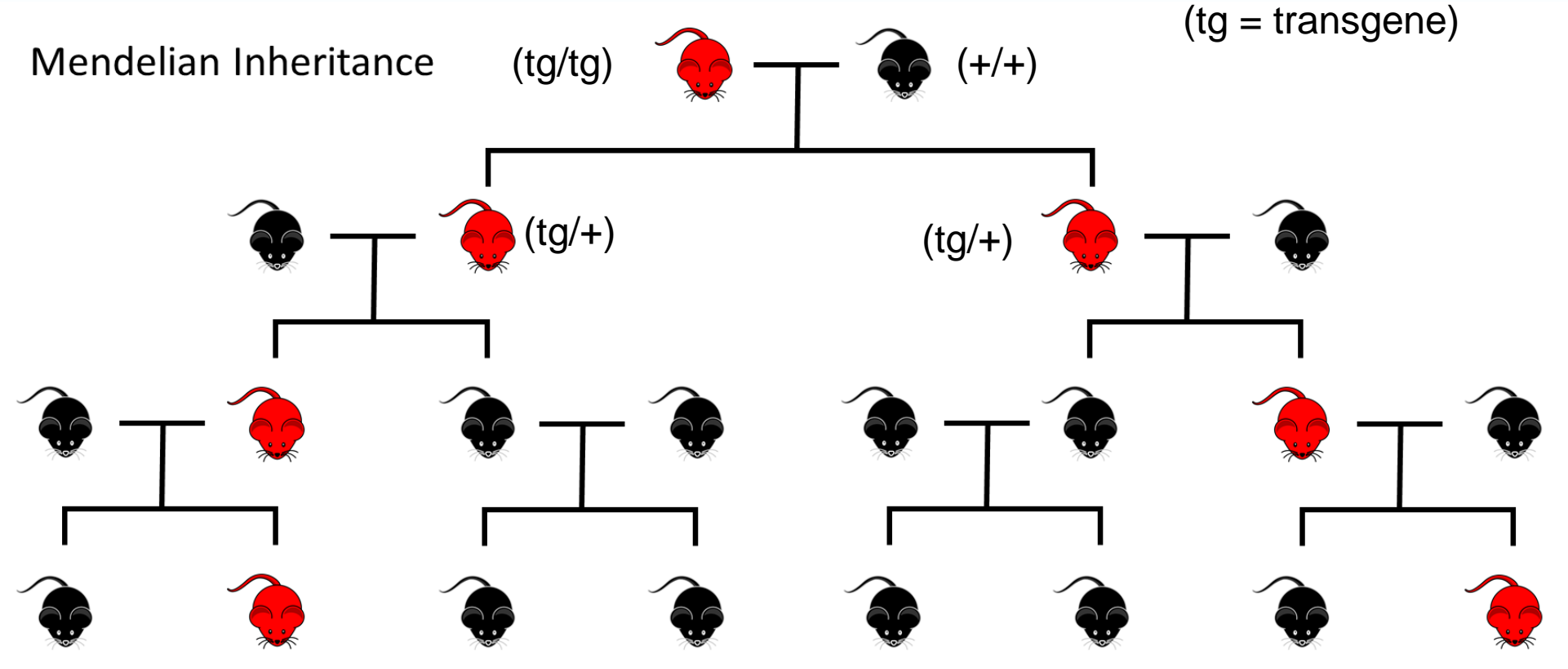
MACQUARIE
University



CSIRO

Inheritance of genetic control without gene drive

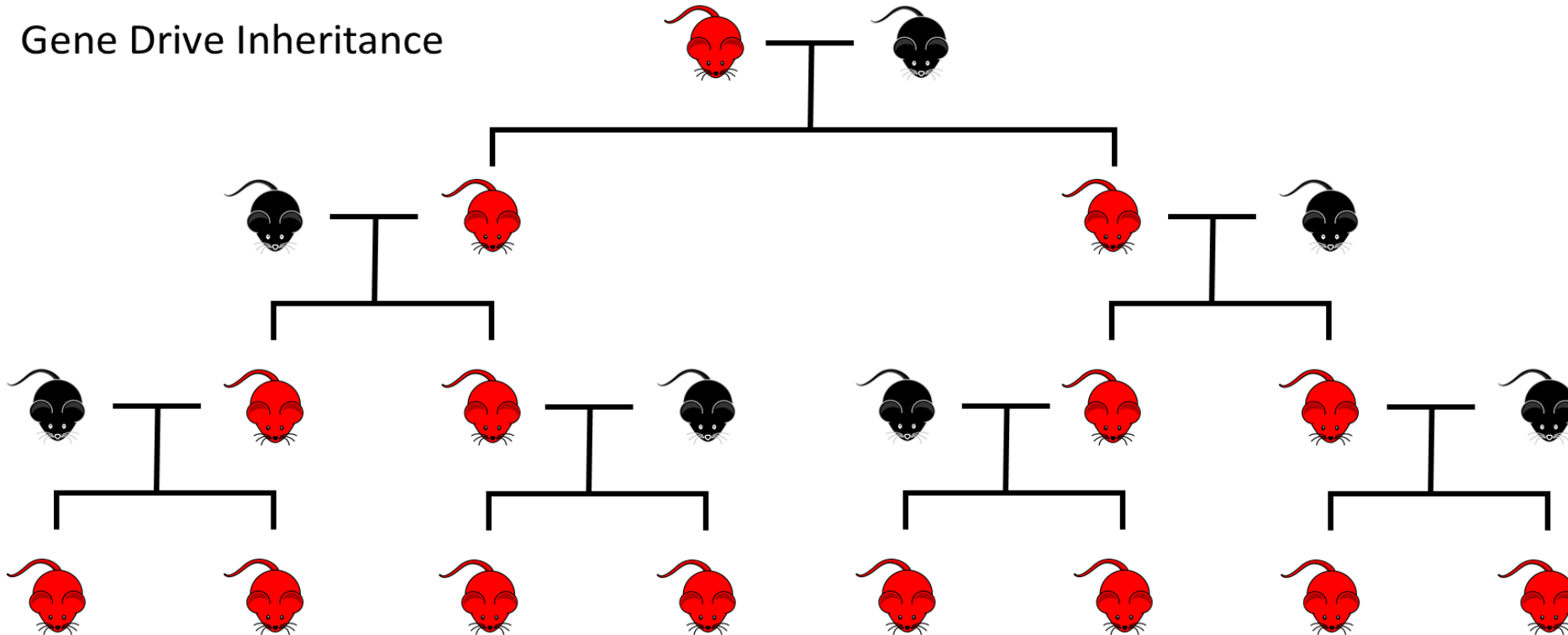
(Courtesy of Paul Thomas, U. Adelaide)



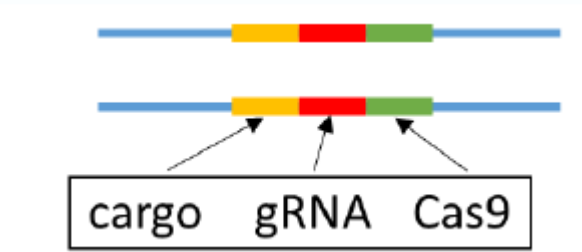
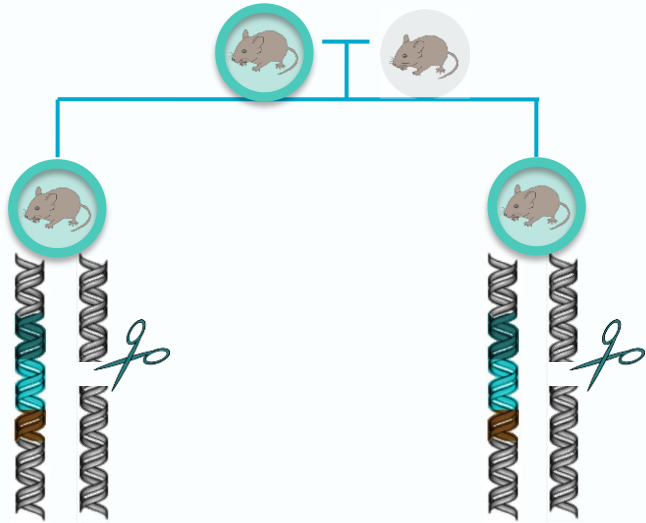
Gene drives increase in frequency by biasing inheritance

(Courtesy of Paul Thomas, U. Adelaide)

Gene Drive Inheritance



Homing Gene Drive Mechanism

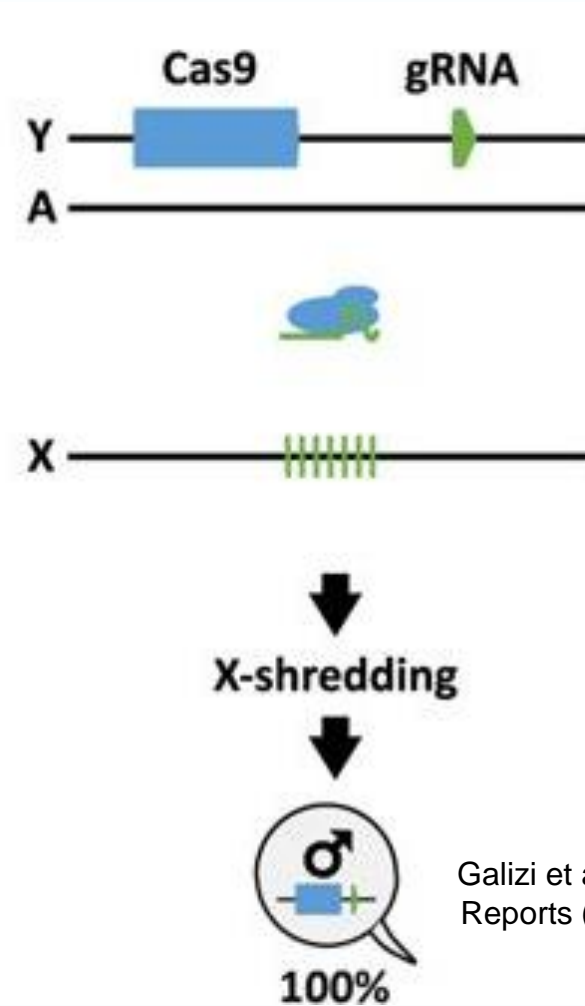


Courtesy of Kevin Esvelt, MIT Media Lab
See Esvelt KM, Smidler AL, Catteruccia F, Church GM (2014) *eLife*

Sex distortion drive: X-chromosome shredder



Paul Thomas

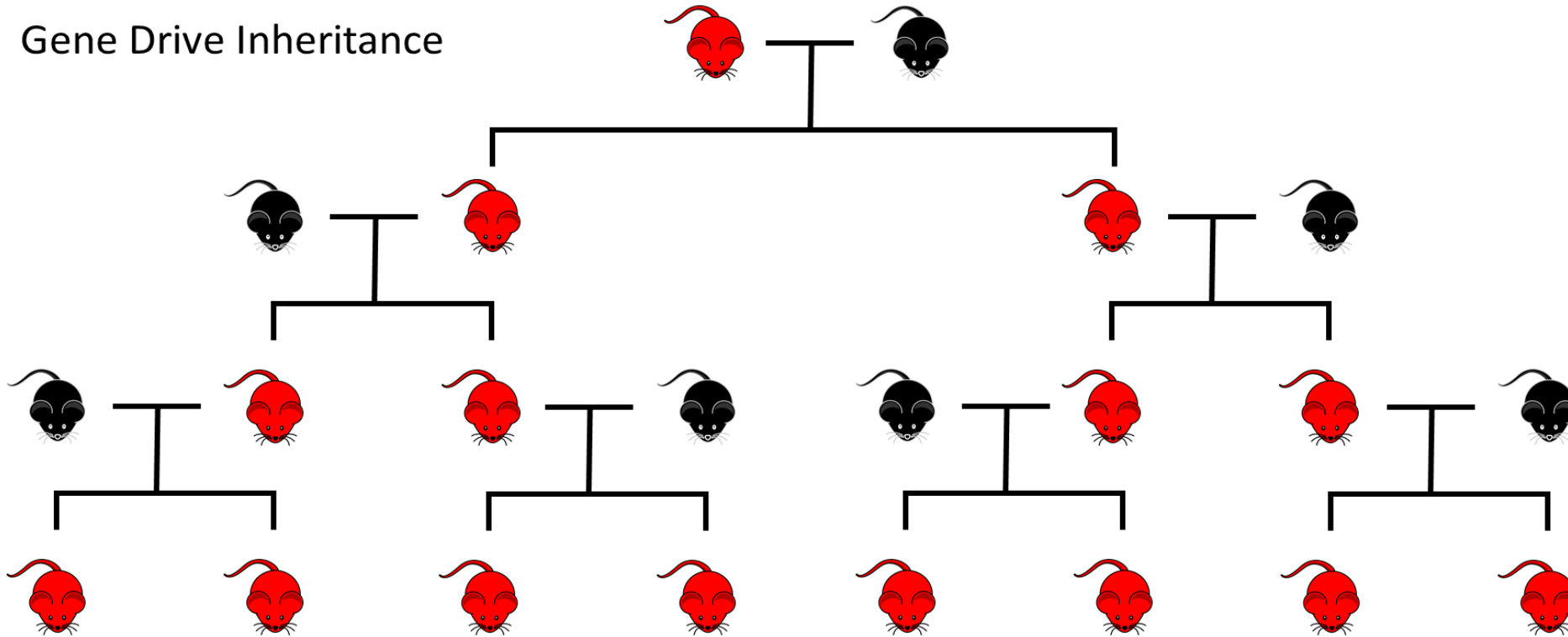


Galizi et al. Sci Reports (2016)

Containing gene drives with technology



Gene Drive Inheritance



1

2

3

Suppression Drives

nature
biotechnology

A CRISPR–Cas9 gene drive targeting *doublesex* causes complete population suppression in caged *Anopheles gambiae* mosquitoes

Kyros Kyrrou^{1,2}, Andrew M Hammond^{1,2}, Roberto Galizi¹, Nace Kranjc¹, Austin Burt¹, Andrea K Beaghton¹, Tony Nolan¹ & Andrea Crisanti¹



Mouse
Plagues



Carp



Spotted-wing
Drosophila

Replacement Drives

PNAS

Highly efficient Cas9-mediated gene drive for population modification of the malaria vector mosquito *Anopheles stephensi*

Valentino M. Gantz^{a,1}, Nijole Jasinskiene^{b,1}, Olga Tatarenkova^b, Aniko Fazekas^b, Vanessa M. Macias^b, Ethan Bier^{a,2}, and Anthony A. James^{b,c,2}

^aSection of Cell and Developmental Biology, University of California, San Diego, La Jolla, CA 92093-0349; ^bDepartment of Molecular & Biochemistry, University of California, Irvine, CA 92697-3900; and ^cDepartment of Microbiology and Molecular Genetics, School of Medicine, University of California, Irvine, CA 92697-4500

Next-generation gene drive for population modification of the malaria vector mosquito, *Anopheles gambiae*

Rebeca Carballar-Lejarazú^a, Christian Ogaugwu^{a,b}, Taylor Tushar^a, Adam Kelsey^a, Thai Binh Pham^a, Jazmin Murphy^a, Hanno Schmidt^c, Yoosook Lee^c, Gregory C. Lanzaro^c, and Anthony A. James^{a,d,1}

^aDepartment of Microbiology & Molecular Genetics, University of California, Irvine, CA 92697-4025; ^bDepartment of Animal and Environmental Biology, Federal University Oye-Ekiti, Oye-Ekiti 371010, Ekiti State, Nigeria; ^cVector Genetics Laboratory, Department of Pathology, Microbiology, and Immunology, School of Veterinary Medicine, University of California, Davis, CA 95616; and ^dDepartment of Molecular Biology & Biochemistry, University of California, Irvine, CA 92697-3900



Cane Toad

Advantages of gene drives

Posted on 5 June 2021 at 11:42AM by **PETA Australia**



There *is* a better solution than just slaughtering mice only to see the population rebound in future years and the crisis recur.

The money will fund a three-year programme of genetic biocontrol research, led by the University of Adelaide, CSIRO, and the Centre for Invasive Species Solutions, to identify fast-acting gene drives designed to spread an inherited characteristic through a population.

Limitations of gene drives

- Speed of control dependent on generation time.
- Released individuals must be reproductively competitive.

Population data to analyse

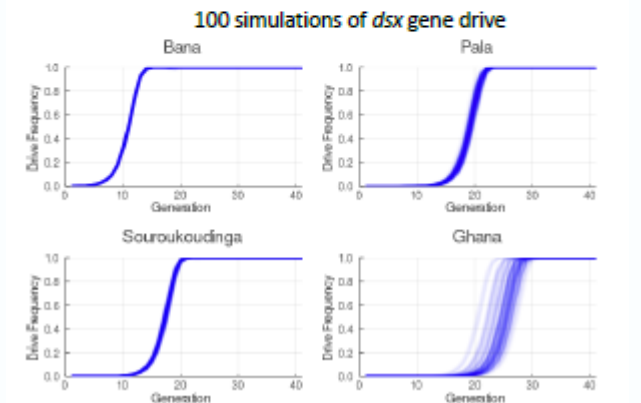
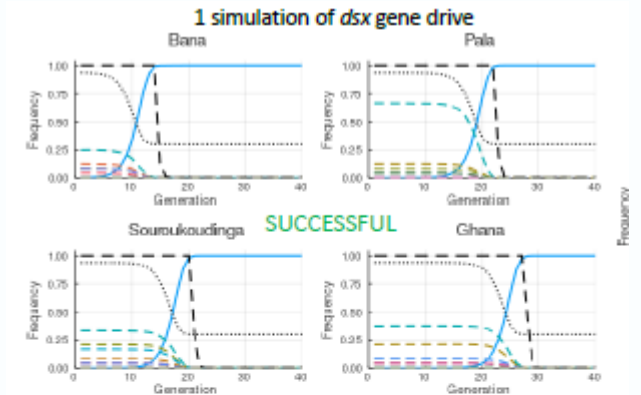
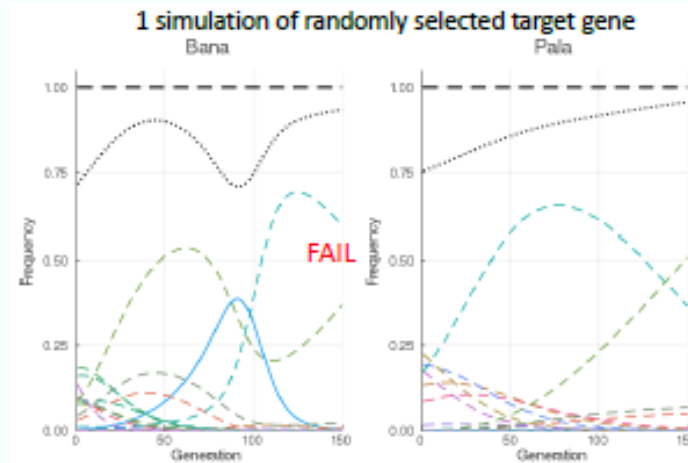
Metadata to select: Map of selected data

Select target population OR Unselect non-target

species	country	location
1. Anopheles gambiae	Burkina Faso	Bana
2. Anopheles gambiae	Burkina Faso	Pala
3. Anopheles gambiae	Burkina Faso	Souroukoudinga
4. Anopheles gambiae	Ghana	Madina
5. Anopheles gambiae	Guinea	Koundara
6. Anopheles gambiae	Guinea	Bomboli
7. Anopheles gambiae	Cameroon	Balgane
8. Anopheles gambiae	Cameroon	Soto Badere
9. Anopheles gambiae	Cameroon	Mayos
10. Anopheles gambiae	Cameroon	Zembe/Borongo
11. Anopheles gambiae	Equatorial Guinea	Boko

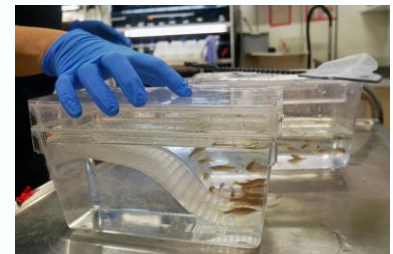
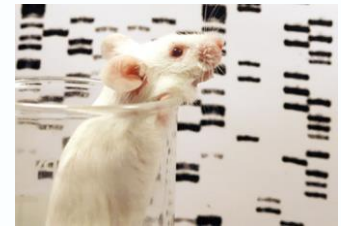
Modules in tabs

Selecting target population



Status of gene drive research

- Functional gene drives have only ever been tested in insects in laboratories or specialized containment facilities, first in *Drosophila* then later against mosquitoes.
 - None have yet been approved for release into the environment.
- In vertebrates, no functional gene drives have as of yet been developed.
 - All current gene drive research in vertebrates is being conducted in model laboratory animals, either in mice or in zebrafish.



Takeaways

- Gene drives should be considered as part of a portfolio of management approaches for IAS, together with existing chemical, biological and genetic control options
- Gene drives provide an option to spread genetic control technologies that would otherwise be infeasible because of scale
- Gene drives may increase the risk of unintended consequences, which can be mitigated using technologies that make them self-limiting in space and/or time



Acknowledgements:



Paul Thomas



Maciej Maselko

CSIRO SYNTHETIC BIOLOGY FUTURE SCIENCE PLATFORM

www.csiro.au

