GENE DRIVE MONITOR

www.genedrivemonitor.org

Cutting through the hype in synthetic biology: Will gene drives work?

Mark Wells, PhD & Ricarda Steinbrecher, PhD

October 2025

m.wells@econexus.info & r.steinbrecher@econexus.info

Hype is becoming increasingly common in how science is communicated, posing problems for decision-makers. Professor Timothy Caulfield, a specialist in science communication at the University of Alberta, explains that 'spin happens throughout the science translation process. There is hype in research grants, peer-reviewed publications, scientific abstracts, institutional press releases, media representations...' [1]. This analysis is supported by empirical studies – for example showing dramatic increases in the use of 'promotional language' over time [2]. Caulfield further argues that hype has been *particularly* prevalent in genetic research.

Using analogies from engineering, the field of synthetic biology has put forth a vision of biology by design. Some practicioners have acknowledged that it has been used by some to promise 'easy solutions to difficult problems' and warn that it must not be framed as 'the one technical solution to many grave world problems' [3]. Engineered gene drives (EGD) are a form of synthetic biology that have attracted much investment and attention by promising just such easy solutions to serious problems. Does the science stand up to the hype?

The ambition: forced genetic modification in the wild

Over the past two decades, researchers have been working to develop gene drive systems – a new form of genetic engineering that aims to bypass normal genetic inheritance to forcibly spread modifications in the wild, even if they are harmful to the population. Proponents of EGDs say they could be used to 'suppress' or eliminate problematic wild species, such as invasive species, disease vectors, or agricultural pests.

If released, gene drives pose serious ecological risks [4]. But it's worth asking: can they deliver on their promises? Communications about high-profile EGD research show examples of common forms of hype – ones that decision-makers need to be aware of.

The hype: implying a usable product is closer than it is

Many of the policy and public discussions around EGD have focused primarily on their potential use for mosquito control or to eradicate invasive rodents on islands. One high-profile proposal is to eliminate mice by spreading female infertility through populations [5]. The researchers claim that their 'tCRISPR' gene drive could achieve this, but this is based on models –

the actual version of tCRISPR they have so far built lacks a key component and so would not function in the wild as their modelling suggests [see box]. Although the abstract of their paper implies the system is feasible, a full proof of concept in a laboratory is still missing. Even if such proof was reached, its performance in scaled-up trials remains highly uncertain due to well-known issues such as drive resistance and mating behaviour [see box]. Since abstracts are read more widely than full papers, readers might miss the technical hurdles still ahead.

In fact, there are still serious doubts about whether gene drives can effectively control wild species. In a recent paper supporting a non-gene drive method for mosquito control, leading gene drive researchers including John Marshall and Omar Akbari state: 'The current state of gene drive technology, however, is technically complicated with issues of drive resistance and uncertainties about their behavior in large-genetically diverse populations that need to be addressed before they transition to the field' [6]. They also acknowledge that because many gene drives are engineered to spread and persist in the environment, 'it is unknown whether these technologies will receive regulatory and community approval for widespread use'.

The hype: dismissing risks by promising (but not delivering) technical solutions

Concerns about gene drives spreading uncontrollably are often met with promises to 'confine' or 'localise' them. Over the past 10 years, 'daisy drives' have often been put forward as the answer to the risk of uncontrolled spread of gene drives. The

Technical hurdles for 'tCRISPR' gene drives

Developing a usable engineered gene drive will involve many incremental steps. The 2022 abstract for this research gives the impression that the goal of a usable system has been reached, with statements like 'This is an example of a feasible gene drive system for invasive alien rodent population control.' The full paper however describes an earlier stage in the research process [5].

So while it is true the researchers have engineered and tested 'transgenic tCRISPR mice' as the abstract states, their 'tCRISPR' construct lacks a crucial element - namely the Cas9 component of the bacterial 'DNA cutter' CRISPR-Cas9. Their 'tCRISPR' construct is therefore only functional (i.e. in disrupting female fertility genes) in mice that have already been engineered to produce Cas9. It would not function in this way in populations of unmodified wild mice.

The claim of a 'feasible gene drive system' is built on results from computer models showing 'that tCRISPR can eradicate island populations', which are reported alongside the laboratory experiments. However the 'tCRISPR' construct used in the model *includes* the necessary Cas9 gene, and so is different to the one that has been built in living mice. [5]

Other challenges are acknowledged in the full paper. One issue is that the mice could become 'resistant' so that the system has no impact on female fertility. This would happen if the female fertility gene targeted by tCRISPR became resistant to cutting by CRISPR-Cas9, whilst retaining it's function. Another potential difficulty is that mating behaviours may hamper the spread of tCRISPR in a natural population [8].

team that first proposed them say on their website: 'we devised a new form of drive system called a "daisy drive" that can only affect local environments.' [7]. However, despite years of significant funding, there is no published evidence that a working daisy drive system can be constructed – so far they have only been 'demonstrated' in computer models. Despite being offered as an answer to the risks of irreversible ecological harms gene drive releases, **daisy drives appear to be a phantom technology – one that can be modelled but not built**.

The hype: dismissing existing technologies and approaches

Christopher Boëte, an evolutionary biologist and specialist in mosquito-borne diseases warns that rhetoric around gene drives targeting mosquitoes 'often goes along with a negative presentation of current "conventional" tools and exaggerated promises about EGD themselves, leading to a situation of hype' [9]. He warns that focusing on the limitations of existing interventions reinforces 'the notion that new tools are needed rather than improving the use of those currently available' [9].

This can be seen in a recent press release describing a new form of mosquito gene drive [10]. It states that 'efforts to block the transmission of malaria have been stalled because mosquitoes have adapted resistance to insecticides and the parasites within mosquitoes that cause malaria have become resistant to drugs'. The World Health Organization (WHO), on the other hand, paints a broader and more nuanced picture, noting successes in malaria control and highlighting other challenges, such as poor access to existing treatments and interventions, humanitarian disasters, climate change, and inadequate funding [11].

Guarding against hype

Promotional terms such as novel, innovative, scalable, efficient, and powerful [2] are often used in synthetic biology to emphasize the newness and promised potency of these technologies. But to robustly assess synthetic biology's promises, decision-makers need to sort out the science from the hype.

Hype can take many forms, from excessive promotional language to not making clear how far a product is from being usable and dismissing alternative approaches. Examples from gene drive research show why it's important to examine claims and compare them with the data. They also show that claims based on modelling or theory need to be distinguished from those based on laboratory experiments.

The causes of unwarranted hype appear to be systemic and entrenched – as Caulfield states 'The profoundly competitive nature of academic research invites the injection of hyperbole and the overpromise of near-future benefit.' This raises difficult questions: How can decision-making for regulation and policy be protected against hype? The same goes for decisions about what to fund and which pathways to pursue in addressing problems. If new technologies are over-hyped as 'solutions', does that affect the level of ecological risk seen as acceptable? And, upon what should we base our debates on regulating EGD – the hype or the complex, and often uncertain, science?

REFERENCES

For more information on the technical barriers to building functioning gene drives, please see: https://genedrivemonitor.org/reality-check

[1] Caulfield T. (2018) "Spinning the Genome: Why Science Hype Matters." *Perspectives in Biology and Medicine* 61(4): 560–571. https://doi.org/10.1353/pbm.2018.0065

[2a] Miller M., B. Batalo and B. Budgell (2022) "Trends in the Use of Promotional Language (Hype) in Abstracts of Successful National Institutes of Health Grant Applications, 1985-2020." *JAMA Network Open* 5(8):e2228676. https://doi.org/10.1001/jamanetworkopen.2022.28676

[2b] Miller M., B. Batalo and B. Budgell (2023) "Promotional Language (Hype) in Abstracts of Publications of National Institutes of Health-Funded Research, 1985-2020". *JAMA Network* Open 6(12):e2348706. https://doi.org//10.1001/jamanetworkopen.2023.48706

[3] Hanson, A. D. and V. Lorenzo (2023) "Synthetic Biology–High Time to Deliver?" *ACS Synthetic Biology* 12(6): 1579–1582. https://doi.org/10.1021/acssynbio.3c00238

[4] CSS, ENSSER, VDW (2019) "Gene Drives: A Report on Their Science, Applications, Social Aspects, Ethics and Regulations." https://ensser.org/publications/2019-publications/gene-drives-a-report-on-their-science-applications-social-aspects-ethics-and-regulations/

[5] Gierus L., A. Birand, et al. (2022) "Leveraging a Natural Murine Meiotic Drive to Suppress Invasive Populations." *Proceedings of the National Academy of Sciences (*USA) 119(46): e2213308119. https://doi.org/10.1073/pnas.2213308119

[6] Gendron W.A.C., R. Raban, et al. (2025) "Evaluating the Cost of Malaria Elimination by *Anopheles gambiae* Precision Guided SIT in the Upper River Region, The Gambia." *PLOS Global Public Health* 5(7): e0004903. https://doi.org/10.1371/journal.pgph.0004903

[7] MIT media lab "Daisy Drives" https://www.media.mit.edu/projects/daisydrives/overview/ (accessed 06/10/25).

[8] Manser A., B. König and A.K. Lindholm (2020) "Polyandry blocks gene drive in a wild house mouse population" *Nature Communications 11(1):5590* https://doi.org/10.1038/s41467-020-18967-8

[9] Boëte C. (2025) "Gene Drive: Communication, Hype, and the Publics." *Journal of Medical Entomology* 62(3):745–748. https://doi.org/10.1093/jme/tjaf007

[10] Aguilera M. (2025) "Stealth Genetic Switch in Mosquitoes Halts Malaria Spread." https://today.ucsd.edu/story/stealth-genetic-switch-in-mosquitoes-halts-malaria-spread (accessed 06/10/25).

[11] WHO. *World Malaria Report 2024: Addressing Inequity in the Global Malaria Response.* Geneva: World Health Organization; 2024. https://www.who.int/publications/b/76893