Meiotic Drivers: Suppressors and Distorters in Drosophila

***Peyton Alder**, Prof. Colin Meiklejohn*

College of Arts and Sciences, School of Biological Sciences

Abstract

Mendelian segregation is a founding principle of genetics, stating allele pairs segregate during gamete formation and randomly combine at fertilization. While rare, evidence of non-mendelian segregation, also known as meiotic drive, shows this principle can be violated. *Dox* (distorter on X) and *mDox* (mother of Dox) are X-linked genes in *Drosophila simulans* that disrupt the development of Y-bearing sperm and cause males to produce biased progeny sex-ratios. In wild-type males, *Dox* and *mDox* don't affect the offspring ratios, because these distorters are normally suppressed by autosomal loci called *tmy* (too much yin) and *nmy* (not much yang). *Nmy* and *tmy* both suppress *Dox* and *mDox* by producing non-coding RNA molecules that instigate the destruction of *Dox* and *mDox* RNAs. Double mutant males carrying non-functional alleles at both *dox* and *nmy* exhibit normal sex-ratios and spermatogenesis, leading to the inference that these distorters and suppressors are interconnected and the primary function of *Dox* is to cause segregation distortion.

Goals/Objectives

Purpose: Determine the relationship between *nmy, tmy, mDox, and Dox*, more specificially, how the distorters influence sex-ratios in *Drosophila simulans* and how these are prevented by the suppressors.

Hypothesis: The absence of *tmy* or *nmy* allows for unregulated *Dox* and *Mdox* to attack the Y-bearing sperm, ultimately causing an excess of daughters in the offspring of these affected males.

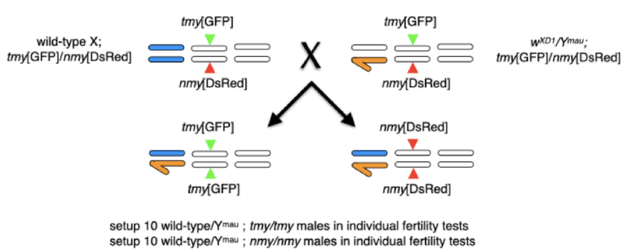

Figure 1. Diagram of crosses for females with wild-type X chromosomes crossed with Ymau males.

Methods and Materials

- Previously, several wild-type *Drosophila simulans* X-chromosomes were fertility-tested when males were homozygous at *nmy* and *tmy.*
- To perform a fertility test, one male is put with three *SimWXD1* females and his offspring's phenotypes, number, and sex are recorded.
- Flies were reared at 22C in food vials with plugs.
- To determine if the fly has a mutant allele at *nmy* and *tmy,* it is looked at under special lighting. *Nmy* mutants have a glint in the eye under DsRed light. *Tmy* are tagged with GFP (Green Fluorescent Protein). These mutants glow in the dark.
- After those initial fertility tests, the wild-type X-chromosomes which contained mutant alleles for *tmy* and *nmy* were crossed so each offspring obtained a *Drosophila mauritiana* Y-chromosome (Ymau) [Figure 1].
- This Y-chromosome came from males who also contained mutant alelles for *tmy* and *nmy.*
- Offspring from this cross were examined and *tmy/tmy*, *nmy/nmy*, and *tmy/nmy* male mutants for each cross were put into a fertility test with 3 *SimWXD1* females.
- In addition, for later genotyping, primers are currently being tested. These are still in the stage of being standardized, so they produced a single band of a predicted size.
- To ensure validity of results, fly phenotypes are checked in each generation to ensure no contamination in the crosses. They are examined for disease and placed in vials with enough food and in an incubator.

Data/Results

- Results of the fertility phenotypes of the wild-type X-chromosomes were found to be varying and different. The X-chromosomes ranged from fertility to sterility, with several exhibiting a sex-ratio [Figure 2].
- The results from the fertility test with the wild-type X-chromosome and Ymau Y-chromosome were very similar to the previous results with just the wild-type X-chromosomes.
- Primers are still being tested but appear to be working well and will be used to start the next phase of the experiment.

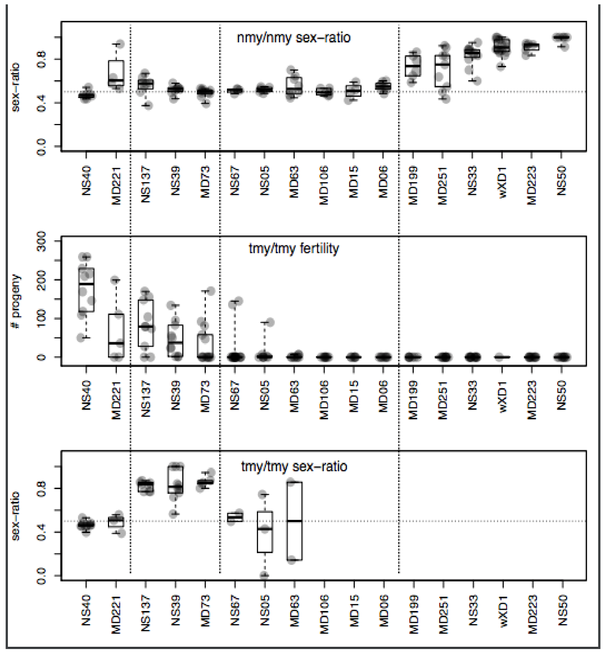

Figure 2. Results of Fertility Tests for wild-type X-chromosomes.

Acknowledgements

- I would like to thank the Meiklejohn lab for their guidance, knowledge, time, and support. I would also like to thank UCARE for the opportunity to pursue this research.

Conclusions/Future Directions

- Results from fertility tests of the wild-type X-chromosomes strongly suggest each X-chromosome is affected differently by the distorters and suppressors.
- The fertility tests including the Ymau chromosome infer that the Y-chromosome has little to do with these fertility phenotypes seen and that *Mdox and Dox* act mostly on X-chromosome.
- In the future, use primers currently being tested to start genotyping these wild-type X-chromosomes using High Resolution Melting Analysis.
- Use these primers to measure the expression of *Dox-like* genes in adult females, adult males, and dissected testes from *SimWXD1* with and without the *tmy* and *nmy* mutations.
- Cross wild-type X chromosomes with males who contain *ago2*. Perform fertility tests after a series of crosses to see how and if *ago2* affects them.

References

Lindholm, AK. Dyer, KA. 2016. The Ecology and Evolutionary Dynamics of Meiotic Drive. Trends in Ecology and Evolution. 4(31): 315-326.

Meiklejohn, CD. Landeen, EL. 2018. Gene Flow Mediates the Role of Sex Chromosome Meiotic Drive during Complex Speciation. eLife. 7(35):e35468.

Helleu, Q. Gerard, PR. Montchamp-Moreau, C. 2015. Sex Chromosome Drive. Cold Spring Harbor Perspectives in Biology. 7(2):a017616.

Meiklejohn, CD. Tao, Y. 2010. Genetic Conflict and Sex Chromosome Evolution. Trends in Ecology and Evolution. 24(4):215-223.