Partitioning Reproductive Success: Experimental Evolution of Male Fertility

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Background

male reproductive success

- Male reproductive fitness is determined by the number of matings that result in a successful fertilization event
- We want to disentangle pre-insemination mating success from fertilization success to understand how reproductive ability evovles

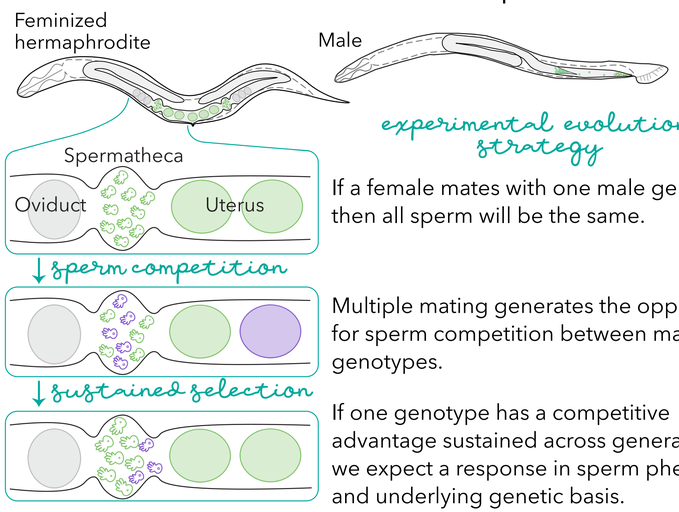
goal: **What is the relative importance of sperm competitive ability in determining total male reproductive success?**

Caenorhabditis elegans

a model reproductive system

- Small, easy to culture, short generation time
- Wealth of genetic tools and genomic information
- Ability to manipulate mating system
  - Feminize hermaphrodites by preventing self-sperm production
  - Induce males at 1:1 sex ratio
- Unique sperm characterized by crawling sperm cells

We used experimental evolution to isolate sperm competitive dynamics to understand their contribution to total reproductive success.



experimental evolution strategy

If a female mates with one male genotype, then all sperm will be the same.

Multiple mating generates the opportunity for sperm competition between male genotypes.

If one genotype has a competitive advantage sustained across generations, we expect a response in sperm phenotype and underlying genetic basis.

Sterility Induction System

using auxin inducible degredation

- Degron tag on critical spermatogenesis gene *spe-44*
- Auxin exposure activates TIR1 to target SPE-44 degredation
- Lack of SPE-44 arrests spermatogenesis and induces sterility

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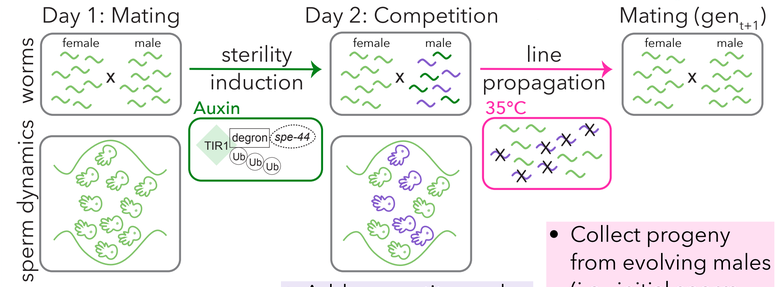
Isolating Sperm Competition

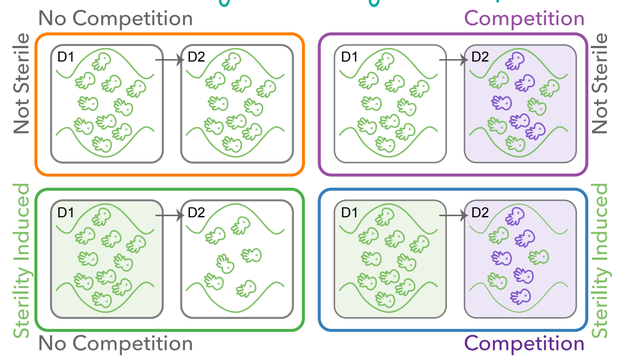
selection on sperm defensive ability



- Evolving females and males mate for 24 hr
- Male sterility is induced
- This isolates selection on sperm already transferred
- Add competitor males to generate sperm competitive pressure
- Already existing sperm must outcompete incoming competitor sperm
- Collect progeny from evolving males (i.e., initial sperm transfer) for next generation
- Heat-shock induction of toxic protein kills competitor progeny

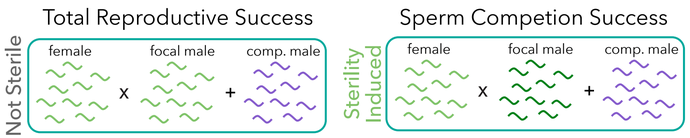
Experimental Evolution Design

factorial design & biological replication



- Three treatments partition pre- and post-insemination selection along with a lab adaptation control (D1 & D2 are Day 1 & Day 2 conditions, respectively)
- Six replicate populations/treatment each maintained at N = 5,000 worms
- Ten sperm competition selective events over 30 generations of evolution

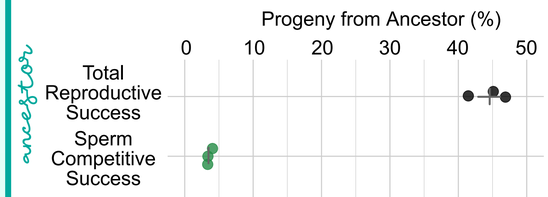
phenotypic assays



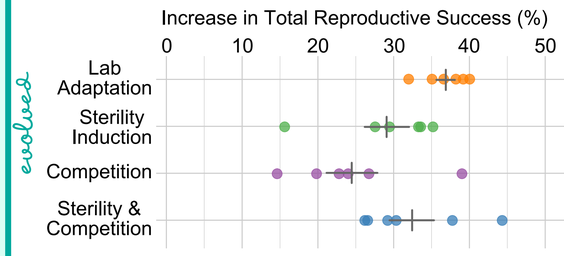
Assay conditions mimic the selective environment under which males evolved.

Competitive Reproductive Response

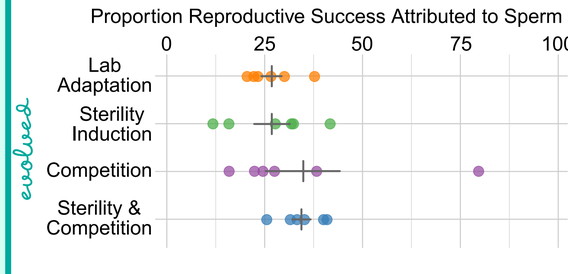
uniform strong response to selection



Only 3.9% of progeny come from ancestral males under induced sterility and competition conditions.



Total reproductive success increases relative to the ancestor and is significantly different across treatments ($F_{3,19}$= 4.2, $p < 0.05$).



Sperm competitive success increases uniformly across all conditions ($F_{3,19}$= 1.4, p = 0.3) with ~35% of total reproductive success attributable to sperm competitive ability.

Each point represents the mean of 3 replicate assays for each treatment (N > 500 worms/point).

Conclusions

- Inducible sterility of males is possible and a potent tool
- Strong underlying response to selection on sperm competition
- Post-insemination interactions are equally as important as pre-insemination interactions

future directions

- Whole genome sequencing of all lines at 4 time points
  - Preliminary analysis suggests relatively few loci respond to selection
- Transcriptomics of mated females to examine female response

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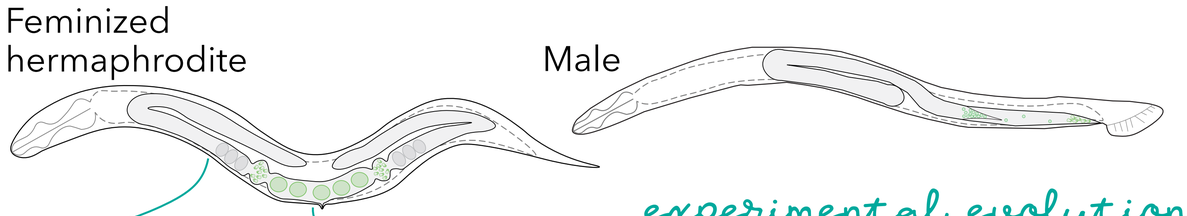

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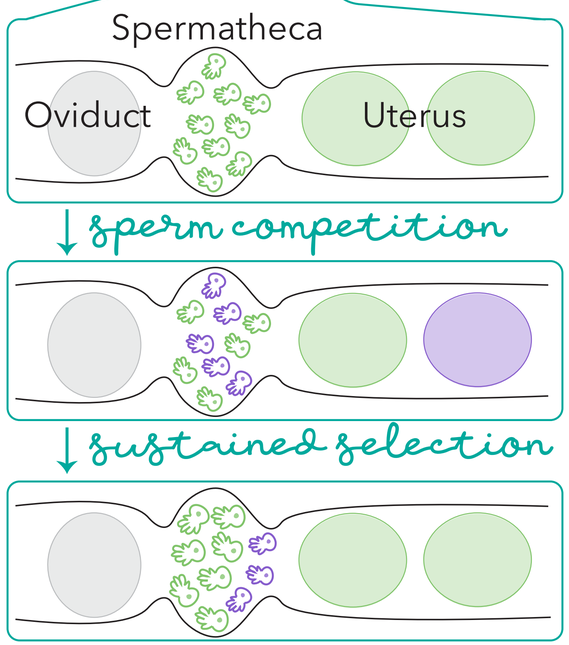

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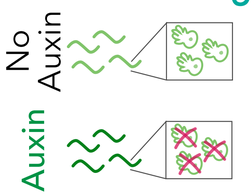

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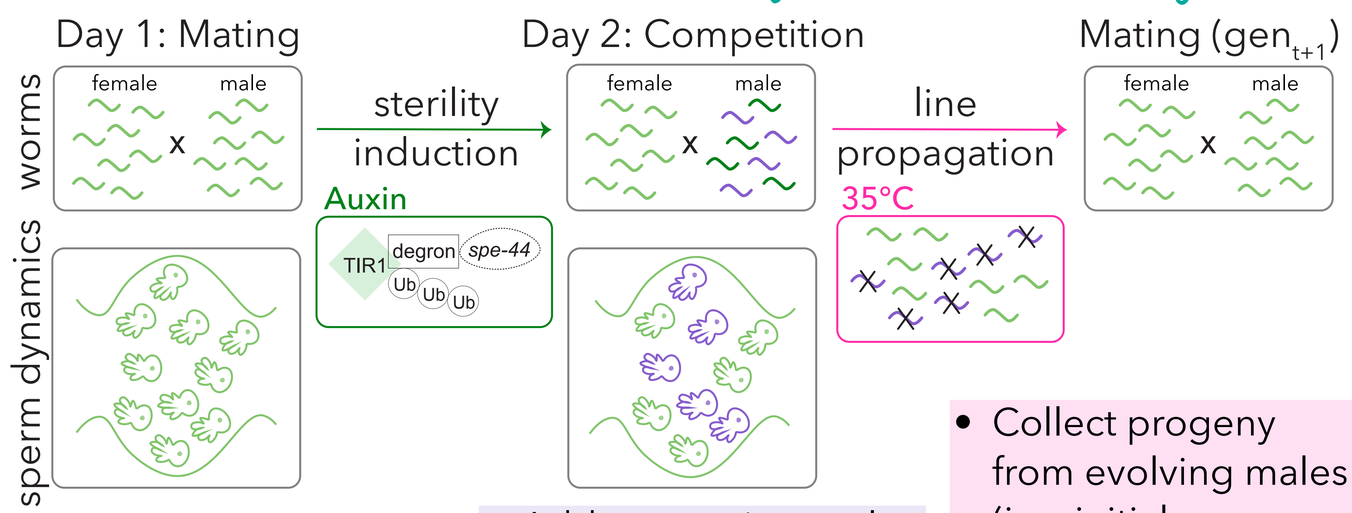

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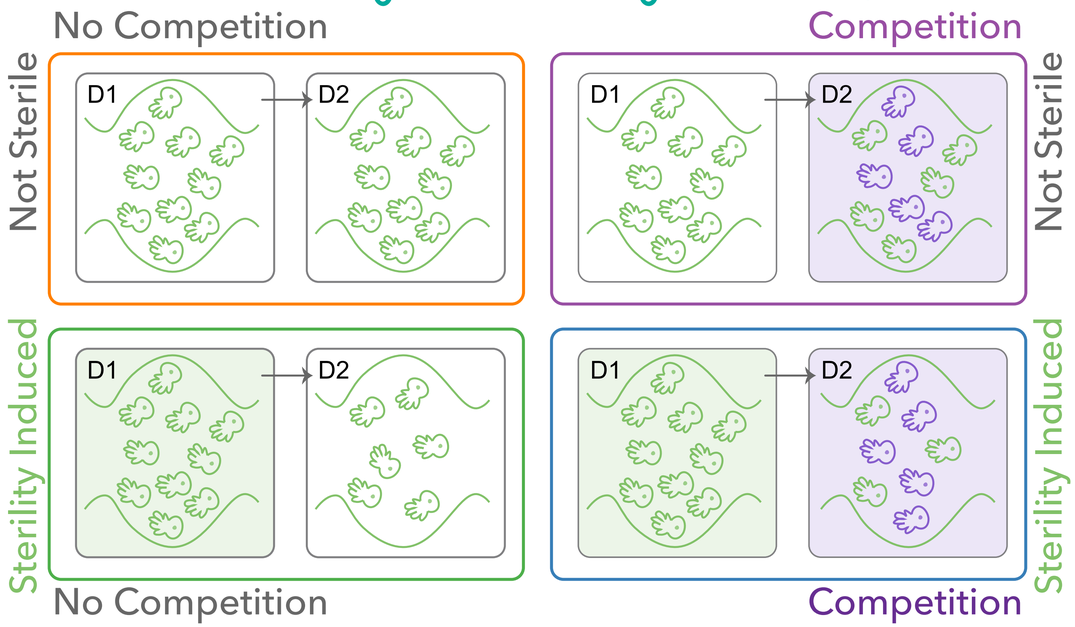

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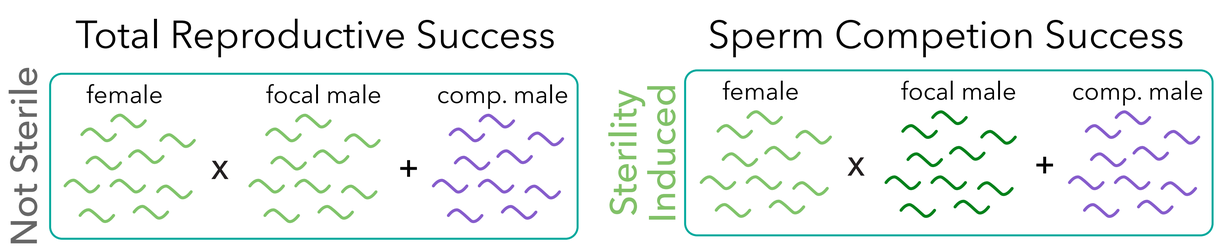

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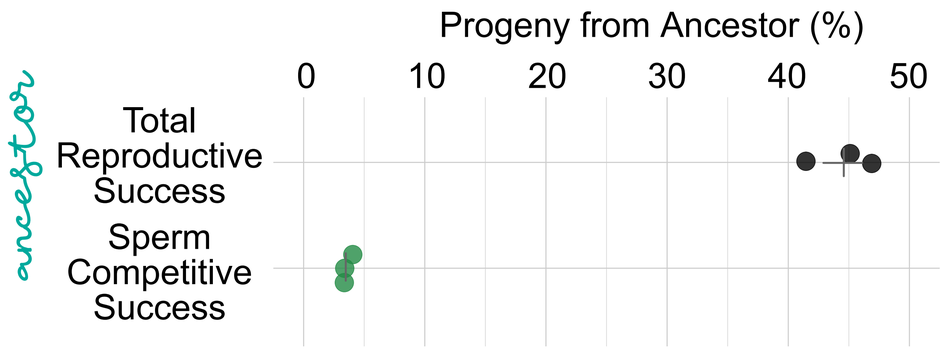

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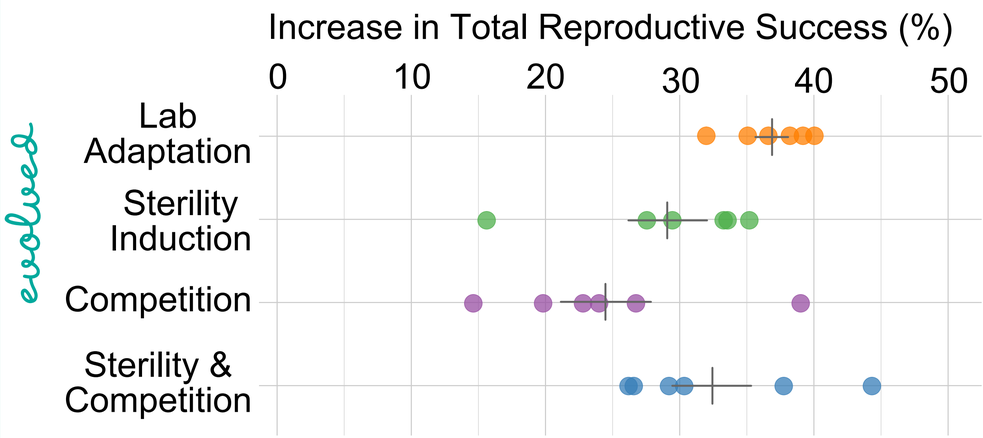

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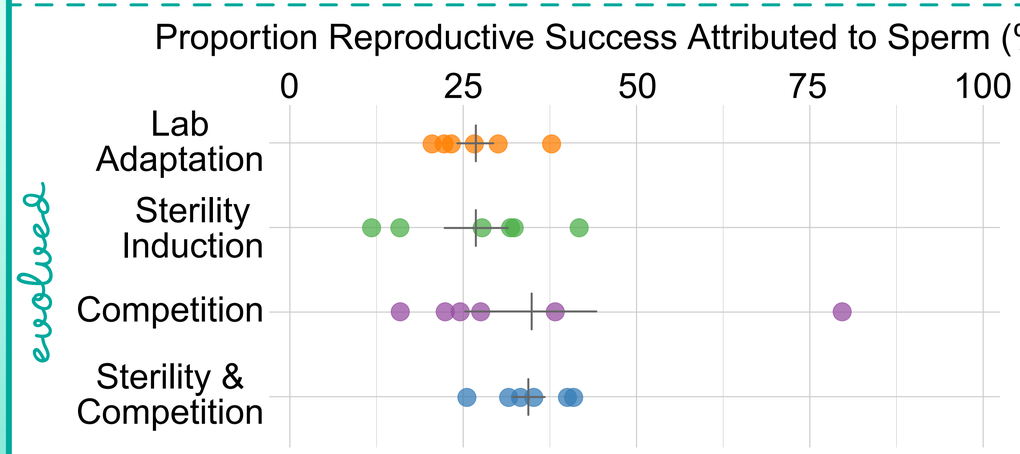

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