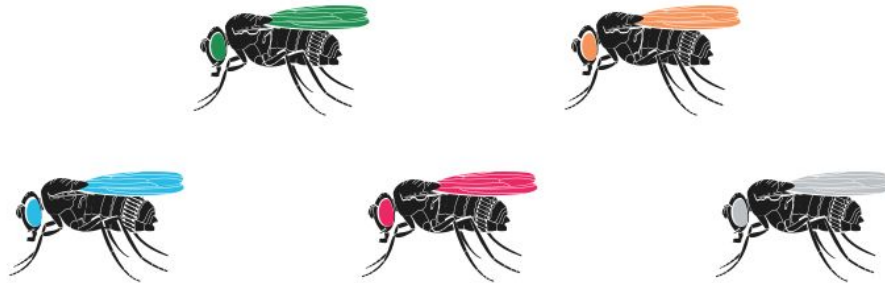


# The Evolution Of Insect Genetic Systems

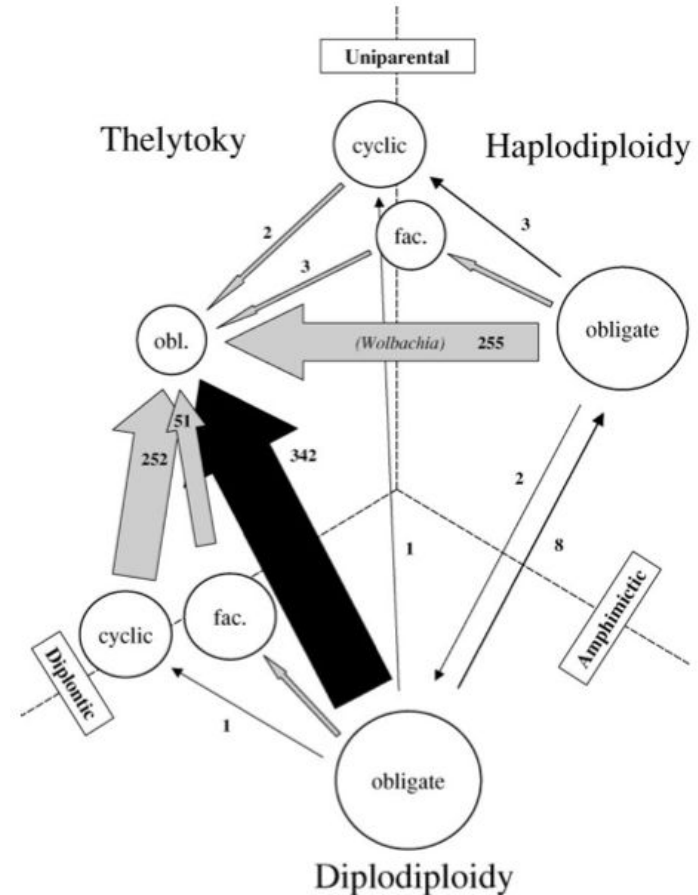
Tyler Myerly  
Dan Sheridan



## Patterns of Evolutionary Transition

Goal: Understanding variation in genetic systems is dependent on understanding the the transition between the different genetic systems

What genetic system is being favored in this image? What causes this?



# Discussion Question

Why is this seen mostly in just insects? We rarely have mammals being able to possess these systems that allow them to produce offspring in different ways. Why wouldn't they lean towards evolving in this way if it is so advantageous?

# Evolution of Alternative Genetic Systems

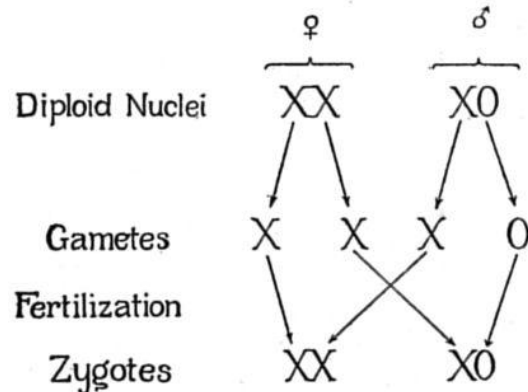
Major classes of systems:

- Diploid males- **Diplodiploidy**
- Effective haploid males- **Haplodiploidy**
- Without males- **Thelytoky**

Mixed systems overlap these three major classes. This is where it gets confusing.

# Diplodiploidy

- Ancestral genetic system
- Individuals have a diploid genome, where each parent contributes a recombined haploid genome to each offspring
- Alternate genetic systems derive from diplodiploidy and evolutionary arise from dynamics such as sex-determination and intersexual conflicts



# Thelytoky

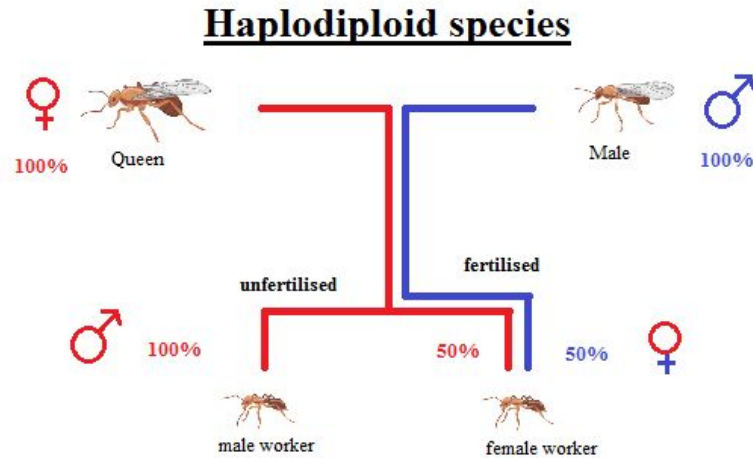
- Females transmit maternal genes and produce only female offspring
- Endosymbiont related
  - Thelytokous Parthenogenesis: No mating and no males
    - Apomixis: no meiosis, diploid egg produced via mitosis
    - Automixis: meiosis where the two products re-fuse to form a diploid female



Aphids alternate between diplodiploidy and apomictic thelytokous parthenogenesis

# Haplodiploidy

- Arrhenotoky and PGE
- Originated at least 10 different times in Insects!



# Haplodiploidy - Parental Genome Elimination (PGE)

- Males begin as diploid zygotes but only produce gametes that carry their mother's genetics.
- The chromosomes inherited from the father are deactivated.
- Synapomorphy to the clade Neococcoidea
- Transition between diplodiploidy and arrhenotoky

# Discussion Question

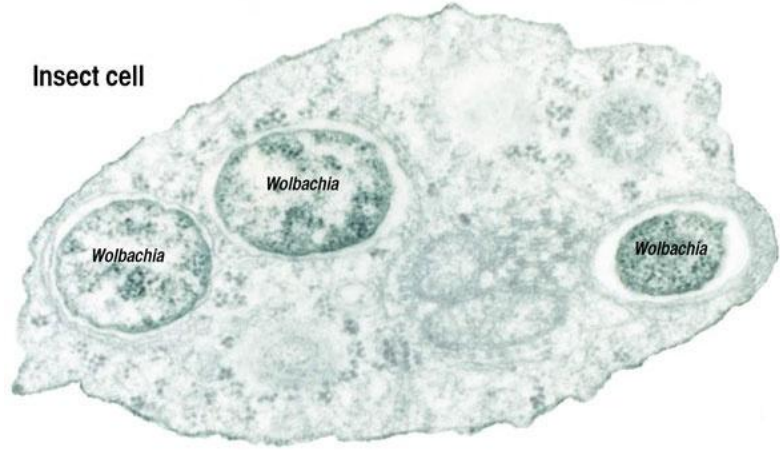
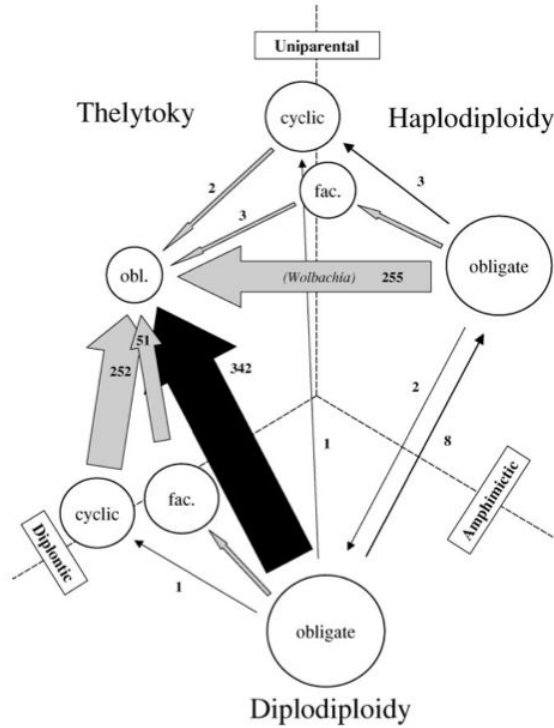
How and why are endosymbionts involved in the transition from diplodiploidy to haplodiploidy (arrhenotoky and PGE)?

Why do endosymbionts deactivate one parental genome?

# Explanation

- Endosymbionts are vertically transmitted through the maternal genome.
- Conflict between host and endosymbiont where males present an “evolutionary dead end” for the symbionts
- Endosymbionts have allowed rapid diversification and niche colonization

# Wolbachia



# Understanding Mixed Systems and the Transition between Genetic Systems

-Addressed in (Ross, 2012)

Hypothesis: Endosymbiotic bacteria is the key driver of the transition through conflicts between hosts and endosymbionts over transmission.



# Discussion Question

Given the extreme diversity in morphology, reproduction, life history, feeding strategy, ecological role, etc. found in insects, is it possible that endosymbionts have been involved in the evolution of other insect behaviors or characters? If so, what might these be?

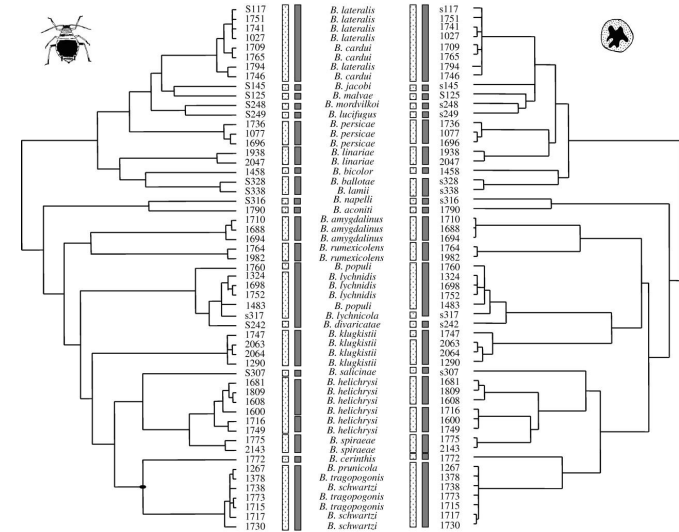
# Endosymbiont role in genetic system evolution

Diversity of Scale insect's genetic systems:

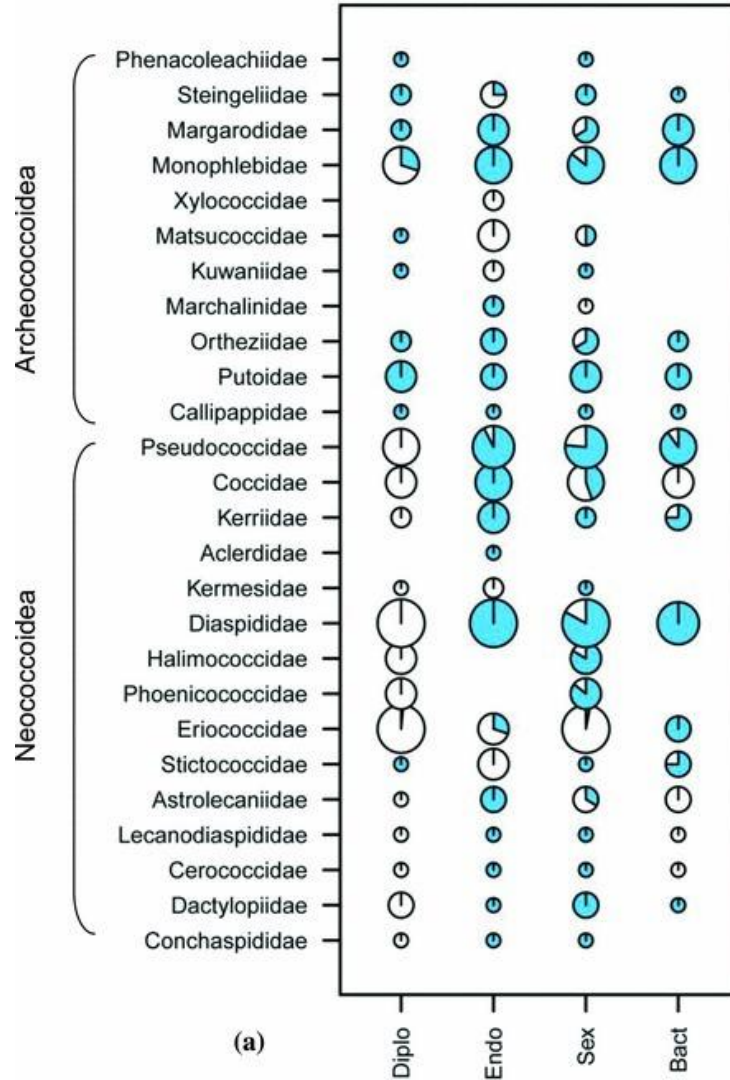
- Assumed sex determination system was diplodiploidy (XX-XO)
- Majority of scale insects also have Paternal Genome Elimination

Role of Endosymbionts:

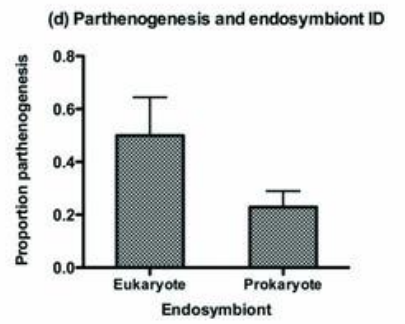
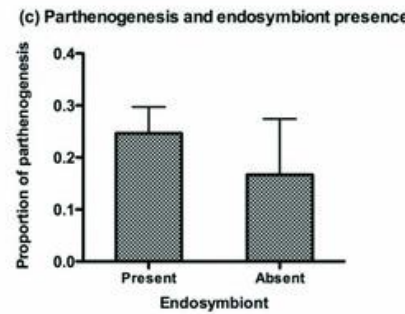
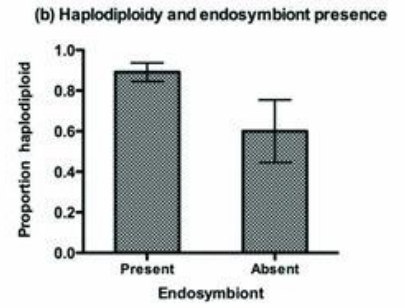
- Favor reproduction of female offspring since males create a dead-end for the symbionts
- Possible mechanism of Haplodiploid evolution



Let's compare the first two columns.....



(a)



(b) Haplodiploidy and endosymbiont presence

(c) Parthenogenesis and endosymbiont presence

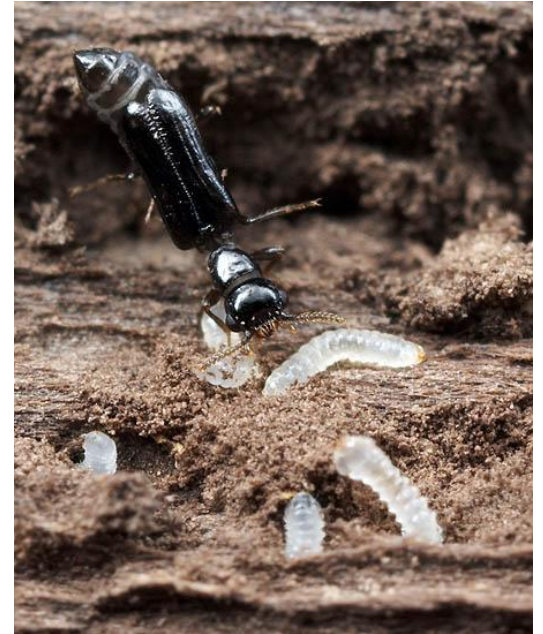
(d) Parthenogenesis and endosymbiont ID

# Conclusion

- Scale insects that possess endosymbionts are more likely to have a haplodiploid genetic system.
- The results support the hypothesis of this study.... BUT correlations do not provide support for the direction of causality.

# The strange tale of *Micromalthus debilis*

- Small beetle and the only species in the family Micromalthidae
- Most of the year *M. debilis* consist of larvae that give live birth to more female larvae (parthenogenetic reproduction)
- However, in late summer: some females pupate and develop into winged adults, the other female larvae produce unfertilized eggs which become **males**
- The male larvae then inserts his head into his mother's genital opening and eats her in order to pupate and become a winged adult!!!



# So why male-specific maternal cannibalism?

We still don't know exactly! Any thoughts?

- Males still don't transmit endosymbionts because of maternally transmitted symbionts to female larvae. (males are a dead-end)
- Cannibalism may be an evolutionary response to this maternally-transmitted symbionts being inactive in males, essentially starving them.
- This cannibalism is probably what therefore minimizes males and drives the *Micromalthus* life-cycle to parthenogenesis

# Hermaphroditism (Don't worry about it)

- Uncommon throughout insects
- Only one known genus of scale insects (*Icerya Purchasi*)
- High frequency of hermaphroditism in close relatives like Crustacea



# Discussion Question

- Why is hermaphroditism uncommon across insects and only present in few scale insect species despite being common in Crustacea and other close relatives?



# Discussion Question

Is the presence of endosymbionts a predictive and/or necessary factor for the development of alternative genetic systems in all eukaryotes?

# Sources

Gardner & Ross. The evolution of hermaphroditism by an infectious male-derived cell lineage: an inclusive-fitness analysis. *American Naturalist* citation, Volume 110, 2011.

Normark B. *Micromalthus debilis*. *Current Biology*, Volume 23 Number 10.

Normark B. The Evolution of Alternative Genetic Systems in Insects. *Annual Reviews Entomology*, Volume 48, 2003.

Ross L., Shuker D., Normark B., Pen I. The role of endosymbionts in the evolution of haploid-male genetic systems in scale insects (Coccoidea). *Ecology and Evolution*, 2012.

Wei J., Niu M., Feng J. Diversity and Distribution Patterns of Scale Insects in China. *Annals of the Entomological Society of America*, Volume 109, Issue 3, 2016.