Evolution of Insect Genetic Systems

Alec Knapp & Arielle Severns
Discussion Question

Why do you think that insects are capable of having so many different genetic systems?
Diplodiploidy

Every individual inherits one haploid genome from mother and one haploid genome from father. Both haploid genomes have equal probability of transmission. Found in majority of insect species.
Discussion Question

When is diplodiploidy a disadvantage?
When is it an advantage?
Haplodiploidy
- Production of haploid males and diploid females
- Males produced from unfertilized eggs
- Arises in insects that use wood as a food source among others.
Discussion Question

Why would this arise in insects that live around or in wood?
Discussion Question

Due to the necessity of the symbionts needed to digest wood.
- Mother has to pass these to offspring, so eusociality must arise, which is brought about in part by haplodiploidy.
- The ancestral trait is to feed on phloem, which also requires endosymbionts.
Thelytoky

- No “silly rigamarole of sex”
- Very common in freshwater and terrestrial invertebrates.
Thelytoky

Parthenogenesis
- Obligate
- Cyclic
- Facultative
Obligate Thelytoky

- There are many origins! Evidence for over 900
- arise from amphimictic populations and may be briefly favored by selection, but on an evolutionary timescale, quickly go extinct.
- produce asexually all year long

Wolbachia
Contagious Thelytoky
Cyclic Thelytoky

- relatively few and well defined
- 5 origins in insects (out of 8 total)
- alternation between sexual and asexual phases
- combines advantages of sexuality with being able to reproduce massive numbers under the right conditions which occurs in asexuality

https://www.youtube.com/watch?v=J7eRGHVx3p0

Aphid Producing Clones Video (start at 18 s)

Micromalthus debilis to be discussed later :)
Mixed Systems

- Regular or irregular alternation between different genetic systems, typically between amphimixis and thelytoky.
- Covers all complex systems in which there is an alteration (either facultatively or cyclically)
- Present characteristics of multiple depending on the environment

- Theyltoky alternating with haplodiploidy
- Theyltoky alternating with diplodiploidy
Hermaphroditism

- several species of *Icerya*
- arrhenotokous tribe of scale insects

- Androdioecious: consisting of hermaphroditic individuals and males
- this system is otherwise unknown in insects and rare in arthropods
Discussion Question

What are possible reasons that hermaphroditism has not arisen in insects? Are there any physiological constraints that may prevent hermaphroditism from developing in insects?
Micromalthus debilis
Micromalthus debilis
also known as “telephone pole beetles”

- a small beetle, the only species in the family Micromalthidae.
- sexually mature as larvae
- consists entirely of thelytokous laviform females

Most of the year, the population consists of female larvae which exist to give birth to more larvae. (parthenogenetic reproduction)........
But in late summer when their habitats start to dry out…. some female larvae develop into pupae, which then molt into winged adult females. SOME produce a single unfertilized egg, which becomes inactive. These eggs will hatch into a male larva, who will insert his head into his mothers genital opening AND FEED ON HER!!!!!!
But the males must be good for something, right?
Additionally, this is the only evolution this species ever does.

The anatomy of adults are still pretty similar to the oldest known beetle fossils.
Wolbachia

Possible source of some thelotoky
- obligate diplodiploidy to obligate thelotoky
- Obligate haplodiploidy to obligate thelotoky
Wolbachia

- Transmitted through eggs, not sperm
- Males die during development or are feminized
- Leads to female thelytokous reproduction
- Can be reversed to revert to arrhenotokous haplodiploidy
Wolbachia

Advantages

- Linked to viral resistance in *Drosophila melanogaster*.
- Also thought to be mediate iron metabolism and create B vitamins
- Higher number of offspring from infected individuals
Wolbachia

Many parasitic nematodes also contain *Wolbachia*.

- When infections start, treatment targets the *Wolbachia*
- This is the same mechanism in insects
- Why might this be?
Wolbachia

This causes sterility or death
- The parasite dies or is unable to reproduce due to the absence of the Wolbachia

This same practice was used to test the reversibility of the bacterial effects.
- When would it be reversible? Non-reversible?
Wolbachia

Females that are multiploid
- XXX or even more
- Males that are diploid and heterogametic
Extrazygotic Inheritance

Offspring starts out as 2 or more cells.
- In sternorrhynca, other cells are bacteriocytes from mother
  - Maternal
- In Iceryine, the offspring is born with totipotent sperm
  - Paternal
Extrazygotic Inheritance

Bacteriocytes cause entirety of maternal genome to be inherited

- Why is this advantageous?
- Why is this bad?
Extrazygotic Inheritance

Good-
- Causes offspring to be born with necessary endosymbionts to survive and thrive in the environment

Different-
- Insect is now much more closely related to mother. They have \( \frac{2}{3} \) mothers genes, and \( \frac{1}{3} \) fathers