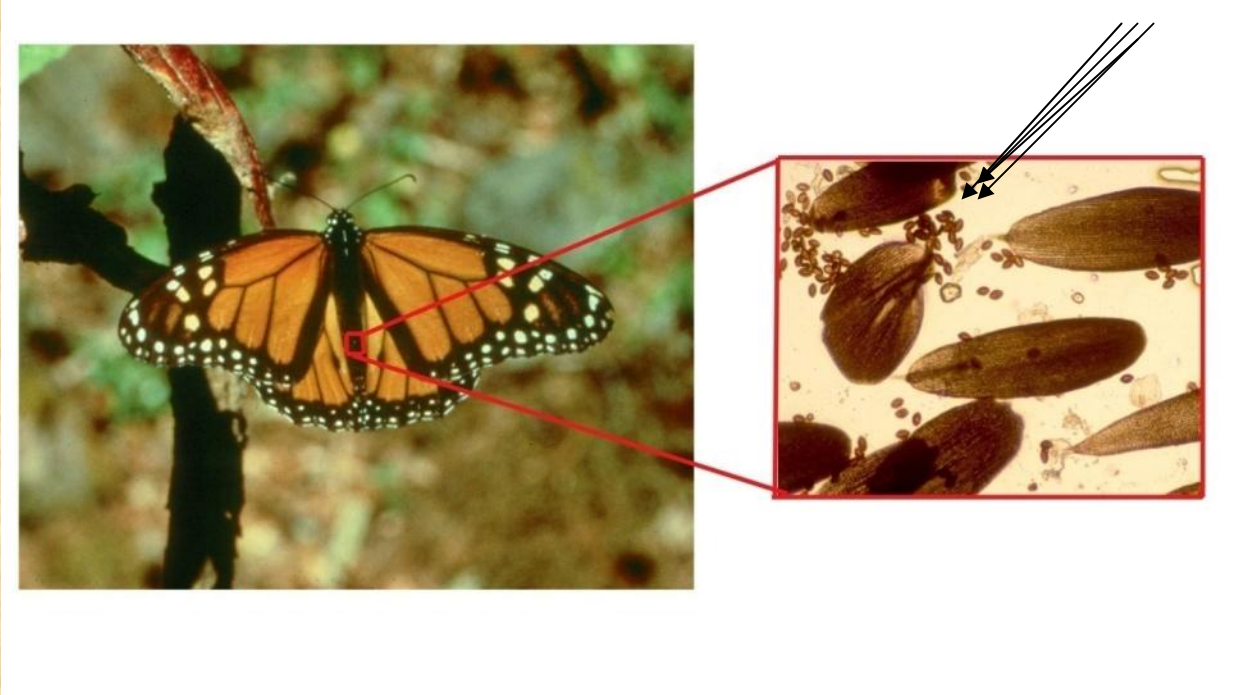
Biology and life cycle of OE

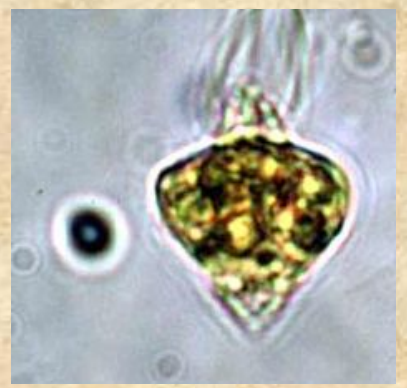
What is OE?

- *Ophryocystis elektroscirrha* (OE)
- Protozoan parasite that infects monarch and queen butterflies

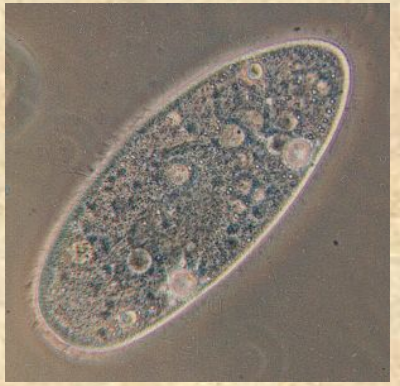


What is OE?

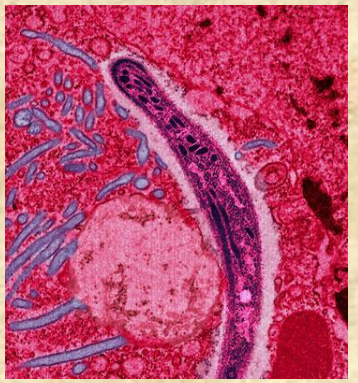
- Protozoans: single celled organisms
- Share many characteristics with animals (often called animal-like protists)



Euglena



Paramecium



Plasmodium

Obligate parasite: must live within a host to grow and multiply.

- Monarch and queen butterflies are the only known hosts of OE

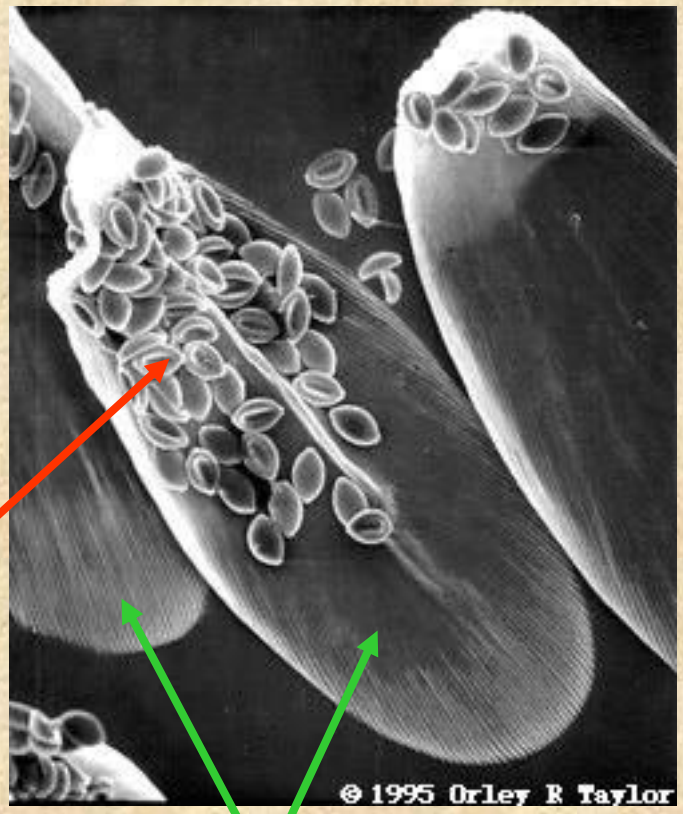
Monarch Butterfly (*Danaus plexippus*)

Queen Butterfly (*Danaus gilippus*)

OE produces spores on the outside of monarchs

- Spores: dormant cells that can resist harsh environmental conditions
- Found on the outside of infected monarchs

Highly Magnified Image



OE spores

Monarch scales

OE Spores

- Greatest concentration of OE spores is on the abdomens of infected monarchs

OE Spores

- Spores are ~ 100x smaller than monarch scales
- Need to view under 40-100x power

Looking for spores using a microscope

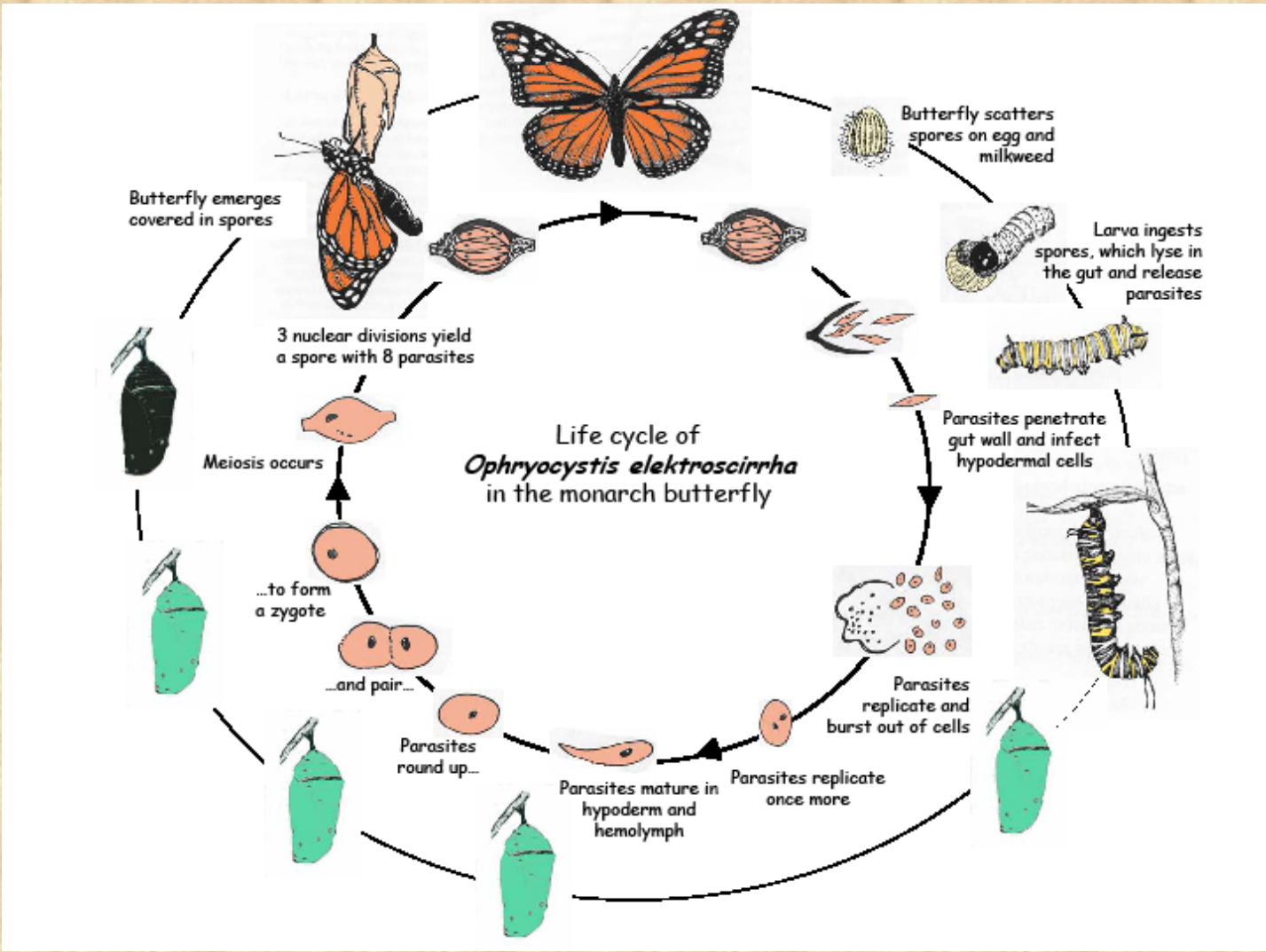
OE Spores

- Spores appear as small, brown or black lemon-shaped objects.

OE Spores

- At 400x

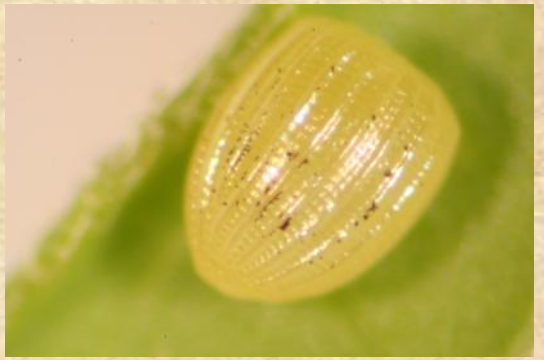
Life cycle of OE is closely related to the life cycle of the monarch butterfly.



OE Life Cycle

- OE can only reproduce inside living monarchs
- Infected females pass the parasite to their offspring when they lay eggs
- Dormant spores on the outside of the female's abdomen are scattered on the eggs and milkweed leaves

Infected females lay eggs and scatter OE spores on eggs and leaves



Dark spots are OE spores

OE Infects the Caterpillar

- When a caterpillar emerges, its first meal is the egg shell
- It ingests OE spores along with the shell and milkweed

Newly emerged caterpillar

A caterpillar eating the egg shell and any OE spores on the shell's surface

OE Moves to the Midgut

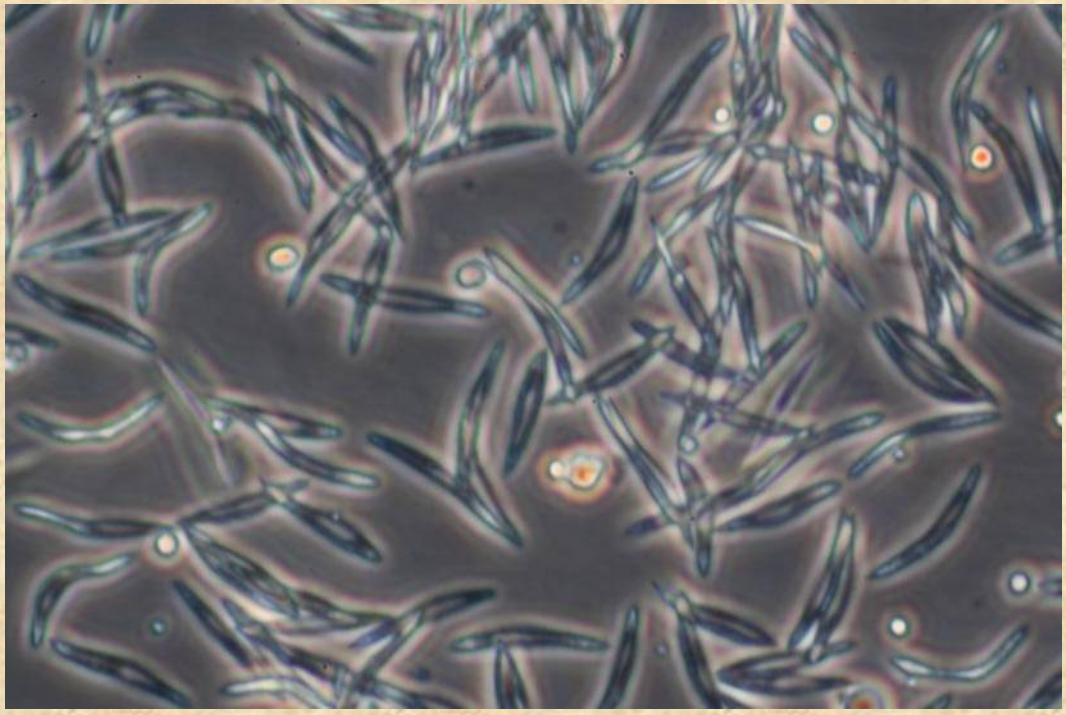
- The dormant spores move through the larva to the midgut
- Digestive chemicals break open the spores releasing the parasites
- The parasites then pass through the intestinal wall to the hypoderm (underneath caterpillar's skin)

OE Reproduces in the Pupa

- Most damage to the butterfly happens during the pupal stage
  - Where OE reproduces asexually
  - Each OE parent cell divides many times, greatly increasing the number of parasites
- The OE parasite then goes through sexual reproduction, followed immediately by meiosis

OE cells in the pupa

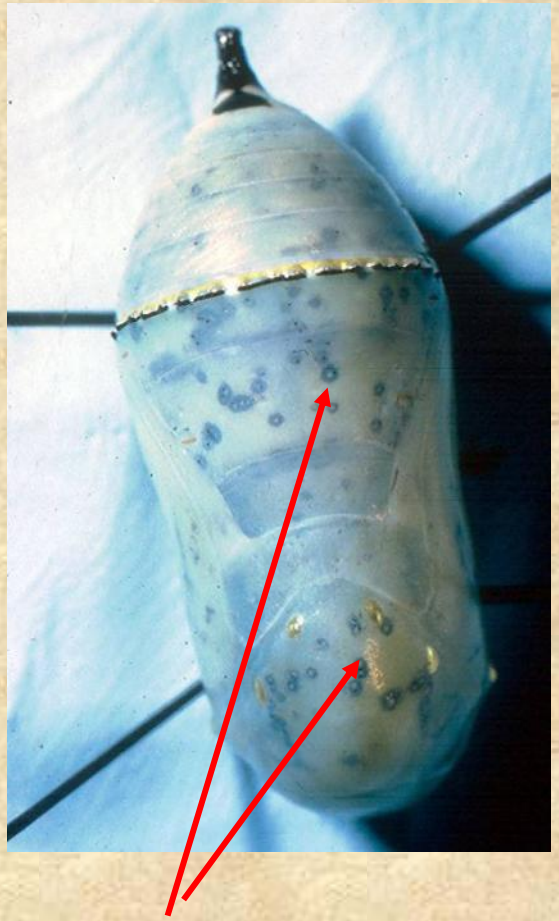
- Merozoites: vegetative, replicating stage of OE
- Single parent cell → many hundreds of daughter cells



OE merozoites in the hemolymph of a 5-day old monarch pupa

Spores Form in the Pupae

- About three days before the adult emerges from the pupa, OE spores begin to form
- Spores allow OE to survive outside of the monarch's body
- The spores can be seen through the integument or outside layer of the pupa



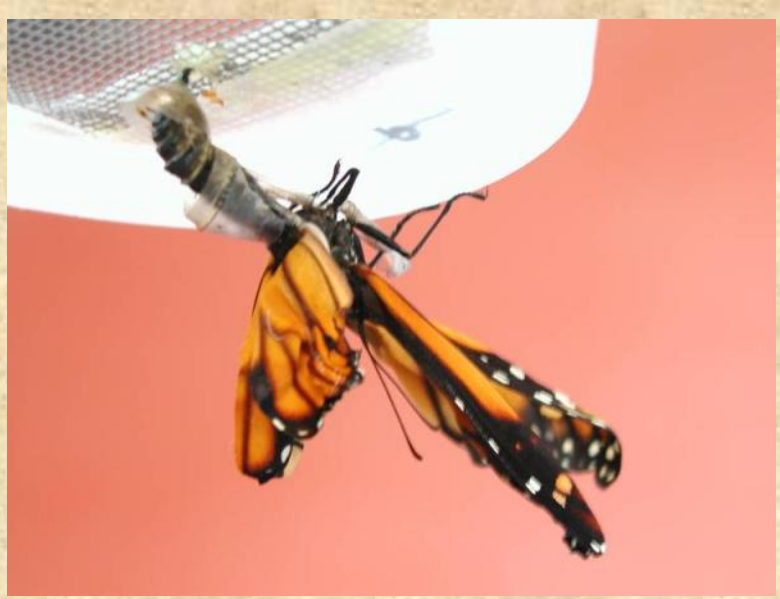
OE Spores

Adult Emerges with Spores

- Infected adults emerge covered with spores
  - *Once butterflies are infected, they do not recover*
  - By the time adults emerge with parasite spores, all physical damage by the OE parasites has been done
  - The parasites do not grow or reproduce on the adults
  - The spores are inactive or dormant until they are eaten by another caterpillar

Parasitized emerging monarchs

- Monarchs that are heavily infected with OE can have difficulty emerging from their pupal cases



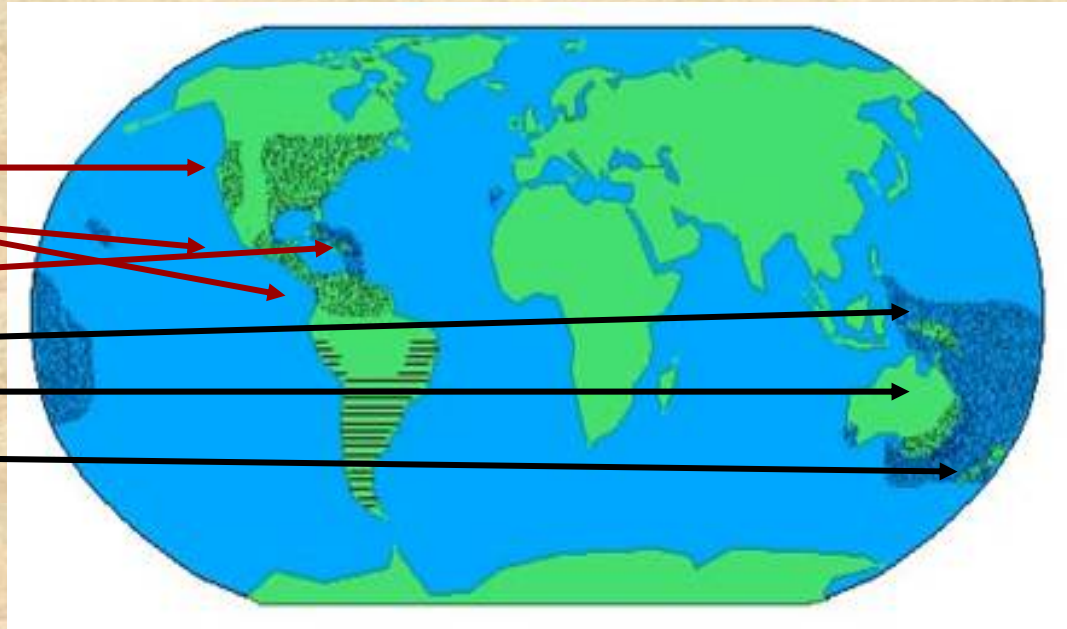
Infected monarchs are covered with millions of tiny OE spores

Where in the World do you Find OE?

- Monarchs have a wide geographic range
- OE occurs in all monarch populations examined to date

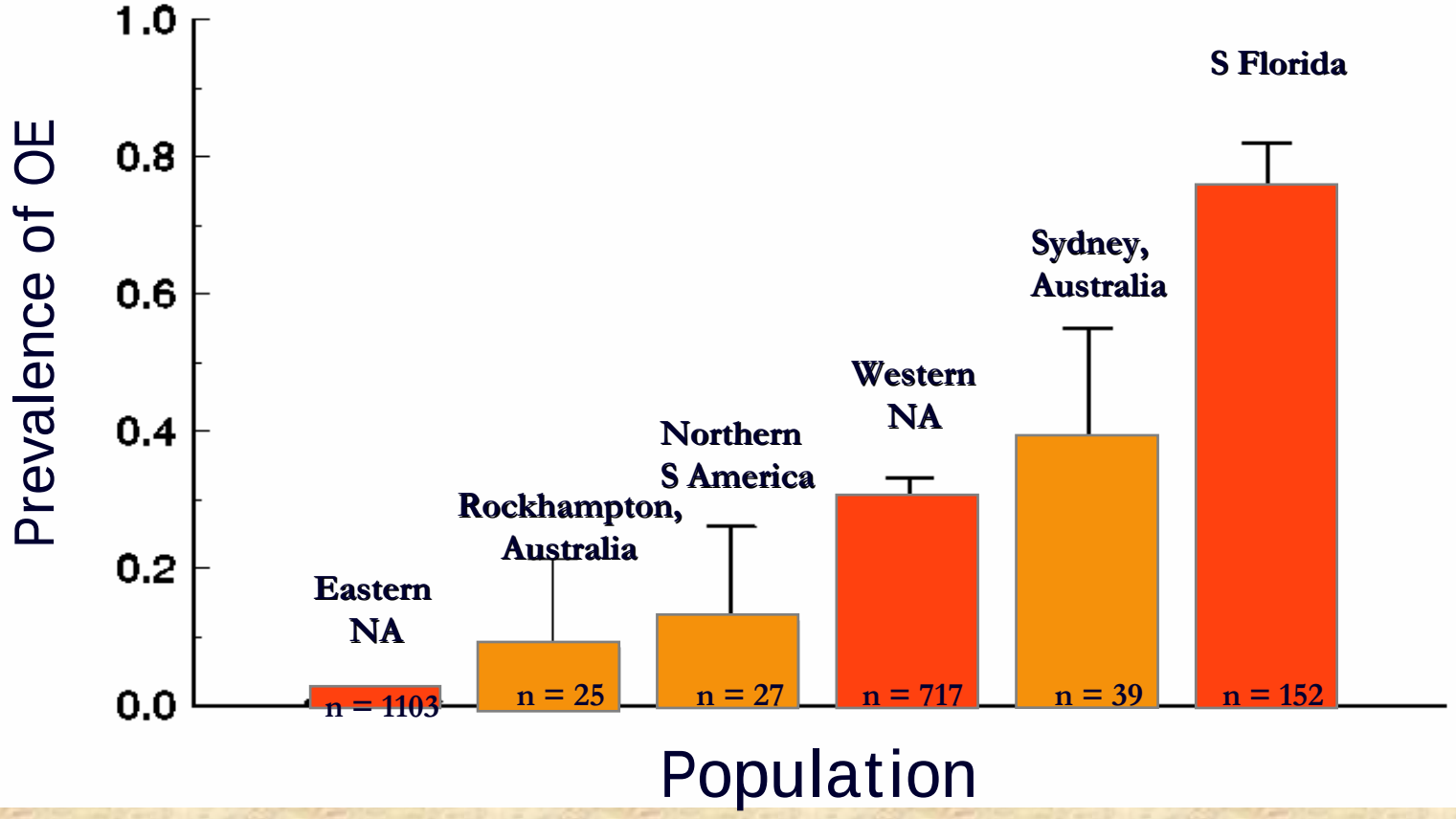
<u>Monarch geographic range</u>:
N. America
Central and S. America
Caribbean Islands

Pacific Islands
Australia
New Zealand

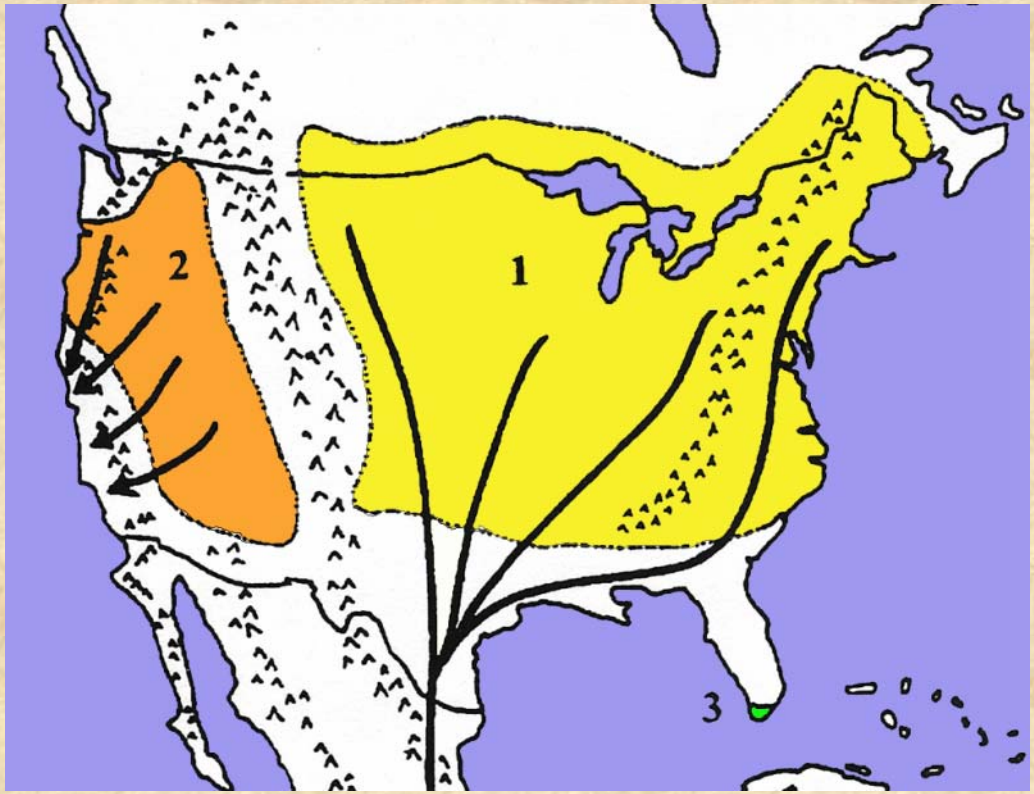


Where in the World do you Find OE?

Prevalence: Measures proportion of monarchs infected with OE
infected / total # sampled (n)



Monarchs in North America
Summer Ranges and Migratory Routes



1. Eastern migratory population

2. Western migratory population

3. South Florida resident population

Eastern Migratory Monarchs

- The eastern migratory population is the largest and most famous
- These monarchs spend the winter in the transvolcanic mountains of central Mexico

Monarchs Overwintering in Oyamel Fir Trees in the Mountains of Central Mexico

Eastern Migratory Monarchs

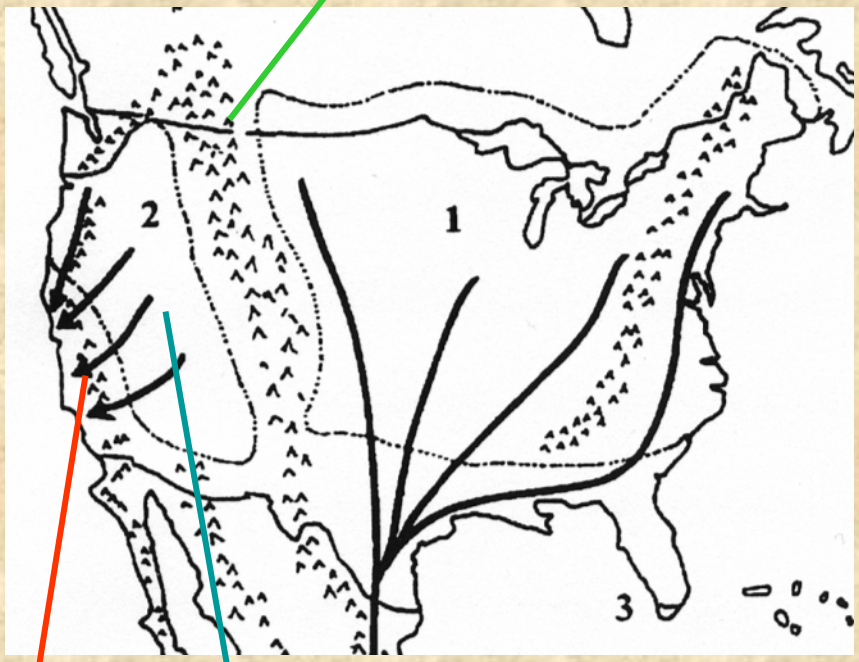
- Spring: After mating, migrate north to their summer breeding grounds in the United States and Canada
- Summer: Several generations of monarchs inhabit lands east of the Rocky Mountains from Alberta to Maine

Eastern Migratory Monarchs

- Fall: tens of millions of monarchs return to Mexico in a spectacular migration

Western Migratory Monarchs

- Shorter, less dramatic migration to their roosting areas on the coast of California
- Overwinter in much smaller groups than the ones in Mexico
- Spring: migrate north and east



Rocky Mountains

Summer Range for Western Monarchs

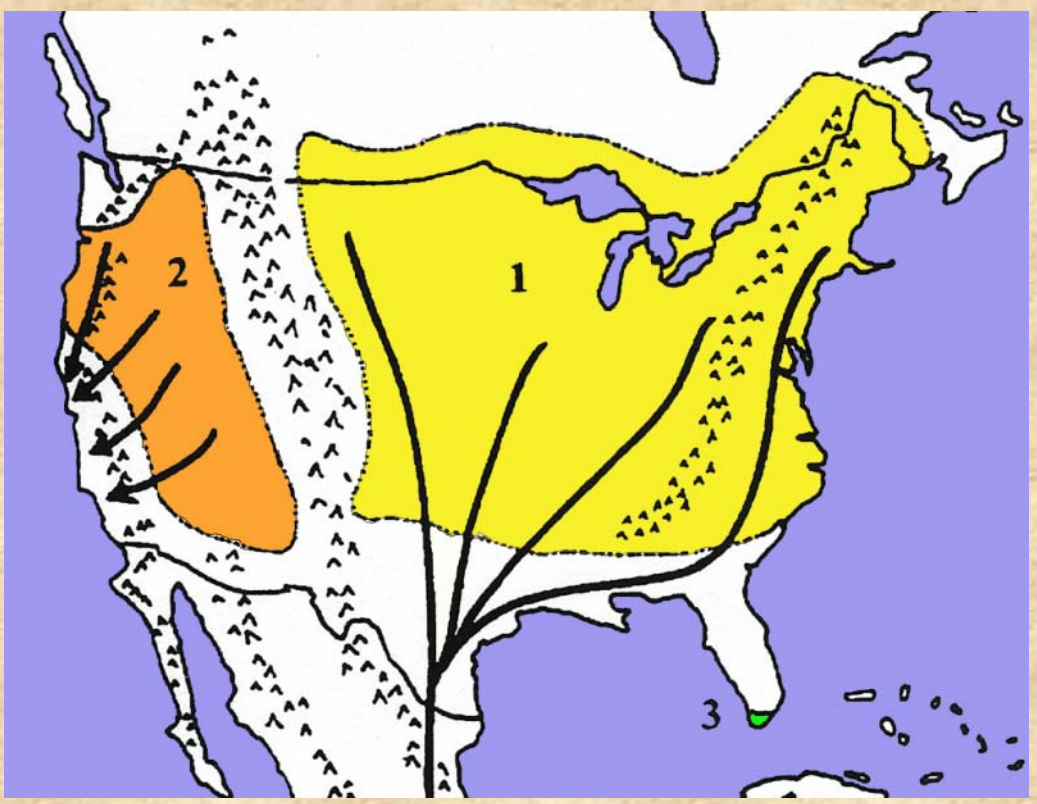
Overwintering Sites for Western Monarchs

Monarchs of South Florida

- Do not migrate
- Milkweed plants grow here all year round, the butterflies do not need to leave the area
- Resident monarchs reproduce throughout the entire year

Monarch larva feeding on tropical milkweed, a common but non-native host plant species in S. Florida

How common is OE in North America?



1. Eastern migratory population

- Less than 10% heavily infected

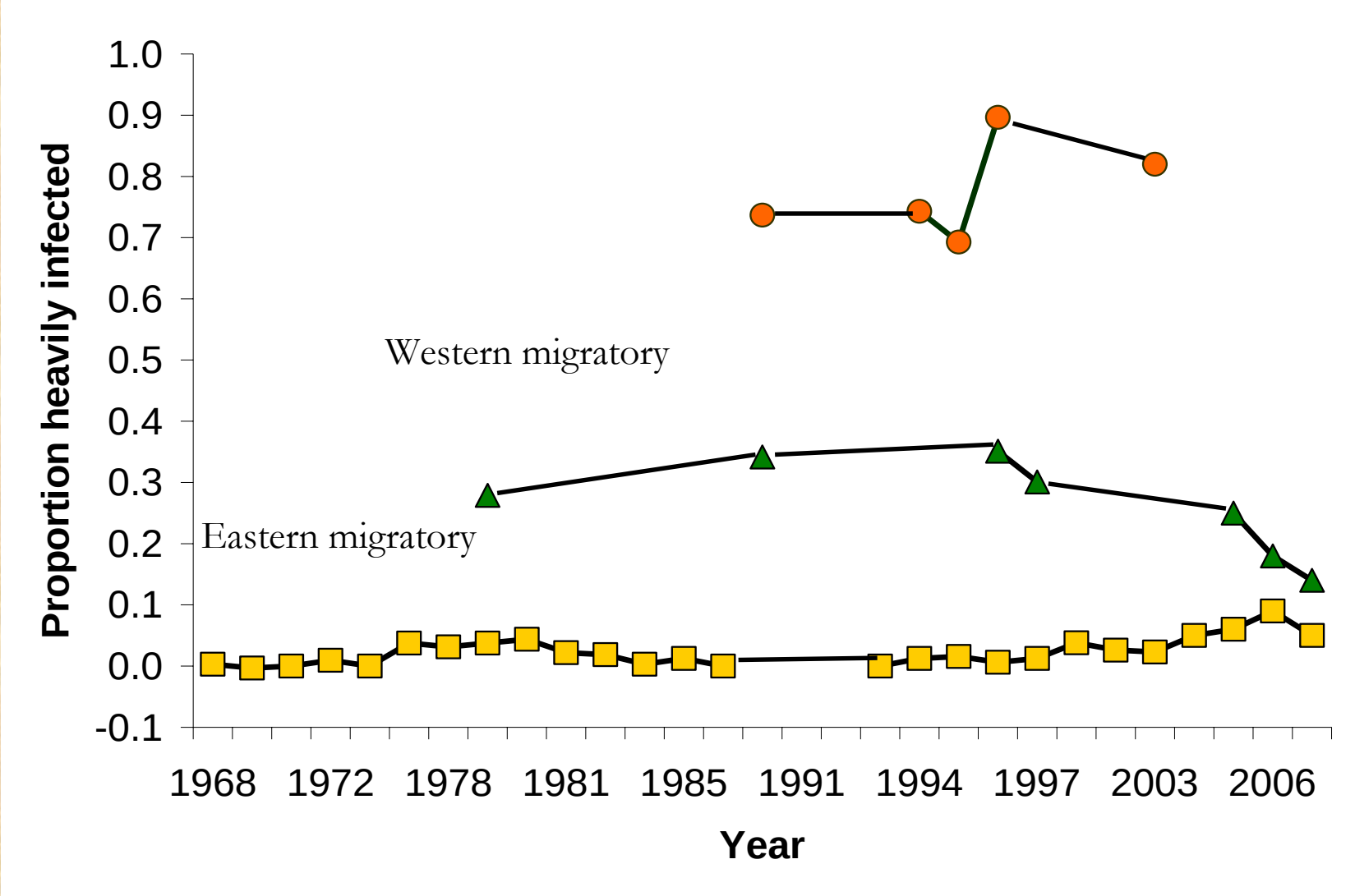
3. South Florida resident population

- Over 70% heavily infected

2. Western migratory population

- 30% heavily infected

Differences between populations have persisted for many decades



Do my Monarchs have OE? What are the Symptoms?

- Butterflies can become sick for many different reasons
- Monarchs infected with OE have a variety of symptoms
  - Caterpillars may have damage to their gut walls
  - Infections may be fatal

Monarch caterpillars often turn brown within a few hours of death.

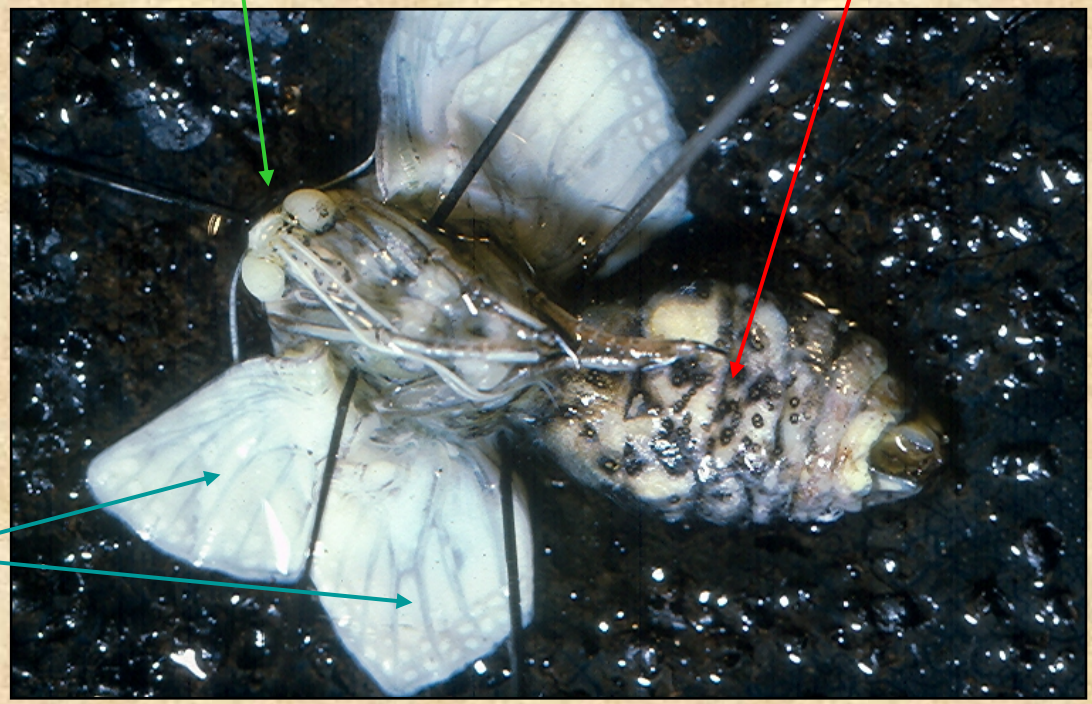
Damage to the Pupa

- Infected pupae may develop dark spots or blotches 2-3 days before the butterfly emerges
  - These abnormal dark areas are parasite spores
  - Spores form on the eyes, antennae, wing veins, but mostly on the abdomen
  - You can see the spores through the outside layer of the pupa a day or two before pigments that color the butterfly normally darken the pupa

Dissected Pupa Showing OE Spores

The dark spots are OE spores

Infected pupa
before dissection



Dissected Pupa

Damaged Adult Monarchs

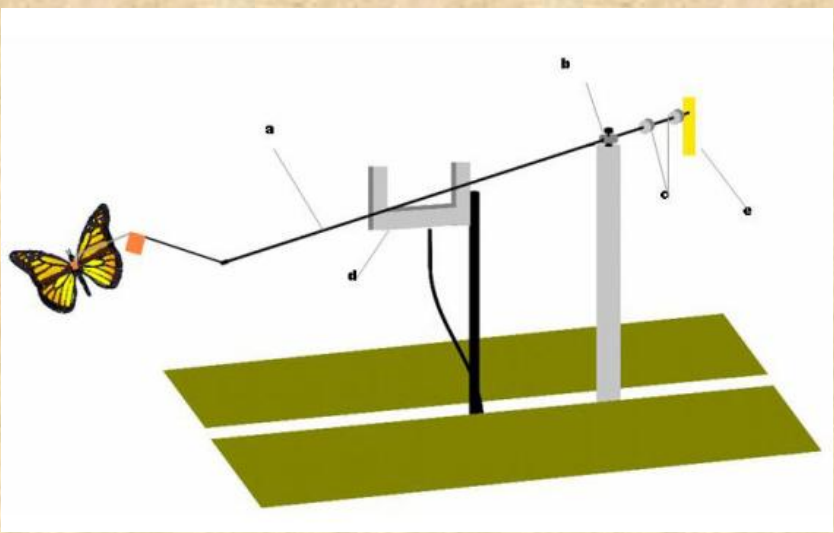
- Heavily infected adults are weak and often have difficulty emerging from the chrysalis
  - Some monarchs die before emerging
  - Others emerge, but are too weak to cling to the pupal case
    - They fall to the ground before fully expanding their wings
    - These severely deformed monarchs do not survive long

Mild infections also harm butterflies

- Infected adults are often smaller than healthy monarchs
  - They weigh less and have smaller wings and shorter lifespans than normal monarchs
- Parasites also damage the cuticle or outside layer of the monarch's abdomen
  - This causes the butterfly to dry out and lose weight faster than normal.
  - Especially a problem if there is a shortage of nectar or water

Parasite infection hinders monarch flight ability

- Studies have shown that monarchs infected with OE can not fly as far or as long as healthy butterflies



Flight mill

A flight mill is used to measure a monarch's flight endurance

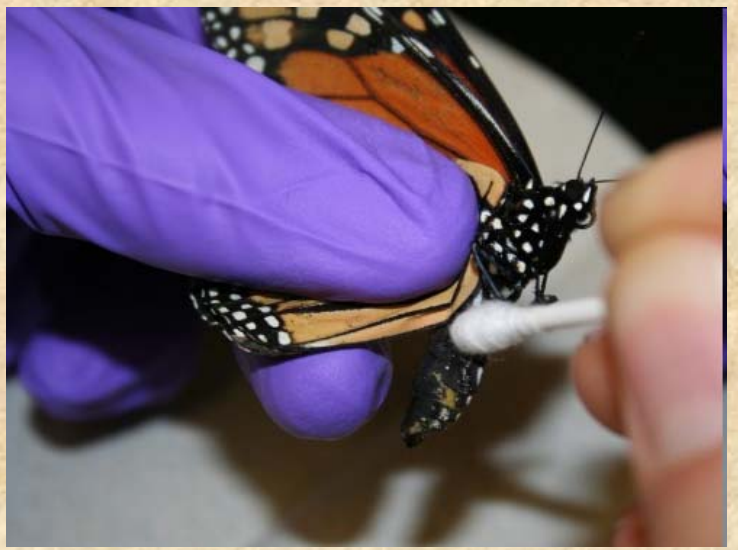
Monarchs with mild infections can transmit disease

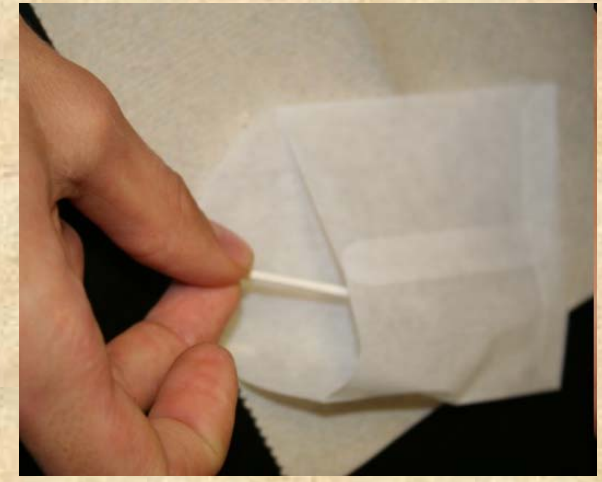
- Infected adults that survive to reproduce will pass the infections on to their offspring

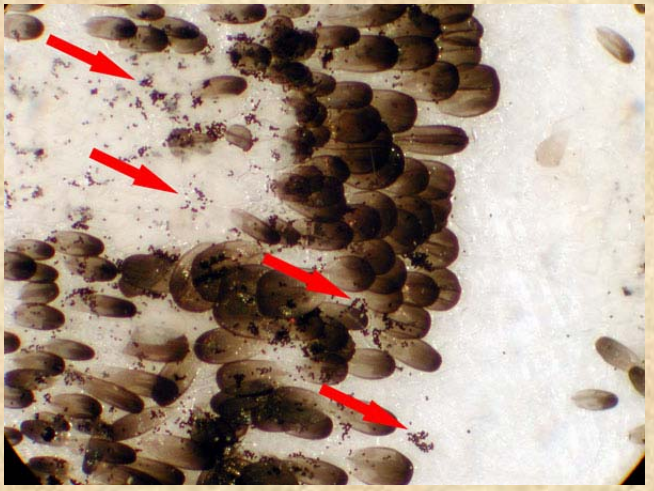
Many infected monarchs look the same as healthy butterflies

- These are all symptoms of OE, but many infected monarchs look healthy
  - They emerge normally and are not deformed
  - The only way to really know if your monarch is infected is to check for parasite spores on its body.
- Easy way to test for infections: swabbing

How to test for OE







Use sterile protocols when handling monarchs

- OE spores are difficult to destroy
- Use latex , nitrile or vinyl gloves when touching butterflies
- Sterilize all tools and surfaces that contact monarchs (counter tops, rearing containers) with 20% bleach solution

Can You Tell Which Monarchs are Infected with OE?