Plant-Insect Interactions: Herbivory

Host-Plant Specificity

- Insects are likely the most significant group of herbivores (43% of all species)
  - Lepidopterans
  - Coleopterans
  - Hemipterans
  - Orthopterans
  - Hymenopterans

Wavy-lined emerald specializes on Asteraceae

Milkweed longhorn beetle, a specialist herbivore

Table 2.1 Numbers of herbivorous species in different insect orders. (Data from various sources)

Insect order	*Total no. of species*	*Herbivorous species*	
		No.	*%*
Coleoptera	349000	122000	35
Lepidoptera	119000	119000	100
Diptera	119000	35700	30
Hymenoptera	95000	10500	11
Hemiptera	59000	53000	91
Orthoptera	20000	19900	100
Thysanoptera	5000	4500	90
Phasmida	2000	2000	100

Plant-Insect Interactions: Herbivory

- Phytophagous
  - ‘Phyto’– plant
  - -phagous—feeding
- Of the big four:
  - 100,000 species of beetles feed on plants
  - 150,000 species of butterflies and moths

Plant-Insect Interactions: Herbivory

Lepidopterans: Largest Lineage of Plant-feeders

- 150,000 species are plant-feeders
- Most of these are specialists

Plant-Insect Interactions: Herbivory

Coleoptera: 2nd largest Order of Plant feeders

- 100,000 species are plant-feeders
- Some generalist, mostly specialists
  - Chrysomelidae
  - Curculionidae
  - Cerambycidae

Plant-Insect Interactions: Herbivory

Orthoptera: Polyneopterans

- 95% are herbivores (mostly generalists)

Plant-Insect Interactions: Herbivory

Host Plants are Mostly Angiosperms

- Flowering plants typically are (relatively)more nutritious
- Easier to digest
- Most available food resource for insects

Milkweed longhorn beetle, a specialist herbivore

Plant-Insect Interactions: Herbivory

Host Plants are Mostly Angiosperms

- Flowering plants typically are (relatively)more nutritious
- Easier to digest
- Most available food resource for insects
- Diversification and co-speciation are rare

Milkweed longhorn beetle, a specialist herbivore

Plant-Insect Interactions: Herbivory

Science ~~can be~~ IS messy

- If most herbivores are specialists, how and why does speciation occur?

Plant-Insect Interactions: Herbivory

Science ~~can be~~ IS messy

- If most herbivores are specialists, how and why does speciation occur?
- Are insects merely one step behind? (Jermy, 1993; Dilcher, 2001)
- Do they affect the evolution of flowering plants? (Jermy, 1984)
- Diversity of insects does not reflect the diversity of flowering plants. (Sepkoski 1993)

Plant-Insect Interactions: Herbivory

The Bullhorn Acacia

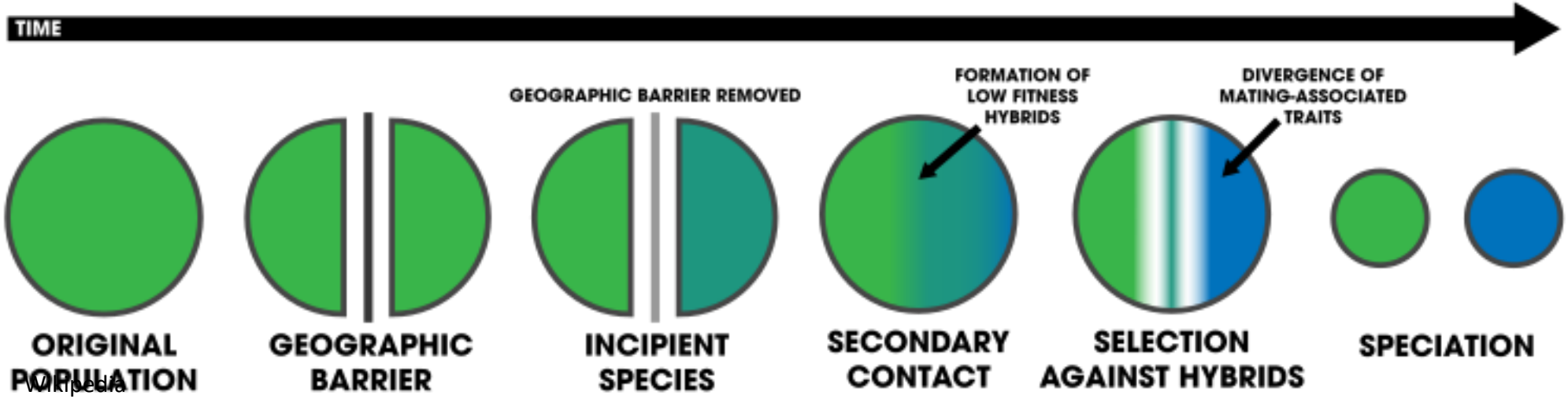
Credit: April Nobile

Credit: Feroze Omardeen/Flickr

Plant-Insect Interactions: Herbivory

Science ~~can be~~ IS messy

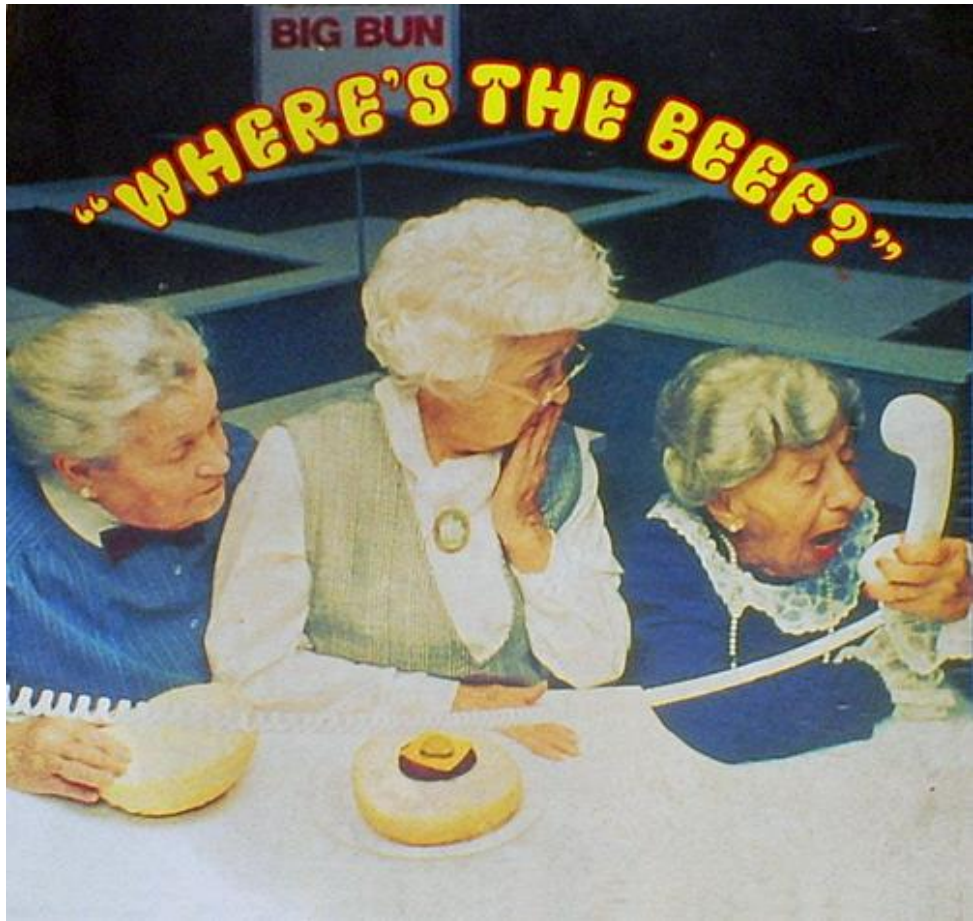
- If most herbivores are specialists, how and why does speciation occur?
- Does specialization promote genetic isolation among insects and plants?
  - Plant detoxification as 'key innovation;'



Plant-Insect Interactions: Herbivory

The challenges of being an herbivore

1. Plant diets *alone* are inferior to additional food sources:
   - Insects are ~14% Nitrogen; Plants, from ~0.5-8%
   - Availability and concentration vary with time
   - Nutrients are often diluted and mixed



Plant-Insect Interactions: Herbivory

The challenges of being an herbivore

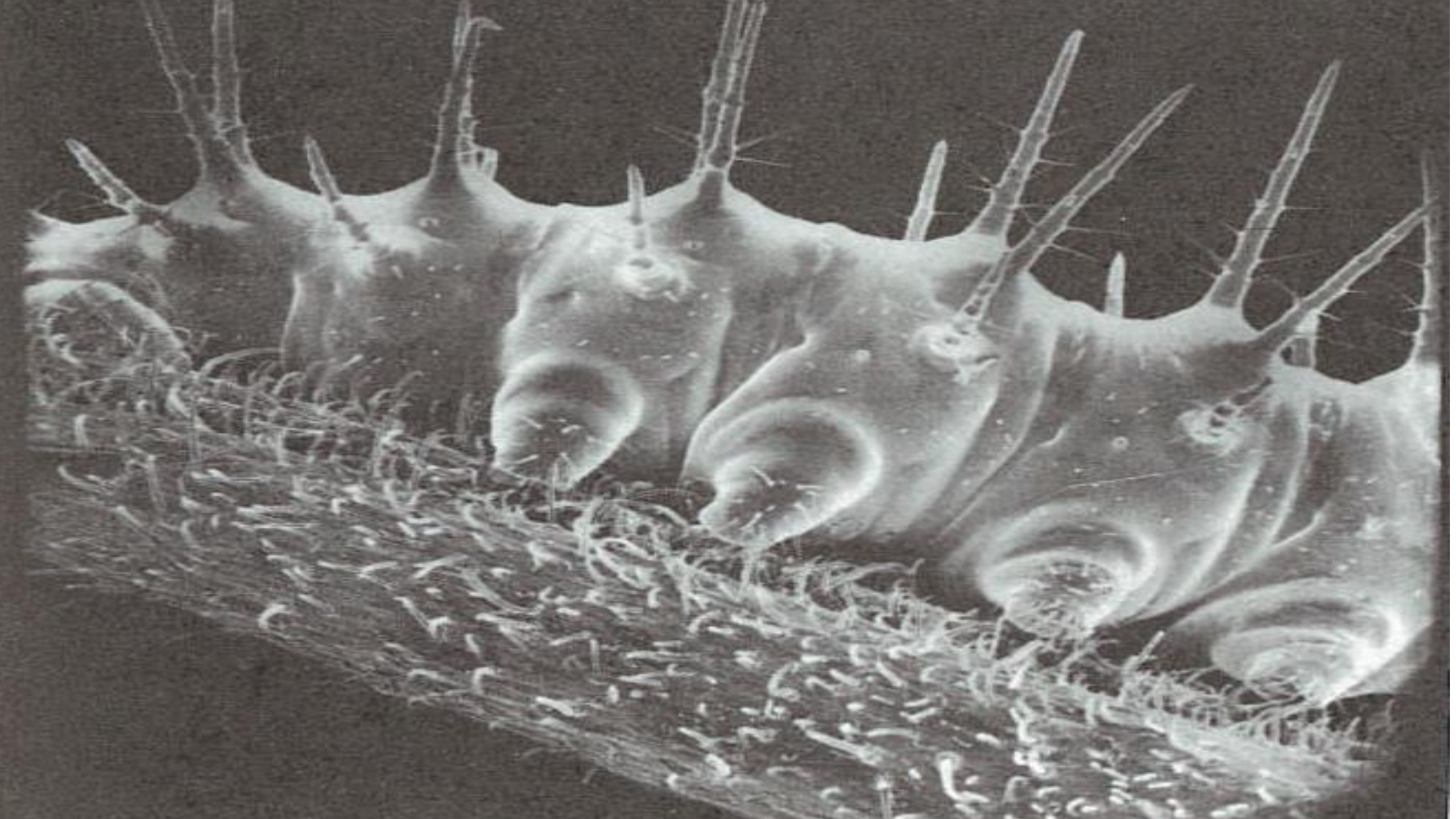
1. Plant diets *alone* are inferior to additional food sources
2. Food can become scarce very quickly

Plant-Insect Interactions: Herbivory

The challenges of being an herbivore

1. Plant diets *alone* are inferior to additional food sources
2. Food can become scarce very quickly
3. Plants are not passive recipients to herbivory:
   - Chemical and Physical defenses must be overcome
   - Quantitative vs. Qualitative* (Plant 'Apparency')
   - Secondary metabolites cause toxicity
   - Spines, hairs, waxy coverings

*The type depends on the selective pressure exerted by insects



Plant-Insect Interactions: Herbivory

Specialization: a top-down view

- Coevolution of plants and insects means that herbivores can overcome toxic plant compounds
- Generalist feeders account for greater biomass overall
  - 90% are specialists
  - 10% are generalists

Plant-Insect Interactions: Herbivory

The challenges of being an herbivore

1. Food can become scarce very quickly
2. More time feeding = more exposure to predators

Outline

A Story for the Ages: Plant-Insect Interactions

- Pollination and Herbivory
- Predation and Parasitism

Plant-Insect Interactions: Predators and Parasites

The Third Trophic Level

- Specialist herbivores can overcome certain plant defenses
- Plants need a second line of defense
  - Attractants (Bentley, 1977; Tilman, 1978)

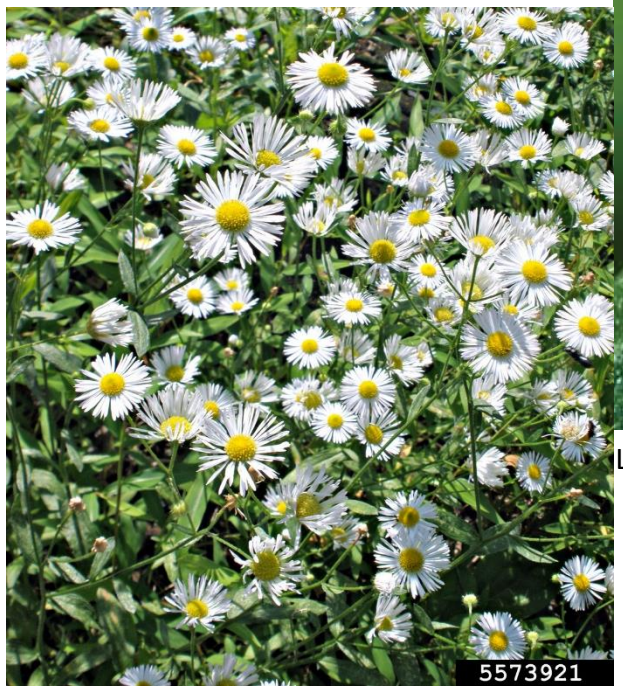
Gall created by cynipid gall wasps.
Credit: Joe Ballenger

Plant-Insect Interactions: Predators and Parasites

The Third Trophic Level

1. Specialist herbivores can overcome certain plant defenses
2. Plants need a second line of defense
   - Attractants (Bentley, 1977; Tilman, 1978)
   - Quality of pollen and nectar affects rates of parasitism

Lygus bug; growingproduce.com



Erigeron spp.; invasive.org

Plant-Insect Interactions: Predators and Parasites

The Third Trophic Level

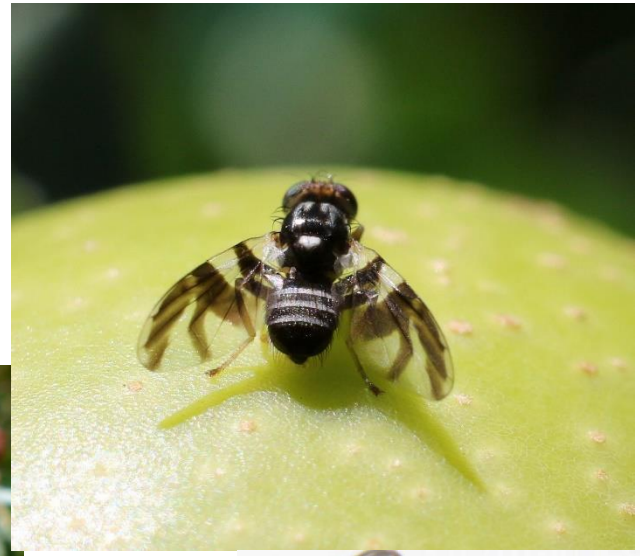
- Specialist herbivores can overcome certain plant defenses
- Plants need a second line of defense
  - Attractants (Bentley, 1977; Tilman, 1978)
  - Quality of pollen and nectar affects rates of parasitism
  - Chemicals emitted from plants may act directly or indirectly (Wei et al., 2007)

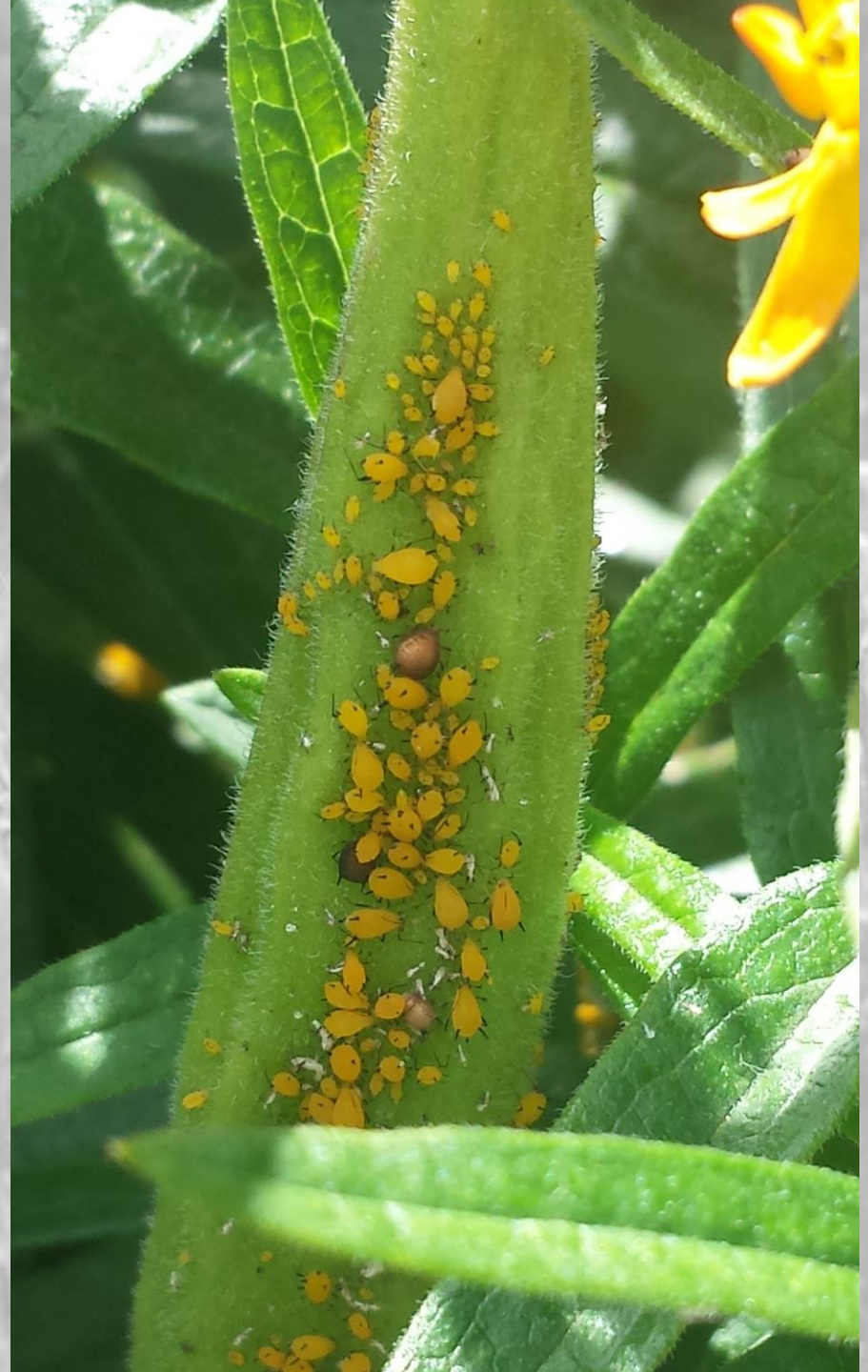
Monarch frass; Dorothy Birch

Plant-Insect Interactions: Predators and Parasites

Plant structure makes all the difference

- Herbivores utilize plant parts to escape predation/parasitism






UC Statewide IPM Project
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A bee mimic robber fly (Asilidae: *Laphria* spp.)
Credit: cotinus/flickr

Plant-Insect Interactions: Predators and Parasites

The Third Trophic Level

- Specialist herbivores can overcome certain plant defenses
- Plants need a second line of defense
- Plants may just be a stopover
  - Some predators/parasites use plant cues for something else

Scelionid wasp, an egg parasite; bugguide.net

Plant-Insect Interactions: Predators and Parasites

Insect Parasites (Parasitoids)

- Usually are much smaller than their hosts
- Life cycles are intricately interwoven with their hosts (many are species specific)
- Mostly Hymenopterans; some Diptera
  - 240,000 (75%) of *all* Hymenopterans are parasitoids
- Can be *idiobionts* or *koinobionts*
- *Hyperparasitism*

Plant-Insect Interactions: Predators and Parasites

Insect Parasites (Parasitoids)

- Can be *ecto- or endoparasitic*
  - *Idiobionts* or *koinobionts*
- Hyperparasitism
- Superparasitism

Jewel wasp, an ectoparasitic koinobiont;
theinsectdiary.blogspot.com

Glomerata wasp adult
Credit: Hans Smid

Stages of parasitism in *Pieris* sp. (Lepidoptera)
Credit: Nigel Venters, nzbutterflies.org