Master Gardener Training
Part 1: An Introduction to the Insects

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March 22, 2017

Outline - Introduction to the Insects

Master Gardener Training, April 15, 201

- **Part 1: An Introduction to the insects**
  - **What is an insect?**
  - **The life history of insects**
  - **Insect flight**
  - **The success of beetles**
  - **Insect mouthparts and feeding strategies**
  - **Coevolution of insects and plants**
- **Part 2: Insect Population Biology**
  - **Why are insects eating my garden?**
  - **Life history strategies of plants and animals**
  - **Food webs, mortality and population ecology**
  - **Predators and the evolution of life**
  - **The concept of biological control**
- **Part 3: Common Insects of Mendocino County**

Learning Objectives - Entomology

Entomology

Richard H. Molinar, Carlton S. Koehler, and L. W. Barclay

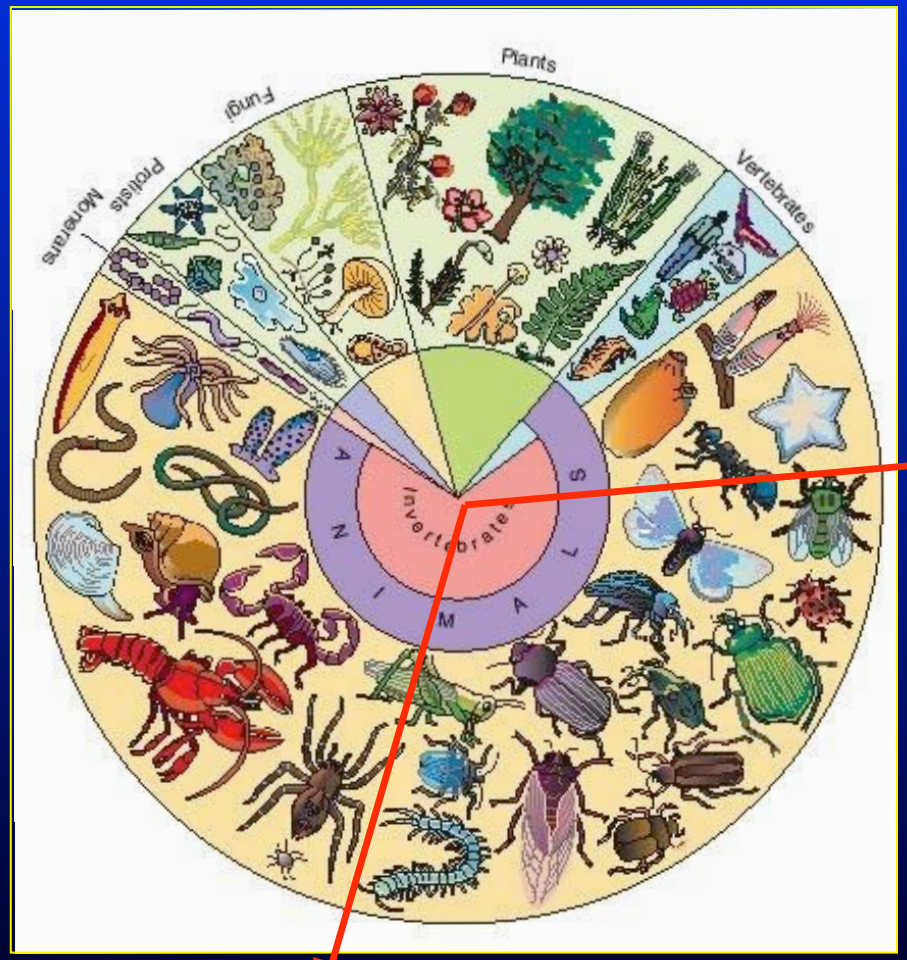
Today's Topics

NING OBJECTIVES

- Understand basic insect and mite pests in the home garden in California.
- Learn about basic insect structure (anatomy), life cycles, and distribution.
- Become familiar with the major groups of insects in the home garden.
- Learn basic information about diagnosing plant problems caused by insects and mites
- Learn about methods and rules for controlling insect pests and basic concepts of integrated pest management (IPM).

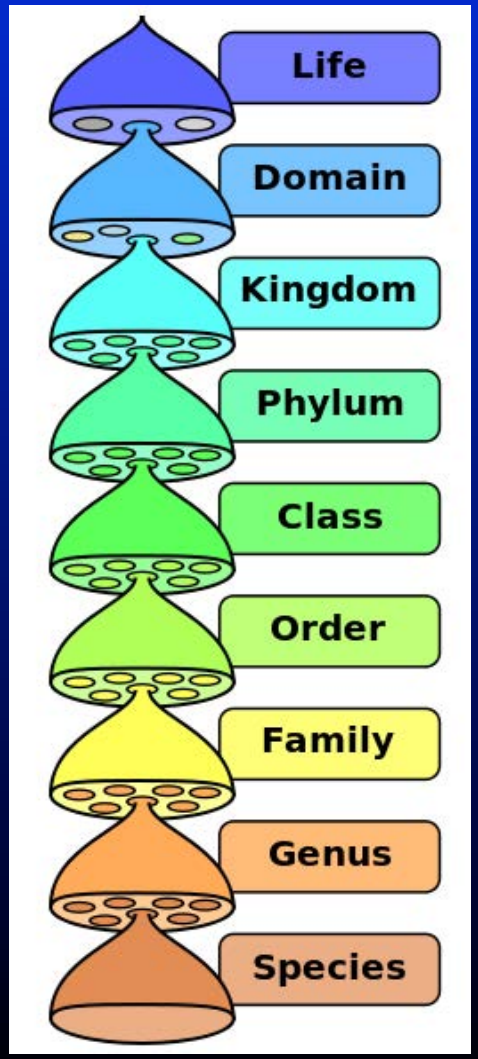
This chapter is intended to be used in conjunction with *Pests of the Garden and Small Farm* (Flint 1998) and *Pests of Landscape Trees and Shrubs* (Dreistadt 1994). Additional insect pest management and diagnosis information appears in chapters 8, 10, and 22 of this book.

Insect Dominate Terrestrial Life



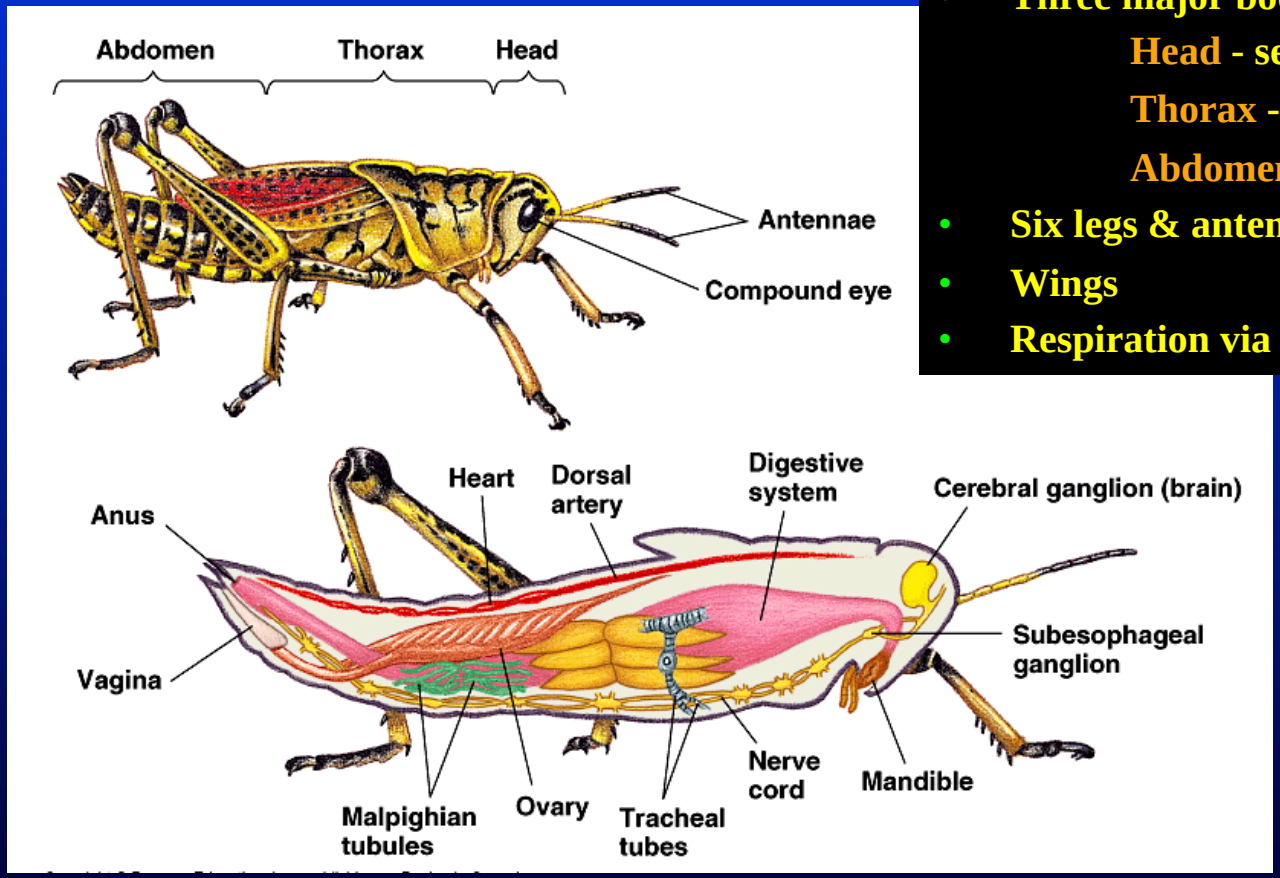
About 1/3 of all described plant and animal species on earth are insects.

How Living Organisms Are Classified

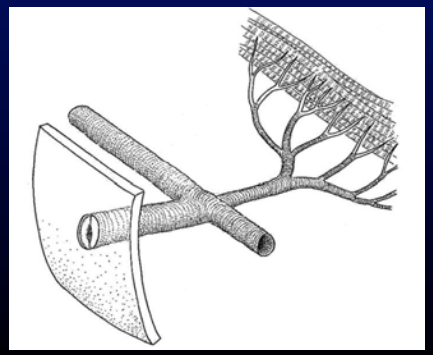


Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Hymenoptera (Bees, Wasps & Ants)
Family: Apidae
Genus & species: *Apis mellifera*
Common name: Honey Bee

What Makes an Animal an Insect?



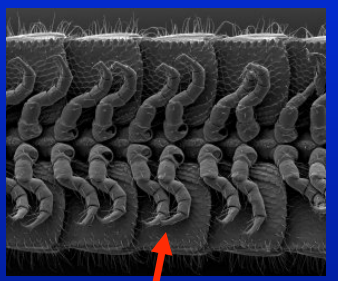
- Three major body parts
  - Head - sensory
  - Thorax - locomotion
  - Abdomen – reproduction & digestion
- Six legs & antennae
- Wings
- Respiration via a tracheal system



Insect breathe with a tracheal system

Millipedes, centipedes, spiders and "pillbugs" are arthropods but NOT Insects

Millipedes

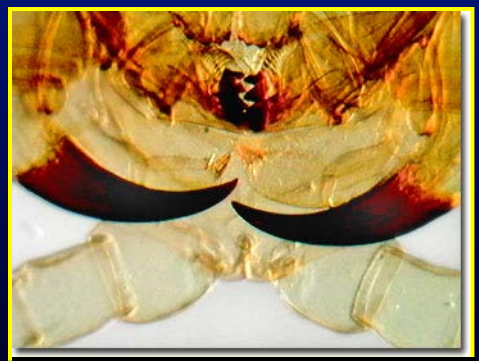


2 pair of legs per segment

Pillbugs

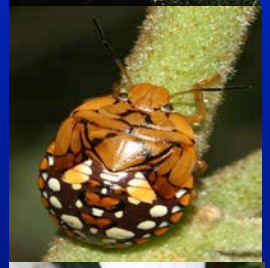
Spider

Centipede



Strong jaws & poison glands



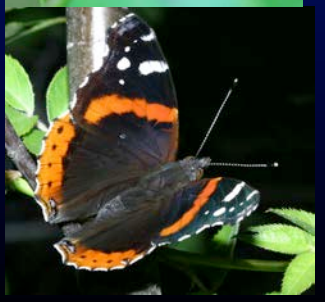


The Major Insect Orders

- **Odonata: Dragonflies & damselflies**
- **Isoptera: Termites**
- **Neuroptera: Lacewings…**
- **Hemiptera: "True" Bugs**
- **Homoptera: Leafhoppers, cicadas…**
- **Orthoptera: Grasshoppers**
- **Coleoptera: Beetles**
- **Diptera: Flies**
- **Hymenoptera: Bees, wasps, ants…**
- **Lepidoptera: Butterflies**

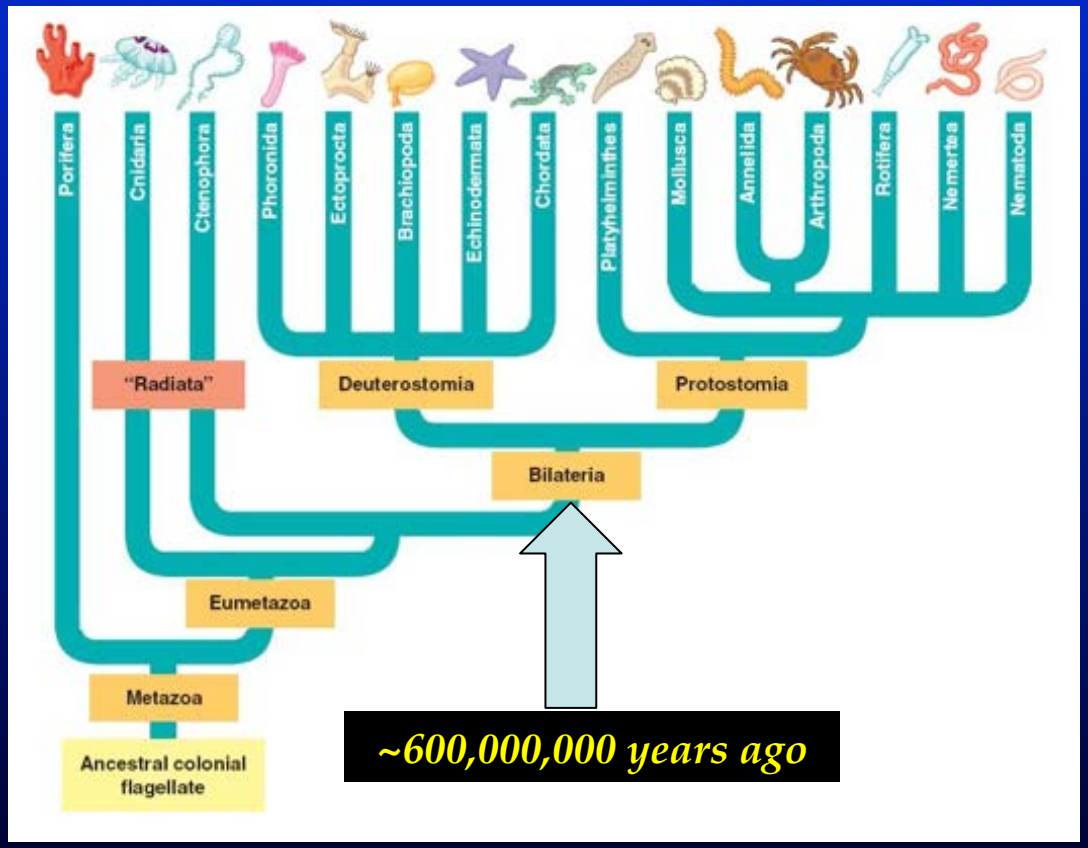


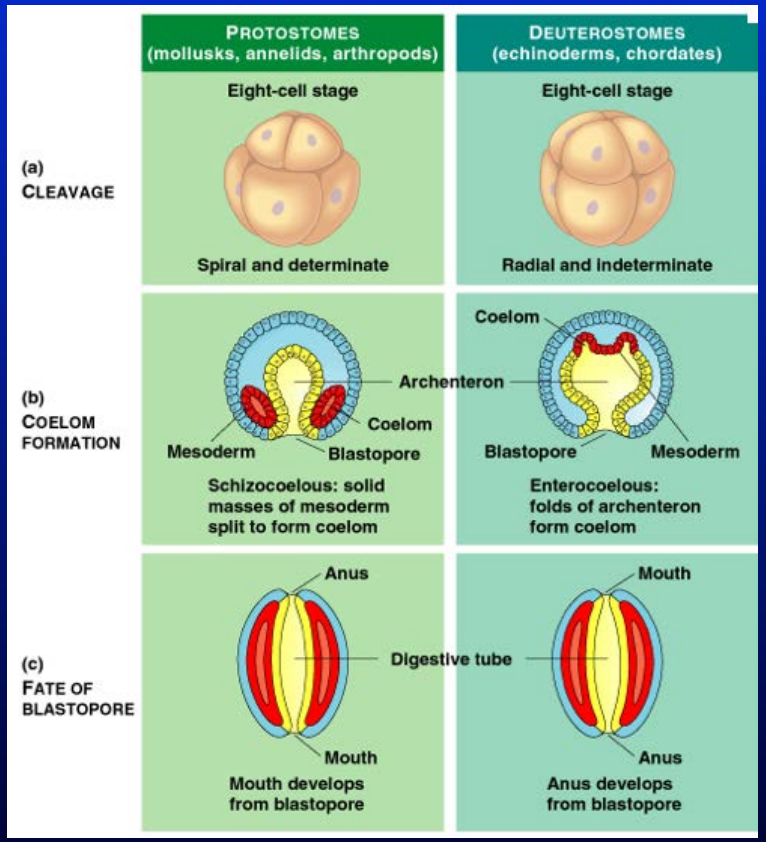




Pteron = wing (Greek)

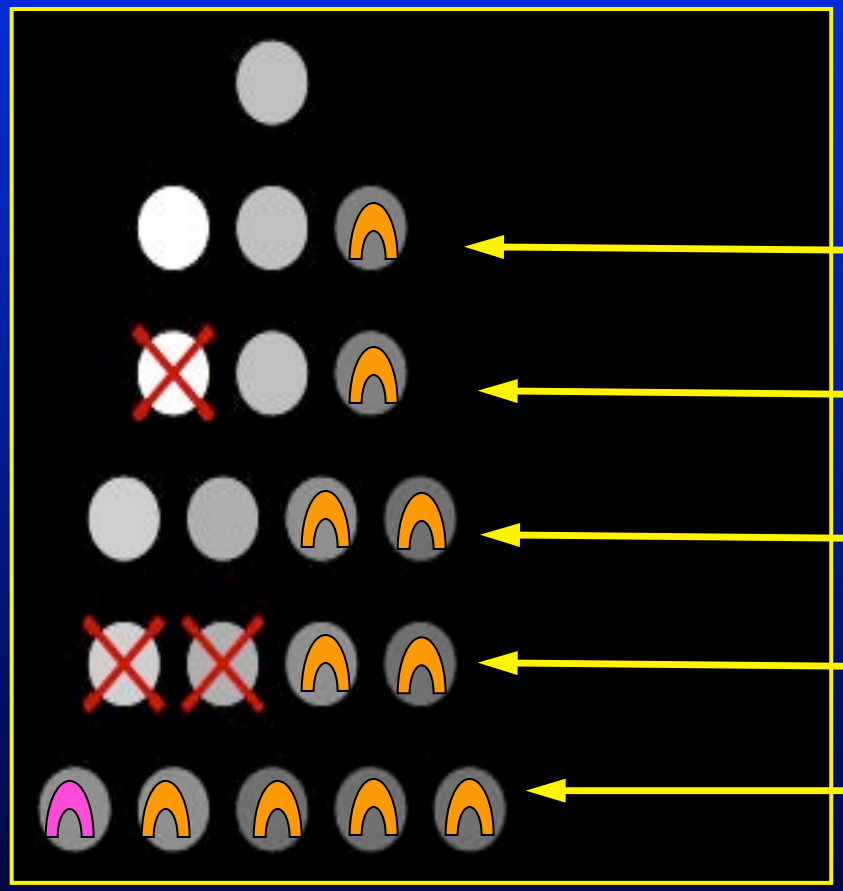
Why are we so different from insects?
A Major Split in the Animal Lineage ~ 600,000,000 Years Ago





The closest relative we share with insects lived 600,000,000 years ago.

How Does Natural Selection Work and Life Evolve?



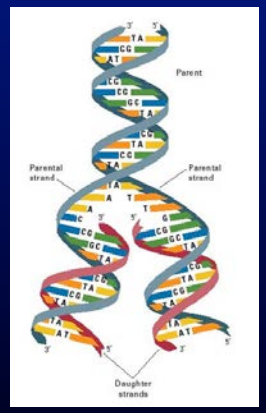
Mutation creates variation

Unfavorable mutations selected against

Survivors reproduce

More selection

And reproduction…
and more mutation



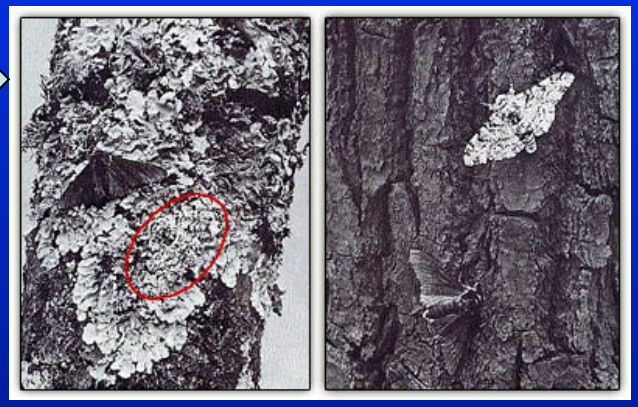
Evolution = change in gene frequency over time

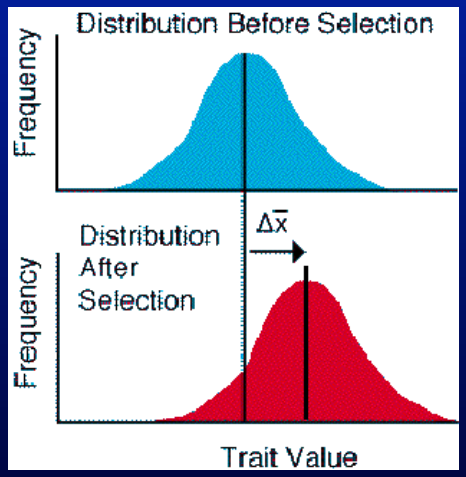
Predation has Shaped the Appearance of Insects

- **Cryptic coloration makes the insect blend into the background**
- **Physical defenses such as hairs & spines**

- **Warning coloration advertises that the insect is poisonous (or not)**

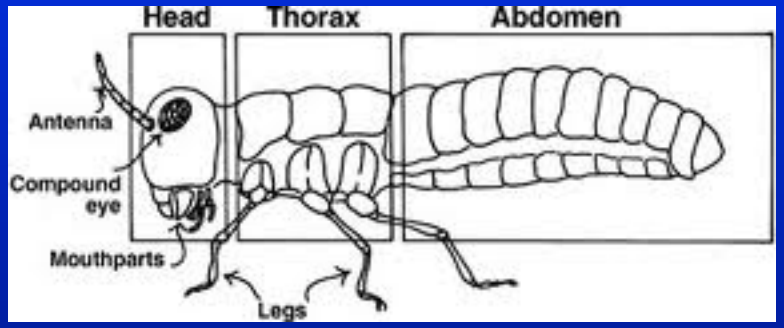
- **Bright colors & eyespots can startle a wood-be predator**





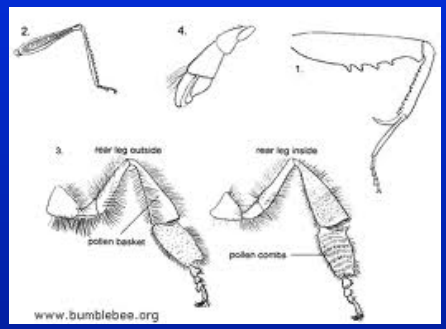
Pollution from the " Industrial Revolution" caused a shift in the proportions of light and dark pepper moths in many populations.

Evolutionary Plasticity of Insect Appendages

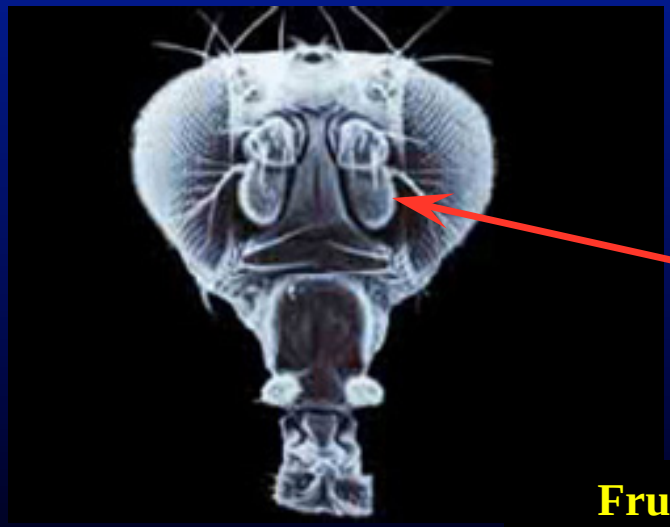


Generalized Insect Body Plan

Bumblebee



Bumblebee Legs



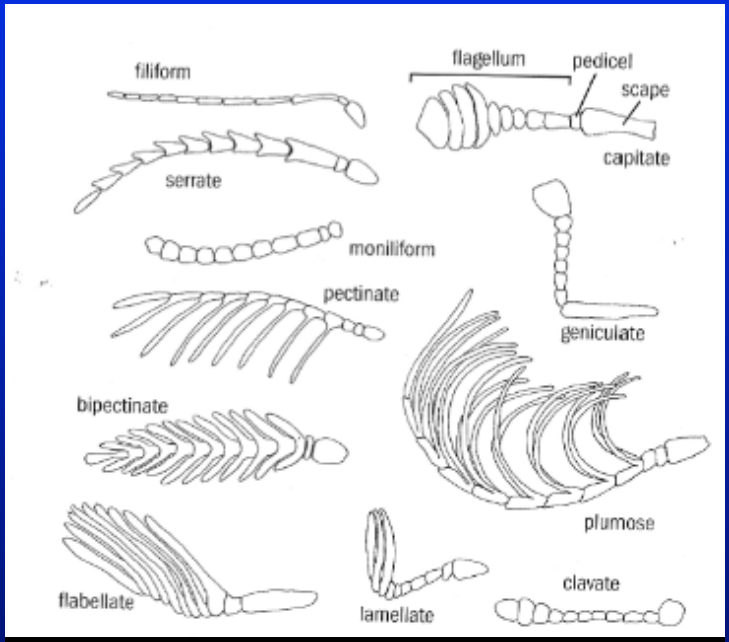
Antenna

Leg

Fruit Fly - *Drosophila*

A single mutation in the fruit fly genome can transform an antenna into a leg.

Diversity of Beetle Antennae



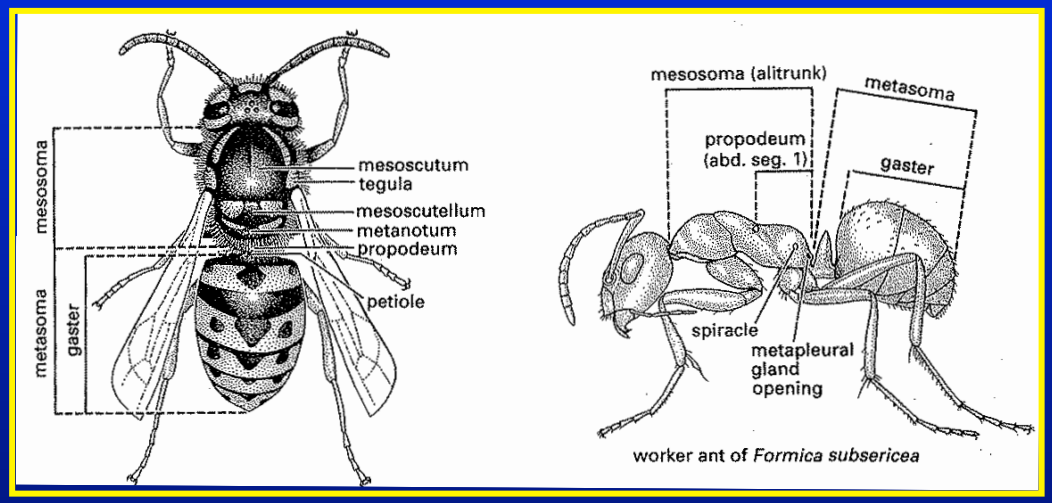
The Antennae of Beetles

Antennal Structure is Useful for Beetle Identification

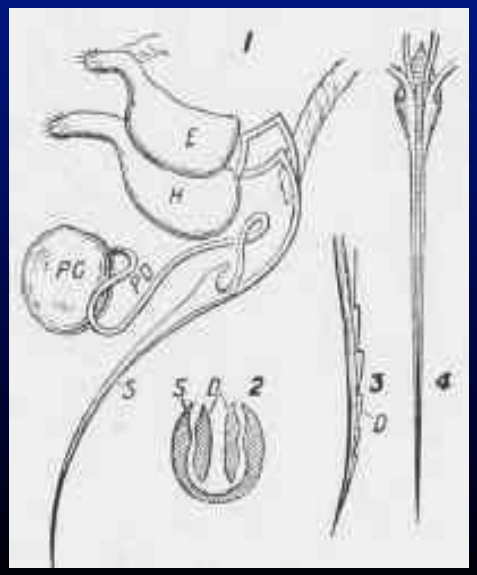
Longhorn Beetle (Cerambycidae)

Japanese Beetle (Scarabaeidae)

Abdominal Structure of the Hymenoptera



- Petiole - narrow constriction between the thorax and abdomen
- Development of the petiole and adaptations of abdominal glands were a major evolutionary developments for the advanced hymenoptera
- Flexibility of abdomen allowed niche expansion by the hymenoptera



The Life History of Animals and Plants

Strategies for Survival and Persistence

Life History = lifetime pattern of growth, development & reproduction

Orb Weaver

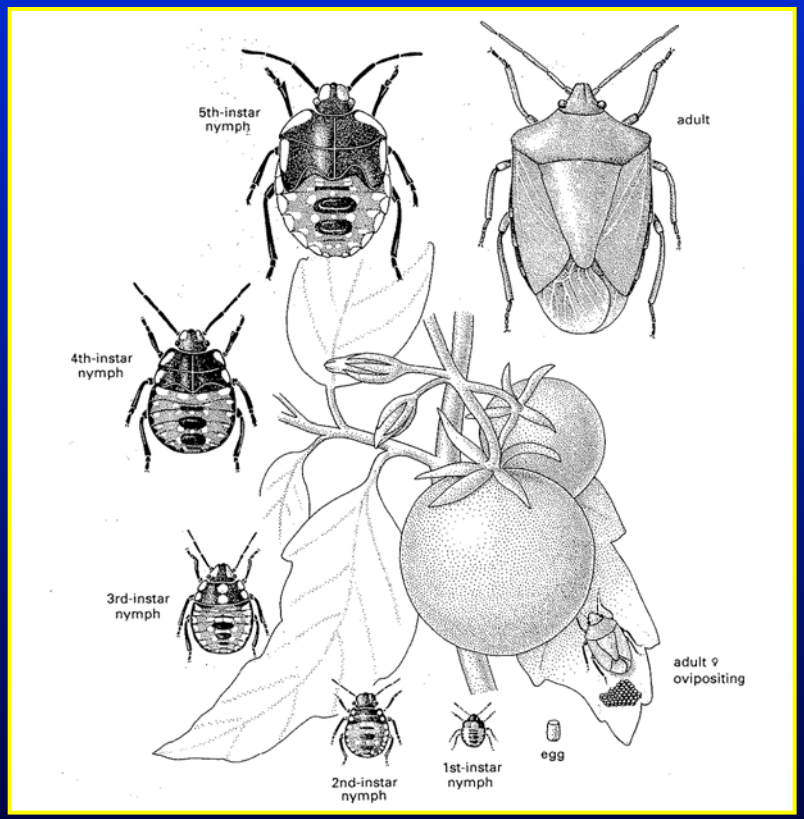
Black Widow

Crab Spider

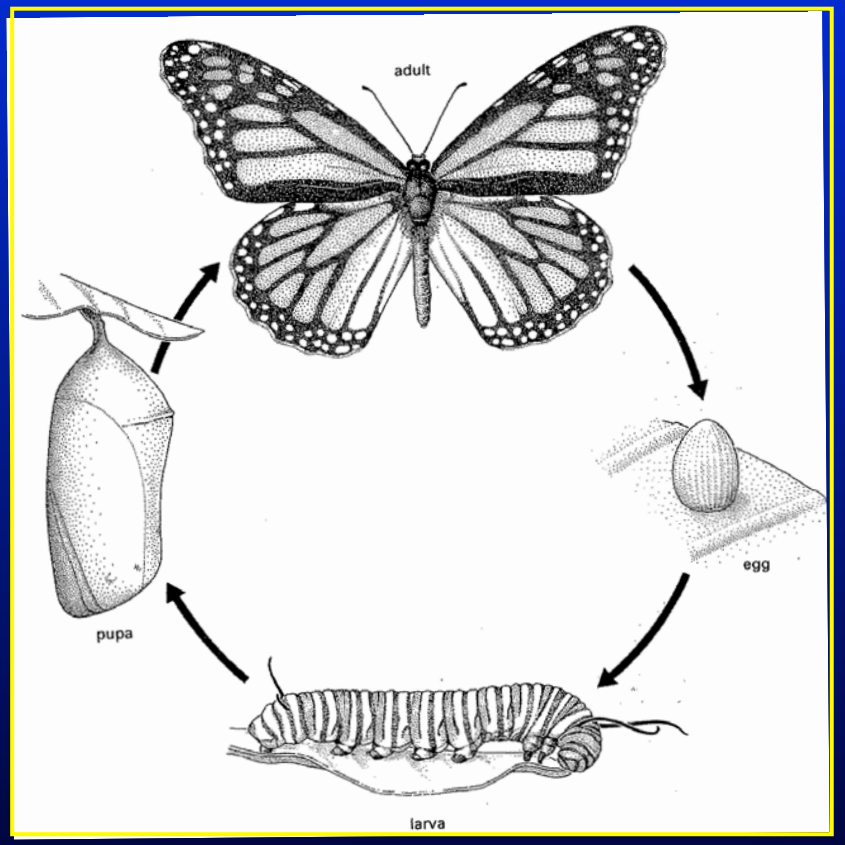
Jumping Spider

Wolf Spider

Insect Metamorphosis - Exploitation of Different Resources by Different Life Stages



Incomplete Metamorphosis
Hemimetabolous



Complete Metamorphosis
Holometabolous

Insects with "Complete" Metamorphosis (Holometabolous)

Beetles
Coleoptera

Butterflies
Lepidoptera

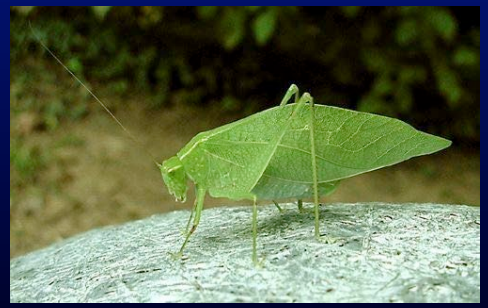
Flies
Diptera

Bees & Wasps
Hymenoptera

Insects with "Incomplete" Metamorphosis (Hemimetabolous)

Dragonflies
Odonata

Termites
Isoptera



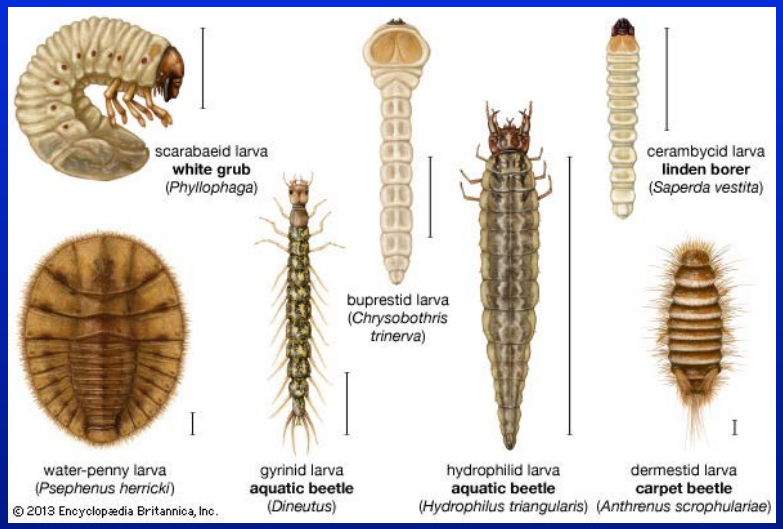
Grasshoppers
Orthoptera

True Bugs
Hemiptera

Names for Immature Insects

- **Larva = immature form of an insect (with complete metamorphosis) after emerging from the egg (a.k.a. instar or stadium, caterpillar)**
- **Nymph = immature form of an insect (with incomplete metamorphosis) after emerging from the egg (a.k.a. instar or stadium)**
- **Naiad = immature form of an aquatic insect (with incomplete metamorphosis) after emerging from the egg**

Insect Larvae Have Diverse Forms



The larvae of beetles exhibit more diversity than any other insect order.

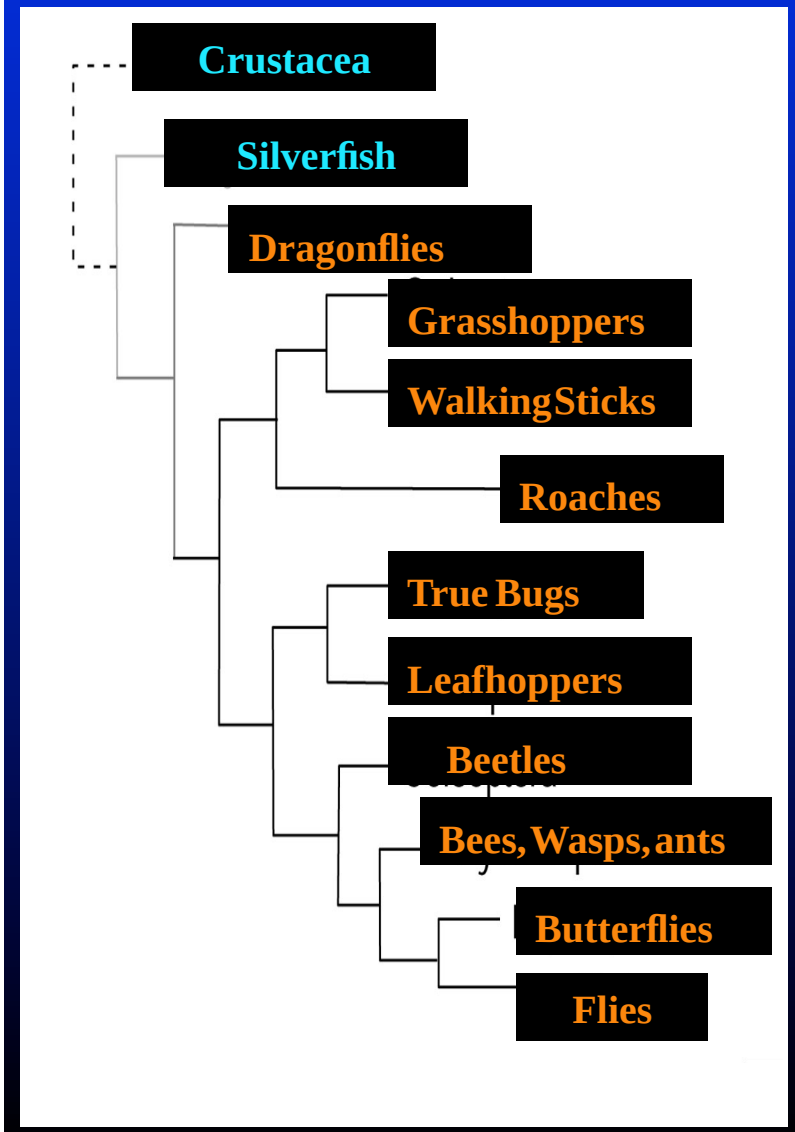
Mosquito Larvae

Butterfly and Moth Larvae

Insect Wings - Key to Success

- Insects are believed to have left the aquatic environment in search of new food sources.
- Why are there virtually no insects in the marine environment? Most likely, the Crustacea had filled all of the niches before insects evolved.

The Evolution of Insect Wings



Ancestral Arthropod

Wingless: Silverfish

Winged

Wings outstretched: Dragonflies, Mayflies

Wings fold over body when not in use

Grasshoppers, Termites, True Bugs

Butterflies, Bees, Flies, Beetles

Wing Evolution

Evolution

Evolution

- Wings are cumbersome when not in use; hence selection for reduction in wing size
- Speed & maneuverability more important than lift
- One pair of wings more efficient aerodynamically

Still works fine!

The Scales of Butterflies & Moths

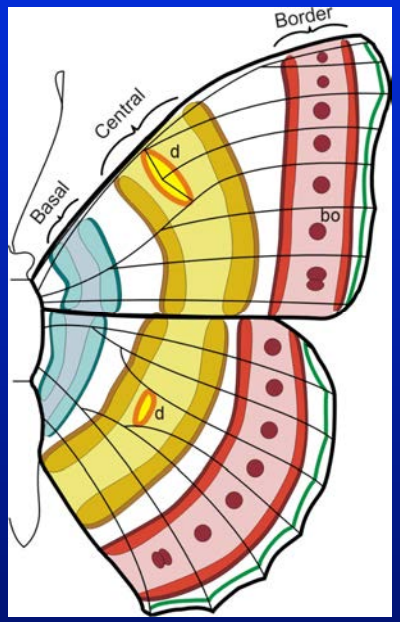
Provide Protection and Warmth

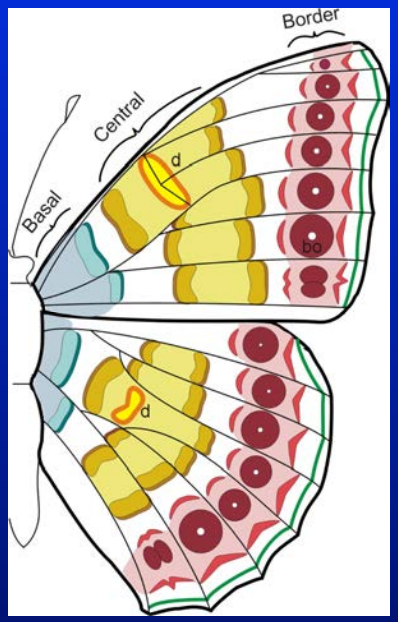



Functionally two wings

Spider predation and the evolution of scales?

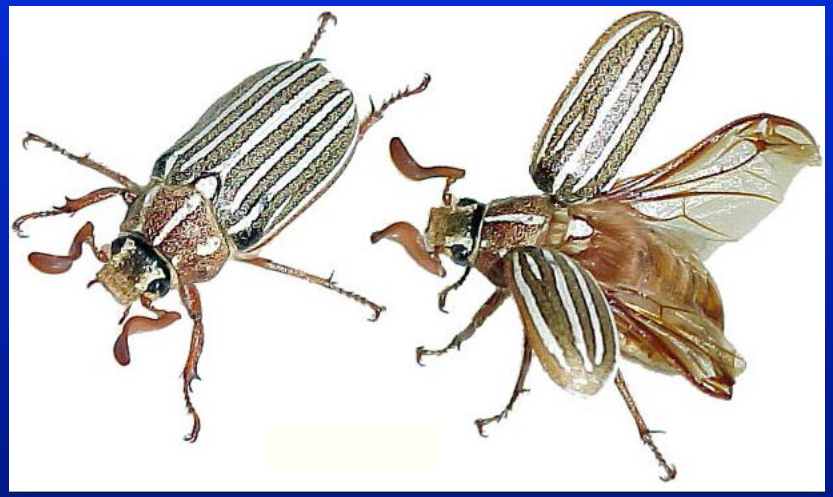
Development of Wing Patterns in the Lepidoptera

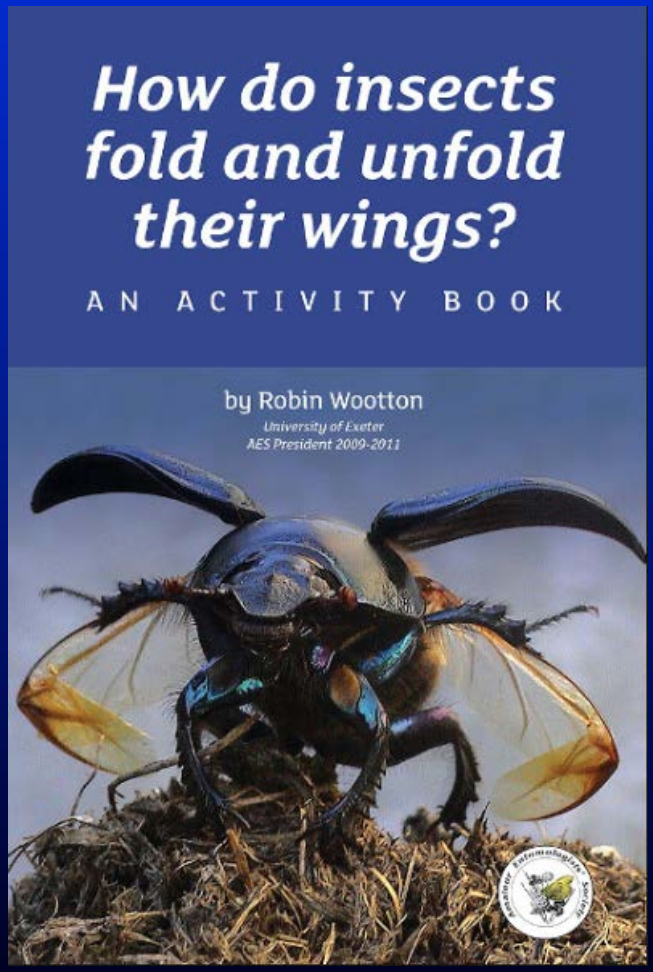




- Perfectly 2 dimensional left to right
- Three general wing areas (basal, central and border)
- Pattern evolution occurs by developmental changes (pigments, displacement, distortion, expansion and contraction and multiplication of elements)
- Promotes rapid & spectacular diversity

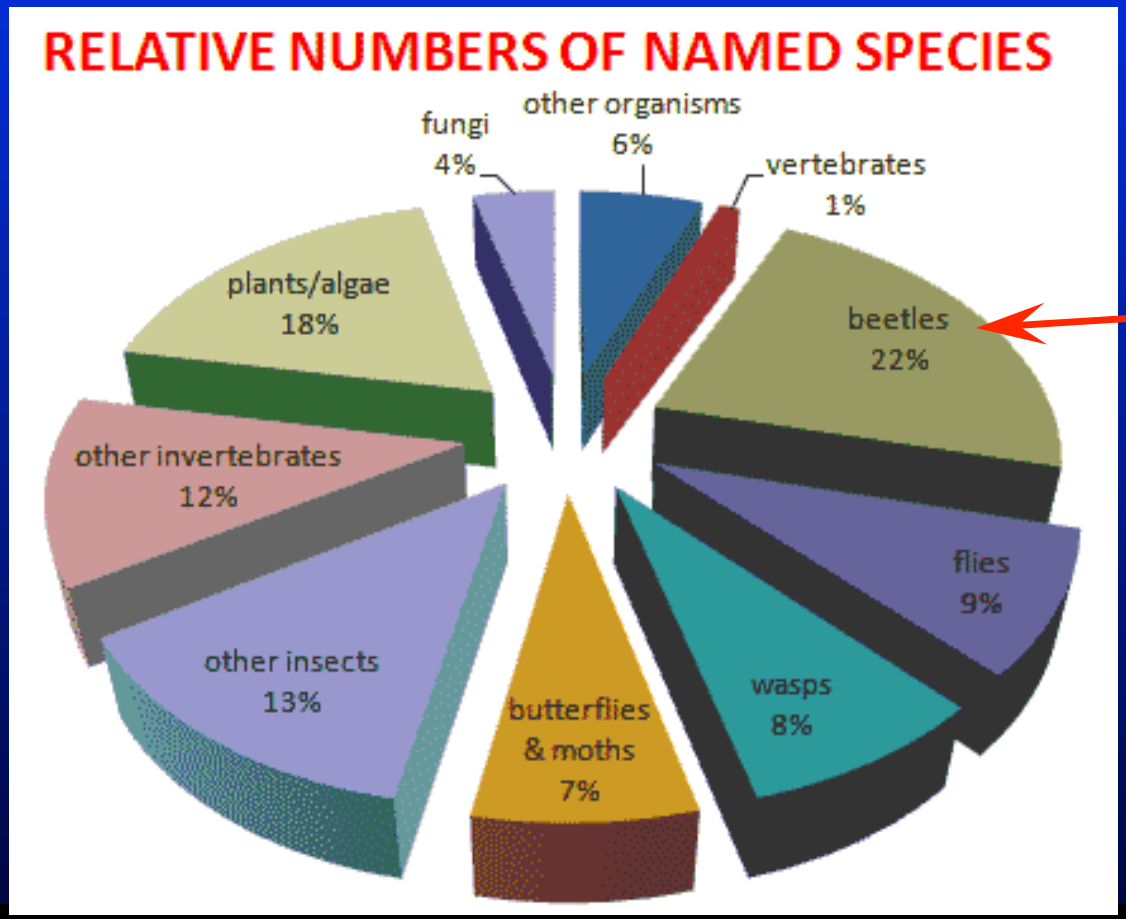
How Do Beetles Store their Wings?





Compared to other Insects, Beetles are Lousy Flyers

Beetles Are the Most Diverse Life Form on Earth



- ~ 350,000 described species: ~10,000 in CA
- 1 in 4 described species on earth is a beetle
- ~ 1 in 15 described species on earth is a weevil

The creator "had an inordinate fondness for beetles"

J.B.S. Haldane (1892 - 1964)
One of the founders of population genetics

The Beetles – Dressed for Success

- Compact, heavily armored bodies that resist abrasion and desiccation
- Dorso-ventrally flattened bodies allow entry into tight spaces (e.g. under bark)
- Retractable appendages for protection
- Wings are protected and housed in a large subelytral space

Dorso-ventrally Flattened Bodies

Heavily armored Beetle Larva

Strong Exoskeleton and Retractable Appendages

Beetle Habitats – They are Everywhere

Freshwater

Living and Dead Wood

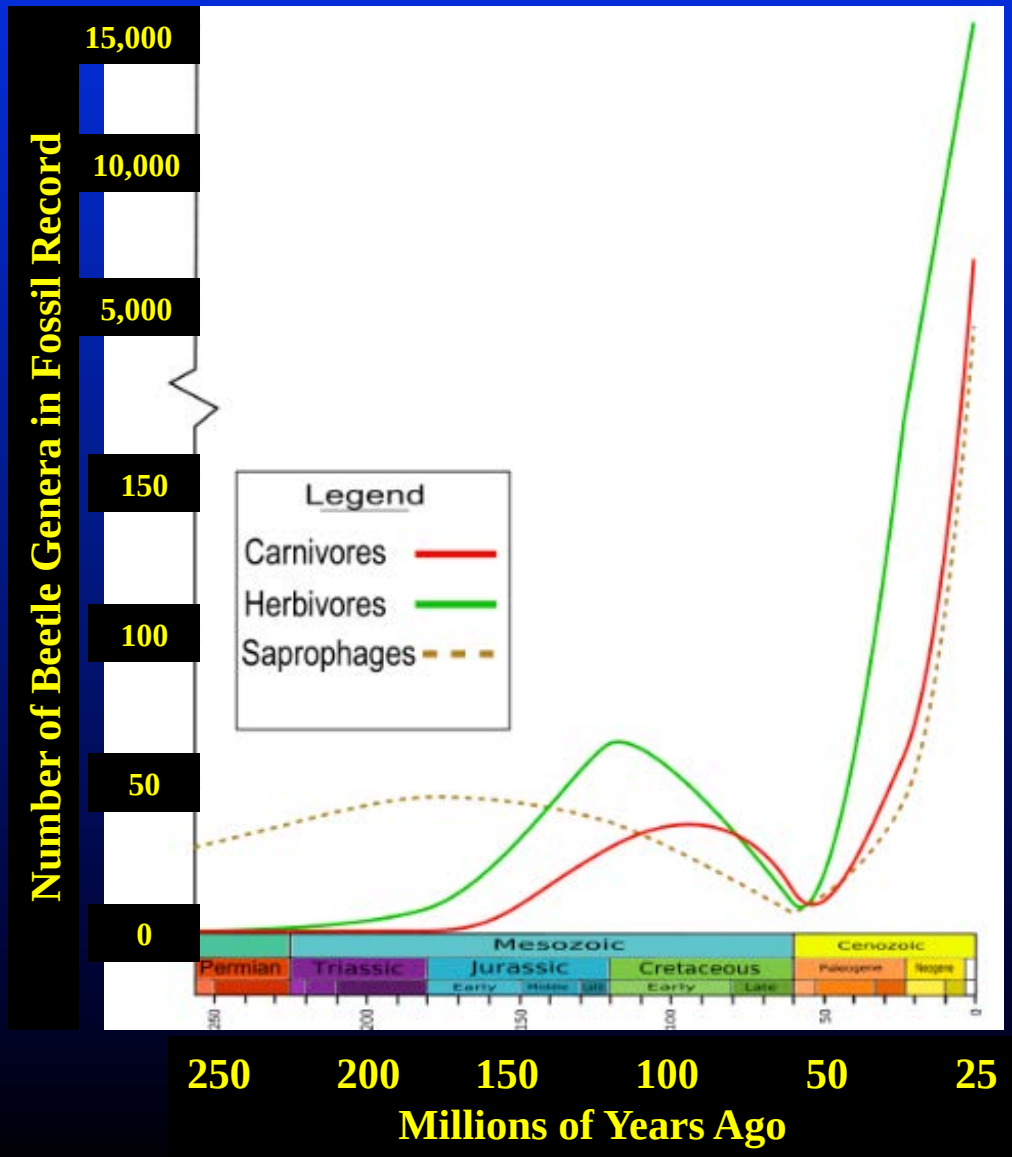
Plants (fruits and nuts)

Deserts

Leaf Litter

Flowers

Early in Earth's History Beetles Radiated into Many Niches

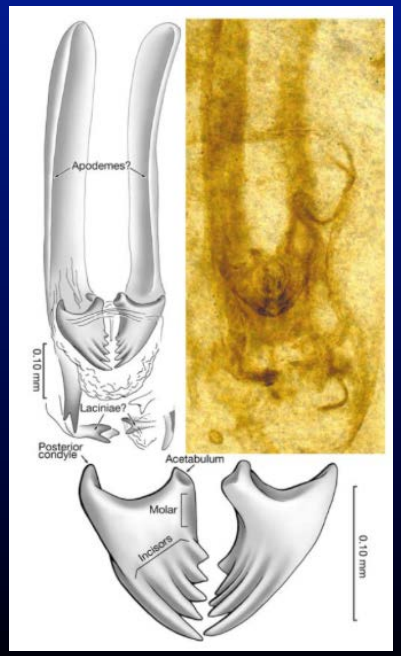


Predaceous Diving Beetle (Dytiscidae)

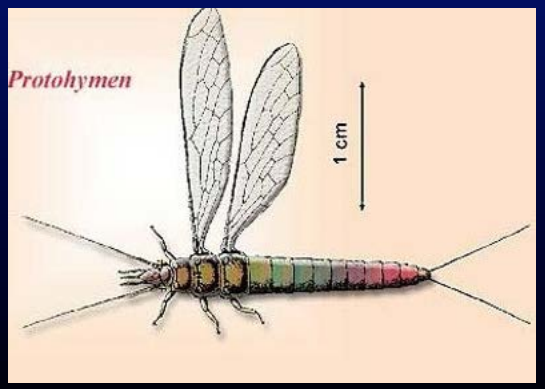
Metallic Wood-boring Beetles (Buprestidae)

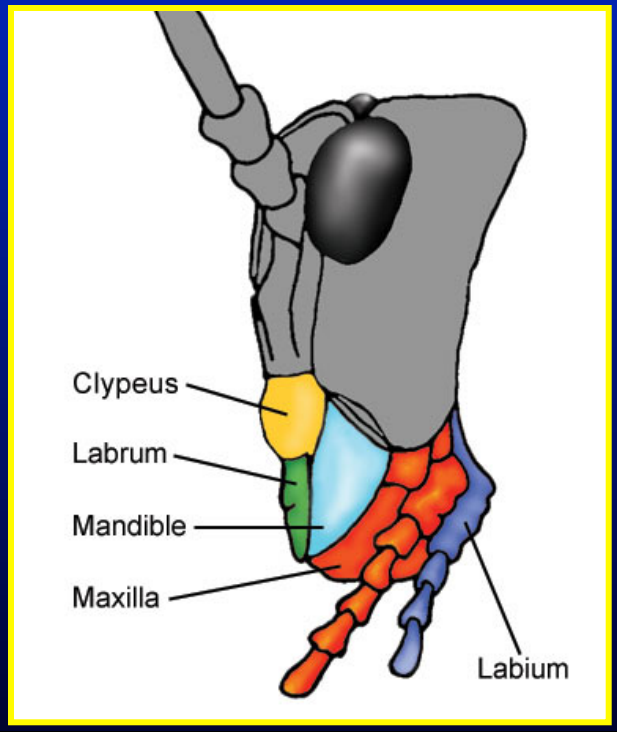
Insect Mouthparts - The Basics

Terrestrial plant life as a food source was the driving evolutionary force behind insect colonization of land



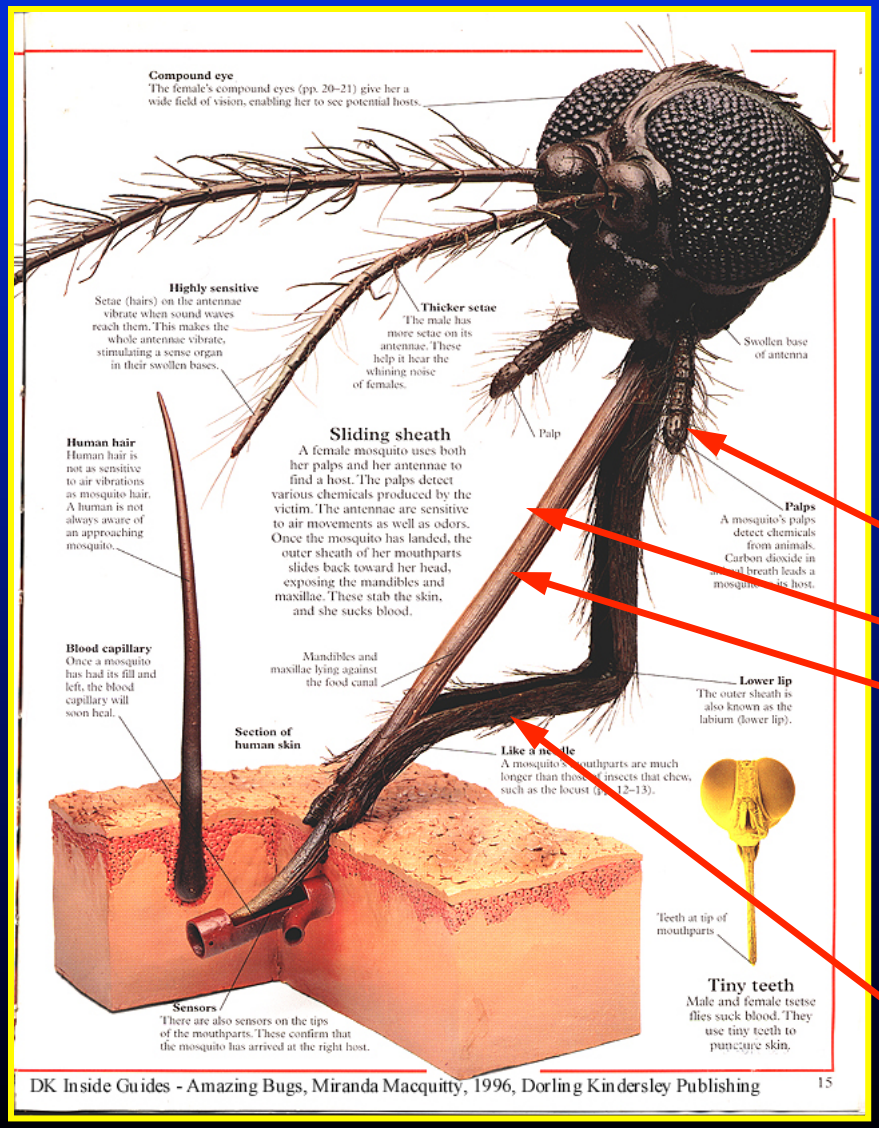
The oldest insect fossil (*Rhyniognatha hirsti*) ~ 400,000,000 years old

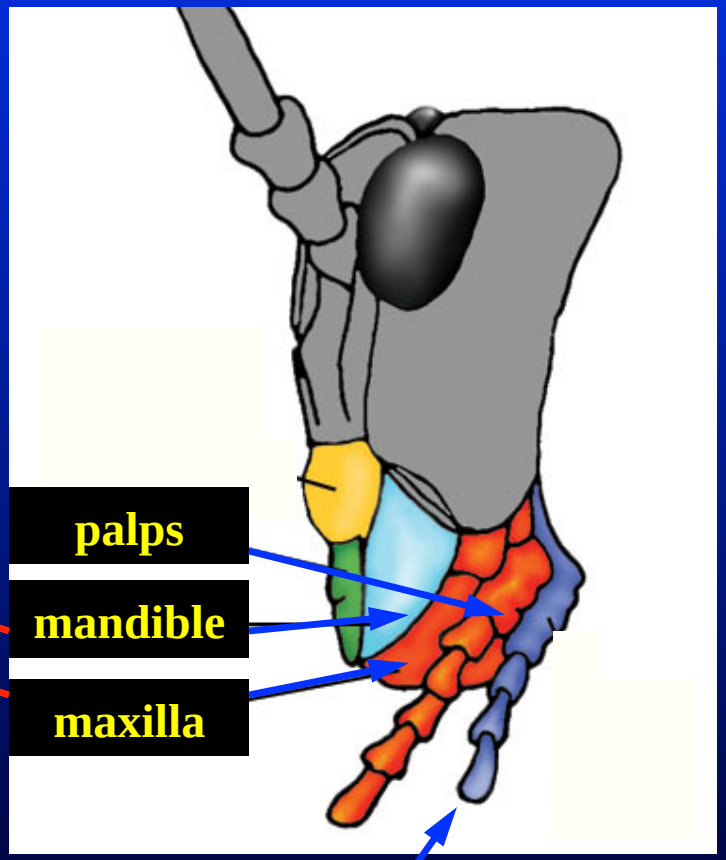




The earliest insects had chewing mouthparts

Chewing and Sucking Mouthparts
Adaptations for Solid & Liquid Foods





palps

mandible

maxilla

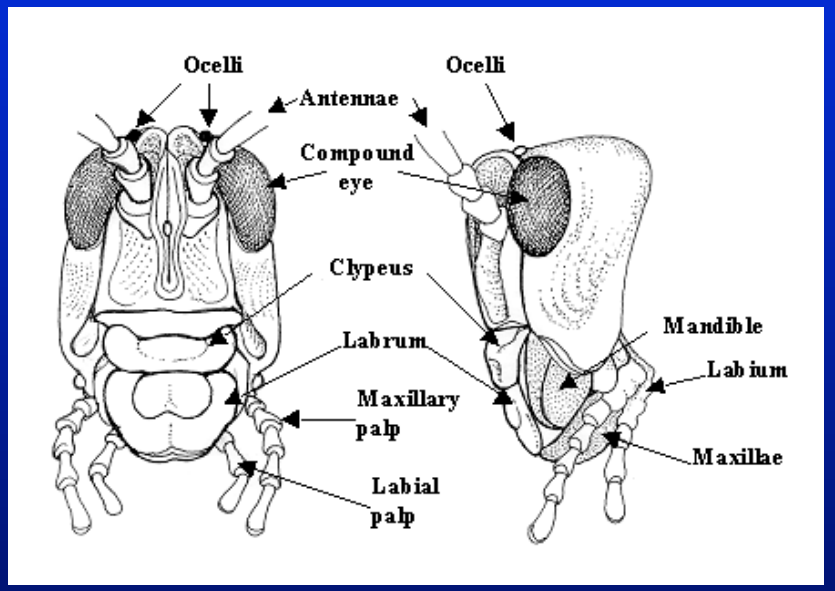
labium

Insects with Chewing Mouthparts

Feeding on Leaves, Shoots, Flowers, Stems & Roots

Beetles

Grasshoppers



Ants & Bees

Caterpillars

Insects with Sucking Mouthparts

Feeding on Phloem, Xylem & Plant Cell Juices

Thrips

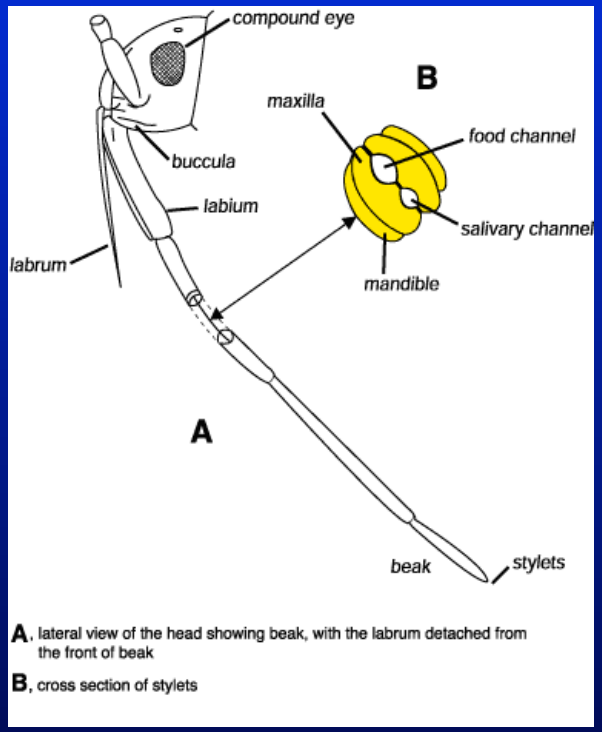
True Bugs

Planthoppers

Aphids

Scales

Cicadas



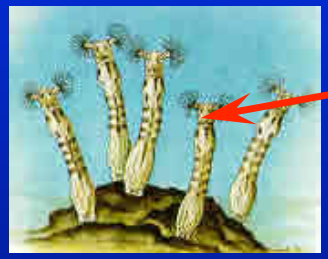
A, lateral view of the head showing beak, with the labrum detached from the front of beak

B, cross section of stylets

Adult Butterflies & Moths

Adaptations for Blood Feeding Mosquitoes & Black Flies

Mosquito - taps into capillaries



Larval black flies filter feed in aquatic habitats

Adult females feed on blood

Black Fly - slashes skin and laps blood

Convergent Evolution in Insect Predators

Praying Mantis

Snake Fly

Mantis Fly

PROTECTING THE PREDATOR

- prey capture with extended raptorial front legs
- elongated thorax places soft abdomen away from prey

Mantis

Mantis Shrimp

The Concept of Coevolution

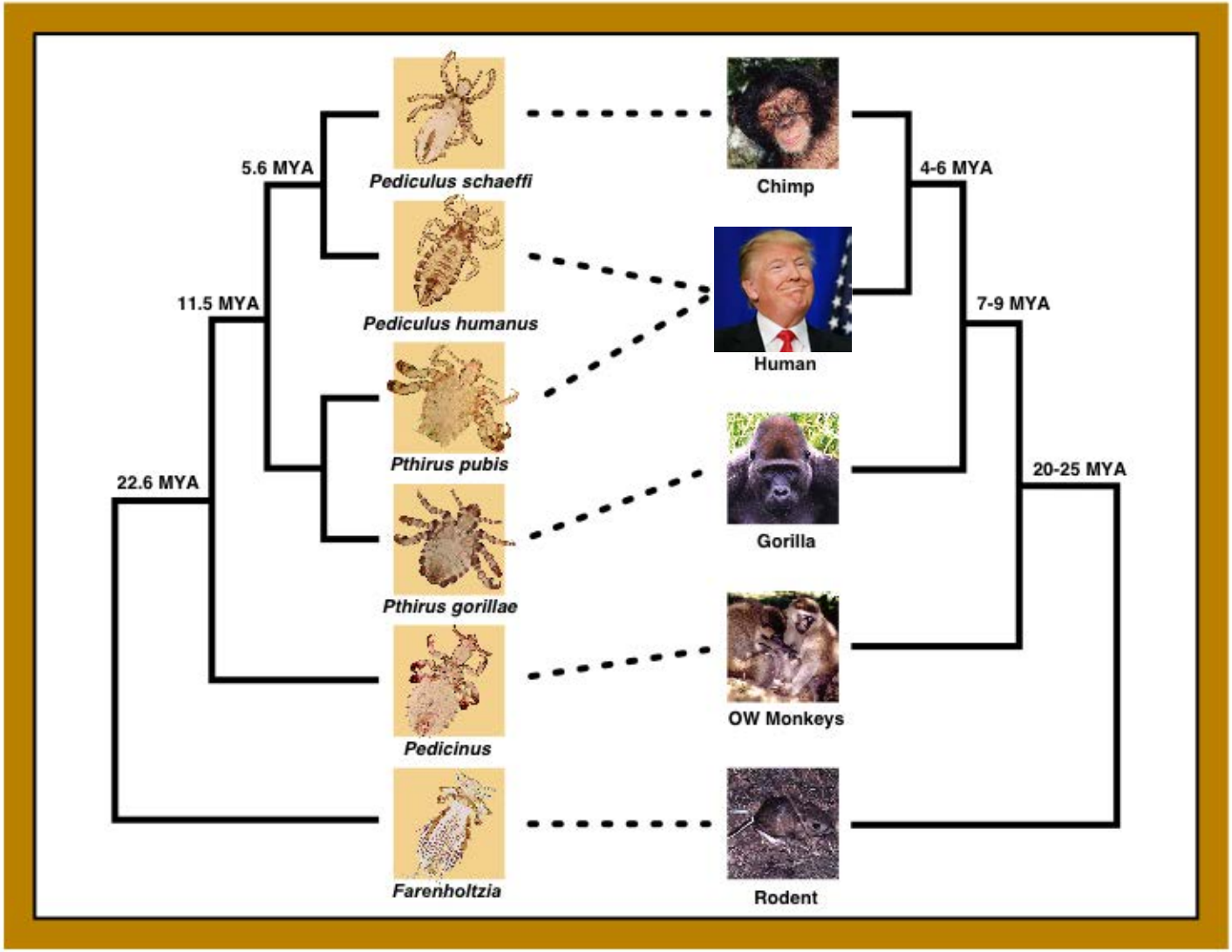
Coevolution = joint evolution of two or more non-interbreeding species in which the evolution of one species is partially dependent on the evolution of the other ("gene for gene evolution")








Coevolution of Primates and Lice



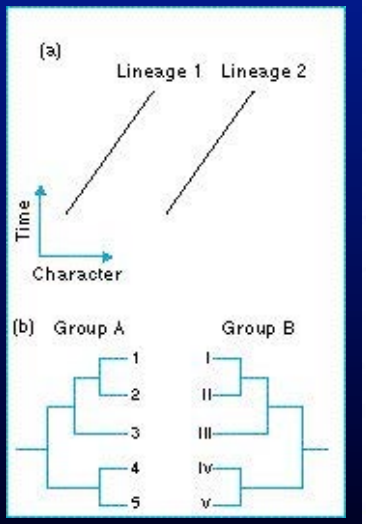
Coevolution of Ants & Fungi

Minor workers on leaves

Atta castes

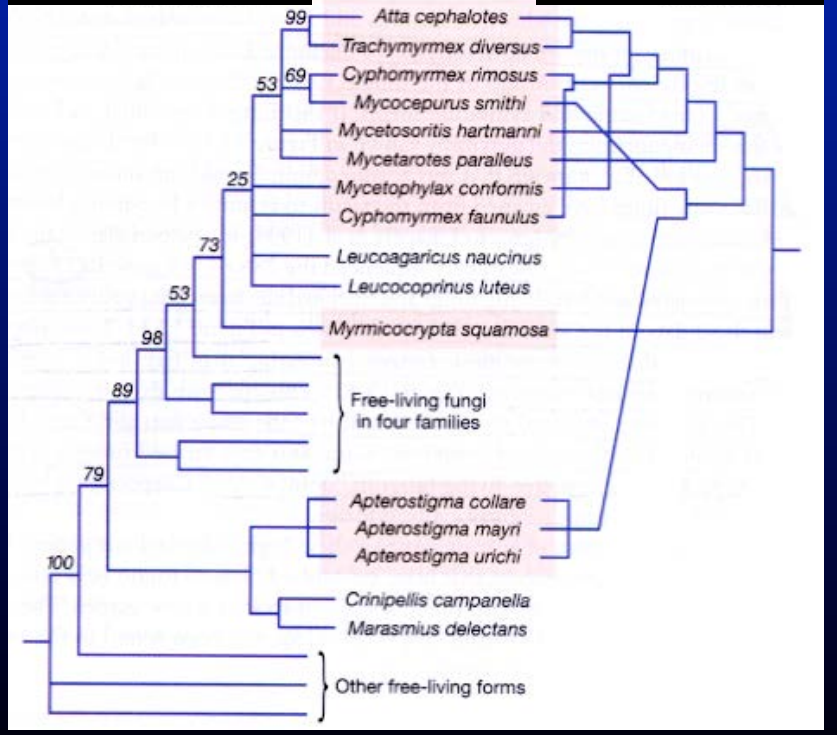
Atta nest

Atta queen, workers & fungus



Fungal Phylogeny

Ant Phylogeny



Phylogenetic Tree of Ants & Fungi

Insects that Mimic Plants
Evidence of a Long and Intimate Relationship

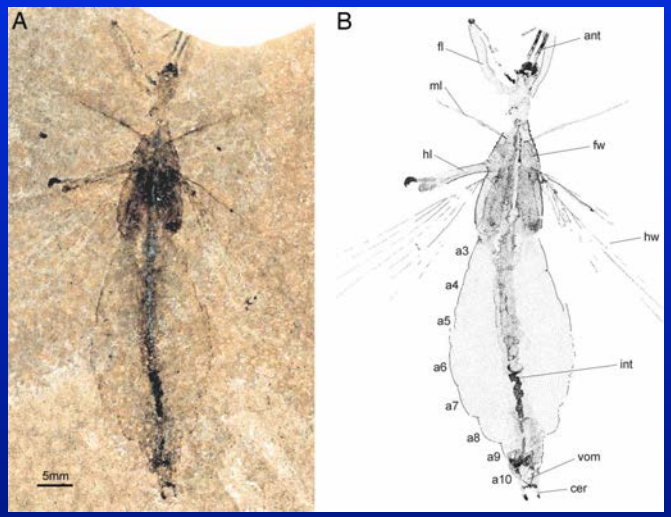








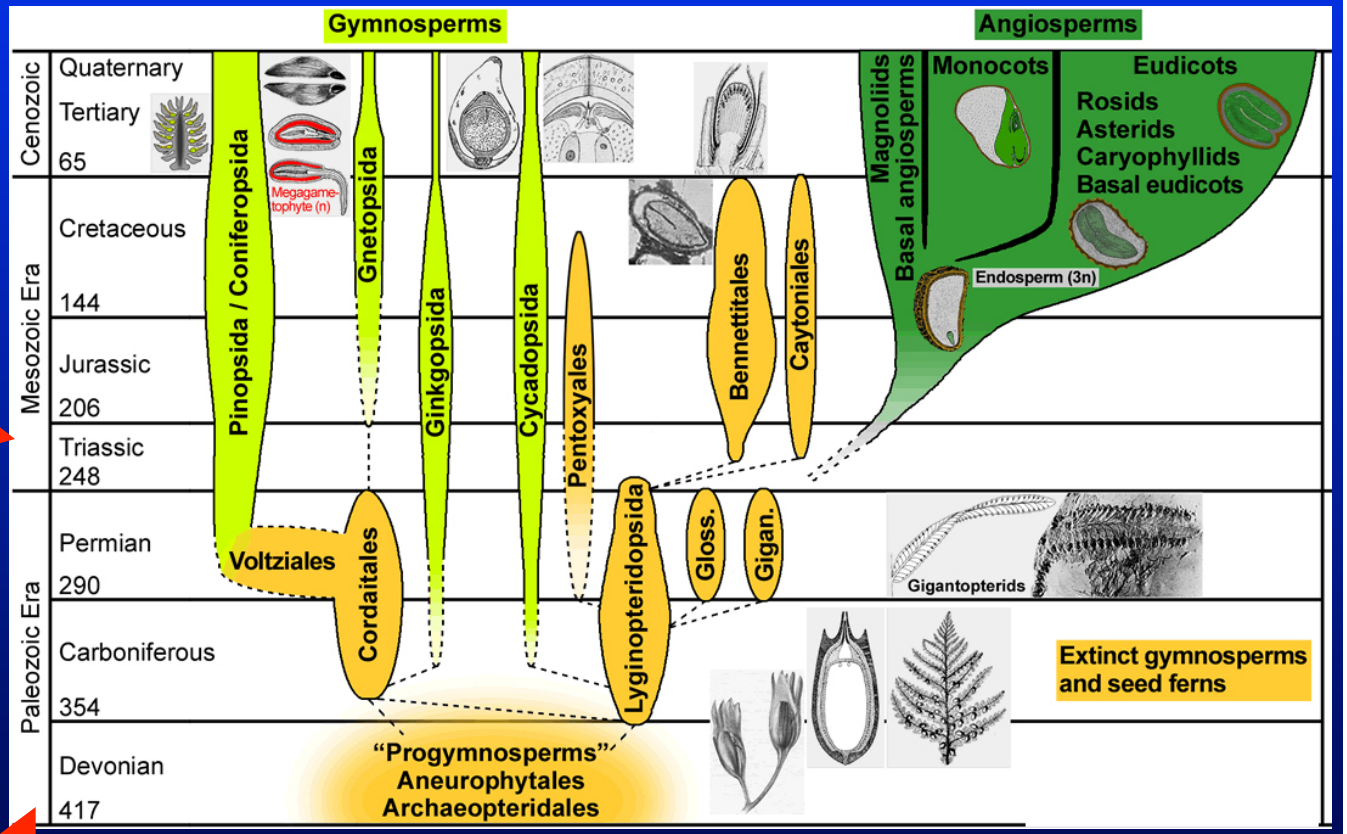

The Fossil Record and Evolution of Insects and Plants



- Leaf insect fossil
- Estimated at 47,000,000 years old
- Virtually same morphology in living leaf insects
- Helps date the origins of mimicking host plant for protection

- Stingless bee trapped in amber
- Estimated at 76 - 84,000,000 years old
- Only unambiguous orchid in the fossil record
- Explains distribution of vanilla orchid…

Evolution of Insects & Flowering Plants



Appearance of the major insect orders

Advanced winged forms radiate

Primitive winged forms radiate

Insect fossil record is poor, but extends back 400 mya (Devonian)

- **Insect evolution occurred rapidly over a period of 100,000,000 years**
- **~ 20% of all insects rely on flowers for food (nectar & pollen)**
- **~ 2/3 of all flowering plants pollinated by insects**

Types of Insect Plant Interactions

Insects Exploit Plants

- Food and water
- A place to live
- Protection from Predators
  - Camouflage
  - Poison

Plants Exploit Insects

- Pollination
- Seed dispersal
- Protection
  - Ants
  - Parasites
  - Predators

Plant Host Range Varies Among Insects

Smith's Blue	Monarch	White Lined Sphinx
Monophagy One host species	Oligophagy Several host species	Polyphagy Many host species

Specialist ⟷ Generalist

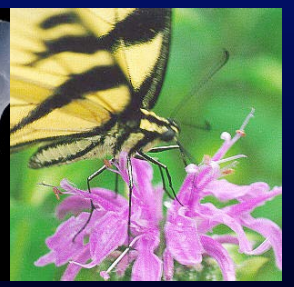
Pollinator Syndromes

Mutualistic Relationships between Higher Plants & Animals

Trait	Pollinator							
	Bats	Bees	Beetles	Birds	Butterflies	Flies	Moths	Wind
Color	Dull white, green or purple	Bright white, yellow, blue, or UV	Dull white or green	Scarlet, orange, red or white	Bright, including red and purple	Pale and dull to dark brown or purple; flecked with translucent patches	Pale and dull red, purple, pink or white	Dull green, brown, or colorless; petals absent or reduced
Nectar guides	Absent	Present	Absent	Absent	Present	Absent	Absent	Absent
Odor	Strong musty; emitted at night	Fresh, mild, pleasant	None to strongly fruity or fetid	None	Faint but fresh	Putrid	Strong sweet; emitted at night	None
Nectar	Abundant; somewhat hidden	Usually present	Sometimes present; not hidden	Ample; deeply hidden	Ample; deeply hidden	Usually absent	Ample; deeply hidden	None
Pollen	Ample	Limited; often sticky and scented	Ample	Modest	Limited	Modest in amount	Limited	Abundant; small, smooth, and not sticky
Flower Shape	Regular; bowl shaped – closed during day	Shallow; have landing platform; tubular, c	Large bowl-like, Magnolia	Large funnel like; cups, strong perch support	Narrow tube with spur; wide landing pad	Shallow; funnel like or complex and trap-like	Regular; tubular without a lip	Regular: small and stigmas exerted





Master Gardener Training
Part 2: Insect Population Biology

Jan O. Washburn

March 22, 2017

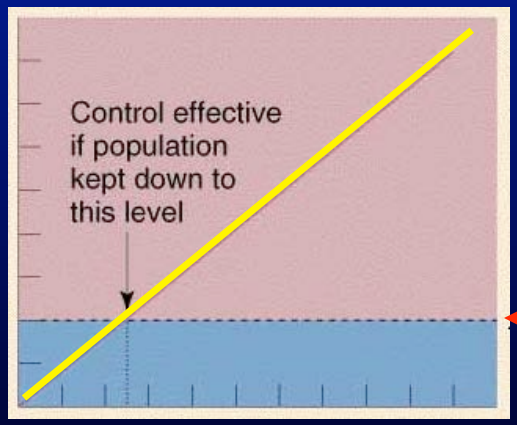
Part 2: Insect Population Biology

- **Part 1: An Introduction to the insects**
  - **What is an insect?**
  - **The life history of insects**
  - **Insect flight**
  - **The success of beetles**
  - **Insect mouthparts and feeding strategies**
  - **Coevolution of insects and plants**
- **Part 2: Insect Population Biology**
  - **Why are insects eating my garden?**
  - **Life history strategies of plants and animals**
  - **Food webs, mortality and population ecology**
  - **Predators and the evolution of life**
  - **The concept of biological control**
- **Part 3: Common Insects of Mendocino County**

Why are there Insect Outbreaks in my Garden?

- 97% of all insects are either harmless or beneficial
- Insect outbreaks are "natural" phenomena
- Most gardens are "artificial" and inherently less "stable"
- Tolerance for insect damage is often low

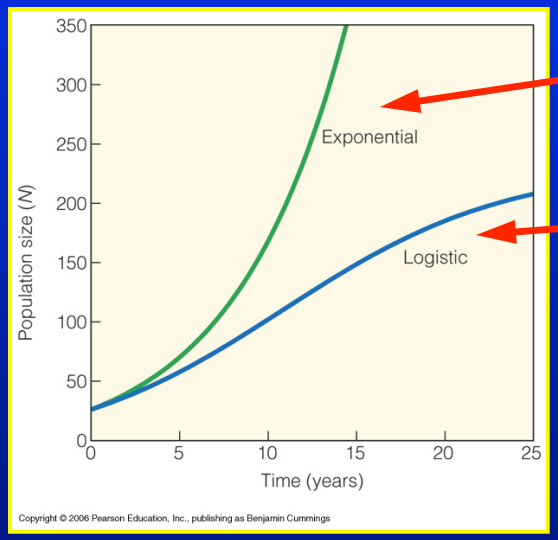
Damage



Pest Population

Economic or Aesthetic Threshold

How do Insect Populations become Pests?

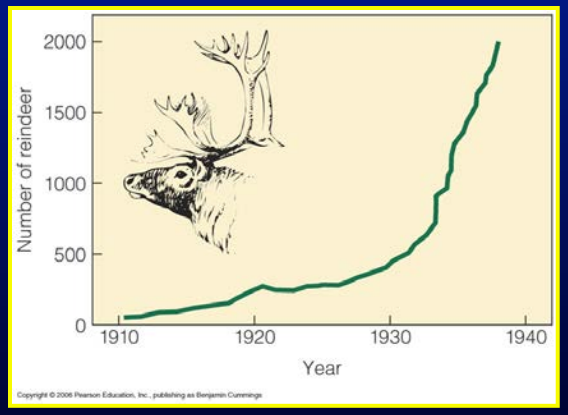


Exponential = No limits to growth

Logistic = Growth is limited

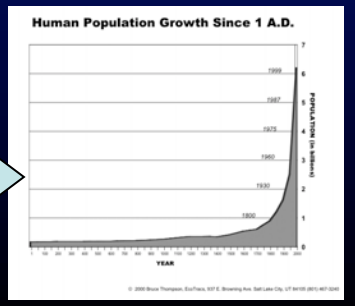
Exponential Growth of Insects

- **Small size**
- **High reproductive rate**
- **Unlimited resources**
- **Rapid response to environment**



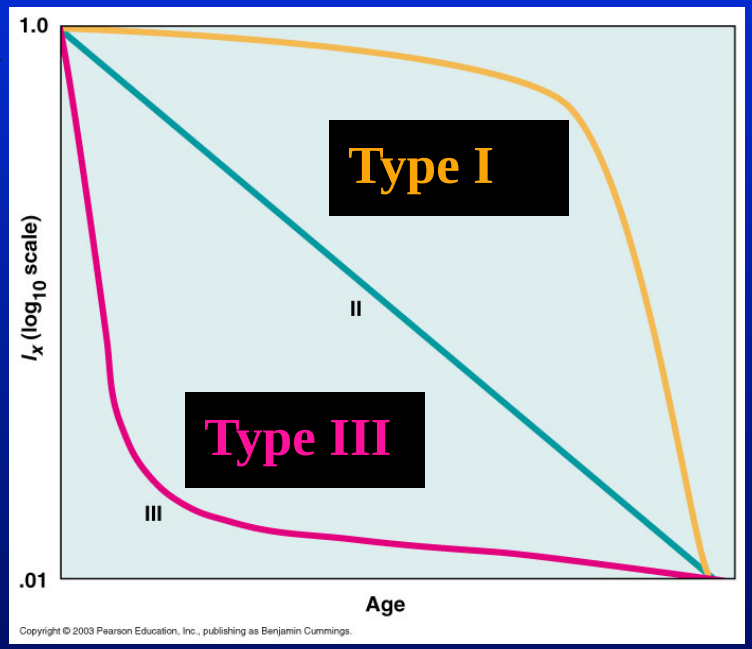
Exponential growth of Reindeer on St. Paul Island

Human Population from 1 A.D. until Present



Survivorship Curves in Nature

Survivorship



Type III

Age

Type I

Initial survivorship is very low (fish, insects, many invertebrates and plants)

Most individuals live their physiological life span and then die (mammals, some plants)

Mortality Can Be Density Independent or Density Dependent

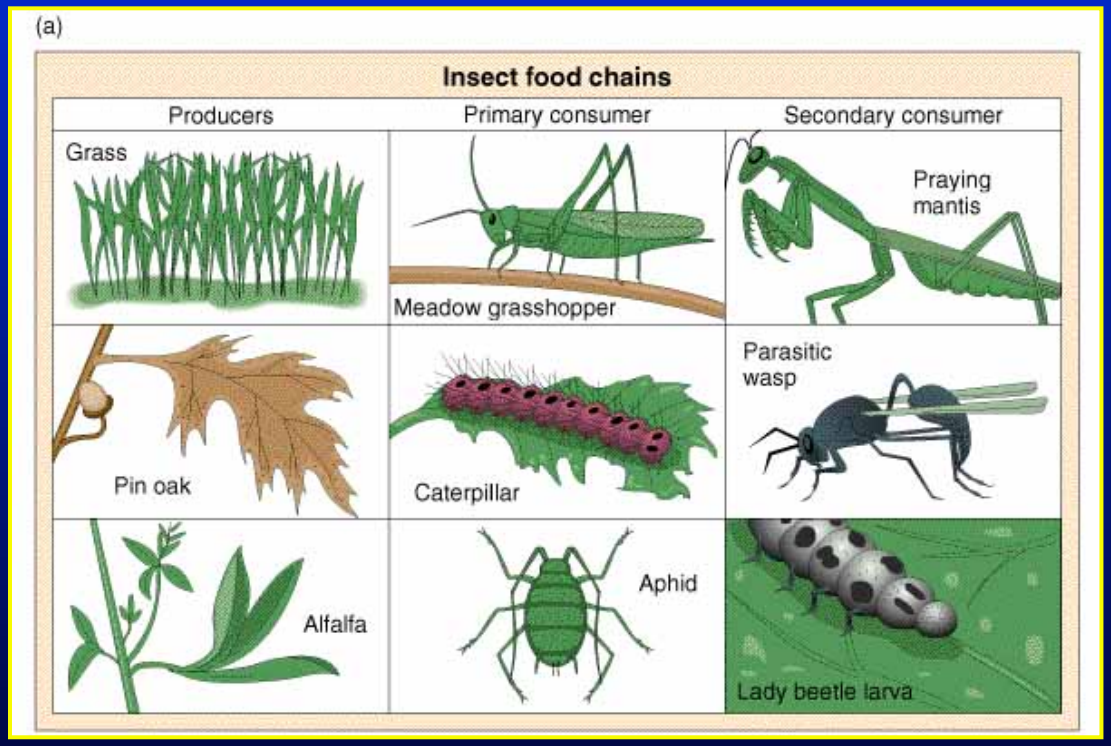
Mortality can be either compensatory or additive.

Density Independent

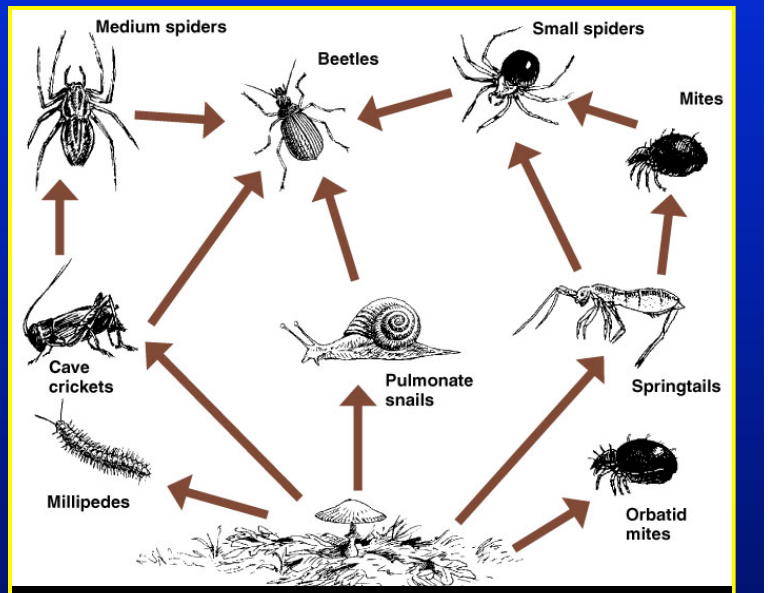
Density Dependent

- **Density Independent - Mortality is independent of population number or density**
- **Density Dependent - Mortality depends on population number or density**

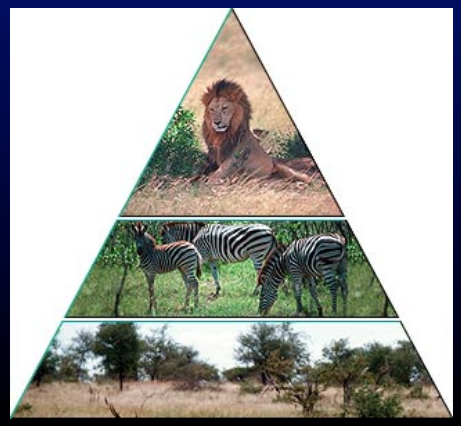
Food Webs - The Pyramid of Numbers
Organization of Communities into Trophic Levels



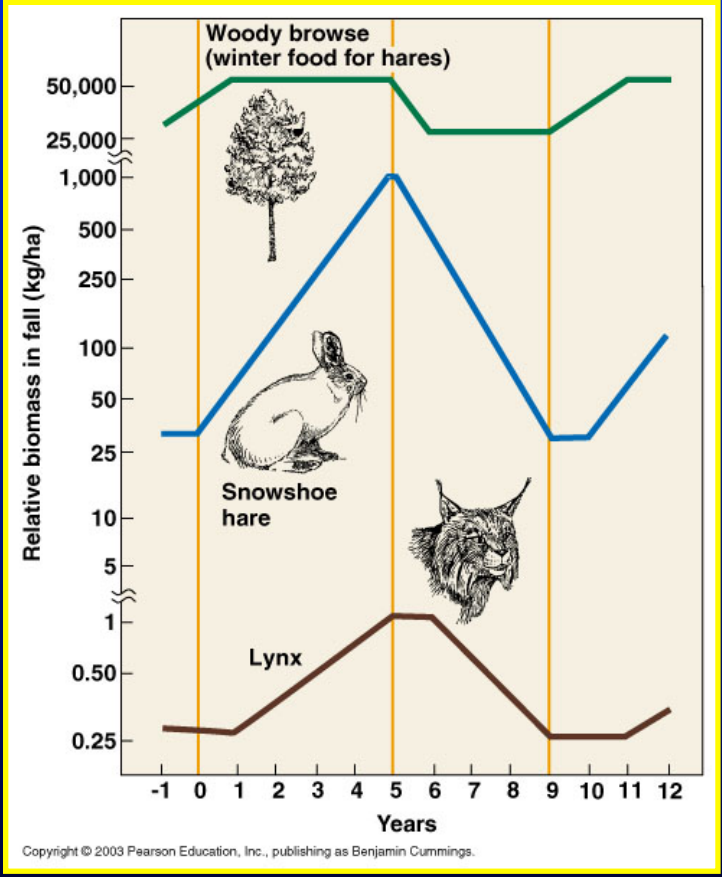
Producers, Primary & Secondary Consumers



Detritus Food Web

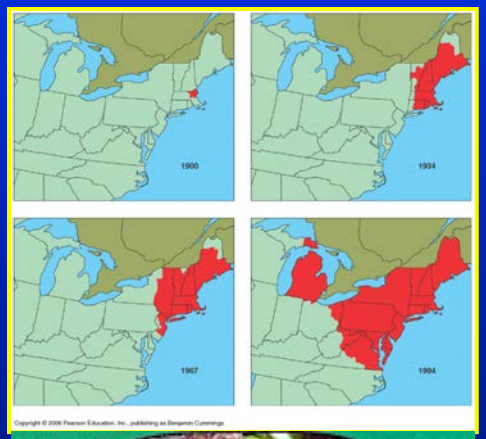


Population Cycling in Nature
The Interdependence of Predators and Their Prey

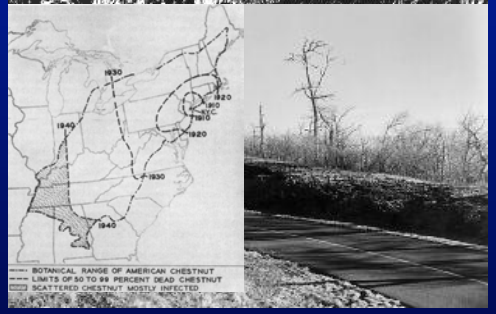


Three-way interaction of woody vegetation, snowshoe hare and lynx

Upsetting the "Balance of Nature"
Invading Species



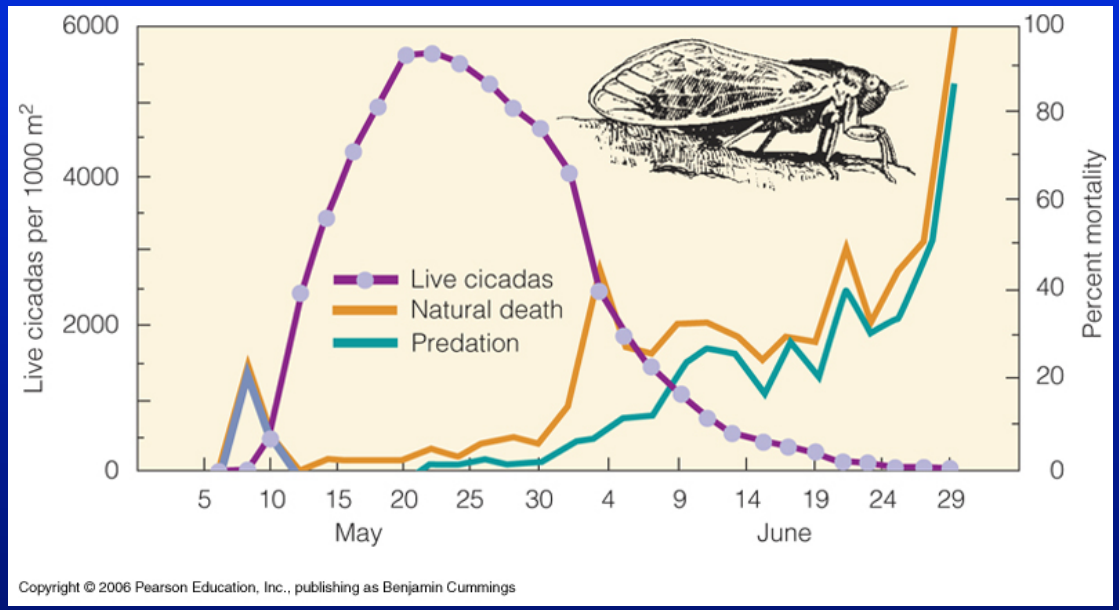
Gypsy Moth



Chestnut Blight

European Starling

Periodic Cicadas & Predator Satiation



Magicicada septendecim
17 year cicada

California Cicada

Periodic Cicada life cycles are 3, 5, 7, 11, 13 & 17 years

Why these numbers?

Cicada

Order: Homoptera Family: Cicadidae

- Large, conspicuous insects
- Membranous, transparent wings
- Xylem feeding as nymphs (and sometimes as adults)
- Mass, synchronized emergence of adults
- Sound production by tympanic membranes (ventriloquists!)
- May cause economic damage from root feeding & egg laying

Cicada Oviposition Damage

California Cicada

Oviposition Scars

Insect Predators Maintain Diverse Plant Communities

Control (left) and Treatment (Right)

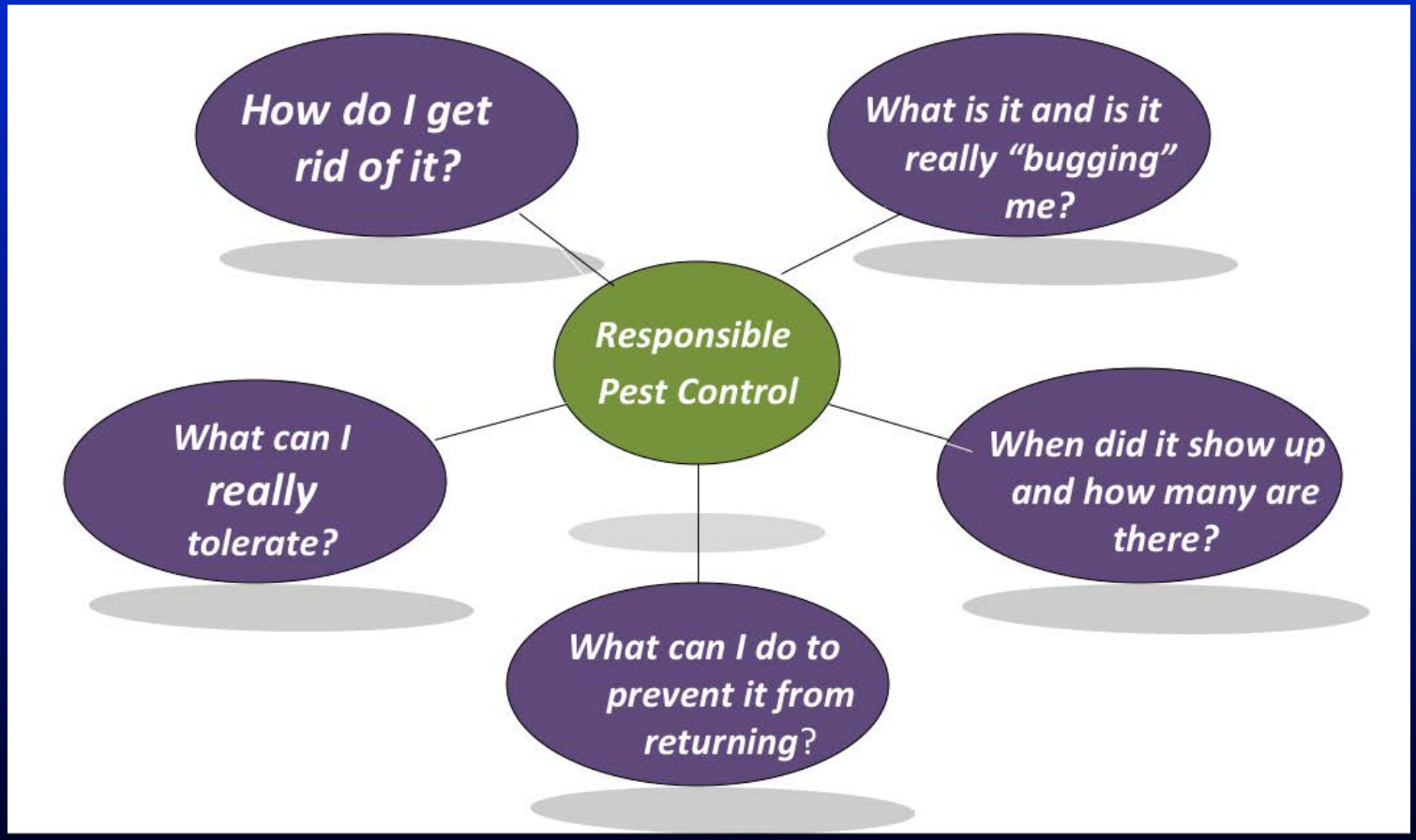
Insects that eat seeds are called predators because they kill entire organisms

- Treatment (Right) - insecticides applied for 8 years, preventing outbreaks of the dominant herbivorous beetle
- This resulted in goldenrod overtaking other plant species and reducing plant species diversity

Controlling Pests in Your Garden

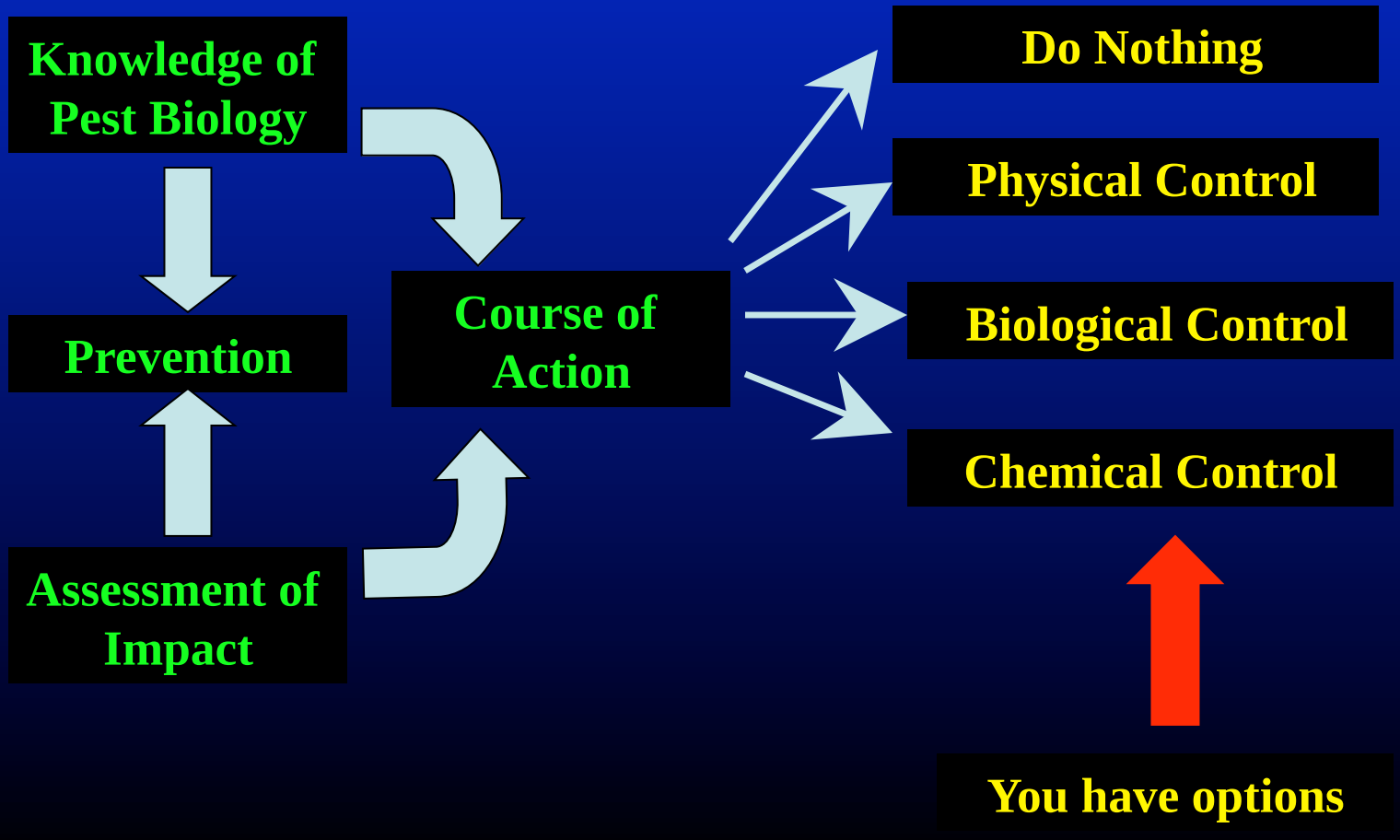
Density Dependent - Level of mortality depends on population number or density

Making Rationale Pest Control Decisions

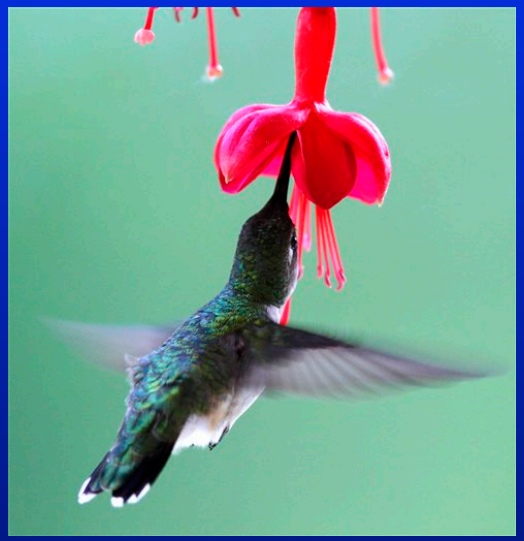


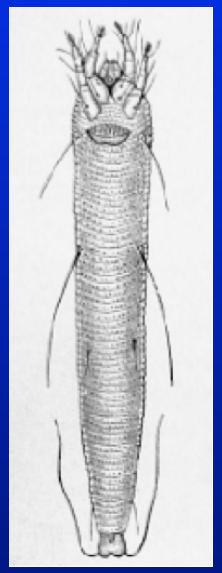
What is Integrated Pest Management (IPM)?

A pest management strategy that is:
sensible, effective & environmentally safe



When to Give Up - Fuschia Mites

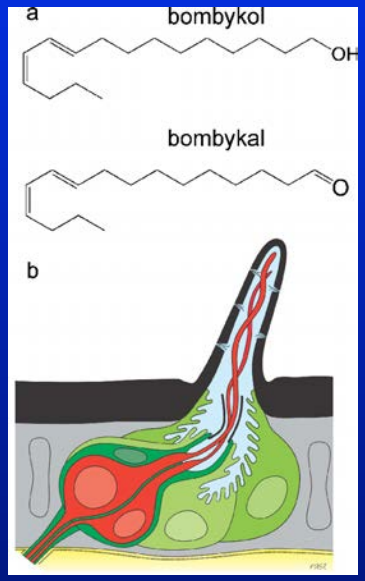




Fuschia mite

Solution: Do not plant cultivars that are susceptible

Pheromones and Insect Control

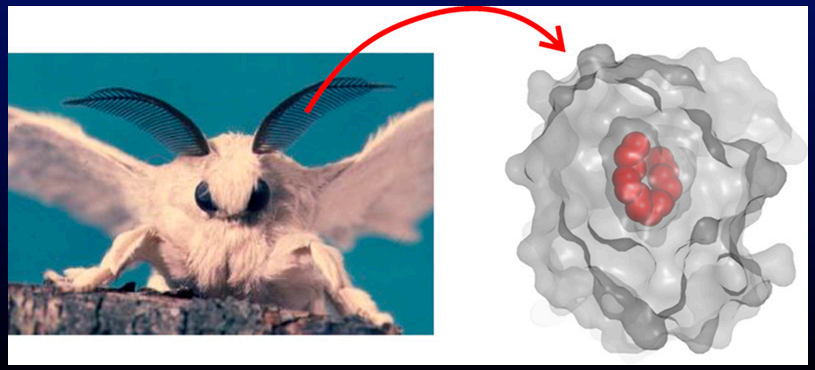


Pheromone receptors on Moth Antennae

- **Pheromone = chemical signals that function to communicate between individuals, influencing behavior and/or body function**
- **Pheromones are extremely host specific**
- **Pheromones are widely used in crop protection**

Pheromones are widely used by social insects

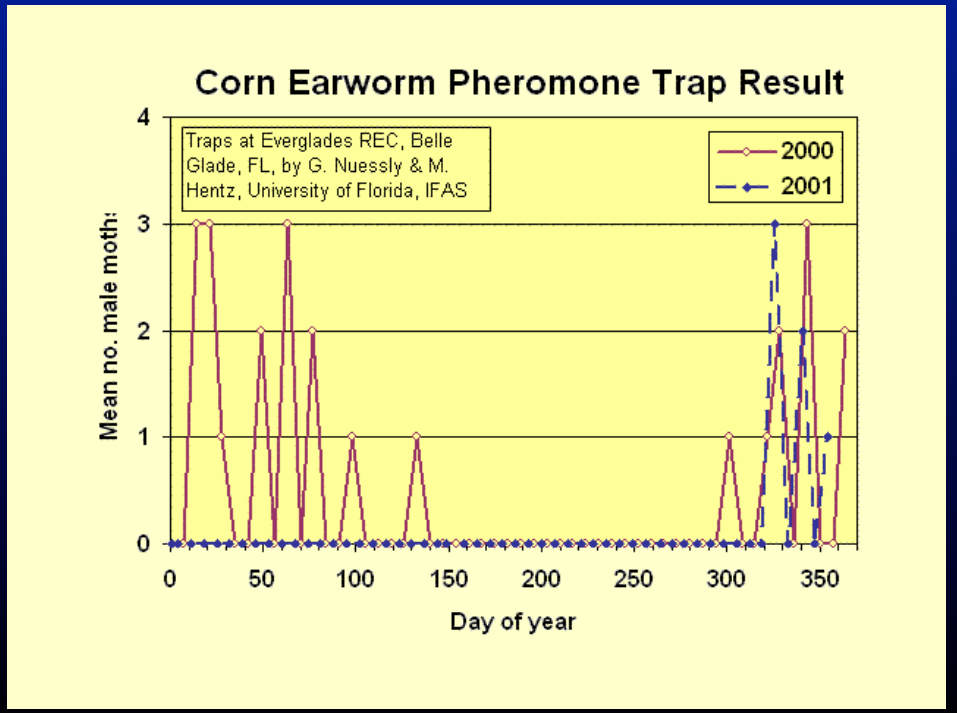
Male Monarch



Female Monarch

How Are Pheromones Used in Pest Control?

- Used to monitor activity of adult pests (for detection and size of infestations)
- Used to detect medfly, gypsy moth, LBAM and many other pests of agriculture and silviculture
- Used for control by disrupting mating

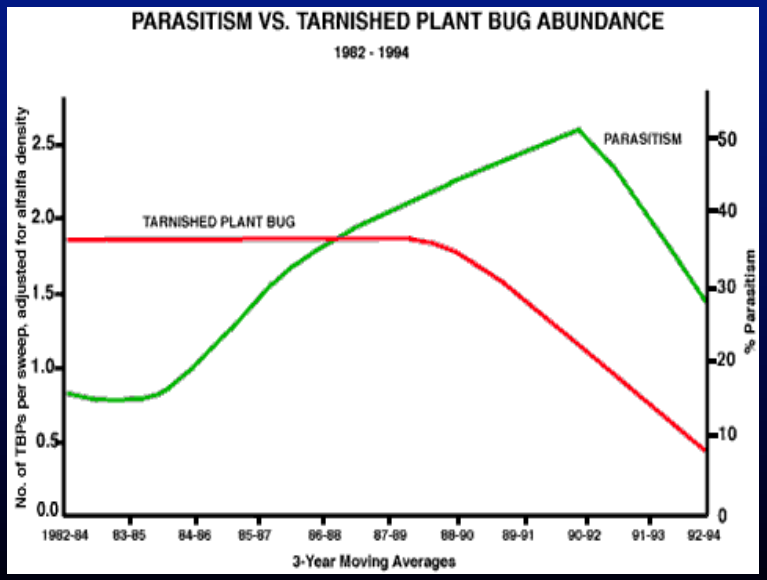


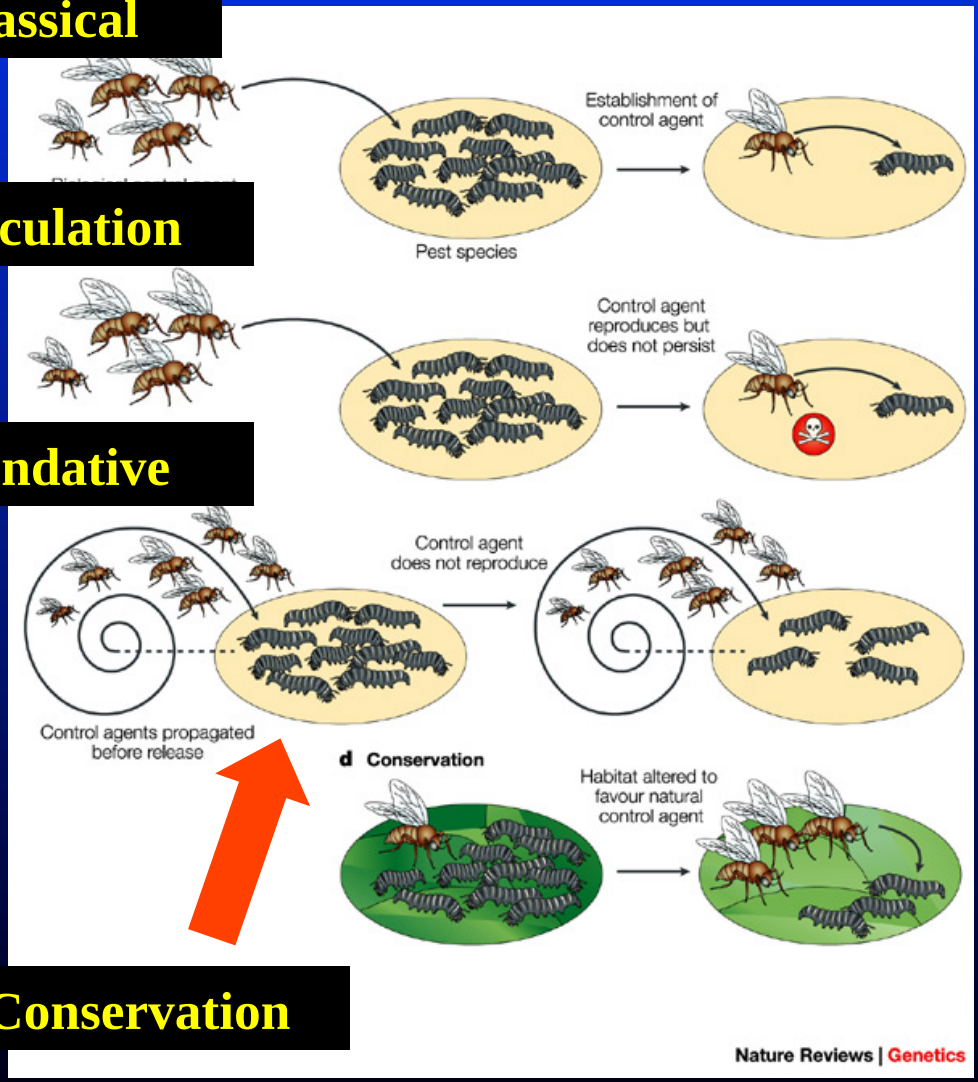
Predators and Parasitoids For Pest Control

Praying Mantis
Generalist Predator

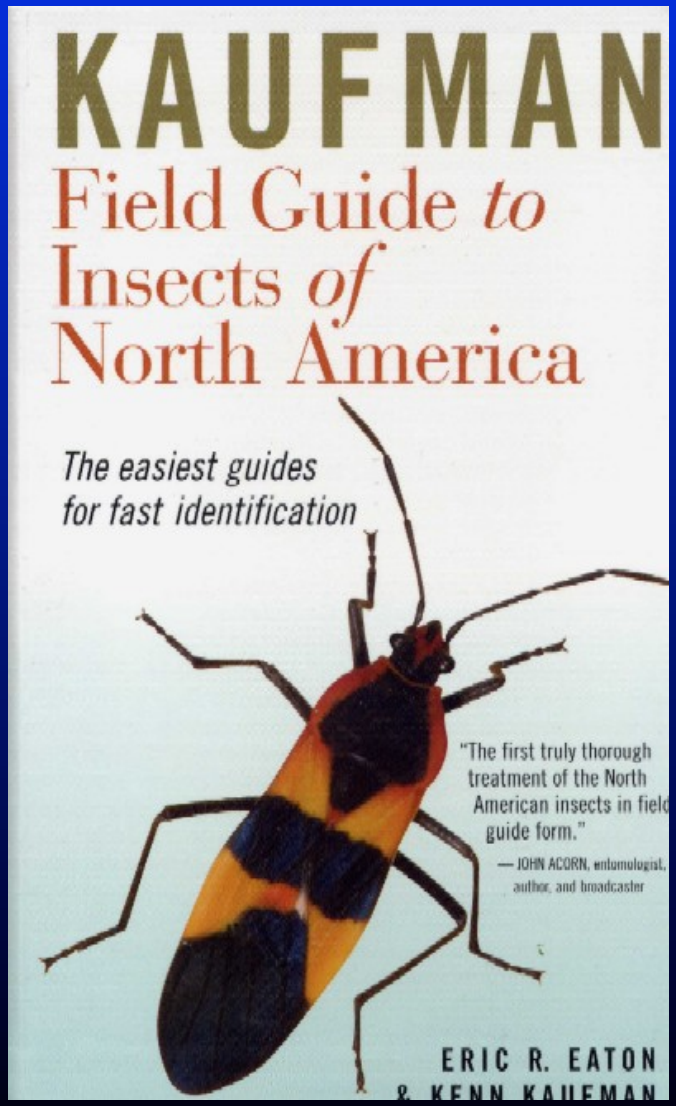
Egg Parasitoid
Specialist Parasite

Manipulating Natural Enemies in Your Garden



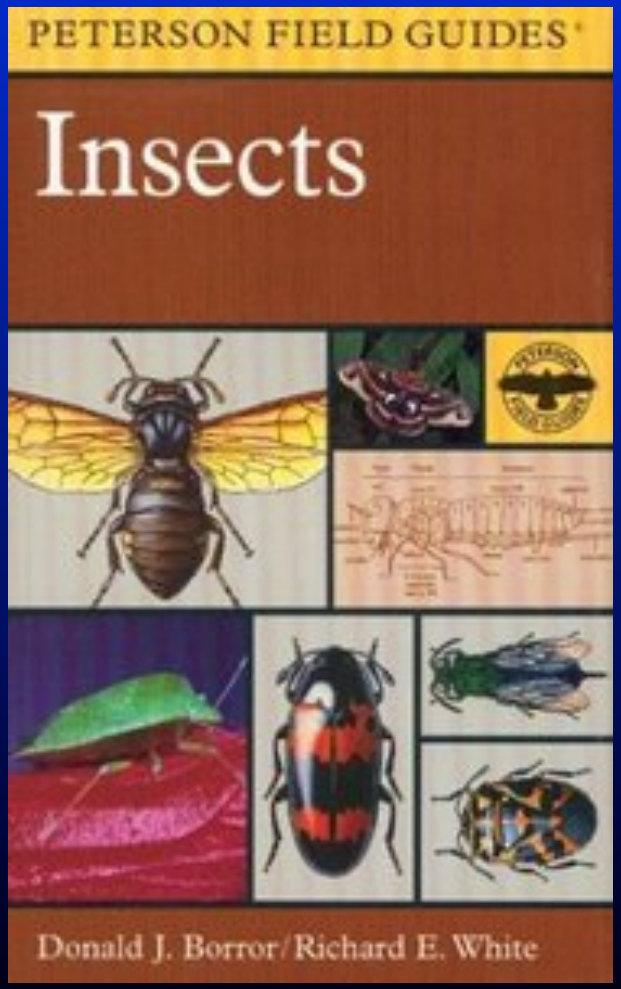


Books For Insect Identification



- Quick reference for the good and bad insects
- Extensive and accurate pictures
- Species are arranged by order
- Scientific names provided with brief range description
- Major ecological features mentioned
- A good place to get a name for a web search

Other Books to Consider for Your Library



Predators

- Organisms that feed on animal tissues (or whole plants = seeds)
- Free-living and usually larger than their prey
- Consume some or many prey over their life
- Many feed on a wide range of insect species

Ladybird Beetles ("Lady Bugs")
Family: Coccinelidae

Larva

Pupa

Eggs

- Larvae and adults prey on soft bodied insects
- Many species in CA, both native and introduced
- Voracious predators and effective control agents,
- Over winters in large aggregations
- Commercially available
- Best used on individual netted plants

Coleoptera: Carabidae - Ground Beetles and Tiger Beetles

Common Black Calosoma

Ground Beetle Eating a Slug

- Among the most commonly encountered beetles in CA
- Third largest family of beetles in CA with ~ 700 species
- As the name suggest, most are ground dwelling
- Most are predatory, feeding on other insects or snails
- Most can run fast, and many expel noxious compounds from the anus
- Tiger beetle larvae develop in sandy soils, and adults are fast flyers

Tiger Beetles

Larva

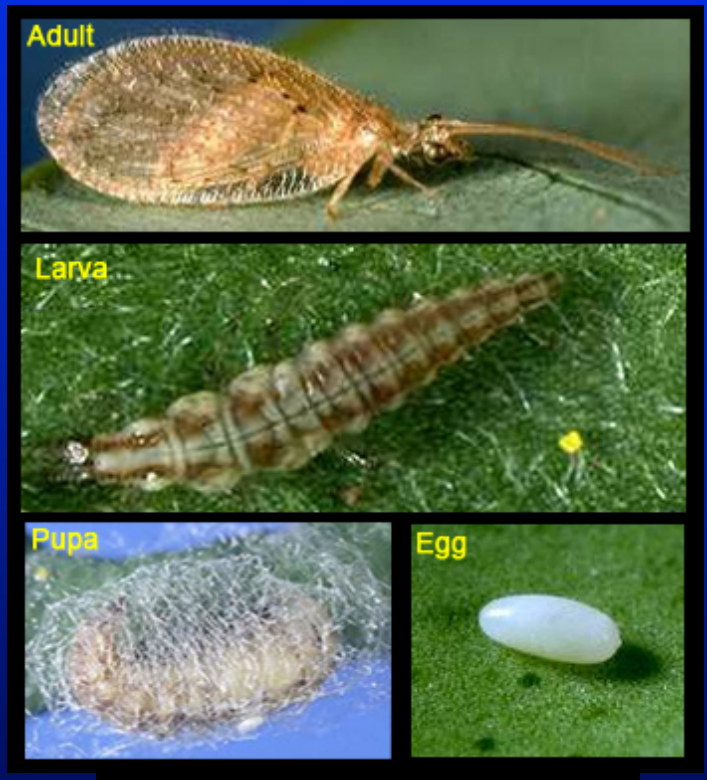
Lacewings (Families: Chrysopidae & Hemerobiidae)

Egg

Larva

Pupa

Green Lacewing



Brown Lacewing

- Larval and adults stages voracious predators
- Prey primarily on soft bodied insects
- Eggs laid on stalks to avoid cannibalism
- Larvae may cover themselves with camouflage

Neuroptera: Raphididae - Snake Flies

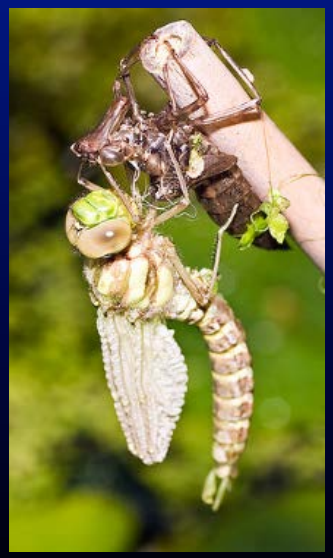
- Larvae and adult are voracious predators of smaller insects
- Larvae are predators in porous rotten wood & leaf litter
- Relatively rare in the garden; look for them in spring and early summer
- Habitat is typically woodland; often found on vegetation (buckeyes & oak in CA -

Odonata - Dragonflies and Damselflies

Dragonfly
Wings out at rest

Damselfly
Wings folded over back

Dragonfly Naiad



Emerging Dragonfly

- Immature forms (Naiads) are voracious predators in freshwater habitats; feed on small invertebrates, fish and tadpoles
- Adults are accomplished aerial predators and often long lived; males frequently territorial
- After emergence, adults spend time away from water, often over fields & garden

Reproductive Biology of Dragonflies and Damselflies

Dragonfly

Damselfly

Copulation - The "Wheel Position"

Oviposition in Tandem

Mantidae -The California Mantis (*Stagmomantis californica*)

Brown Morph

Green Morph

Egg Case

- All stages prey are predatory
- Young feed in vegetation; climb as they age
- Adults feed almost exclusively on bees and wasps
- Adults die before winter; eggs overwinter
- Easily introduced into the garden

Orthoptera: Stenopelmatidae - Jerusalem Cricket "Potato Bug" or "Ninas de la Tierra"

- Common ground dwelling insects in northern CA
- Large and capable of delivering a nasty bite
- Omnivorous and opportunistic predator; will feed on any animal it can subdue
- Roll over when disturbed and wave their spiny legs
- Commonly found under objects and in subterranean burrows

Reduviidae: Ambush Bugs & Assassin Bugs

- Common on flowers, but may be well camouflaged (Ambush bugs)
- Nymphs and adults prey on small insects
- "Generally" do not bite when handled

Syrphidae: Hoverflies


larva

- Larvae of some species live on plants & feed on aphids
- Adults commonly seen nectar feeding on flowers
- Many mimic bees and wasps


pupa


egg

Diptera: Syrphidae - Hoverfly

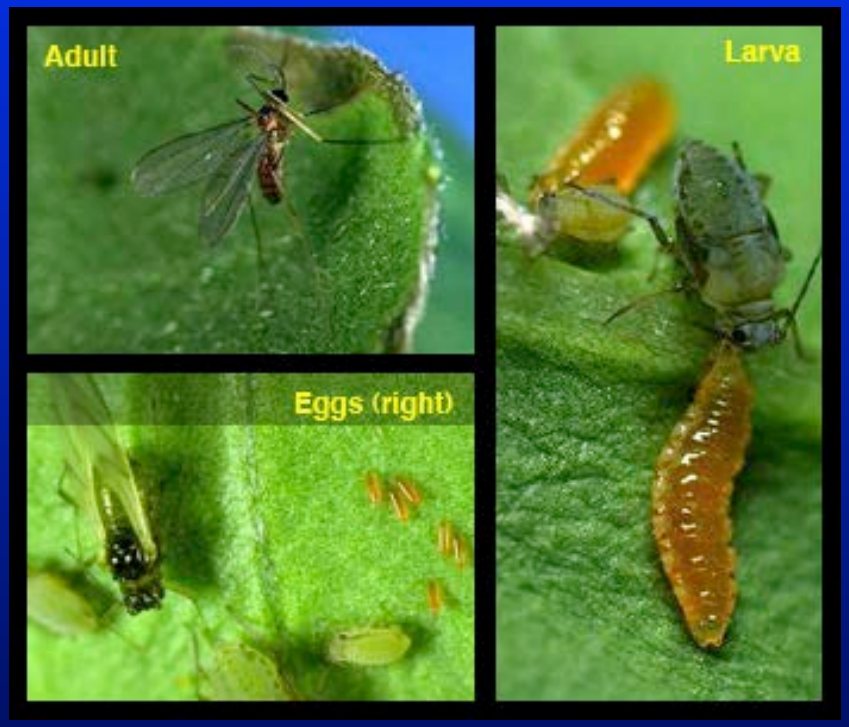
Syrphid Fly

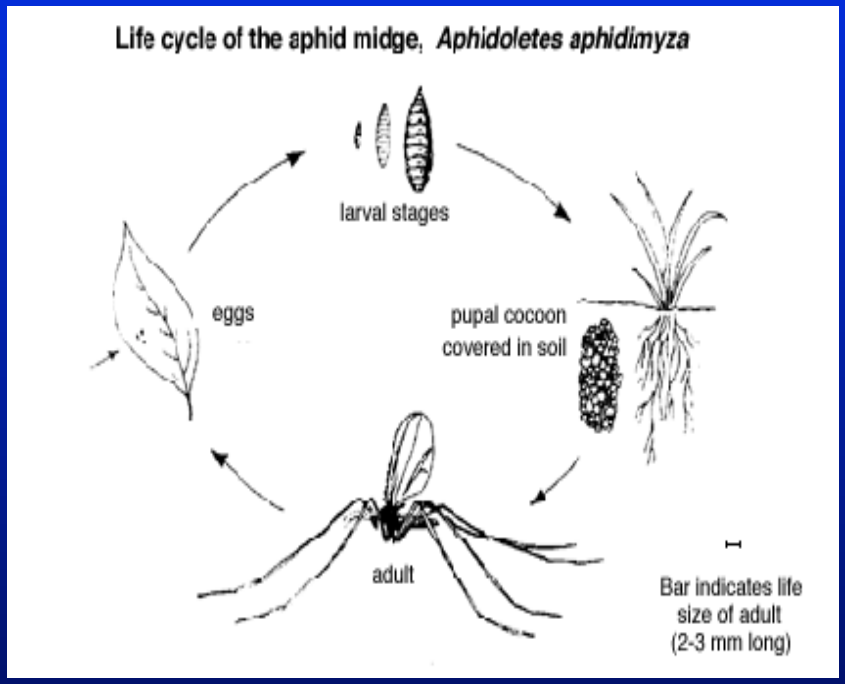
Honey Bee

Ascilidae: Robber Flies

- Larvae in soil or wood, some predaceous
- Adults common on vegetation
- Adults are aerial predators, often taking prey much larger than themselves

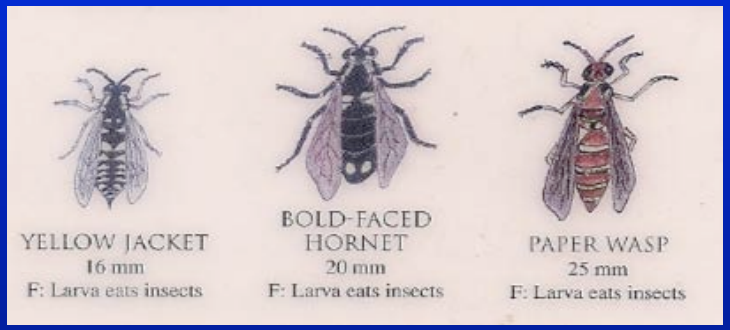
Cecidomyiidae: Aphid Midges





- Adults are small (2-3 mm) mosquito-like flies
- Larvae efficient generalist aphid predators
- Larva may consume up to 100 aphids to complete the life cycle
- Life cycle typically 3 - 6 week; multiple generations per year
- Very effective natural enemies found in a wide variety of crops

Vespidae: Paper Wasps, Yellow Jackets & Hornets



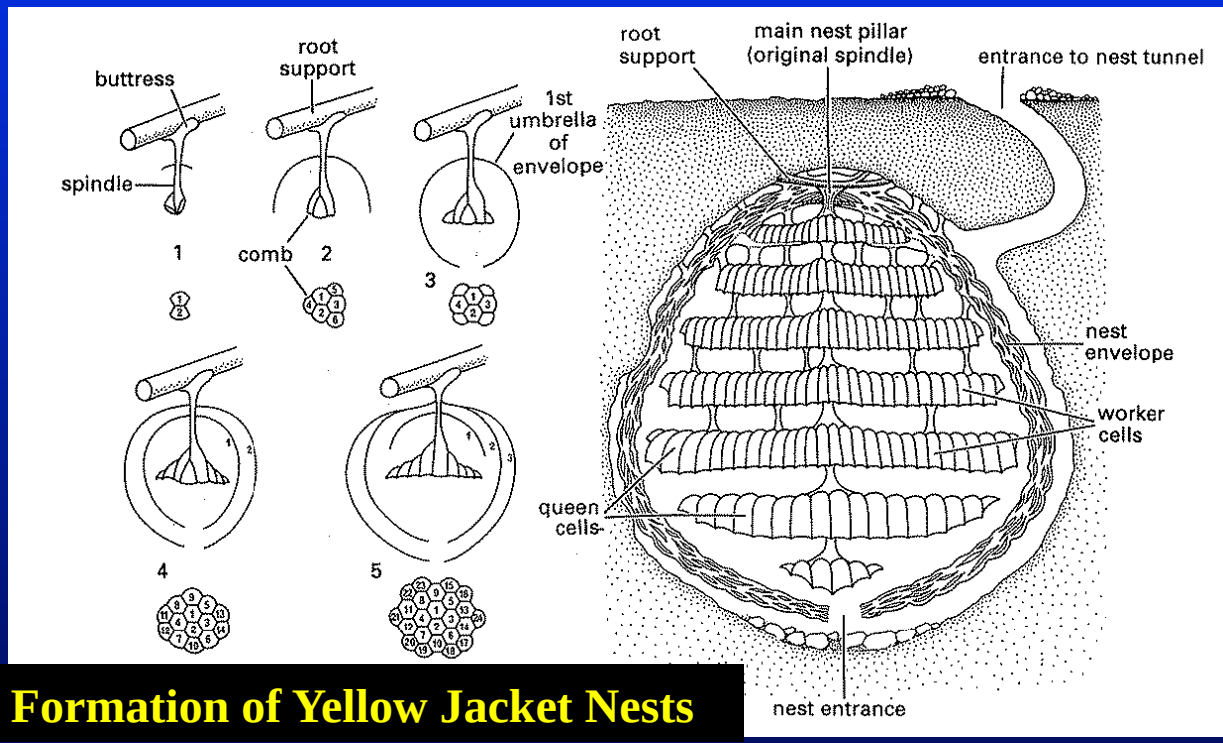
Bald Faced Hornet

Paper Wasp

Potter Wasp

- Adults are omnivores; consume many kinds of insects
- Common on flowers
- Typically black with yellow markings
- Some are social, most are not
- Both queens and workers sting
- Overall beneficial, but often a pain to deal with

Yellow Jackets



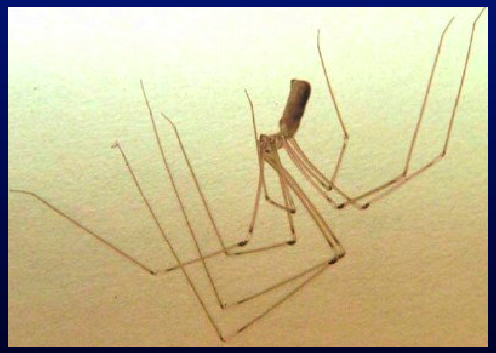
Formation of Yellow Jacket Nests

Spiders - Effective Generalist Predators

Orb Weaver
European Import

Orb Weaver
Native

Wolf Spider
Ground Predator



Long Jawed Orb Weaver
Imported

Crab Spider
Ambush Predator

Jumping Spider
Substrate Predator

Parasites – “Parasitoids”

- Most insect parasites kill their hosts (“Parasitoids”)
- Most important group of insect natural enemies
- All insect stages attacked
- Abundant in nature and very common in the garden
- Larvae attack a wide variety of insects
- Primarily wasps, but includes some flies

Bombyliidae: Bee Flies

Nectar Feeding

- Adults often resemble bees
- Adults are common on flowers
- Some are pollinators
- Larvae are parasitic on a wide variety of insects

Larvae on Tiger Beetle Larva

Sphecidae: Mud Daubers & Thread-Waisted Wasps

- Adults often seen on flowers feeding on nectar, pollen and insects
- Parasitize all major insect orders
- Prey are paralyzed and returned to the nest
- Nest in ground burrows or build mud nests
- Young feed as parasites on paralyzed host
- Important biological control agents in nature

Chrysididae: Cuckoo Wasps

- Small wasps (< 12 mm) that are metallic green or blue in color
- Body usually coarsely sculptured
- Larvae are external parasites of the larvae of other bees & wasps
- Some are egg parasites of walking sticks
- Frequently seen visiting flowers in the garden

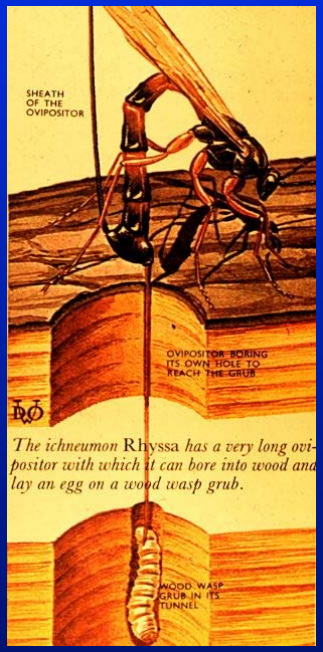
Pompilidae: Spider Wasps

- Dark blue or black with colored wings; recognized by nervous wing twitch
- Adults hunt spiders, primarily on the ground
- Larvae are external parasites on paralyzed spiders

Braconidae: Braconids Wasps

- >2000 species in North America
- Adult wasps are small (< 15 mm)
- Most are parasitoids (similar to ichneumonids)
- All life stages (egg, larva, pupa & adult) of host are attacked
- Solitary & gregarious parasitoids
- Extremely beneficial insect

Ichneumonids - Ichneumonidae



- > 3500 species in North America
- Adult wasps are variable in size
- Most are parasitoids, feeding either internally or externally
- Hosts include larvae of all major insect orders
- Extremely beneficial insects

Hosts include larvae from several families of wood boring beetles

Tachinid Flies - Family Tachinidae

- One of the largest families of flies
- Adults resemble houseflies with bristles
- Larval parasites
- Common parasitizing tent caterpillars
- Important biological control agents of many pests
- Common in gardens on flowers

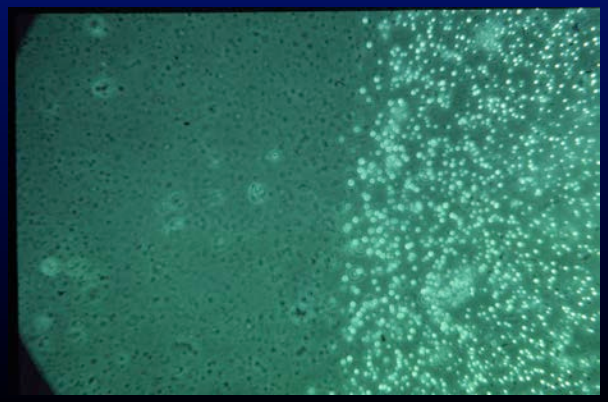
Eggs

Pathogens and Diseases

- Includes viruses, bacteria, protozoa &fungi
- Every species on earth is infected by one or more pathogens; insects are no exception
- Often responsible for dramatic changes in host populations (e.g., honeybees)
- Important regulators of natural populations
- Density dependent mortality factors

Viruses - Baculovirus & Iridescent Virus

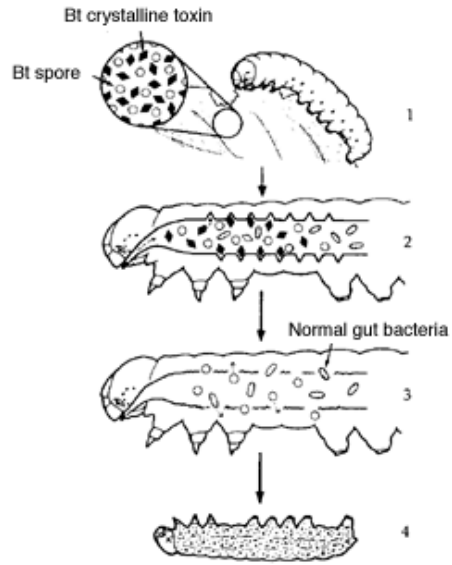
- Baculoviruses infect lepidopteran larvae
- Host specific, fatal pathogens
- Liquify host at the end of pathogenesis
- Important natural control agents for gypsy moth and forest tent caterpillars
- Some commercially available



Iridescent Virus

Bacteria - Bti Formulations

Action of *Bacillus thuringiensis* var. *kurstaki* on caterpillars



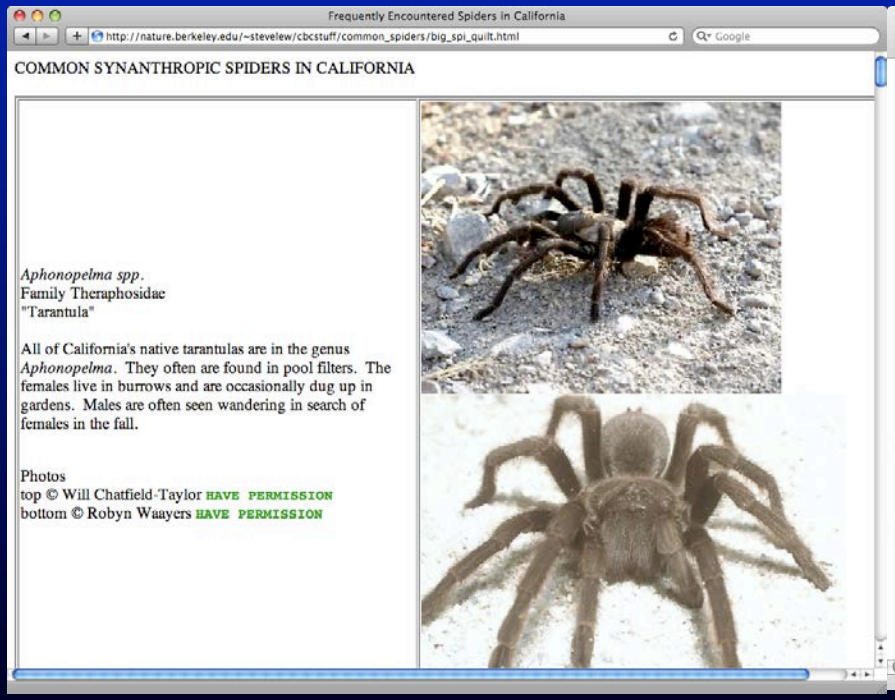
1) Caterpillar consumes foliage treated with Bt (spores and crystalline toxin).
2) Within minutes, the toxin binds to specific receptors in the gut wall, and the caterpillar stops feeding.
3) Within hours, the gut wall breaks down, allowing spores and normal gut bacteria to enter the body cavity; the toxin dissolves.
4) In 1-2 days, the caterpillar dies from septicemia as spores and gut bacteria proliferate in its blood.

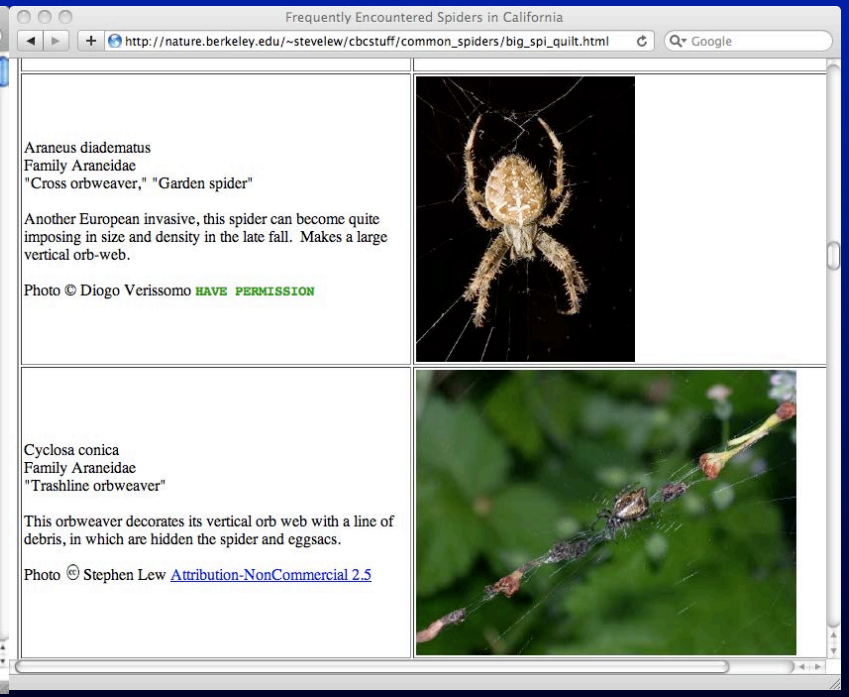
What Can You Do to Enhance Natural Enemies in Your Garden?

- Diversify your garden. Physical complexity is key.
- Provide nectar and pollen sources for predators and parasites
- Plant for continual bloom throughout the growing season
- Don't be to fastidious about keeping the garden "clean"
- Tolerate some chewing; it's the sign of a healthy garden
- If a plant species is continually infested grow something else
- Introduce appropriate predators and parasites
- Avoid pesticide use

Websites of Interest

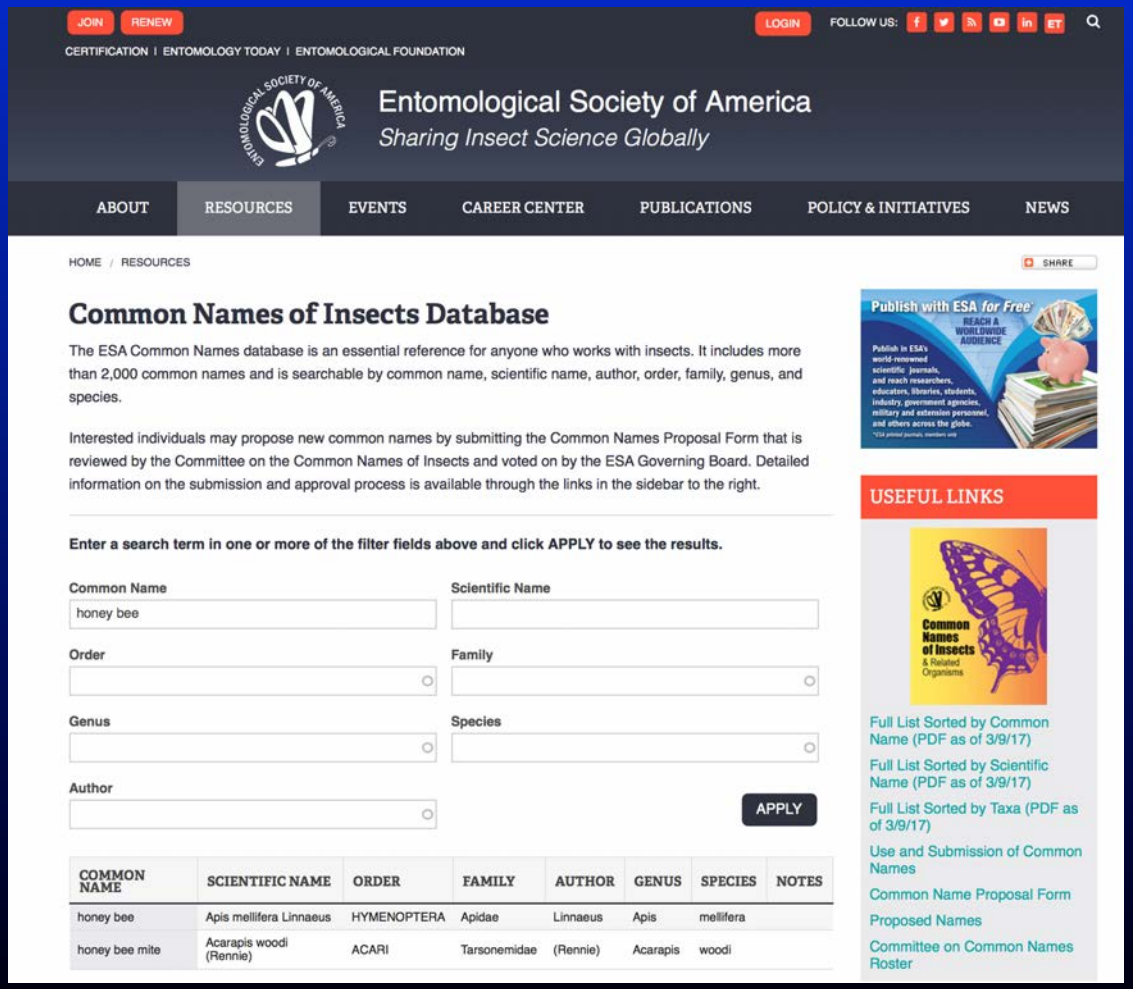
http://nature.berkeley.edu/~stevelew/cbcstuff/common_spiders/big_spi_quilt.html
Common spiders of California





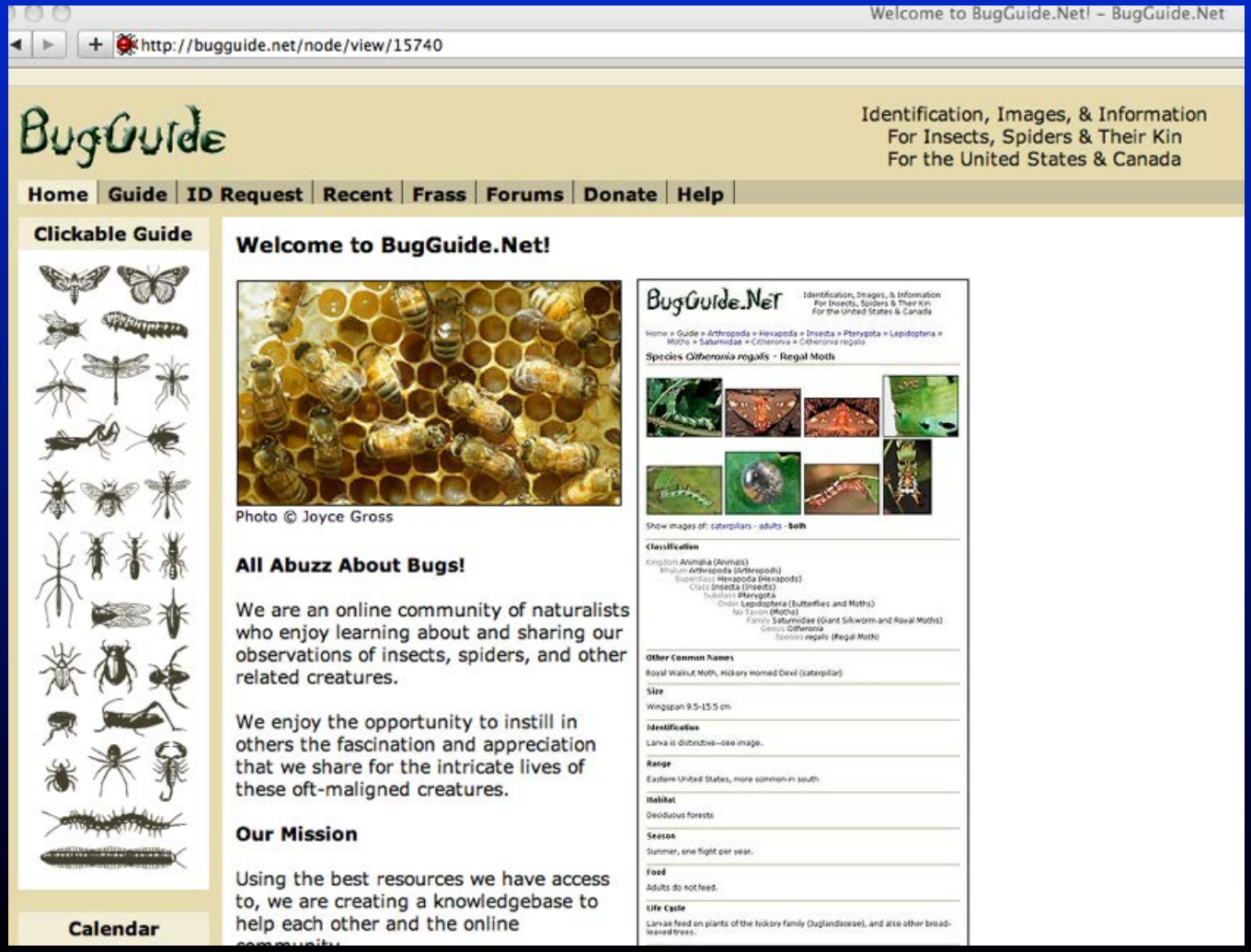
Website of Interest

http://www.entsoc.org/Pubs/Common_Names/index.htm - Entomological Society of America website with sanctioned common names



Website of Interest

http://bugguide.net/node/view/15740



Master Gardener Training
Part 3: Common Insects of Mendocino County

Jan O. Washburn

March 22, 2017

Hemiptera: Gerridae – Water Striders

Water Strider

Habitats of each genus of Family Gerridae[5]

Genus of family Gerridae	No. of marine species	Brackish	Neritic	Oceanic
Asclepios	4	Yes	Yes	No
Halobates group 1	39	Yes	Yes	No
Halobates group 2	7	No	No	Yes
Stenobates	1	No	Yes	No
Rheumatometroides	1	Yes	No	No
Rheumatobates	6	Yes	Yes	No

Piercing/sucking Mouthparts

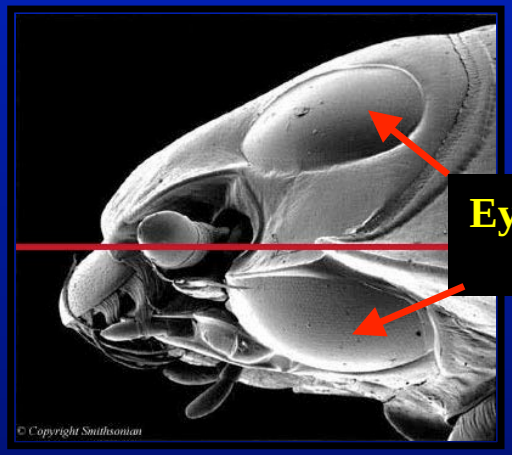
Sea Skater

- Inhabit calm surface waters, a few species are found in the open ocean
- These are predatory insects that feed on invertebrates that fall into the water
- Ripples in the water are detected by sensory hairs on the front legs

Coleoptera: Gyrinidae - Whirligig Beetles

Physical Gill

- Predators
- Adults feed on insects trapped on the water surface
- Aggregate on water surface to avoid predation
- Capable of swimming underwater



Eyes Above and Below the Water

Larvae Are Aquatic and Predaceous

Coleoptera: Dytiscidae - Predaceous Diving Beetles

Sunburst Diving Beetle

- Predaceous adults and larvae are found in a variety of fresh water habitats
- Adults oval, streamlined (up to 33 mm)
- Hind legs are short, fringed and placed posteriorly; awkward on land
- Adults carry air under their elytra (physical gill)

Dytiscid Larvae

Homoptera: Cercopidae - Spittlebugs ("Froghoppers")

Spittlebug Nymph

Adult Spittlebug

Spittle mass with nymph

Isoptera: Subterranean Termites

Diptera: Tipulidae - Crane Flies

- ~ 15,000 described species in family
- Largest "flies" in California
- Often know as "mosquito hawks"
- HARMLESS INSECTS
- Larvae often in moist habitats
- Adults are often non-feeding; some feed on pollen/nectar

Hemiptera: True Bugs

Squash Bug

Box Elder Bug

- ~ 2000 species in family worldwide
- All are plant feeders (phloem)
- Many produce “repugnatorial secretions
- Bright colors advertise that the insect is distasteful or poisionous

Hempitera: Pentatomidae - Stinkbugs

- ~ 3000 described species
- "stink bug" is actually a complex of green & brown species/races//populations
- Most are plant feeders (phloem)
- Major pests of rice and crucifers
- All stages produce "repugnatorial secretions"

Hymenoptera: Tenthredinidae – Saw Flies

Pontania sp.

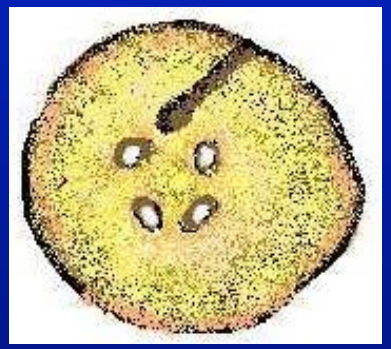
Leaf Mining Sawfly

- Form leaf, petiole & leaf edge-roll galls
- Common on Willow (*Salix* spp.); several species on native snowberry
- Specific will clones attacked
- Usually one generation per year, but *Pontania californica* is active year round

What is a Gall?

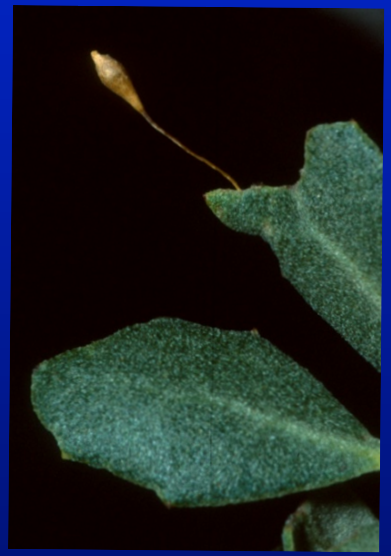
A plant gall is a tumor-like growth of plant tissue produced by the host plant in response to the chemical and/or mechanical stimuli of another organism such as an insect, mite, fungus, virus, or bacterium.

Gall Structure



For insect induced galls, the gall most frequently serves as a brood chambers for the immature stages of the insect

Hymenoptera: Cynipidae – Gall Wasps



Cynipids have Complex &Variable Life Histories

Sexual Generation spring/ summer

Asexual Generation fall/ winter

Alternation of sexual and asexual generations

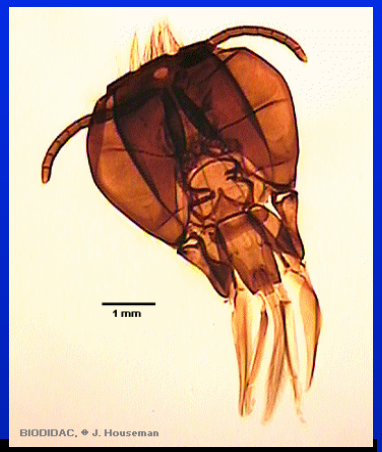
Hymenoptera: Calcidoideae

- Large group with >2200 species in North America
- Most are small to minute in size (0.5 - 3.0 mm) and common in the garden
- Recognized by reduced wing venation
- Often metallic & brightly colored
- Most are parasitic on eggs & larvae of other insects
- Hosts include coleoptera, diptera, leopidoptera, hymenoptera & homoptera

Hymenoptera: Andrenidae - Digger or Mining Bees

Nectar Robbing by Bees

Nectar Robbing by a Carpenter Bee



Head & Mouthparts of Typical Bee

Many species of bees will "rob flowers" by climbing to the back of the flower (avoiding the reproductive parts) and harvesting nectar after chewing a hole in the corolla tube.

Honeybee robbing pollen from a bumblebee

Hymenoptera: Megachilidae - Leafcutting Bees

- Moderate in size & stout in the body
- Females carry pollen on the ventral surface of the abdomen
- Frequently nest in wood
- Larvae of most feed on leaves provisioned by the adult
- Leaf damage is a common sight in California gardens

Hymenoptera: Mutillidae -Velvet Ants

- Females are wingless & resemble "hairy ants"
- ~ 450 species in North America
- Black with yellow, orange, red or white hairs
- Common ground insects, particularly in the arid west
- Poorly known life histories; those that are described are pupal parasites of wasps & bees
- FEMALES INFLICT A VERY PAINFUL STING!

Coleoptera: Chrysomelidae – Leaf Beetles

- One of the largest families of plant eating beetles
- ~ 40,000 species world wide; ~ 500 species in CA
- Most are specialists and feed on only one or a few closely-related plant species
- Larvae of most feed on live plant material and pupate in the soil
- Many are economic pests, and some are useful for biological control of noxious weeds

Chrysomelid Larvae

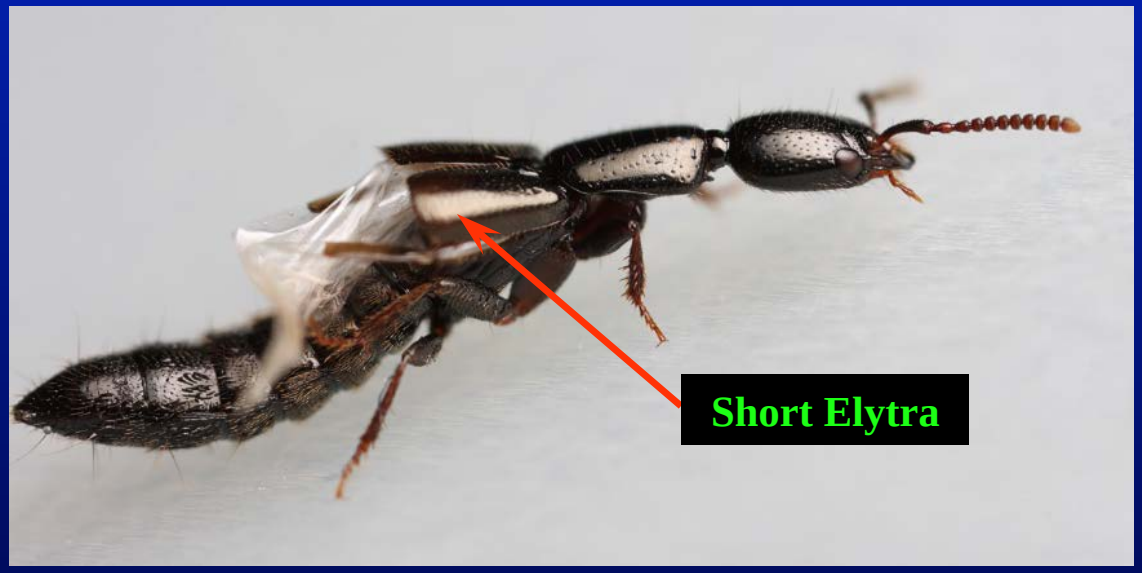
Coleoptera: Rove Beetles - Staphylinidae

Adult Rove Beetle

Rove Beetle Larva

Pictured Rove Beetle is a nocturnal species common in seaweed on the coast

- Largest beetle family in CA with ~ 1500 species
- Elytra very short
- Live in leaf litter and decaying plant material
- Most are predators of small arthropods
- May lift abdomen or release noxious secretions when disturbed



Coleoptera: Curculionidae - Weevils or Snout Beetles

- Largest animal family on earth with > 60,000 described species; ~ 600 in CA
- Most adults identified by their extended mouthparts
- Adults and larvae feed on live plants; specialize in feeding on nuts and seeds
- Larvae of many species burrow into stems
- Major economic pests, many with cosmopolitan distributions

Coleoptera: Buprestidae - Metallic Wood-boring Beetles

Golden Buprestid

Metallic Color and Bullet Shape

- Many species brightly colored and/iridescent
- Streamlined, bullet-shaped bodies with saw tooth antennae
- Among the most destructive wood boring insects
- Larvae are legless and feed on sapwood of branches, roots and trunk as well as heartwood
- Fast flying

Buprestid Larva

Coleoptera: Scarabaeidae -Ten-Lined June Beetle


Adult


Larva

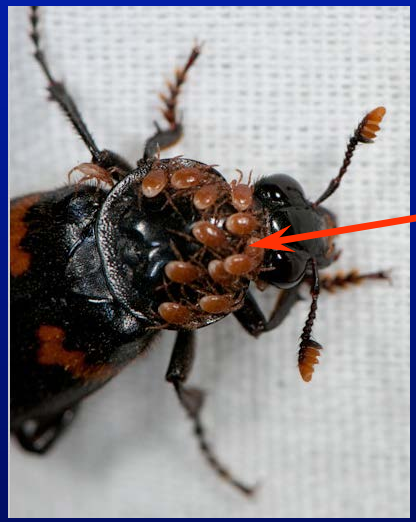
- Common in California (except deserts)
- Larvae feed on roots
- Adults may feed on pine needles
- June/July on coastal prairie

Coleoptera: Silphidae - Carrion and Burying Beetles

Black Burying Beetle

Silphid Larva

- Feed on decaying plant and animal material
- Antennae sensitive to the odors produced by cadavers
- Burying beetles bury small mammals and birds
- Some adult burying beetles exhibit parental care



Mites

Some burying beetles carry mites that disperse on cadavers and eat fly eggs, reducing food competition for their young

Coleoptera: Lampyridae - Fireflies and Glowworms

Adult ♂ California Glowworm

- Elongated, flattened, soft-bodied beetles
- 18 species in CA, but none exhibit bio luminesce during flight
- Among CA species, adult ♀♀ resemble wingless larvae
- Bioluminescent light organ on ventral surface of abdomen
- Larvae inhabit leaf litter; feed on snails, slugs and insects
- Adults are predatory or do not feed

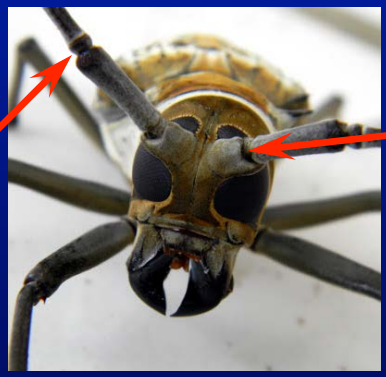
Wingless ♀ Glowworm

Male *Photinus*

♀California Pink Glowworm

Coleoptera: Cerambycidae - Longhorn Beetles

- Largest beetle found in CA
- ~ 20,000 species world wide: ~ 350 species in CA
- Most CA species are brown or black; many are nocturnal
- Larvae of most feed on live or dead plant material; most bore into plant tissues
- Important role in recycling dead wood
- Often observed on flowers
- Long antenna (usually has 11 segments with the second one small) notched into the eye



Small Second Antennal Segment

Antenna Attaches In Eye Socket

Lepidoptera: Saturnidae - Silkmoths

- Medium to very large in size
- Our largest Lepidoptera
- Adults are short-lived
- Adults do not feed
- Several diurnal species in CA

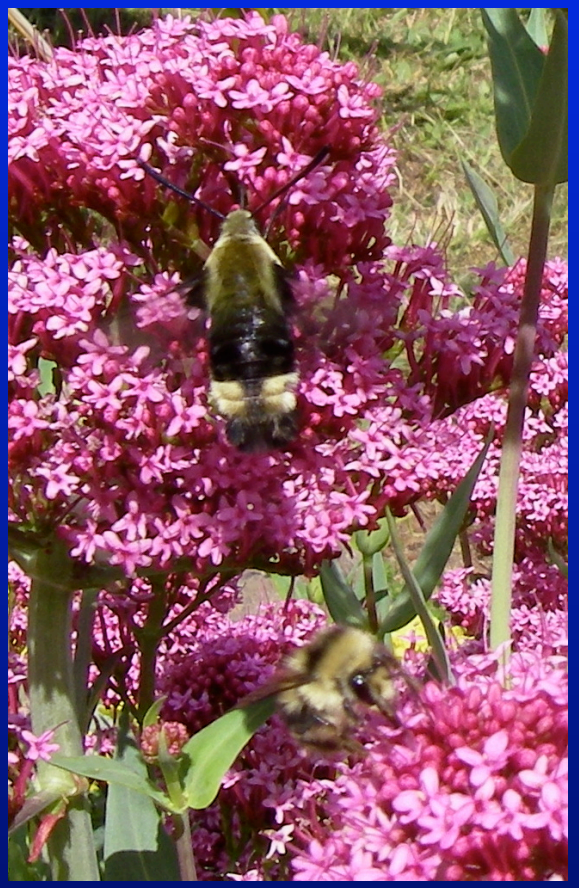
Ceanothus Silkmoth

Ceanothus Silkmoth Larva

Hemileuca sp.
Diurnal Silkmoth

Redwood moth

Lepidoptera: Sphingidae - Hawkmoths



Lepidoptera: Sphingidae - Hawkmoths

Tobacco Hornworm

White Lines Sphinx

Lepidoptera: Dioptidae - California Oak Moth

Phryganidia californica
California Oak Moth

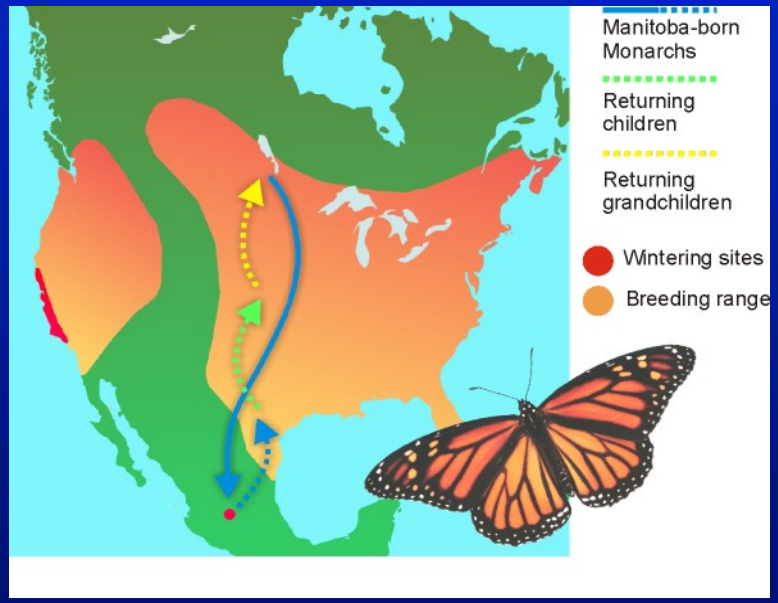
- Larvae feed primarily on live oak
- 2 or 3 generations per year
- Adults fly from spring until fall
- May defoliate mature trees completely
- Outbreaks occur about every 5 - 10 years

Lepidoptera: Arctiidae - Tiger Moths

- Family contains ~11,000 species
- Often brightly colored (tiger moths) and distasteful
- Larvae called "wooly bears"
- Larvae and adults of many species are diurnal

Cinnabar moth introduced into the US to control ragwort

Lepidoptera: Danaidae – Monarch Butterfly



No life stage of the Monarch can survive freezing temperatures.

Lepidoptera: Nymphalidae - Brush Footed Butterflies

- Many species vary from moderate to large
- Name derived from greatly reduced front legs
- Rest/Walk on four legs
- Larvae feed on many plant species

Buckeye

Painted Lady

Crescent

Red Admiral

Anglewing

Checkerspot

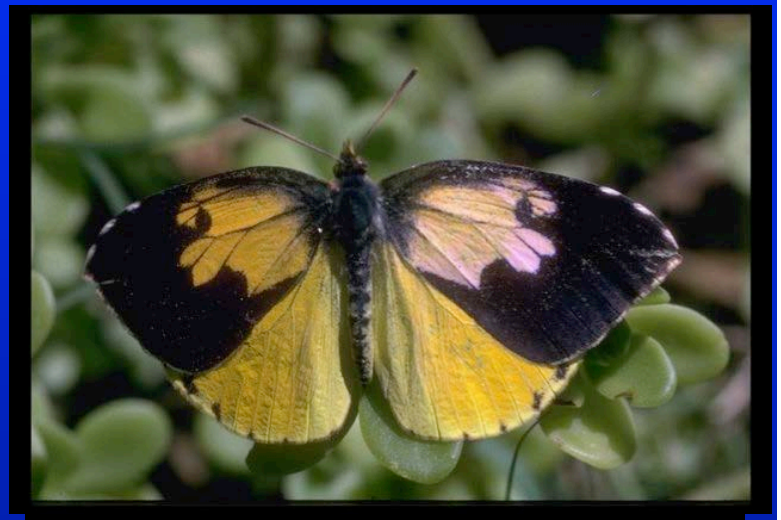
California Sister

Lorquin's Admiral

Zerene Fritilary

Lepidoptera: Pieridae - Whites, Sulfurs & Orangetips

- Small to medium in size
- Yellow or white background color
- Often sexually dimorphic
- Larvae feed on crucifers



California Dogface
STATE INSECT OF CALIFORNIA

Sara Orangetip

Spring White

Alfalfa Butterfly

Cabbage White

Checkered White

Lepidoptera: Satyridae - Wood Nymphs

- Small to medium in size
- Almost all are brown with eyespots
- Common in woodlands and meadows
- Characteristic flight - wings fully close
- Larvae feed on grasses

Common Ringlet

Common Wood Nymph

Lepidoptera: Hesperiidae - Skippers

- Small in size
- Wings held partially opened at rest
- Thick bodied and stout
- Characteristic skipping flight
- Larvae feed on grasses & sedges
- ~ a dozen local "Grass Skippers"

Dusky Wing Skipper

Checkered Skipper

"Grass Skippers"

Lepidotpera: Lycaenidae - Blues, Hairstreaks & Coppers

- Small, generally fly close to the ground
- Hairstreaks have tails and false eyespots
- Larvae are slug like; some are tended by ants
- Larvae of some eat ant larvae & pupae
- Great Purple Hairstreak feeds on Mistletoe
- Hairstreaks typically rest with wings folded

Great Purple Hairstreak

Gray Hairstreak

Purplish Copper

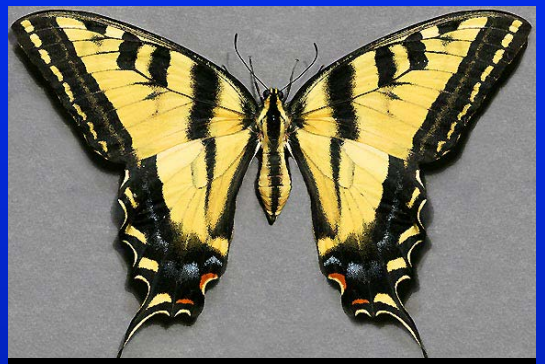
Acmon Blue

Bramble Hairstreak

Leopidoptera: Papilionidae - Swallowtail Butterflies

Anise Swallowtail

Pipevine Swallowtail



Western Tiger Swallowtail

Polymorphic Anise Swallowtail Swallowtail Pupae

Osmeteria

Pale Swallowtail

Polymorphic Pale Tiger Swallowtail Pupae

The Life Cycle of the Pale Swallowtail

Adult

Chrysalis

Eggs

Young Larvae

Old Larvae

The Pipevine Swallowtail

Redspotted Purple
Palatable Mimic

Pipevine Swallowtail Adult & Larvae

Mimicry and the Pipevine Swallowtail

Unpalatable Monarch

Palatable Vicery

Unpalatable Pipevine Swallowtail

Palatable Mimics – Eastern North America

Red-Spotted Purple

Eastern Tiger Swallowtail – Dark Form ♀

Diana Fritillary - ♀

In Eastern North America, more than half a dozen butterfly species mimic the poisonous pipevine swallowtail to avoid predation.

Dutchman's Pipe - CA Native

Dutchman's Pipe - *Aristolochia californica*

Fungus Gnat

Pipevine Swallowtail

- Flowers of the Dutchman's Pipe attract and capture fungus gnats
- After pollination, flowers release pollen and allow flies to leave the flower

Odonata - Dragonflies and Damselflies

Dragonfly
Wings out at rest

Damselfly
Wings folded over back

Dragonfly Naiad

Emerging Dragonfly

- Immature forms (Naiads) are voracious predators in freshwater habitats; feed on small invertebrates, fish and tadpoles
- Adults are accomplished aerial predators and often long lived; ales frequently territorial
- After emergence, adults spend time away from water, often over fields & garden

Reproductive Biology of Dragonflies and Damselflies

Dragonfly

Damselfly

Copulation - The "Wheel Position"

Oviposition in Tandem

Orthoptera: Stenopelmatidae - Jerusalem Cricket "Potato Bug" or "Ninas de la Tierra"

- Common ground dwelling insects in northern CA
- Large and capable of delivering a nasty bite
- Omnivorous and opportunistic predator; will feed on any animal it can subdue
- Roll over when disturbed and wave their spiny legs
- Commonly found under objects and in subterranean burrows