Introduction to Entomology

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Texas Master Naturalist
Human Attitudes

- **“Good Insects”**
  - Butterflies
  - Ladybugs
  - Caterpillars
  - Damselflies
  - Crickets

- **“Bad Insects”**
  - Wasps
  - Mosquitos
  - Flies
  - Fleas
  - Ants
  - Termites
  - Bedbugs
  - ...

Are you fearful of some insects? Why?
The Evil June Bug

Hell on Wings
Topics

- Why study insects?
- History
- Classification
- Insect lifecycle & morphology
- Insect orders & identification
- Insect collection and preservation
Why Study Insects?

- Insects represent an estimated 95% of species on Earth
  - 91,000 species described in the U.S. alone
  - Estimate 70,000 yet to be described in the U.S.
    - You may be able to name an insect species!
- Insects represent an estimated 20% of all animal biomass on Earth
- Insects have altered the course of human history
- Insects provide valuable ecosystem services
- Insects cause major economic loss
- Insects are vectors of disease
Insects and Human History

- Impacts on Human Population Centers
  - Bubonic Plague

- Impacts on Military Campaigns
  - Losses from insect-borne diseases turned back Napoleon in Syria, Egypt, and Russia

- Innovation
  - Paper wasps inspired French naturalist Rene Antoine Ferchault de Reaumer to suggest the use of wood as a papermaking fiber in 1719
Human Disease Vector

- Mosquito Borne
  - Dengue Fever
  - West Nile
  - Malaria
  - Yellow Fever
  - Encephalitis
- Sand Fly Borne
  - Leishmaniasis
- Flea Borne
  - Plague, Typhus
- Many infect wild and domestic animals

Impact of Climate Change Under Study

Source: Public Library of Science
Source: USDA
Source: CNN
Ecosystem Services

- Food
  - Fish, Birds, Reptiles, Mammals

- Biological Control
  - Fire Ant Decapitating Wasp

- Pollination
  - $57 million in US alone

- Decomposition
  - Structural Breakdown
  - Waste Removal
  - Nutrient Cycling

- Soil Formation

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Ecosystem Services Emerging as Method to Assign Economic Value
Forest Impacts

- **Disease Vectors**
  - Dutch Elm Disease
  - Chestnut Blight

- **Leaf Damage**
  - Leaf rollers
  - Skeletonizers

- **Wood Damage**
  - Borers
  - Budworms
  - Galls/Cankers

- **Fruit Damage**
  - Acorn Weevils
Classification

Kingdom Animalia

Phylum Arthropoda

Subphylum Trilobita
  extinct

Subphylum Uniramia
  Class Chilopoda
  centipede
  Class Diplopoda
  millipede

Class Insecta
  Order Coleoptera
  beetles
  Orthoptera
  grasshoppers
  Diptera
  flies & mosquitoes
  Hymenoptera
  bees, wasps, ants
  Lepidoptera
  butterflies & moths

Subphylum Chelicerata
  Class Xiphosura
  horseshoe crabs

Class Arachnida
  spiders, scorpions, ticks

Source: biologycorner.com
History and Evolution

- **First Arthropods**
  - Appeared during the Cambrian period between 500m and 600m years ago.
  - Transitioned to a land environment between 490m and 443m years ago.

- **First Insects**
  - Appeared during the Devonian period about 400m years ago.
  - Most insect orders and families established during the Jurassic period between 208m and 145m years ago.
Insect Morphology
Arthropod Characteristics

- Arthropod means "jointed foot"
  - all arthropods have jointed appendages
- Segmented body
- Multiple leg pairs
- Exoskeleton for protection & support
- Open circulatory system
- Compound eyes
- Wings in many groups
- Respiration using spiracles and trachae
- Class Insecta
  - 3 body parts - head, thorax, abdomen
  - 3 pairs of legs
  - Wings in most
  - All appendages attach to the thorax
Insects go through several distinct life stages through a process called metamorphosis.

**Incomplete Metamorphosis**
Immature insects resemble adults. No pupal stage.
Eg. Hemiptera

**Complete Metamorphosis**
Immature insects do not resemble adults. Pupal stage.
Eg. Coleoptera

Diagrams by Cornell University
Caterpillars vs. Inchworms vs. …

- Identifying characteristics
  - Prolegs
  - Color/Patterns
  - Presence of hairs
  - Number of prolegs
  - Presence of dorsal horn

- Butterflies & Moths - Lepidoptera
  - 5 pair prolegs or less
  - Hooks on prolegs

- Sawflies, Wasps - Hymenoptera
  - 6 prolegs or more
  - No hooks on prolegs
Insect Morphology

(a female short-horned grasshopper)

Source: The Robinson Library
Insect Morphology – Mouth Parts

**Mandible**
Photo by Pest and Diseases Image Library
Used for biting and grinding solid foods

**Piercing-Sucking**
Photo by Jim Occi
Used to penetrate solid tissue and then suck up liquid food

**Sponging**
Photo by Manaaki Whenua Landcare Research
Used to sponge and suck liquids.

**Siphoning**
Photo by James Politte
Used to suck liquids.
Insect Morphology – Antennae

**Aristate (Diptera)**
Photo by The Insects of Cedar Creek

Antennae are pouch-like with a lateral bristle.

**Capitate (Lepidoptera)**
Photo by Peter Wirtz

Antennae are abruptly clubbed at the end.

**Clavate (Coleoptera)**
Photo by Ein Paradies liegt uns zu Fisch - das Mostviertel

Antennae are gradually clubbed at the end.

**Filiform (Coleoptera, Blattaria)**
Photo by Donald Duerr, USDA Forest Service

Antennae have a thread-like shape.
Insect Morphology – Antennae

**Geniculate (Hymenoptera)**
Photo by the University of Nebraska-Lincoln

Antennae are hinged or bent like an elbow.

**Lamellate (Coleoptera)**
Photo by Gerald J. Lenhard, Louisiana State University

Clubbed antennae end in nested plates...

**Moniliform (Isoptera)**
Photo by the USDA Forest Service

Antennae have a beadlike shape.

**Pectinate (Coleoptera)**
Photo by the USDA Forest Service

Antennae have a comb-like shape.
Insect Morphology – Antennae

Plumose (Lepidoptera, Diptera)
Photo by Gerald J. Lenhard, Louisiana State University
Antennae have a feather-like shape.

Serrate (Coleoptera)
Photo by Steve L. Brown, University of Georgia
Antennae have a saw-toothed shape.

Setaceous (Odonata)
Photo by Richard Seaman
Antennae have a bristle-like shape.

Insect Antennae are an Excellent Identification Feature
Insect Morphology – Legs

**Ambulatory (Hemiptera, Coleoptera)**
Photo by Scott Bauer, USDA ARS

These legs are made for walkin’.

**Cursorial (Blattaria, Coleoptera)**
Photo by Clemson University

Legs are modified for running.

**Fossorial (Othoptera, Hemiptera)**
Photo by Scott Bauer, USDA ARS

Fore legs are modified for digging.

**Natorial (Coleoptera Hemiptera)**
Photo by Dale Parker, AquaTax Consulting

Legs are modified for swimming.

Very Similar. Cursorial Segments are Thinner and Longer
Insect Morphology – Legs

**Raptorial (Hemiptera, Mantodea)**
Source: Wikimedia Commons

Fore legs modified for grasping (catching prey).

**Saltatorial (Orthoptera)**
Photo by Joseph Berger

Legs adapted for jumping. These legs are characterized by an elongated femur and tibia.
Insect Morphology – Wings

Insects have evolved many variations of wings, and an individual insect may possess more than one type of wing. Wing venation patterns are commonly used to ID insects at the family and species level.

Some insects are unable to fold their wings. 
(Ephemeroptera and Odonata)

Most insects are able to fold their wings over the body.

Photo by Alex Wild

Photo by Clemson University
**Insect Morphology – Wings**

**Membranous** (Odonata, Neuroptera, Diptera, Hymenoptera, Isoptera)

Photo by Scott Bauer, USDA ARS

Wings are thin and more or less transparent.

**Halteres** (Diptera)

Photo by The Insects of Cedar Creek

Hind wings are reduced to mere nubs used for balance during flight.

**Elytra** (All Coleoptera)

Photo by Scott Bauer, USDA ARS

Hardened forewings of beetles modified to protect the hind wings when at rest.

**Hemelytra** (Hemiptera)

Photo by Russ Ottens, University of Georgia.

Hardened throughout the proximal two-thirds, while the distal portion is membranous...
Insect Morphology – Wings

**Tegmina** (Orthoptera, Blattaria, Mantodea)
Photo by The Insects of Cedar Creek

Lathery forewings that help protect the hind wings.

**Scales** (Lepidoptera, Trichoptera)
Photo by Ronald F. Billings, Texas Forest Service

Scales allow for vivid color patterns
Insect Orders
Insect Orders

- **Coleoptera** - Beetle
- **Lepidoptera** – Moth, Butterfly, Skipper
- **Hymenoptera** – Ant, Wasp, Bee
- **Diptera** – Fly
- **Hemiptera** – “True Bugs”
- **Odonata** – Damselfly, Dragonfly
- **Orthoptera** – Grasshopper,
- **Isoptera** - Termite
- **Mantodea** - Mantid
- **Blattaria** - Cockroach
- **Dermaptera** – Earwig
- **Trichoptera** – Caddisfly

- **Psocoptera** - Booklice
- **Phthiraptera** – Lice
- **Thysanoptera** - Thrips
- **Neuroptera** – Dobsonfly, Antlion
- **Mecoptera** - Scorpionfly
- **Siphonaptera** - Flea
- **Collembola** - Springtail
- **Thysanura** - Silverfish, Bristletail
- **Ephemeroptera** - Mayfly
- **Phasmdida** – Walkingsticks
- **Plecoptera** – Stonefly

**DNA research altering the landscape – Hemiptera vs Homoptera**
Coleoptera

- **Beetles**
  - ≈ 400,000 species described
    - 40% of insects
    - Found in every ecosystem
  - Complete metamorphosis
  - Hardened front wing covers called “elytra” for protection
    - Rear wings for flying
  - 344 species known to be used as human food
    - Larval stages
  - Historically important
    - Egyptian scarab beetles

*Ash Borer* Debbie Miller, USDA Forest Service, Bugwood.org

*Pecan Weevil* Clemson University. Bugwood.org
Lepidoptera

- **Butterflies, Moths & Skippers**
  - ≈ 300,000 species described
    - Only 12,500 are butterflies
  - Complete metamorphosis
  - Four well-developed wings
    - Overlapping scales
  - **Butterflies**
    - clubbed antennae
    - Caterpillars very distinctive!
  - **Moths**
    - feathery or straight antennae
  - **Skippers**
    - hooked antennae

**Painted Lady**
Whitney Cranshaw, Colorado State University, Bugwood.org

**Catalpa Sphinx**
Herbert A. Pase III, Texas Forest Service, Bugwood.org

**Silverspotted Skipper**
David Cappaert, Michigan State University, Bugwood.org
Hymenoptera

- Bees, wasps, sawflies, ants
  - ≈ 130,000 species described
  - Complete metamorphosis
  - Social or solitary
  - Hind wings are connected to the forewings by a series of hooks
  - Ovipositors on females
    - Slice or penetrate plant material
  - Wasps – stalk connecting abdomen
Diptera

- Flies
  - ≈ 100,000 species described
  - Complete metamorphosis
  - Single pair of wings
    - Rear pair reduced to stubs called halteres
  - Filiform, stylate, or aristate antennae
  - Larvae (grubs) have no legs
Hemiptera - “True Bugs”

- Cicadas, aphids, hoppers, scales, whiteflies.
- ≈ 50,000 – 80,000 species described
- Highly modified mouthparts (“beak”) for piercing and sucking
- Feed on plants, other insects, or blood
- Incomplete metamorphosis
- Five-segmented antennae
- Forewings are either entirely membranous, or partially hardened.
  - Often with distinctive “triangle” pattern
Odonata

- **Dragonflies & Damselflies**
  - ≈ 5,000 species described
  - Carnivorous
  - Setaceous antennae
  - Very large eyes
    - Mouths below eyes
  - Two pair of membranous wings
  - Incomplete metamorphosis
    - Nymphs are aquatic

- **Key Differences**
  - Wing size
  - Wing resting position
  - Shape of abdomen
  - Flight speed
Insect Damage

Most plant damage done by immature insects
Foliar Damage

- Free Feeding
  - Caterpillars completely devour foliage

- Leaf Mining
  - Caterpillars tunnel in space between leaf surfaces
  - Where did caterpillar start and end?

Free Feeding
Steven Katovich, USDA Forest Service, Bugwood.org

Leaf Mining
Gyorgy Csoka, Hungary Forest Research Institute, Bugwood.org
Foliar Damage

- Leaf Rolling
  - Caterpillars roll leaf with silk and feed inside fold

- Skeletonizing
  - Caterpillars consume material between leaf ribs

Leaf Roller on Redbud
Photo: Chris Ebling

Skeletonized Chinquapin Oak
Photo: Karen Ebling
Foliar Damage

- **Leaf gall**
  - Leaf tissue grows around and protects immature insect

- **Petiole gall**
  - Petiole tissue grows around and protects immature insect
Foliar Damage

- **Webworms**
  - Construct webs of silk for protection during rest and feeding
  - **Fall Webworm**
    - Common on Pecan
  - **Eastern Tent Caterpillar**
    - Common on Cherry
Foliar Damage

- **Bagworms**
  - Construct sacks out of foliage for protection during rest
  - Rarely kill tree

- **Budworms**
  - Burrow into tree buds to feed
  - Spruce budworm responsible for major tree loss periodically

*Bagworm on Chinquapin Oak*
Photo: Karen Ebling

*Spruce Budworm*
Edward H. Holsten, USDA Forest Service, Bugwood.org
Wood Damage

Twig galls

- Females lay eggs in twig
- Hormones cause twig to grow tissue around egg.
- Larva feed and pupate within gall
- Emerge from gall as adults

Marble gall on Chinquapin Oak
Photo: Chris Ebling
Wood Damage

Stem borers

- Females burrow into woody stem and lay eggs
- Larva feed and pupate in wood
- Transmit fungal disease
- Structural damage
Wood Damage

Bark borers

- Females burrow under bark and lay eggs in distinctive patterns
- Larva feed on tissue under bark and pupate
- Cut off food and water flow
- Transmit fungal disease

Elm Bark Beetle
John A. Williams, USDA Forest Service, Bugwood.org

Southern Pine Beetle
Ronald F. Billings, Texas Forest Service, Bugwood.org
Insect Collecting

So you want to collect bugs?
Where Do We Find Insects?

Insects Are Everywhere!
Catch Them!

Aquatic Sweep

Aerial

Sweep

Photo: University of Mississippi

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Catch Them!

Beat Net
Catch Them!

Pitfall Trap
Diagram: U of Florida

Often filled with Propylene Glycol
Kill Them!

- Killing jars
  - “Hard” insects only
  - Different sizes for different insects
  - Kill the insect as quickly and humanely as possible
    - Ether
    - Ethyl Acetate
    - Alcohol

- “Soft insects”
  - Small jars/tubes filled with alcohol
Identify Them!

Find a guide as close to where you will be collecting as possible
Mount and Store Them!

Mounting Pins

ID Labels

Spreading Board

Storage
Get out and start collecting!