Biodiversity, Invasive Species, and Plant Biosecurity

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Questions to be Answered

- What is biodiversity and why is it important?
- What are invasive species and how can they affect biodiversity?
- How are invasive species introduced?
- Who monitors for invasive species?
- What does plant biosecurity have to do with my pizza?
- What is agroterrorism?

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Vocabulary

- Native species
- Introduced species
- Invasive species
- Biodiversity
- Plant Biosecurity
- Vector
- Agroterrorism
- USDA -APHIS-PPQ Select Agent and Toxins

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What is Biodiversity?

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Fungi – USFWS
all others - PowerPoint clipart

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Why is Biodiversity Important?

Photo Credit:
PowerPoint clipart

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What Changes the Biodiversity in an Area?

- Weather events
- Natural catastrophes
- Climate change
- Land conversion
- Invasive species

Invasive species in our natural ecosystems

- Emerald ash borer

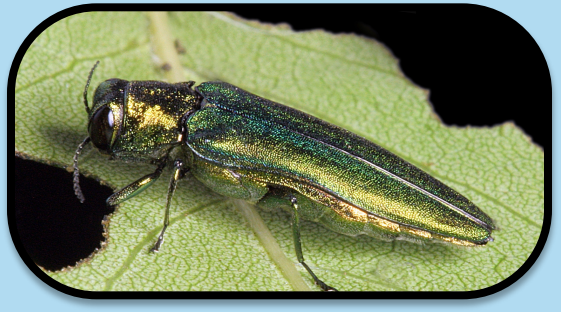

Photo Credit:
Damaged ash trees: Daniel Herms, The Ohio State University, www.bugwood.org, #5171038
Beetle: David Cappaert, Michigan State University, www.bugwood.org, #2106098
Larvae: David Cappaert, Michigan State University, www.bugwood.org, # 1460071
Tunnels: Art Wagner, USDA APHIS PPQ, www.bugwood.org, #5147090

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Invasive species in our natural ecosystems

- Asian long horned beetle

Photo Credit:
Chipping trees: Larry R. Barber, USDA Forest Service, www.bugwood.org, #3047034
Beetle: Michael Bohne, www.bugwood.org, #1262001
Larvae: Thomas B. Denholm, New Jersey Department of Agriculture, www.bugwood.org, #1253027
Tunnels: Steven Katovich, USDA Forest Service, www.bugwood.org, #1398111

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Invasive species in our natural ecosystems

- Sudden oak death

Photo Credit:
Joseph O'Brien, USDA Forest Service, www.bugwood.org, #1427112

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Invasive species in our natural ecosystems

- Laurel wilt

Photo credits:
Damage: CL Harmon, University of Florida
Adult and tunneling: Lyle Buss, University of Florida

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How are invasive species introduced?

Photo Credit:
Kudzu: Kerry Britton, USDA Forest Service, www.bugwood.org, #0002156
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Who monitors for invasive species?

- Department of Homeland Security - Customs and Border Protection (DHS-CBP)
- United States Department of Agriculture - Animal and Plant Health Inspection Service – Plant Protection and Quarantine (USDA-APHIS-PPQ)
- Cooperative Agricultural Pest Survey Program (CAPS Program)
- State Departments of Agriculture
- Others
- You

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What does plant biosecurity have to do with my pizza?

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For example…

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Invasive species that affect agriculture

- Brown marmorated stink bug

Photo credit:
adult: Susan Ellis, www.bugwood.org, #5369380
Egg and nymphs: David R. Lance, USDA APHIS PPQ, www.bugwood.org, #1460052
On fruit: Gary Bernon, USDA APHIS, www.bugwood.org, #1113016

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Invasive species that affect agriculture

- Citrus Greening

Photo credit:
Larvae: Lyle Buss, University of Florida
All others: Florida Department of Agriculture and Consumer Services, Division of Plant Industry – http://www.freshfromflorida.com/pi/chrp/greening/cgphotos.html

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Invasive species that affect agriculture

- Gumming Disease

Left: Healthy rye
Right: infected rye

Photo credit:
http://www.ars.usda.gov/SP2UserFiles/Place/00000000/opmp/RathayibacterPoisoningFeb2010.pdf

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Invasive species that affect agriculture

- Potato wart disease

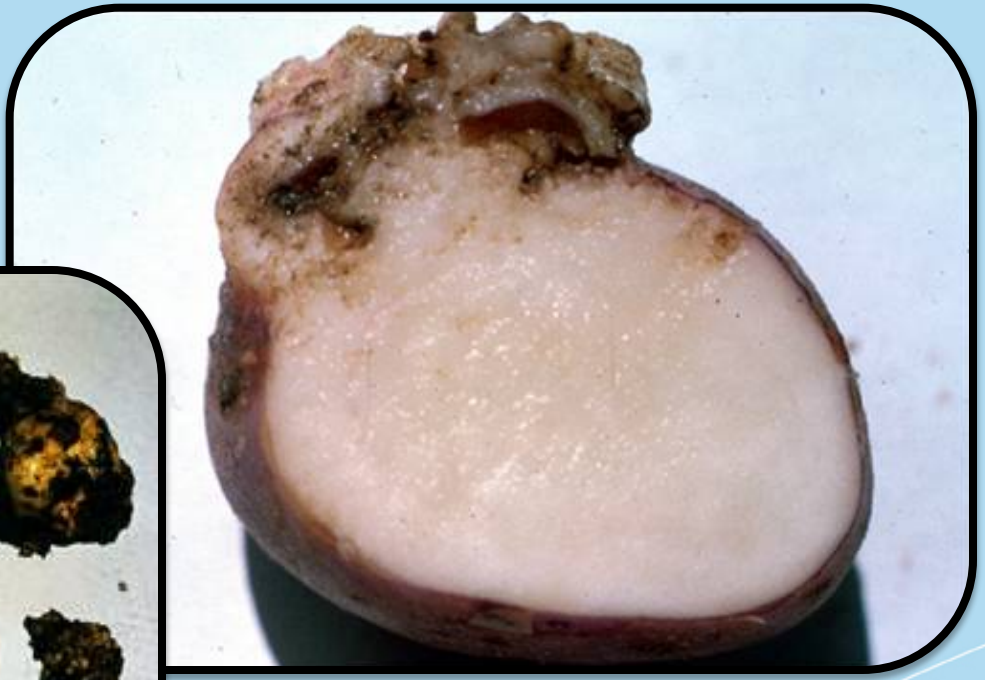

Photo credits:
Central Science Laboratory, Harpenden Archive, British Crown, www.bugwood.org, #0454023 and Michael Hampson, http://www.ars.usda.gov/SP2UserFiles/Place/00000000/opmp/PotatoWart70109.pdf

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What if someone introduced an invasive pest or disease on purpose?

- Glanders, anthrax, and rinderpest were introduced on purpose during both World Wars

Photo Credit: Scott Bauer, USDA-ARS, USDA-ARS Image Gallery, http://www.ars.usda.gov/is/graphics/photos/, Image No. k8855-1 and No. k4148-10

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What if someone tried to destroy a crop on purpose?

- Colorado potato beetle, Mercury poisoning oranges, and pesticide poisoning of grapes

Photo Credit:
Beetles: David Cappaert, Michigan State University, http://www.bugwood.org/, #5178045
Oranges: USDA-ARS Image Gallery, http://www.ars.usda.gov/is/graphics/photos/, #K3644-12
Grapes: Patrick Tregenza, USDA-ARS, USDA-ARS Image Gallery, http://www.ars.usda.gov/is/graphics/photos#K5632-3

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Crop Concerns – History or News?

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Summary

- Biodiversity is very important practically, economically, aesthetically and emotionally.
- Invasive species can drastically affect the biodiversity of our natural ecosystems.
- Invasive species can be introduced by accident or intentionally through international trade, human travel, and smuggling.
- There are many agencies and individuals that monitor for invasive species.
- Plant biosecurity is concerned with invasives that affect our natural ecosystems as well as invasives that can affect our food supply.
- There have been documented agroterrorism incidents in the past. Plant biosecurity is also concerned with potential agroterrorism events.

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Student Activity #1: Biodiversity Comparison

- Questions:
  - How do you calculate biodiversity?
  - How does the biodiversity of two different ecosystems compare?
  - Are there similarities in biodiversity between the two types of ecosystems?

How do you calculate biodiversity?

- Follow along in Student Handout 1A: How to Calculate Biodiversity
- We measure biodiversity using diversity indices:
  - A diversity index is a mathematical measure of species diversity in a given community.
  - It is based on the species richness (the number of species present) and species abundance (the number of individuals per species).
  - The more species you have, the more diverse the area, right?
  - However, there are two types of indices, dominance indices and information statistic indices.

The equations for the two indices we will study are…

- Shannon Index (H) = - $\sum_{i=1}^{s} p_i \ln p_i$

- Simpson Index (D) = $\frac{1}{\sum_{i=1}^{s} p_i^2}$

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Shannon Index

- Shannon Index (H) = - $\sum_{i=1}^{s} p_i \ln p_i$

- an information statistic index
  - It assumes all species are represented in a sample and that they are randomly sampled.
  - Can you point out any problems in these assumptions?
- **p** is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), **ln** is the natural log, **Σ** is the sum of the calculations, and **s** is the number of species.

Simpson Index

- Simpson Index (D) = $\frac{1}{\sum_{i=1}^{s} p_i^{\,2}}$
- a dominance index
  - It gives more weight to common or dominant species. In this case, a few rare species with only a few representatives will not affect the diversity.
  - Can you point out any problems in these assumptions?
- **p** is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), **Σ** is still the sum of the calculations, and **s** is the number of species.

Example 1

Order	description	number	(math)	p_i	p_i^2	ln p_i	p_i ln p_i
Orthoptera (grasshopper)	green with red legs	6	6/27	0.222	0.049	-1.505	-0.334
Orthoptera (grasshopper)	brown with a yellow stripe	5	5/27	0.185	0.034	-1.687	-0.312
Lepidoptera (butterfly)	large, blue	1	1/27	0.037	0.001	-3.297	-0.122
Lepidoptera (butterfly)	small, blue	3	3/27	0.111	0.012	-2.198	-0.244
Coleoptera (beetle)	red & blue	12	12/27	0.444	0.198	-0.812	-0.360

Example 1

- **s** (number of species) = 5
- **N** (total number of individuals) = 27
- **Σ** (sum) of $\mathbf{p_i^2}$ $(n/N)^2$ = 0.294
- **Σ** (sum) of $\mathbf{p_i \ln p_i}$ = -1.372

- **H** = -(-0.334 + -0.312 + -0.122 + -0.244 + -0.360) = **1.372**
- **D** = 1/ (0.049 + 0.034 + 0.001 + 0.012 + 0.198) = 1/0.294 = **3.4**

Example 2

order	description	number	(math)	p_i	p_i^2	ln p_i	p_i ln p_i
Hymenoptera (wasp)	black	12	12/91	0.132	0.017	-2.025	-0.267
Hymenoptera (wasp)	purple	21	21/91	0.231	0.053	-1.465	-0.338
Hymenoptera (bee)	striped	5	5/91	0.055	0.003	-2.900	-0.160
Orthoptera (grasshopper)	green with red legs	25	25/91	0.245	0.060	-1.406	-0.345
Orthoptera (grasshopper)	brown with a yellow stripe	2	2/91	0.022	0.0004	-3.817	-0.084
Lepidoptera (butterfly)	large, blue	17	17/91	0.187	0.035	-1.677	-0.314
Lepidoptera (butterfly)	small, blue	9	9/91	0.099	0.010	-2.313	-0.229

Example 2

- **s** (number of species) = 7
- **N** (total number of individuals) = 91
- **Σ** (sum) of $\mathbf{p_i^2}$ $(n/N)^2$ = 0.179
- **Σ** (sum) of $\mathbf{p_i}$ **ln** $\mathbf{p_i}$ = -1.736

- **H** = -(-0.267 + -0.338 + -0.160 + -0.345 + -0.084 + -0.314 + -0.229) = **1.736**
- **D** = 1/(0.017 + 0.053 + 0.003 + 0.060 + 0.00004 + 0.035 + 0.010) = **5.59**

- Which area is more diverse? The bigger number is more diverse.

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Community Similarity

- Calculating community similarities (what the communities have in common in terms of species) helps us determine if we are comparing apples to apples and oranges to oranges.
- There are many indices that do this, we will use Sorenson's coefficient.
- Sorenson's coefficient gives a value between 0 and 1, the closer the value is to 1, the more the communities have in common.
  - Complete community overlap is equal to 1, complete community dissimilarity is equal to 0.

Sorenson's Coefficient

- Sorenson's Coefficient (CC) = $\frac{2C}{S1+S2}$

- Where C is the number of species the two communities have in common, S1 is the total number of species found in community 1, and S2 is the total number of species found in community 2.

Example 1

- There are 20 species found in community 1 and 25 in community 2. Between them, they have 5 species in common. The calculation would be:
  - Sorenson's Coefficient (CC) = $\frac{2*5}{20+25}$ = 10/45 = 0.222
  - According to Sorenson's coefficient, these communities do not have much overlap or similarity.

Example 2

- There are 15 species found in community 1 and 25 in community 2. Between them, they have 12 species in common. The calculation would be:
  - Sorenson's Coefficient (CC) = $\frac{2*12}{15+25}$ = 24/40 = 0.6
  - According to Sorenson's coefficient, these communities have quite a bit of overlap or similarity.

For this assignment…

- Your group will be assigned one of three sampling methods
  - Visual search
    - Turn over rocks, turn over logs, look on leaves, and tree bark, collect what you see
    - Video of how to conduct a visual search
  - Beat sheet
    - For use on woody vegetation
    - Video of how to use a beat sheet
  - Sweep net
    - For use on non-woody vegetation
    - Video on how to use a sweep net
    - Video on how to remove organisms from a sweep net
    - Video on collecting flying insects from a sweep net
- Be sure to label your samples!

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For this assignment…

- Using Student Handout 1B: Biodiversity Worksheet, you will identify the adult insects you collected to the ordinal level using the dichotomous key and the hand lenses provided
  - Be sure to keep your sample sites separate!
  - Place all individuals of the same description together
    - For example, if you identified a wasp with brown and yellow stripes from site 1, write down the ordinal name (hymenoptera) and its description on the chart (brown and yellow stripes) and then count the number of individuals of this “species” you collected.
- Using this data, you will calculate the biodiversity of the two sites using the Shannon and Simpson Index
- You will also calculate the community similarity of the two sites using Sorenson’s Coefficient

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Review of Dichotomous Key Terms

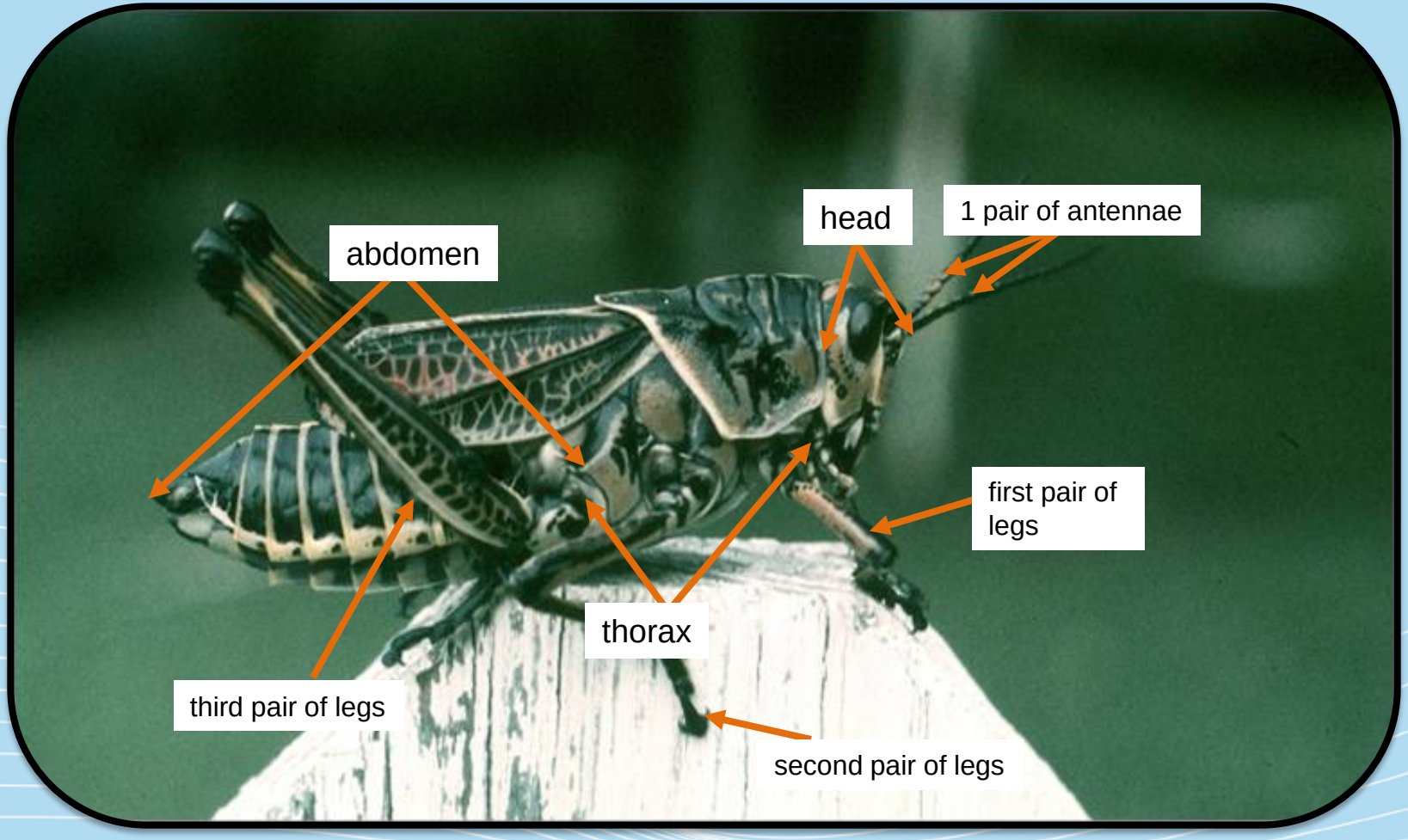

Photo Credit:
Jerry A. Payne, USDA Agricultural Research Service, www.bugwood.org, #1224208

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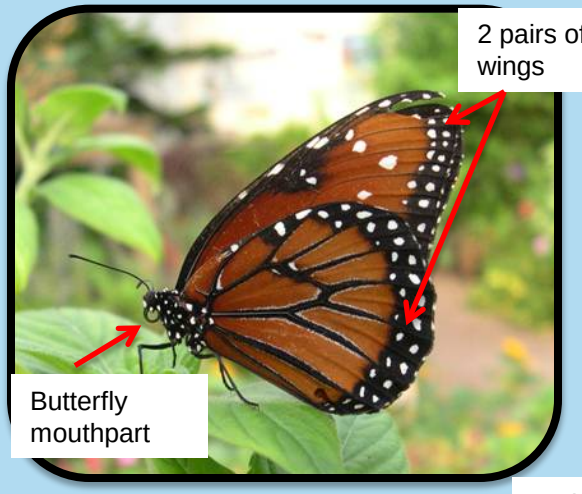
Review of Dichotomous Key Terms



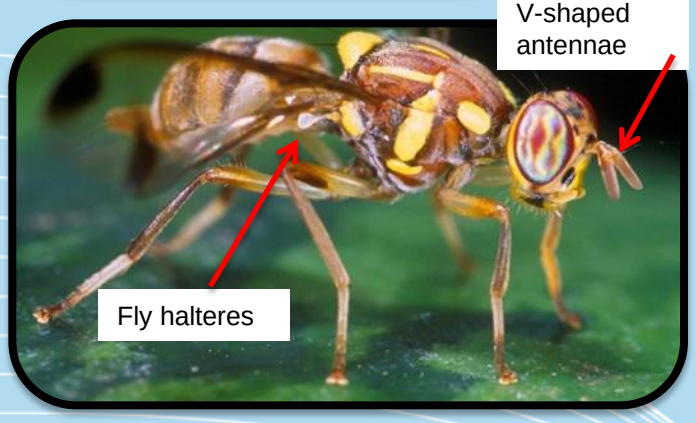
2 pairs of obvious wings

Butterfly mouthpart

Moths are more chunky and have more hair ↓

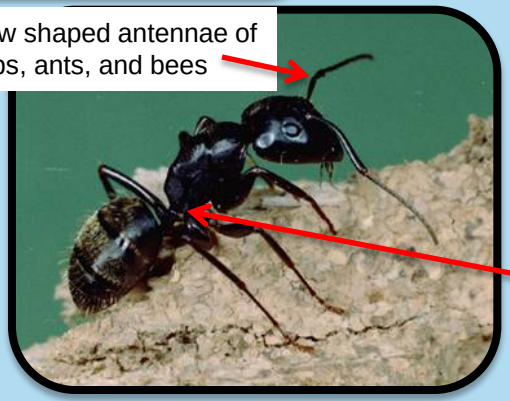
← Dragonfly

Damselfly ↓



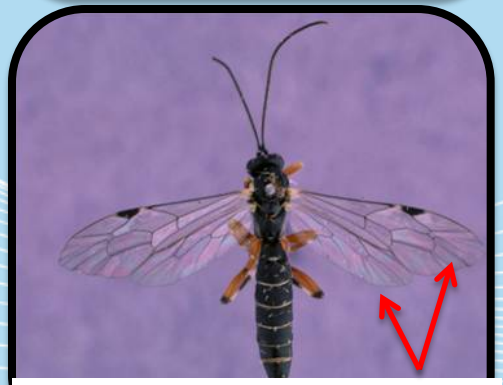
V-shaped antennae

Fly halteres



Elbow shaped antennae of wasps, ants, and bees

Narrow waist of wasps, ants, and bees



Hind wings are smaller than forewings in wasps, ants, and bees

Photo Credits:
Butterfly: Stephanie Stocks, University of Florida
Moth: Gerald J. Lenhard, Louisiana State Univ, www.bugwood.org, #0014195
Dragonfly: Edward L. Manigault, Clemson University Donated Collection, www.bugwood.org, #1225012
Damselfly: David Cappaert, Michigan State University, www.bugwood.org, #2158082
Fly: Scott Bauer, USDA Agricultural Research Service, www.bugwood.org, #1317036
Ant: Clemson University - USDA Cooperative Extension Slide Series, www.bugwood.org, #1234159
Wasp: Gerald J. Lenhard, Louiana State Univ, www.bugwood.org, #0014172
Bee: David Cappaert, Michigan State University, www.bugwood.org, #2186092

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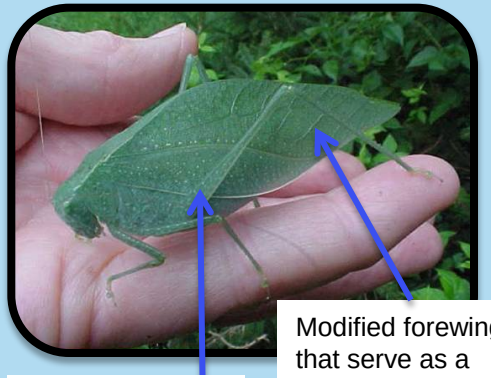
Review of Dichotomous Key Terms

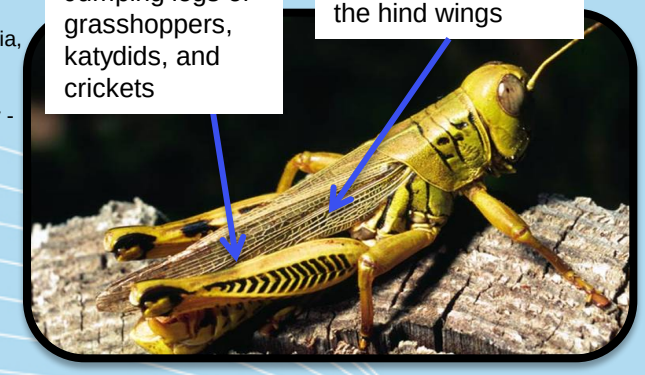
Photo Credit: Jeanine Soter, www.Bugwood.org, #9009001 and Gerald J. Lenhard, Louiana State Univ, www.bugwood.org, #0014088 and Gyorgy Csoka, Hungary Forest Research Institute, www.bugwood.org, #1231089

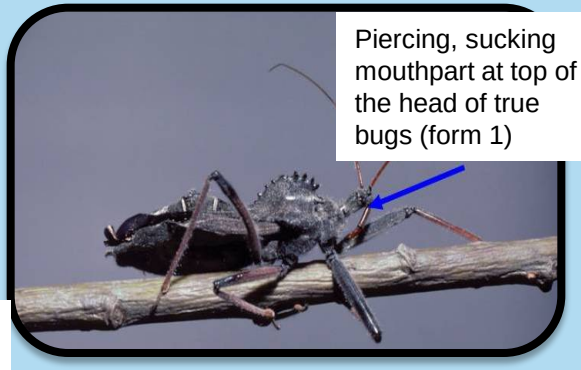


Modified forewings that serve as a protective cover for the hind wings

Jumping legs of grasshoppers, katydids, and crickets

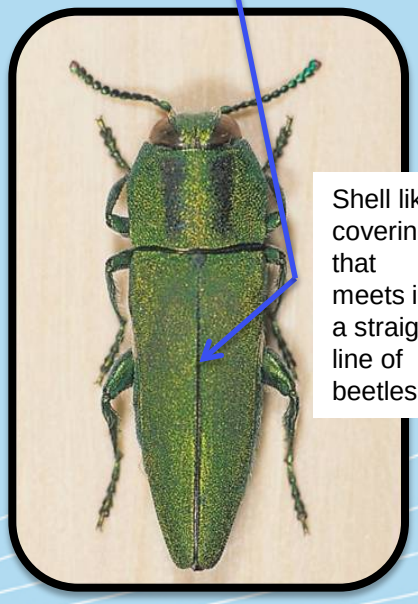
Photo Credit: David Riley, University of Georgia, www.bugwood.org, #2511007 and Clemson University - USDA Cooperative Extension Slide Series, www.bugwood.org, #1435020 and Gyorgy Csoka, Hungary Forest Research Institute, www.bugwood.org, #1231061





Piercing, sucking mouthpart at top of the head of true bugs (form 1)

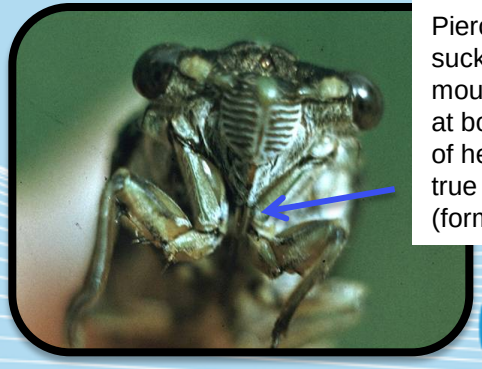
"X" on the back of true bugs (form 1)



Shell like covering that meets in a straight line of beetles

Photo Credit: Larry R. Barber, USDA Forest Service, www.bugwood.org, #0488089 and Edward L. Manigault, Clemson University Donated Collection, www.bugwood.org, #1225112

Wings held rooflike of true bugs (form 2)



Piercing, sucking mouthpart at bottom of head of true bugs (form 2)

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Student Activity #2: "Un-Wanted" Posters

- Question:
  - What do you think would happen to the biodiversity of a natural ecosystem found in the United States if an exotic pest or disease became established?
  - What do you think would happen to our food supply (and our health) if an exotic pest or disease became established in one of our agricultural systems?
  - How would you warn the public about it?

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For this assignment…

- You will research a plant, animal, or disease that is not found in the United States and then brainstorm what would happen to the biodiversity if it became established in a natural ecosystem or what would happen to our food supply (and health) if it established in an agricultural system.
- You may choose a pest or disease that is already known to cause problems in other countries or you can choose any plant or animal that is not already found here (such as hyenas or kangaroos or the European beech tree)
- Follow along in Student Handout: “Un-Wanted” Posters

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For this assignment…

- Questions to be answered:
  - To which country is this particular animal, plant, disease, etc. native and is it found anywhere else?
  - What habitat would you find this organism (average temperature, average rainfall, etc.)? Do you find a similar habitat here in the United States? If so, where?
  - What is the life history of this organism?
    - i.e. what does it look like, does it look different at different times in its life (particularly important if it is an insect), when does it become reproductive, what time during the year does it reproduce, how much offspring does it produce, how does it reproduce, how long does it live, does it undergo hibernation, what does it eat, is a similar food source found here, how does it disperse?
  - What impact could this organism have on an ecosystem found in the United States?

For this assignment…

- Take all the information you have found and put it together as an “Un-Wanted” Poster that you design in PowerPoint.
- Size you poster to be 40 inches X 30 inches
- Be sure to include images of the organism with your poster.
- Be sure to include your references.

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Student Activity #3: Computer Lab

- Go to the computer lab and complete the e-learning module.
- You must create a username and password.
- Go through the module and take the quiz at the end.
- If you pass with a 70% or better, print out the certificate of completion and turn it in for credit.
  - If you did not pass the quiz the first time, you may take the module again.

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- September 2011
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National Institute of Food and Agriculture (NIFA)

Center for Invasive Species and Ecosystem Health (i.e. the Bugwood Network)

Local and Regional Integrated Pest Management programs (IPM)

U.S. Department of Homeland Security (DHS)

USDA-APHIS

Extension Disaster Education Network (EDEN)

U.S. Forest Service

Cooperative Agriculture Pest Survey Program (CAPS)

National Plant Board (NPB) and State Departments of Agriculture

National Plant Diagnostic Network (NPDN)

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