PHC 6937: Water Biology

Aquatic Insects
Taxonomy, Ecology & BioControl Case Study

Dr. Jim Cuda, Associate Professor
Department of Entomology and Nematology
352-392-1901 x126 jcuda@ifas.ufl.edu

Research Area: Biological Control of Aquatic & Terrestrial Weeds


Topics

• Introduction
• Overview of Aquatic Insect Taxa
• Habitat Classification and Terminology
• Example of Trophic Organization and Function
  – Hydrilla BioControl Case Study
• Questions?

Topics

• Introduction
• Overview of Aquatic Insect Taxa
• Habitat Classification and Terminology
• Break
• Example of Trophic Organization and Function
  – Hydrilla BioControl Case Study
• Questions?
May Flies Stop Motorists

“Lawrence Rutz stops his truck on the west channel bridge at LaCrosse, WI, yesterday to clear mayflies from the front of the vehicle. The insects got so thick they obstructed the view of the driver, clogged radiators, and made the roadway of the bridge slippery.”

Chicago Daily News
July 8, 1946

Why Study Aquatic Insect Communities?

- Basic research on population dynamics
  - Predator-prey interactions
  - Trophic relationships
  - Competition studies
- Applied research (Pest Management)
  - Control of human and animal pests
    (e.g., mosquitoes, black flies, horse flies)
  - Pollution studies
    (e.g., mayfly naids, moth fly larvae)
  - Biological control of aquatic weeds
    (e.g., alligatorweed, water hyacinth, Hydrilla, and Hygrophila)

Life History Adaptations for Aquatic Existence

- Osmoregulation
  - Wax layer
  - Excretion
- Gas exchange
  - Atmosphere
  - Plant breathers
  - Temporary & Permanent Air Stores
  - Tracheal Gills
  - Oxygen transport (adults)
  - Hemoglobin
- Temperature
  - Thermal death 30 to 40° C
Topics

- Introduction
- Overview of Aquatic Insect Taxa
- Habitat Classification and Terminology
- Break
- Example of Trophic Organization and Function
  - Hydrilla BioControl Case Study
- Questions?

Higher Classification Scheme

- Phylum Arthropoda
  - Class Insecta (Insects)
    - Subclass Apterygota (w/o Wings)
      - Order Collembola (Springtails)
    - Subclass Pterygota (w/ Wings)
      - Infraclass Paleoptera (Wings cannot twist)
        - Order Ephemeroptera * (Mayflies)
        - Order Odonata * (Dragonflies & Damselflies)
      - Infraclass Neoptera (Wings can twist at base)
        - Division Exopterygota (Wings develop ext.)
          - Order Plecoptera (Stoneflies)
          - Order Hemiptera (True Bugs & Hoppers)

Classification Scheme (cont’d)

- Subclass Pterygota
  - Infraclass Neoptera
    - Division Endopterygota (Wings develop int.)
      - Order Neuroptera (Dobsonflies, etc.)
      - Order Trichoptera * (Caddisflies)
      - Order Lepidoptera (Moths)
      - Order Coleoptera (Beetles)
      - Order Hymenoptera (Wasps)
      - Order Diptera (Moth flies, Mosquitoes, Midge)
  * Entirely aquatic
Order Collembola- Springtails
• Small Size
• Antennae Short
• Simple Eyes
• Presence of Forked Abdominal Appendage
• Chewing/Stylet Mouthparts
• Detrivores
• Simple Metamorphosis
  – Immatures and Adults Live in Same Habitat
  – Primitively Wingless

Order Ephemeroptera- Mayflies
• Small to Medium Size
• Antennae Bristle-like
• 2 to 3 Thread-like Tails
• Nymphs (Naiads) w/ Abdominal Gills
• Wings Triangular & Held Upright at Rest
• Chewing Mouthparts
• Detrivores
• Simple Metamorphosis
  – Molt as Winged Adults

Order Odonata- Dragon- & Damselflies
• Medium to Large Size
• Large Compound Eyes
• Antennae Bristle-like
• Chewing Mouthparts
• Nymphs (Naiads) w/ Abdominal or Rectal Gills
• Wings Elongate & Held Dorsally or Laterally at Rest
• Predaceous
• Simple Metamorphosis
Order Plecoptera- Stoneflies
- Small to Medium Size
- Antennae Long, Slender
- Chewing Mouthparts
- Membranous Wings Folded Flat Over Body
- Body Soft, Flattened
- Cerci Present
- Omnivores
- Branched Gills on Thorax
- Simple Metamorphosis

Order Hemiptera- True Bugs
- Small to Large Size
- Antennae Bristle-like
- Piercing Mouthparts
- Wings Membranous at Apex
- Body Slender to Oval
- Raptorial Front Legs
- Predaceous
- Breathing Tube or Air Bubble
- Simple Metamorphosis

Giant Water Bug Outbreak
Customers stomp and cringe as swarms cover a Pasco shopping plaza. They’re huge, creepy - and crunchy in sauce.

By ALEX LEARY, Times Staff Writer
© St. Petersburg Times published June 21, 2003

Electric Light Bug, Lethocerus sp.
Order Neuroptera- Dobsonflies, etc.
- Small to Large Size
- Antennae Long, Slender
- Chewing Mouthparts
- Wings Membranous w/ Numerous Cross Veins
  - Held Roof-like Over Body
- Lateral Abdominal Gills
- Predaceous
- Complete Metamorphosis

Order Trichoptera- Caddisflies
- Small to Medium Size
- Antennae Long, Slender
- Chewing Mouthparts
- Wings Hairy, w/ Scales
  - Held Roof-like Over Body
- Larvae Caterpillar-like
  - Construct Cases
- Omnivorous
- Complete Metamorphosis

Order Lepidoptera- Moths
- Small to Medium Size
- Antennae Variable
- Sucking (A) / Chewing Mouthparts (L)
- Scales on Wings
- Respiration Variable
  - Cutaneous, Air Bubble, Tracheal Gills
- Phytophagous
- Complete Metamorphosis

Photo Credit: www.cals.ncsu.edu
Photo Credits: J. Hodges & T. Murray
Waterlily leafcutter, Synclita obliteralis (Lep.: Crambidae)
Order Coleoptera- Beetles

- Small to Large Size
- Antennae Variable
- Chewing Mouthparts
- Hardened Wings (Elytra)
- Respiration Variable
  - Plastron, Air Bubble, Abdominal Gills
- Predaceous
- Complete Metamorphosis

Photo Credit: S. Boucher

Order Hymenoptera- Wasps

- Small in Size
- Antennae Long
- Chewing Mouthparts
- Membranous Wings
- Respiration Variable
  - Air Bubble, Cutaneous
- Parasitic
- Complete Metamorphosis

Photo Credit: P. Coon

Order Diptera- Flies

- Small to Medium Size
- Antennae Variable
- Sucking / Chewing Mouthparts
- 1 Pair Membranous Wings
- Respiration Variable
  - Cutaneous, Air Tubes
- Omnivorous
- Complete Metamorphosis

Photo Credit: A. Wild & J. Neuwanger
Topics

• Introduction
• Overview of Aquatic Insect Taxa
• Habitat Classification and Terminology
• Break
• Example of Trophic Organization and Function
  – Hydrilla BioControl Case Study
• Questions?

Aquatic Habitat Classification System

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivers</td>
<td></td>
</tr>
<tr>
<td>• Lotic-erosional</td>
<td>– running-water riffles</td>
</tr>
<tr>
<td>• Lotic-depositional</td>
<td>– running-water pools</td>
</tr>
<tr>
<td>Lakes</td>
<td></td>
</tr>
<tr>
<td>• Lentic-limnetic</td>
<td>– open water (shallow)</td>
</tr>
<tr>
<td>• Lentic-littoral</td>
<td>– shallow shore area</td>
</tr>
<tr>
<td>• Lentic-profundal</td>
<td>– open water (deep)</td>
</tr>
<tr>
<td>• Benthos</td>
<td>– sediments</td>
</tr>
</tbody>
</table>

Merritt & Cummins (1996)
**Lentic (Lake) Communities & Zones**

- **Surface Film**
  - Pleuston - Surface Dwelling Organisms
- **Limnetic Zone** - Open Water to Light
- **Penetration Limit**
  - Nekton - Free Swimming Organisms
  - Plankton - Free Floating Organisms
- **Littoral Zone** - Shallow Region Where Plants Grow
  - Diverse Assemblage of Insects
- **Profundal Zone** - Low Light, No Plant Growth → Low O₂ Levels
- **Benthos** - Sediment

---

**Lentic Communities and Zones**

(Perry & Cummins 1996)

---

**Modes of Existence in Aquatic Habitats**

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pleuston</strong></td>
<td>Hemiptera: Gerridae</td>
</tr>
<tr>
<td></td>
<td>Diptera: Culicidae</td>
</tr>
<tr>
<td><strong>Limnetic / Littoral</strong></td>
<td></td>
</tr>
<tr>
<td>Divers</td>
<td>Coleoptera: Dytiscidae</td>
</tr>
<tr>
<td>Swimmers</td>
<td>Ephemeroptera: Siphlonuridae</td>
</tr>
<tr>
<td>Clingers</td>
<td>Trichoptera: Hydropsychidae</td>
</tr>
<tr>
<td>Sprawlers</td>
<td>Odonata: Libellulidae</td>
</tr>
<tr>
<td>Climbers</td>
<td>Odonata: Aeshnidae</td>
</tr>
<tr>
<td><strong>Benthos</strong></td>
<td>Burrowers: Diptera: Chironomidae</td>
</tr>
</tbody>
</table>

Merritt & Cummins (1996)
### Functional Feeding Groups

<table>
<thead>
<tr>
<th>Category</th>
<th>Food Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shredders</td>
<td>Living plant tissue</td>
</tr>
<tr>
<td>Collectors</td>
<td>Decomposing FPOM</td>
</tr>
<tr>
<td>Scrapers</td>
<td>Periphyton and CPOM</td>
</tr>
<tr>
<td>Piercers</td>
<td>Algae and plant cell fluids</td>
</tr>
<tr>
<td>Predators</td>
<td>Animal tissue (multiple prey)</td>
</tr>
<tr>
<td>Parasitoids</td>
<td>Animal tissue (single prey)</td>
</tr>
</tbody>
</table>

Merritt & Cummins (1996)

### Topics

- Introduction
- Overview of Aquatic Insect Taxa
- Habitat Classification and Terminology
- Break
- Example of Trophic Organization and Function-
  - Hydrilla BioControl Case Study
- Questions?

### Topics

- Introduction
- Overview of Aquatic Insect Taxa
- Habitat Classification and Terminology
- Break
- Example of Trophic Organization and Function-
  - Hydrilla BioControl Case Study
- Questions?
Hydrilla verticillata (L.f.) Royle

- Rooted submersed aquatic plant
- Tropical and subtropical distribution
  - Native range: Africa, Asia, Australia
- Monotypic stands
  - Displace native spp.
  - Reduce biodiversity
- Dense surface mats
  - Impede navigation
  - Interfere with flood control

Why is Hydrilla Invasive?

Enemy Escape Hypothesis

- Native Specialist Enemies Control Abundance and Distribution of Native Plants
- Escape from Specialist Enemies is Key Contributor to Exotic Plant Success
- Enemy Escape Benefits Exotics Because They Gain a Competitive Advantage Over Native Plants as a Result of Being Liberated from Their Pests


Wakulla Springs, April 2002
HYDRILLA TROPHIC ORGANIZATION AND FUNCTION

Terrestrial Organic Nutrients → Microbes → CPOM → DOM → Microbes → Photosynthesis → Hydrilla (Non-native Producer)

Chironomids (Scrapers) (Collectors) → CPOM → Microbes → Chironomids (Scrapers) (Collectors)

Odonate naiads (Predators) → Hydrilla (Non-native Producer) → Chironomids (Scrapers) (Collectors)

Microbes → Classical BioControl Agents

Benthic Inorganic Nutrients → Light → Photosynthesis → Hydrilla (Non-native Producer) → Chironomids (Scrapers) (Collectors) → Microbes

FPOM → Microbes → Chironomids (Scrapers) (Collectors) → Odonate naiads (Predators)
Hydrellia pakistanae Deonier (Diptera: Ephydridae)

- Imported from India
- Released in 1987 by USDA
- Larvae - leaf miners
- Life cycle ~ 21 days
- Established Southeast US
- Ineffective ?

HYDRILLA TROPHIC ORGANIZATION AND FUNCTION

Terrestrial Organic Nutrients → Microbes → DOM → Microbes → Chironomids (Scrapers) (Collectors) → FPOM → Microbes → Benthic Inorganic Nutrients

Light → Photosynthesis

Hydrellia (Non-native Producer) → Feces

Odonate naiads (Predators) → Microbes

Hydrellia spp. (Shredders) → Microbes

Predator-Prey Cycles
CAIPS, 1995-1997

H. PAKISTANAE DENSITY (no. / m²)

DOM SUBSTRATE DENSITY (no. / m³)
**Trichopria columbiana** (Ashmead)  
(Hymenoptera: Diapriidae)

- Pupal endoparasitoid
- Parthenogenetic
  - *Wolbachia* induced?
- Females semi-aquatic
- Capture air under wings

**Factors Impacting *Hydrellia***

- Parasitism
  - Significant
  - Upwards of 30%
    - Late in growing season
  - Pupal parasitoid behavior
    - Selects wide range
    - Stage chosen = most successful

**Surface Temp. & Population Curves**  
CAIPS, 1995-1997

![Graph showing surface temp. & population curves](graph.png)
HYDRILLA TROPHIC ORGANIZATION AND FUNCTION

Terrestrial Organic Nutrients

CPOM

DOM

Microbes

Microbes

Chironomids (Scrapers) (Collectors)

FPOM

Microbes

Light

Photosynthesis

Benthic Inorganic Nutrients

Feces

Odonate naiaids (Predators)

Hydrilla (Non-native Producer)

Grilloptera

Shredders

Parapoynx

Microbes

Microbes

Microbes

Cricotopus

Shredders

Parapoynx

Hydrilla Attacking Moth

Parapoynx diminutalis Snellen

• Adventive spp. from Asia
• Collected in 1976, Ft. Lauderdale Area
• Principle host plant is hydrilla
• Introduced via aquarium trade
• Damage to hydrilla minimal and sporadic
• Poor biocontrol agent

HYDRILLA TROPHIC ORGANIZATION AND FUNCTION

Terrestrial Organic Nutrients

CPOM

DOM

Microbes

Microbes

Chironomids (Scrapers) (Collectors)

FPOM

Microbes

Light

Photosynthesis

Benthic Inorganic Nutrients

Feces

Odonate naiaids (Predators)

Hydrilla (Non-native Producer)

Grilloptera

Shredders

Parapoynx

Microbes

Microbes

Microbes

Cricotopus

Shredders

Parapoynx
Hydrilla Attacking Midge
*Cricotopus lebetis* Sublette

- Identified Dec 1998
- Collected in 1959, Natchitoches, LA
- Described 1964
- Hydrilla in Louisiana?
  - Natchitoches, 1973
- Immigrant or native species????

Life Cycle of *Cricotopus lebetis*

Hydrilla Growth Pattern
Glasshouse Tank Experiment, 1998
Topics

- Introduction
- Overview of Aquatic Insect Taxa
- Habitat Classification and Terminology
- Break
- Example of Trophic Organization and Function
  - Hydrilla BioControl Case Study
- Questions?