PHC 6937: Water Biology

Aquatic Insects

Taxonomy, Ecology & BioControl Case Study

Spring Semester 2011

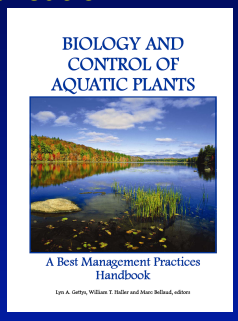
UF UNIVERSITY of FLORIDA
IFAS Research

Instructor

- Contact Information:
  - Dr. Jim Cuda, Associate Professor
  - Phone 352-273-3921
  - Email: jcuda@ufl.edu
- Research Area:
  - Biological Control of Aquatic and Terrestrial Weeds

2009 Publication

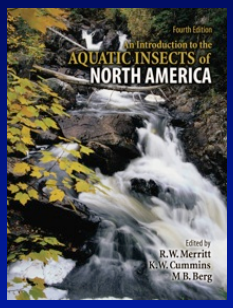
- Three Chapters:
  - Aquatic Plants, Mosquitoes & Public Health
    - Chapter 5
  - Introduction to BioControl of Aquatic Weeds
    - Chapter 8
  - Insects for BioControl of Aquatic Weeds
    - Chapter 9

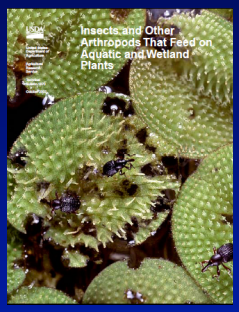


References

- Merritt, R. W., K. W. Cummins, and M.B. Berg (eds.). 2008. An Introduction to the Aquatic Insects of North America, 4thrd edition. Kendall / Hunt, Dubuque, IA
- Center, T. D., F. A. Dray, Jr., G. P. Jubinsky, and M. J. Grodowitz. 1999. Insects and Other Arthropods That Feed on Aquatic and Wetland Plants. USDA, Agricultural Research Service, Technical Bulletin No. 1870.

References





Topics

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

Learning Objectives

- Reasons for Studying Aquatic Insects
- Aquatic Existence Problems and Solutions
- Respiration Adaptations
- Scientific & Common Names of Aquatic Insect Orders
- Terminology for Major Aquatic Habitats
- Different Modes for Aquatic Existence
- Types of Functional Feeding Groups

Topics

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

Hell on Earth

- Rainy Season Triggers Midge Swarms on Lake Victoria, Africa
- Locals Catch & Eat Insects
- 'Patty' Composed of 0.5 Million Contain 7X More Protein Than Beef

www.dailymail.co.uk/sciencetech/article-11042...

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, midges, black flies, horse flies)
  - Pollution Studies
    (e.g., mayfly naiads, midge & 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^{o} C

Topics

- Introduction
- Overview of Aquatic Insect Taxa
- Habitat Classification and Terminology
- Example of Trophic Organization and Function
  - Hydrilla Midge 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 Pleocoptera *(Stoneflies)
          - Order Hemiptera (True Bugs & Hoppers)

* Entirely aquatic

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, Midges)

* Entirely aquatic

Order Collembola- Springtails

- Small Size
- Antennae Short
- Simple Eyes
- Presence of Forked Abdominal Appendage
- Chewing/Stylet Mouthparts
- Detritivores
- Simple Metamorphosis
  - Immatures and Adults Live in Same Habitat
  - Primitively Wingless

Photo Credit: S. Hopkin

Order Ephemeroptera- Mayflies

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

Photo Credit: G. Firebaugh

Order Odonata- Dragon- & Damselflies

- Medium to Large Size
- Large Compound Eyes
- Antennae Bristle-like
- Chewing Mouthparts
- Nymphs (Naiads) w/ Terminal Abdominal or Rectal Gills
- Wings Elongate & Held Dorsally or Laterally at Rest
- Predaceous
- Simple Metamorphosis

Photo Credit: P. Myers

Order Plecoptera- Stoneflies

- Small to Medium Size
- Antennae Long, Slender
- Chewing Mouthparts
- Membranous Wings Folded Flat Over Body
- Body Soft, Flattened
- Cerci Present
- Branched Gills on Thorax
- Omnivores
- Simple Metamorphosis

Photo Credit: S. Houston & T. Murray

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

Photo Credit: www.cals.ncsu.edu

Giant Water Bug Outbreak

St.Petersburg Times ONLINE TAMPA BAY

The invasion of the giant water bug

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

Photo Credit: www.cals.ncsu.edu

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

Photo Credits: J. Hodges & T. Murray

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

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

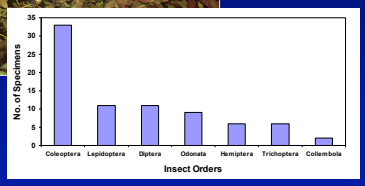
Photo Credit: P. Coon

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. Neuswanger

Hygrophila Survey 2007



Topics

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

Aquatic Habitat Classification System

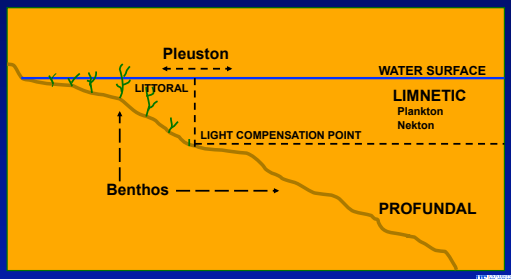
Category	Description
Rivers	
• Lotic-erosional	– running-water riffles
• Lotic-depositional	– running-water pools
Lakes	
• Lentic-limnetic	– open water (shallow)
• Lentic-littoral	– shallow shore area
• Lentic-profundal	– open water (deep)
• Benthos	– sediments

Merritt et al. (2007)

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 O_2 Levels
- Benthos- Sediment

Lentic Communities and Zones
(Merritt et al. 2007)



Modes of Existence in Aquatic Habitats

Category	Examples
• *Pleuston*	– Hemiptera: Gerridae
	– Diptera: Culicidae
• *Limnetic / Littoral*	
– Divers	– Coleoptera: Dytiscidae
– Swimmers	– Ephemeroptera: Siphlonuridae
– Clingers	– Trichoptera: Hydropsychidae
– Sprawlers	– Odonata: Libellulidae
– Climbers	– Odonata: Aeshnidae
• *Benthos*	
– Burrowers	– Diptera: Chironomidae

Merritt et al. (2007)

Functional Feeding Groups

Category	Food Type
• Shredders	– Living plant tissue
• Collectors	– Decomposing FPOM
• Scrapers	– Periphyton and CPOM
• Piercers	– Algae and plant cell fluids
• Predators	– Animal tissue (multiple prey)
• Parasitoids	– Animal tissue (single prey)

Merritt et al. (2007)

Topics

- Introduction
- Overview of Aquatic Insect Taxa
- Habitat Classification and Terminology
- **Example of Trophic Organization and Function-**
  - **Hydrilla Midge 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

http://www.dep.state.fl.us/lands/invaspec/index.htm

Hydrilla's Impact on Wildlife

WEED SCIENCE SOCIETY OF AMERICA

Weeds Won't Wait: Don't Hesitate

For Immediate Release

Contact: Lisa Garhan
630.836.9412
lisag@achievainc.com

Weed Science Society of America
Invasive Plant Spotlight

ALGAE-HARBORING HYDRILLA CAUSING BALD EAGLE DEATHS IN THE SOUTHEAST

LAWRENCE, Kan. (March, 31, 2008) — The aquatic invasive plant hydrilla (*Hydrilla verticillata*) not only is a costly nuisance impeding waterways and recreational lakes, it also may have deadly impacts on eagles and waterfowl. Its invasive nature earned it a spot on the Federal Noxious Weed list in 1979 and it is the topic of this Invasive Plant Spotlight from the Weed Science Society of America.

Hydrilla is a quick growing, invasive plant that forms a dense mat in lakes, ponds and reservoirs. It is a safe haven for the fast-growing epiphytic cyanobacterial algae, a blue-green algae, which grows on top of the hydrilla and is potentially toxic to birds. It is suspected that when waterfowl, namely coots, eat the algae-harboring hydrilla, they become poisoned by the algae's neurotoxins and subsequently suffer from a neurological disease known as avian vacuolar myelinopathy. The eagles, in turn, eat the infected coots and succumb to the disease as well.

"According to the research, avian vacuolar myelinopathy was first documented in 1994 at DeGray Lake in Arkansas," says Susan B. Wilde, Ph.D., research professor at the University of South Carolina and member of the Weed Science Society of America. "Since then, more than one hundred bald eagle deaths are believed to be associated with the disease. And it is estimated that the numbers of deaths are much higher, but because of scavenging animals, it often is difficult to recover the carcasses of dead eagles soon enough to test for the disease. But in places where dead eagles are found, invasive aquatic vegetation—primarily hydrilla—and the blue-green algae are always present," says Wilde.

Hydrilla is an invasive plant that originated in India and Asia. It was first introduced into the United States as an aquarium plant back in the 1950s. Improper disposal of hydrilla from aquariums, distribution through animal contact and the plant's ability to "hitchhike" on boats that have been in multiple bodies of water and not cleaned underneath after each use, has lead to its voracious spread over the years. "Hydrilla is most prevalent in the southeast but can be found in fresh water lakes and rivers in most coastal states," says Wilde.

more

Algae-Harboring Hydrilla Causing Bald Eagle Deaths in the Southeast

Why is Hydrilla Invasive?

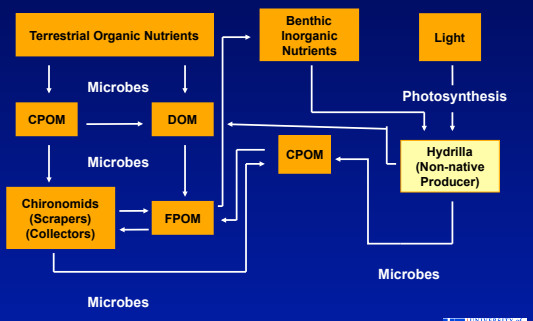
Enemy Escape Hypothesis

- 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

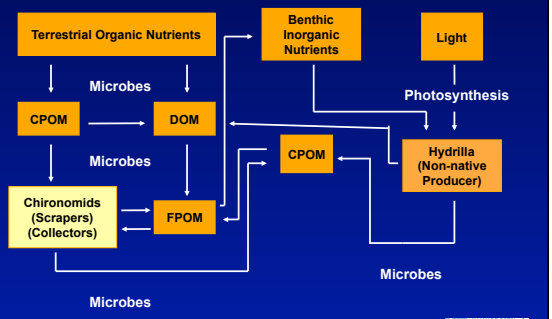
Williams, J. R. 1954. The biological control of weeds. - In: Report of the Sixth Commonwealth Entomological Congress, London, UK, pp. 95-98.

Wakulla Springs, April 2002

HYDRILLA TROPHIC ORGANIZATION AND FUNCTION



HYDRILLA TROPHIC ORGANIZATION AND FUNCTION

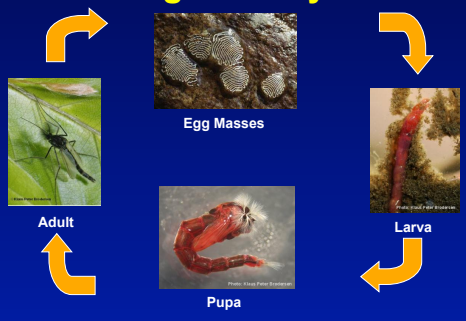


Chironomidae - Midges

- Non-Biting Primitive Flies
- Inhabit Variety of Aquatic Habitats
- Larvae are Beneficial
  - Food for Fish, Birds, and Invertebrates
  - Recycle Organic Nutrients
  - Indicators of Pollution
- Adults Considered Pests
  - Swarms Cause Asphyxia in Cattle, Driving Accidents, Contaminate Food, Transport Bacteria, Allergic Reactions

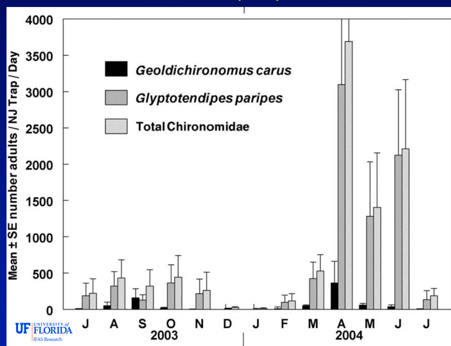
Ali (1996)

Midge Life Cycle



Pestiferous Midge, *Glyptotendipes paripes*

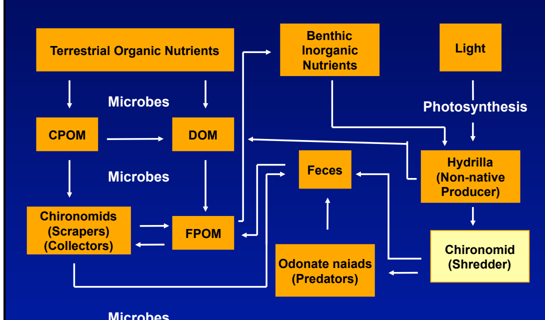
Ali et al. (2008)



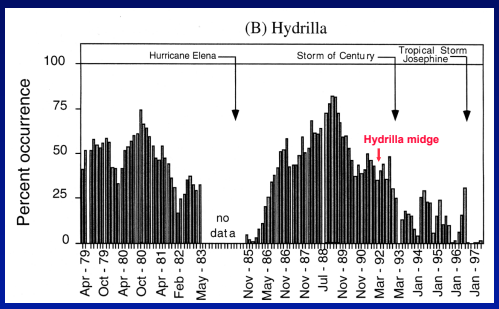
Chironomus plumosus L.

Bugs bite Yankees, Indians pick up win

HYDRILLA TROPHIC ORGANIZATION AND FUNCTION



Crystal River, Citrus County, FL



Mataraza et al. (1999)

Crystal River, Citrus County, 1998

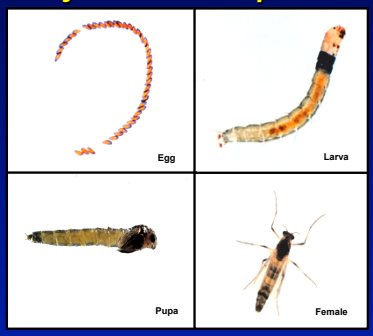
Why isn't Hydrilla a Problem?

Hydrilla Midge
Cricotopus lebetis Sublette

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

Epler et al. (2000)

Life Cycle of *Cricotopus lebetis*

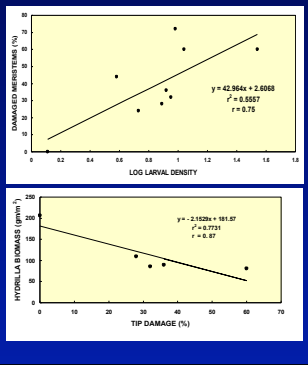


Cuda et al. (1999, 2002)

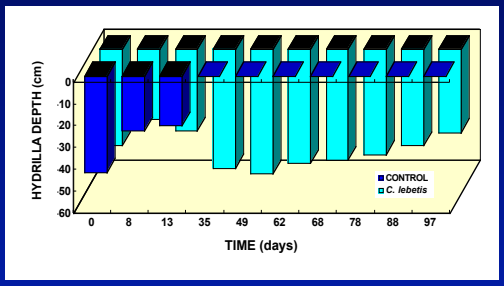
Larvae and Associated Tip Damage

Cuda et al. (2002, 2010)

Plantation Inn Canal, 1998



Hydrilla Growth Patterns
Glasshouse Experiment, 1998



Block 1: Control

Block 1: Midge

Web Sites

Center for Aquatic and Invasive Plants
Institute of Food and Agricultural Sciences
UNIVERSITY OF FLORIDA

http://plants.ifas.ufl.edu/

Plant Management in Florida Waters
Invasive plants and related issues for lakes, rivers, springs, marshes, swamps and canals

http://plants.ifas.ufl.edu/guide/biocons.html

IPM Integrated Pest Management Florida

http://ipm.ifas.ufl.edu/

Topics

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