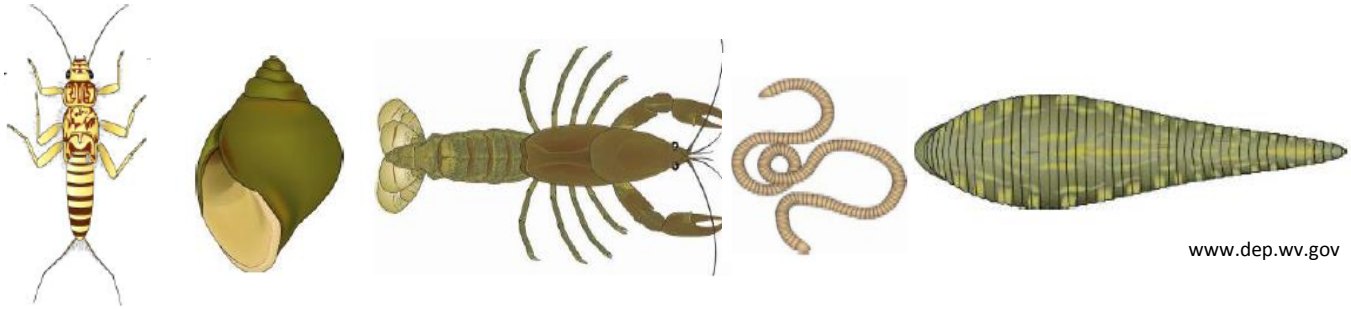
Aquatic Macroinvertebrates 101

Definition

- Spineless organisms that can be seen with the naked eye
- Aquatic forms require water for at least one part of their life cycle
- Examples: Insects, Mollusks, Crustaceans, Worms, Leeches



www.dep.wv.gov

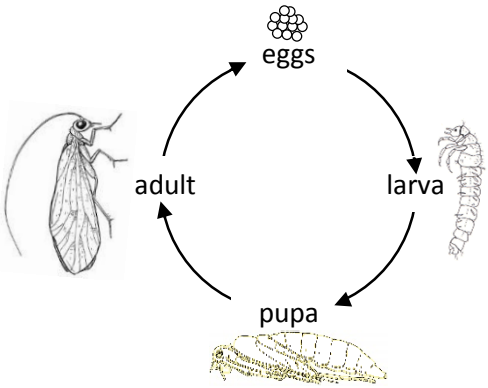
Biological Indicators

After sampling a site, the community of macroinvertebrates is identified and entered into an Index of Biotic Integrity (IBI). An IBI is a multi-metric index that calculates an overall score of biological integrity for the sample location. Macroinvertebrates are suitable indicators because they are:

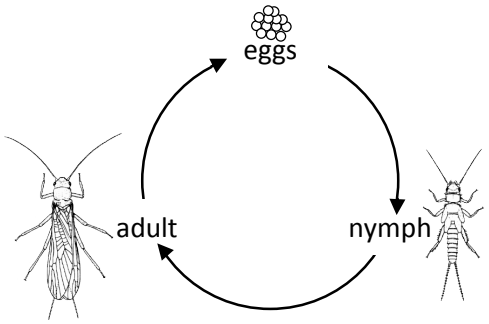
- Highly adapted to specific environments
- Ubiquitous and present in nearly every aquatic habitat on the planet
- Relatively stationary, providing an assessment of specific sample locations
- Variably sensitive/tolerant to pollution and stressors
- Able to integrate impacts through time (versus a water chemistry grab sample "snapshot")

Aquatic Insect Life Cycles

- 2 weeks to 2+ years with 1 to all life cycles spent in water
- Two types of development: complete and incomplete metamorphosis



Complete Metamorphosis
Larvae different from adult
Flies, beetles, caddisflies



Incomplete Metamorphosis
Larvae similar to adult
Mayflies, stoneflies, dragonflies, true bugs

biokeys.berkeley.edu; cals.ncsu.edu

Functional Feeding Groups (FFGs)

FFG	How they Eat	What they Eat	Habitat
Predators	Bodies designed to chase, capture, and kill prey	Catch and eat live organisms	All habitat types but more diverse in stable environments
Collector-filterers	Catch food through filtering devices, such as net-like structures	Fine and dissolved organic matter suspended in water column	Usually on stream substrates
Collector-gatherers	Physically gather food	Decomposing fine organic matter in and on sediment	Stream bottom sediment
Scrapers/Grazers	Use special razor-like mouthparts to scrape	Scrape algae off of rocks and organic surfaces	Areas in stream (usually rocks) with enough light to make algae grow
Shredders	Use chewing mouthparts designed to shred, cut, bite or bore	Leaves and vegetation (CPOM) and wood	Areas in stream with lots of tree canopy cover

Habit/Behavior

Habit	Description
Clinger	Remain stationary on bottom substrates in flowing waters
Climber	Feed on SAV by climbing
Sprawler	Found on surface of SAV and substrates
Burrower	Feed on fine organic matter while buried in sediments
Swimmer	Controls velocity and direction of movements
Diver	Swims from surface to bottom of water column

Main Factors Influencing Habitat Utilization

Physiological Constraints	Trophic Considerations	Biotic Interactions	Physical Constraints
O_2 Availability Temperature Osmoregulation	Food Acquisition	Competition, Predation	Habitat Conditions (ex: current)

Types of Aquatic Environments

Flowing waters (streams)
More often headwaters but can be larger
Characteristic riffle-pool sequence
Riffles, rapids, waterfalls keep water oxygenated
Water velocity can be very high
Sediment deposition typically low
Variety of inorganic substrates present
Coarse organic matter (e.g. leaves, woody debris)

Flowing waters (streams)
Where slope of land is flatter (e.g. coastal plain)
Characteristic meanders, runs, and bends
Water velocity slower
Higher fine inorganic and organic deposition
Potential for excess silt and sedimentation
Less aeration and higher oxygen limitation

Non-flowing waters (wetlands, lakes, etc.)
Wet year-round
May have hypoxic or anoxic conditions
Major biotic interactions (predation, competition)
Fine inorganic substrates (silt, muck)
Aquatic vegetation prevalent

Flowing and non-flowing waters
Ephemeral, wet during only part of the year
Major physiological constraints
Alternating wet and dry periods
Oxygen limitation
Extreme temperature fluctuations

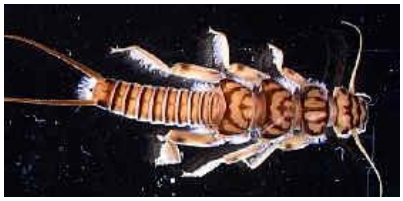
Lotic Environments: High Gradient

Major Environmental Challenge:
Physical constraints, most notably the churning high velocity water in riffles and rapids

Adaptations:

Respiration

Cutaneous
Gas exchange through general body surface



Tracheal Gills
Lamellate or Filamentous

www.dec.state.ny.us

Morphological

Body Form

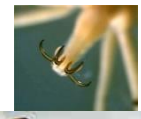
Streamlined

Dorsoventrally Flattened

Appendages

Hydraulic Suckers

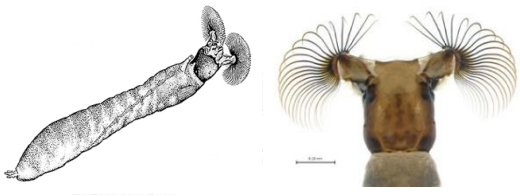
Hooks and Claws



Ballast
Heavy stones in caddisfly larvae cases

www.dec.state.ny.us; www.benthos.org/imagelibrary; Hynes 1970; Ward 1992

Unique Feeding Strategy:
Collector-Filterers utilize the current, remaining stationary and catching food as it flows past



Black fly larvae labral fans

Net-spinning caddisfly larvae

Hynes 1970; Wiggins 1996; www.benthos.org/imagelibrary

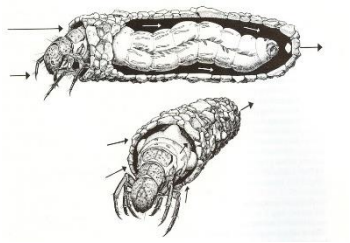
Lotic Environments: Low Gradient

Major Environmental Challenges:
Sediment deposition and oxygen stress

Adaptations:

Respiration

Creation of ventilatory currents



Large lamellate or operculate gills

Hynes 1970; Caucci and Nastasi 1986

Morphological

Covering of long, fine hairs

Burrowing hooks and tusks

Flattened Bodies and Lateral Projections

Cryptic Coloration

Ward 1992; Caucci and Nastasi 1986; www.benthos.org/imagelibrary

Unique Feeding Strategies:
Collector-Gatherers and predators

Unique Habits:
Burrowers, sprawlers, and climbers

Lentic Environments: Permanent Wetland Habitats

Major Environmental Challenges:
Biotic Interactions (predation, competition) important; oxygen limitation and anoxic conditions; fine sediments (silt, muck)

Adaptations:

Respiration

Respiratory tubes to acquire atmospheric oxygen

Physical gills to carry air on the body

www.benthos.org/imagelibrary

Morphological

Predatory Feeding Appendages

Extendable Labium

Piercing/Sucking Mouthparts

Scraping Appendages (Snails)

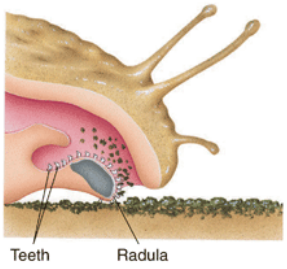
Hind Leg Swimming Modifications

Air/Water Surface Adaptations

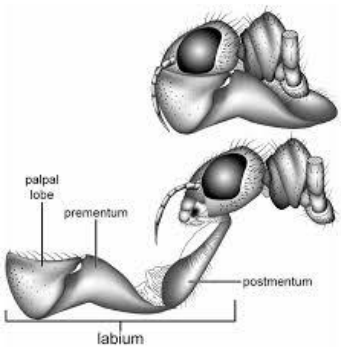
www.dec.state.ny.us; www.benthos.org/imagelibrary; Hynes 1970; www.waterbugkey.vcsu.edu; www.aquaticinsectsofcentralvirginia.blogspot.com

Unique Feeding Strategies:

Scrapers:



Predators:



www.jayreimer.com; www.cals.ncsu.edu

Unique Habits: Swimmers and Divers

Lotic and Lentic Environments: Temporary Habitats

Major Environmental Challenges:
Alternating wet/dry conditions; alternating lotic/lentic conditions; wide temperature fluctuations; oxygen limitation

Adaptations:

Respiration

Spiracular discs for "breathing" in air or water

http://www.landcareresearch.co.nz

Behavioral/Life Cycle

- Burrowing in substrates
- Long diapause or aestivation in egg stage
- Desiccation tolerance in egg or larval stage
- Rapid larval development and timing of emergence
- r-selective strategies
- Over-wintering in permanent water bodies; invading when water returns

Examples:

Fingernail clams close valves, burrow in substrate, enter dormant state in dry periods; populations in unstable habitats with shorter generation times and larger litter sizes than those in permanent habitats

Planorbid snails burrow in substrate, seal shell openings with dry mucous

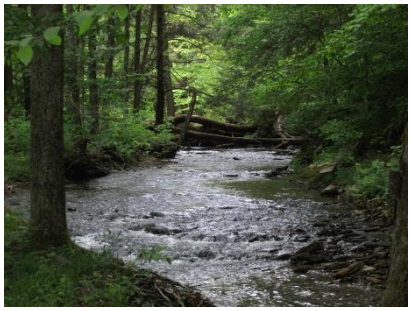
Siphlonuris mayflies oviposit in stream channel; eggs remain in channel during dry phase; immature larvae migrate to floodplain in late winter or early spring where they develop rapidly and emerge as terrestrial adults in late spring as the floodplain dries. *Leptophlebia* mayflies have similar seasonal migration trend

Limnephilus caddisfly larvae emerge in spring as adults before habitats dry; females enter ovarian diapause in terrestrial vegetation during dry period; re-emerge in fall to deposit desiccation-resistant egg masses under rocks and logs in areas that will experience inundation in the spring. First instar larvae remain in these protective, gelatinous matrices until water returns

Mature larvae of *Ironoquia* caddisflies burrow into the fallen leaves along banks or pool edges just before habitats dry and aestivates for several months before pupation.

www.dec.state.ny.us; Caucci and Nastasi 1986

Impacts to Aquatic Systems

	Healthy System (Reference Standard)	Impacted System
Streambank Erosion (Stream)	 • Coarse substrate (boulder, cobble, gravel) • High levels of dissolved oxygen • Clear water column (low turbidity) • Cold temperatures • Forest canopy	  • Riffle substrates embedded in fine sediment • Dissolved oxygen decreases • Suspended sediments (high turbidity) • Warmer temperatures • Open canopy

Flow Alteration (Riparian FP or W)	 
	• Persistent, seasonal hydroperiod
	  ○ SW & GW
	• Stable temperatures
	• Forest canopy
	  ○ Organic matter & woody debris
		 
		• Short, unpredictable hydroperiod
		  ○ SW & GW
		• High temperature fluctuations
		• Long drought periods
		• Open canopy
		  ○ Algae, fine sediment

Other Impacts

Agriculture and Waste Discharge

- Lower levels of dissolved oxygen—extremes (anoxia)
- High nutrient concentrations (e.g., phosphates, nitrates)

Road salts

- Increased salinity