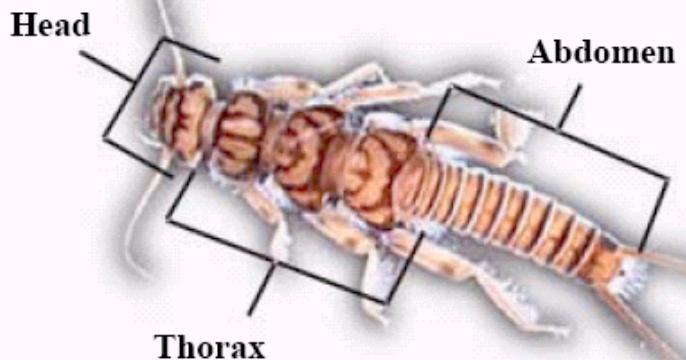


# Aquatic Benthic Macroinvertebrates

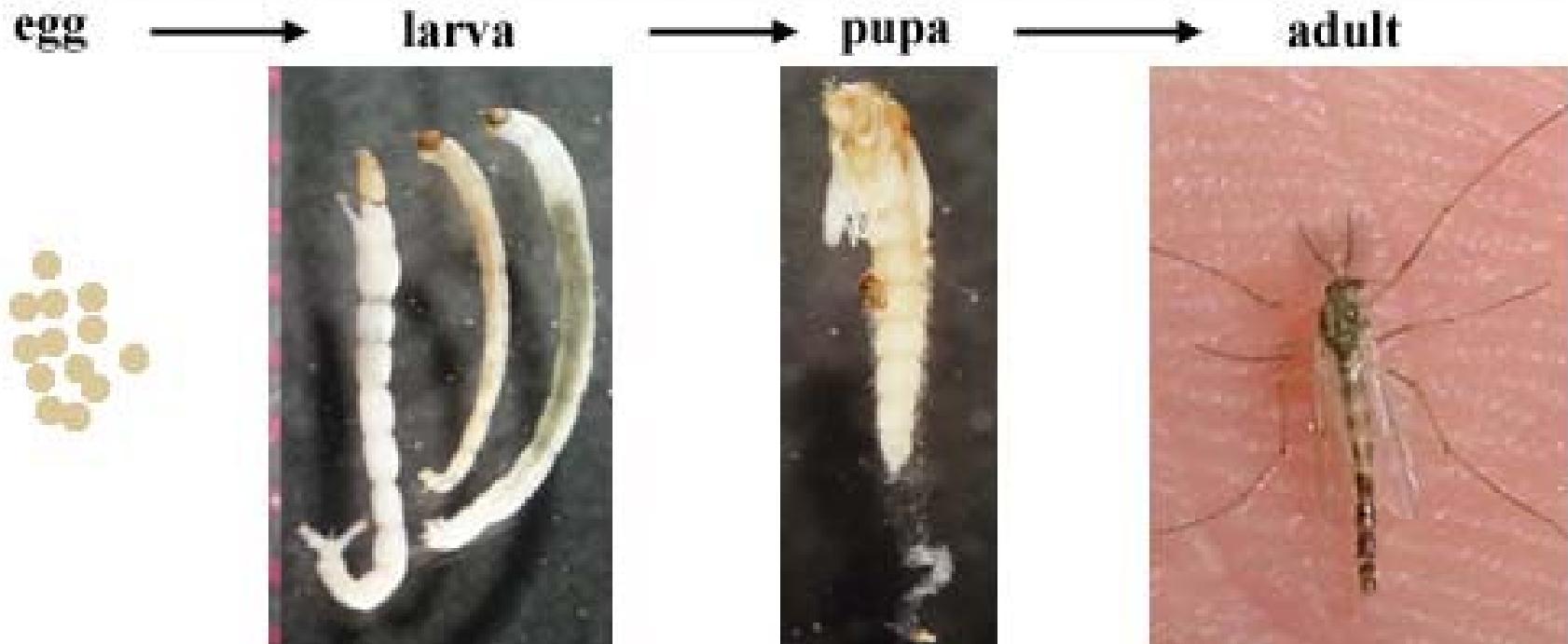
As Water Quality Indicators

# What Classifies an Insect?



1. Three segmented body
2. Three pairs of legs
3. Two pairs of wings or rudimentary wings

# Complete Metamorphism



# Incomplete Metamorphism

egg → larva → adult





# Aquatic Insect Orders

- **Ephemeroptera** (Mayflies)
- **Odonata** (Dragonflies & Damselflies)
- **Plecoptera** (Stoneflies)
- **Hemiptera** (True Bugs)
- **Trichoptera** (Caddisflies)
- **Lepidoptera** (Moths)
- **Coleoptera** (Beetles)
- **Megaloptera** (Dobsonflies, fishflies, alderflies)
- **Diptera** (True flies)

# Tolerance Values

How much pollution can you stand?

# Intolerant to:

- Low levels of DO
- High Water Temperature
- High Amounts of Sediment in Water
- Nutrient Enrichment
- Toxic chemicals and heavy metals

# Tolerance Values

On a scale of 0-10

- 0 = no tolerance
- 10 = very tolerant to pollution and low DO

# General Tolerance Ranges for Orders of Macroinvertebrates

- Ephemeroptera (Mayflies) 0-7
- Plecoptera (Stoneflies) 0-4
- Trichoptera (Caddisflies) 0-8
- Odonata (Dragonflies) 1-3  
    (Damselflies) 5-9
- Megaloptera (Dobsonflies) 0-4
- Diptera (True Flies) 2-10
- Coleoptera (Beetles) 2-5
- Crustacea (Crayfish, Scuds, Sowbougs) 4-7
- Mollusca (Snails, Clams) 6-8
- Oligochaeta, Hirudinea (Worms, Leeches) 8-10

# Habitat Requirements for Low Tolerance Organisms

- ☛ Riffles
- ☛ Mostly low order streams
- ☛ Clear, cold water
- ☛ High oxygen content
- ☛ Well shaded
- ☛ Low nutrients
- ☛ Relatively undisturbed

# Identifying Orders of Macroinvertebrates

# Quick Review

- Kingdom (Animalia)
  - Phylum (Arthropoda)
  - Class (Insecta)
  - Order (Plecoptera)
  - Family (Perlidae)
  - Genus (*Paragnetina*)
  - species (*media*)



Infra-Class: **Paleoptera** (old winged) ex: Ephemeroptera & Odonata

Infra-Class: **Neoptera** (new winged) ex: All other Aquatics

# For Comparison

- Kingdom (Animalia)
  - Phylum (Chordata)
    - Class (Mammalia)
      - Order (Carnivora)
        - Family (Canidae)
          - Genus (Canis)
            - \* Species (familiaris)
            - + Variety (Golden Retriever)



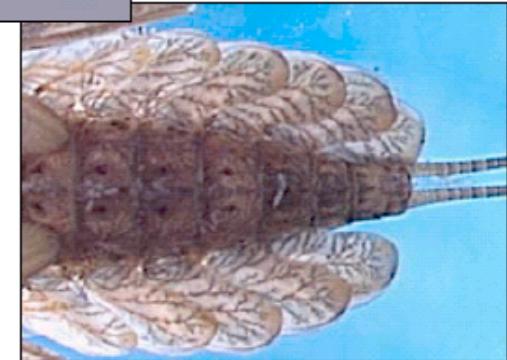
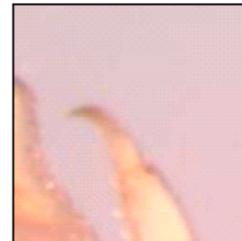
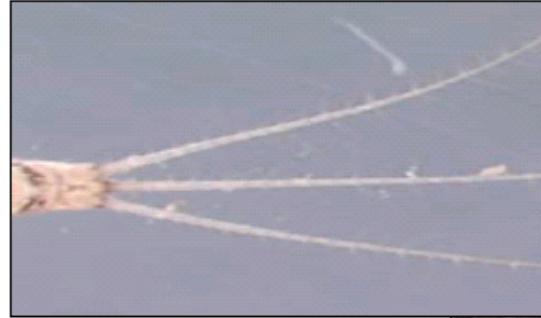
# Ephemeroptera (Mayflies)



# Ephemeroptera

## Identification

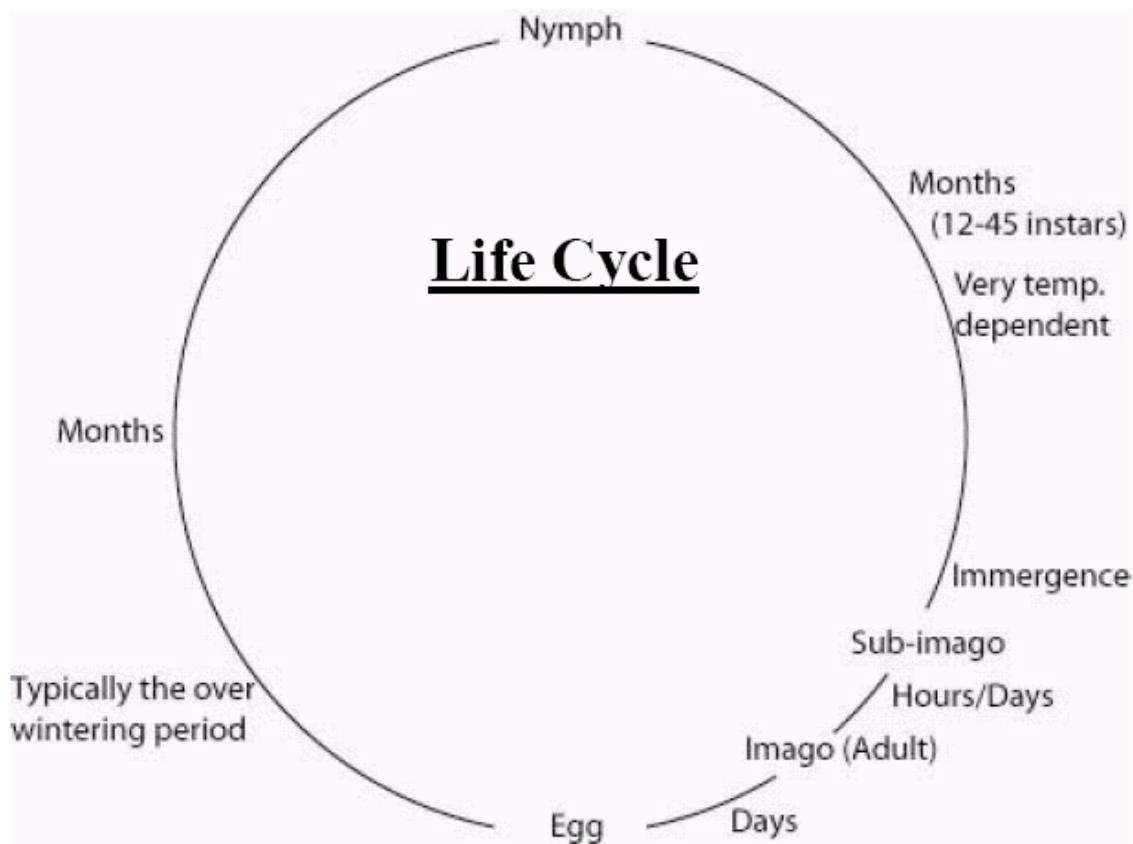
- 3 caudal filaments
- combination of gills
- one tarsal claw
- developing wing pads



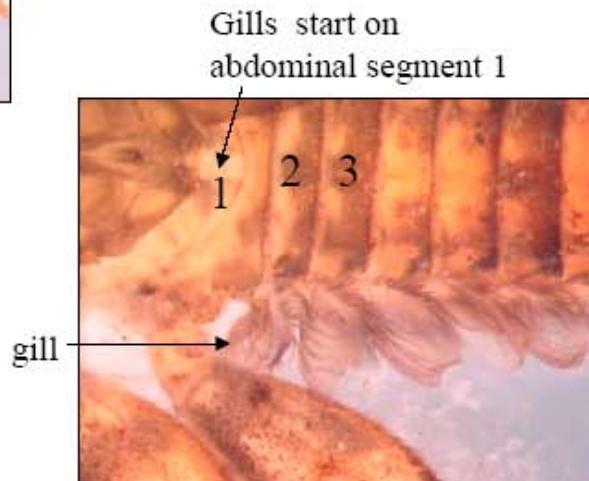
## Ephemeroptera (Mayflies)

- ☛ 675 Species in 20 Families, Evolved 280-300 mya (carboniferous)
- ☛ Two adult stages, Most are univoltine
- ☛ Gills on abdominal segments (usually) 1-7
- ☛ 3 (sometimes 2) long caudal filaments
- ☛ Primarily grazers and collector-gatherers (algae or detritus), most are herbivores or detritivores,
- ☛ Majority in cool, clean headwater streams (some species prefer lentic (pond) environments)
- ☛ Tolerance value for species ranges from 0-7
- ☛ Greatest diversity found in 2nd and 3rd order streams
- ☛ Most require a high DO content (some can withstand fairly low conditions)

# Ephemeroptera



# Heptageniidae



# Ameletidae



# Baetidae



# Plecoptera (Stoneflies)



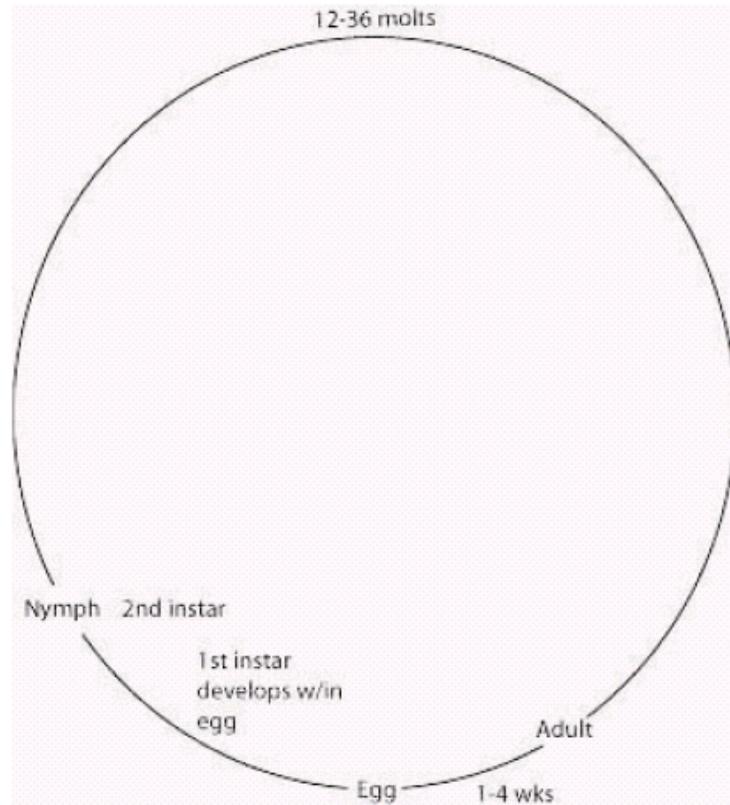
Patrick Edwards, PSU

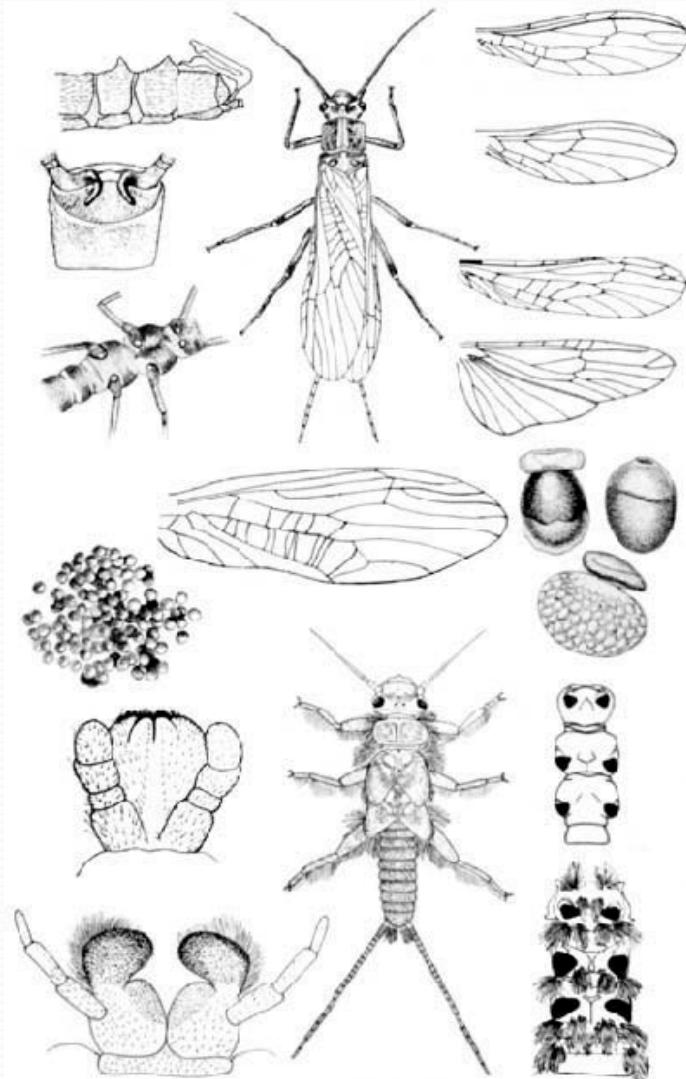
# Plecoptera

## General Info.

- Clean, Cold, fast moving, highly oxygenated streams
- Reach greatest diversity in North America
  - HBI for species 0-4
- Crawlers

## Life Cycle





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## Plecoptera (Stoneflies)

- ☛ 614 species are known from North America
- ☛ Often the top predators in the invertebrate food chain
- ☛ They are important in biological monitoring
- ☛ Distinguishing characteristics: two long cerci, relatively long antenna
- ☛ Compound eyes, two or three ocelli, chewing mouthparts, two pairs of thoracic
- ☛ Wing-pads, and three segmented tarsi with two claws on each tarsus



## Nemouridae



**Leuctridae**

# Perlidae





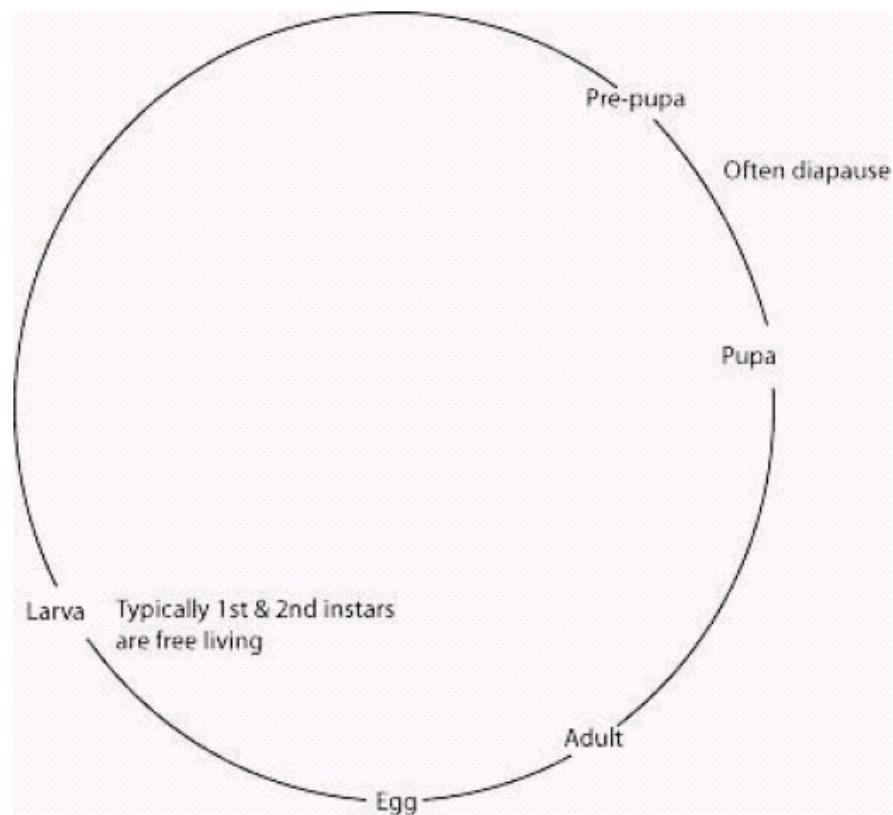
## Trichoptera (Caddisflies- Netspinners/Casemakers)

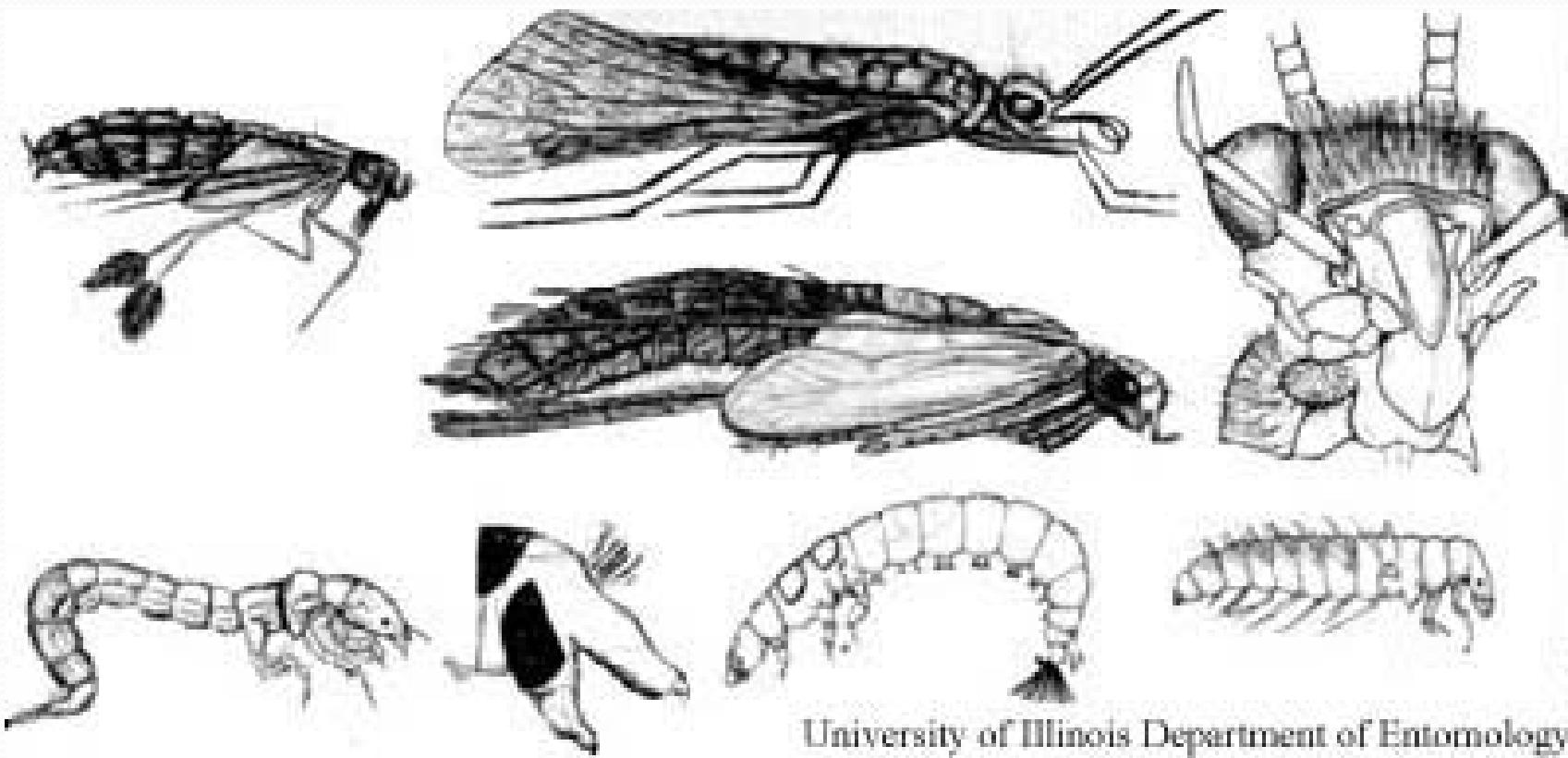
# Trichoptera

## General Info.

- Greatest diversity in cool lotic systems
  - HBI for species 0 – 8
- C-F, C-G, SCR, SHR, PRD

## Life Cycle





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## Trichoptera (Caddisflies) (1400 Species)

- ☛ Netspinners larvae use silk from their labial glands to construct retreats and nets, to filter or gather food such as algae, detritus,
- ☛ Netspinners or freeliving are mostly predators- on other arthropods
- ☛ Casemakers larvae construct portable cases that are barrel-shaped, purse like, or saddle-shaped
- ☛ Casemakers are mostly herbivores that feed on periphyton
- ☛ All larvae pupate in completely closed cocoon
- ☛ Have simple eyes, chewing mouthparts, very short antennae, 3 pairs of thoracic legs, single tarsal claw, and fleshy prolegs on the last abdominal segment
- ☛ Many larvae have single or branched gills on the abdominal segments, respiration is through the integument and abdominal gills

# Casemakers Limnephilidae



## **Odontoceridae**



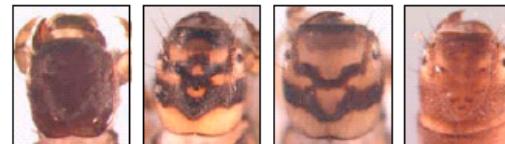
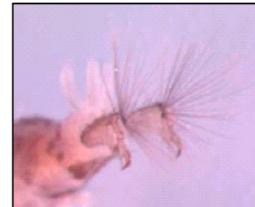
# **Helicopsychidae**



Posterior claw with  
comb-like teeth,  
photo at 200x

# Netspinners

## Hydropsychidae



# Odonata

## Paleoptera

Anisoptera - Dragonflies



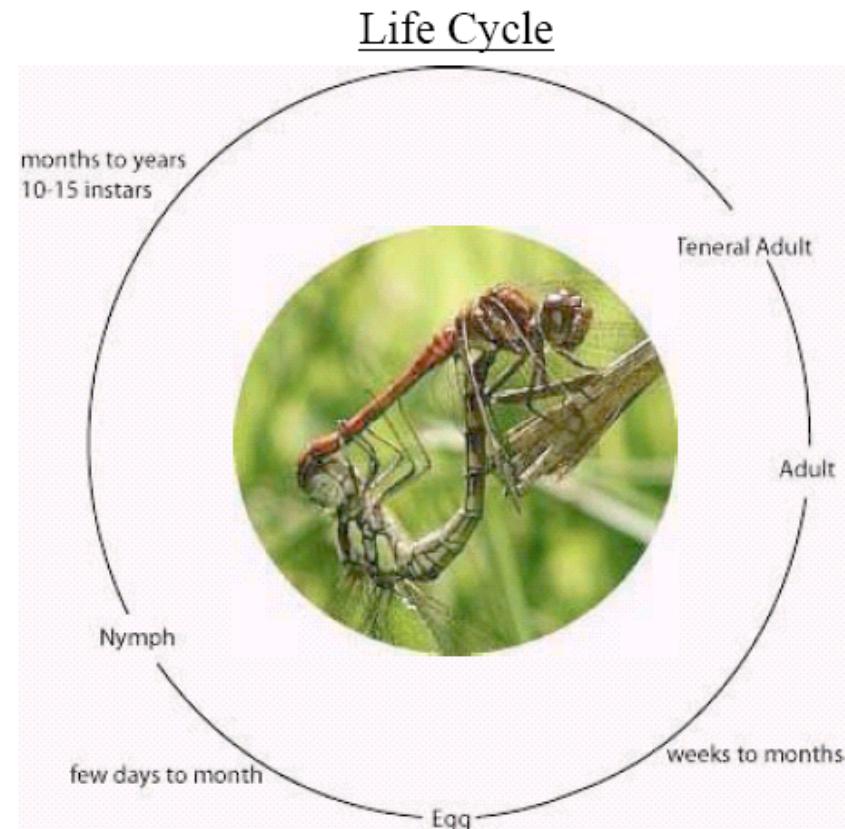
Zygoptera - Damselflies



# Odonata

## General Info.

- Greatest diversity in lowland streams and ponds (Lentic)
  - HBI for species 1-9
- Move via rectal “jet propulsion” (**VIDEO!!!!**)
- Beneficial predators (prey on “pest” insects)



## Odonata (Dragonflies/Damselflies)

- ☛ 9 families and 47 species
- ☛ 2 suborders Anisoptera and Zygoptera
- ☛ Lower lip (labium) is long and elbowed and is folded back against the head when not feeding
- ☛ Wing pads are present on the thorax
- ☛ Three pairs of segmented legs, two claws
- ☛ No gills are found on the sides, but damselflies have three flat, elongate gills on the end of the abdomen
- ☛ Body is either long and stout or oval and somewhat flattened. Head is narrower than the thorax and abdomen
- ☛ In dragonflies, three short, stiff, pointed structures occur on the end of the abdomen, forming a pyramid-shaped valve



# Odonata



# Coleoptera

- Means the “Sheath Winged”
- Greatest spp. richness of all insects
- Secondary invaders of aquatic realm

## Identification

- All adults w/ hardened fore wings
- W/ chewing mouthparts
- Larvae are variable (refer to keys)



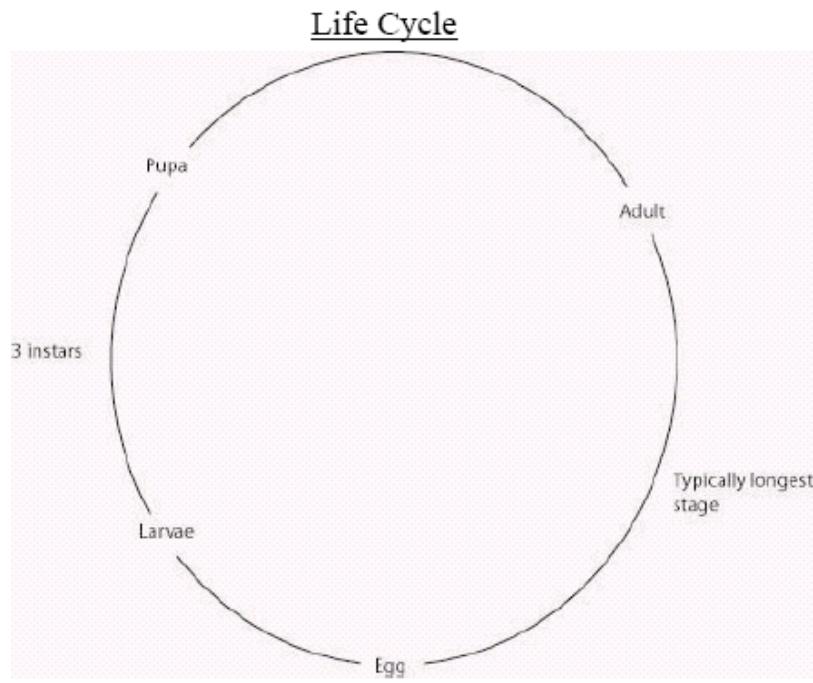
# Coleoptera (Beetles)

- ☛ 20 aquatic families and 1,000 species
- ☛ Head has thick hardened skin
- ☛ Thorax and abdomen of most kinds have moderately hardened skin, but the abdomen has thin, soft skin in some kinds
- ☛ No wing pads occur on the thorax
- ☛ Three pairs of segmented legs extend from the thorax in most kinds, but some kinds have no segmented legs
- ☛ No structures project from the sides of the abdomen in most kinds, but some kinds have flat plates or stout filaments
- ☛ No prolegs or tapering filament occurs on the end of the abdomen

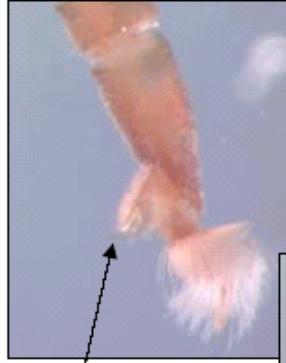
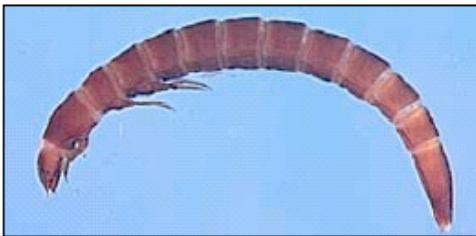
# Coleoptera

## General Info

- Broad range of Habitats
- Never really the dominant group in lotic systems
  - HBI for species 2 - 6
- Respiration thru:
  - Self contained bubbles
  - Cuticular
  - Plastron (hairs)
  - Piercing plant tissues



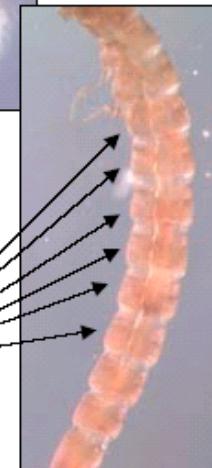
# Elmidae



W/ moveable  
ventral  
operculum

&

6 lateral  
pleurites



# Psephenidae

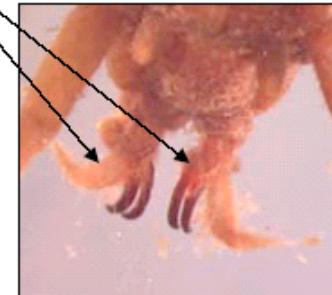
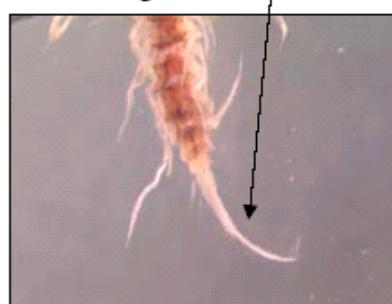


# Megaloptera

- Hellgramites and Alderflies
- Small order
- Poor fliers
- Can burrow into substrate during drought

## Identification

- W/ lateral abdominal filaments
- Abdomen terminates in either 2 prolegs w/ 2 hooks each or a single filament.



# Megaloptera (Helgamites)

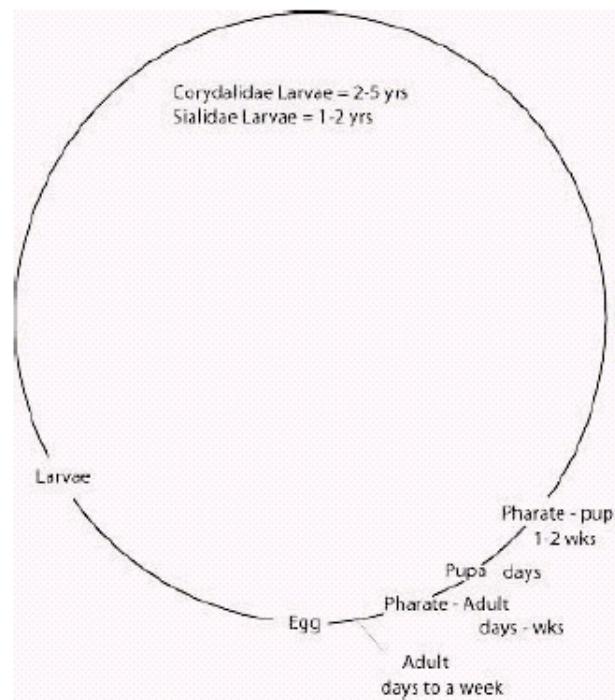
- ☛ 2 families 46 species
- ☛ Head and thorax have thick, hardened skin, while the abdomen has thin, soft skin.
- ☛ Prominent chewing mouthparts project in front of the head.
- ☛ No wing pads occur on the thorax
- ☛ Three pairs of segmented legs extend from the thorax
- ☛ Seven or eight pairs of stout, tapering filaments stick out from the sides of the abdomen
- ☛ End of the abdomen has either a pair of prolegs with two claws on each proleg, or a single long, tapering filament

# Megaloptera

## General Info

- Only larvae are terrestrial
- Highly predaceous (aggressive)
- Lotic and Lentic
  - HBI for species 4

## Life Cycle



# Diptera

Brachycera



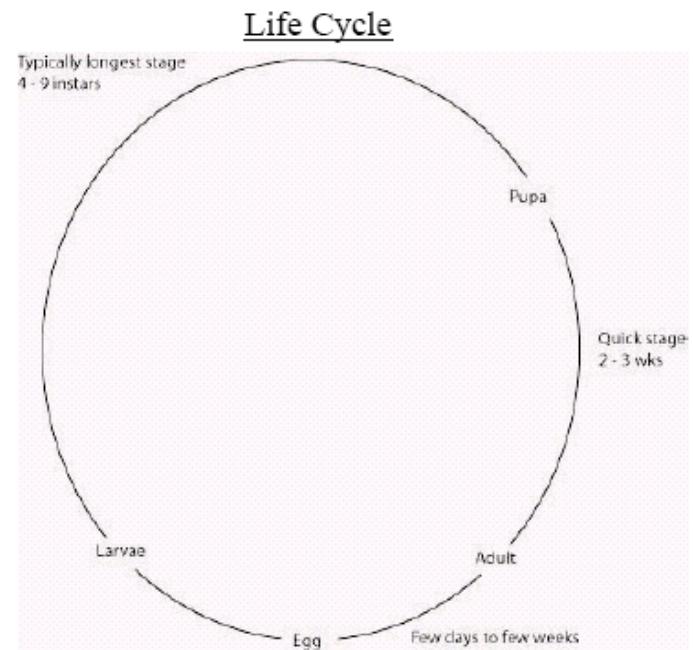
Nematocera



# Diptera

## General Info.

- Exhibit both Open & Closed respiratory systems.
- Found in every aquatic habitat.  
except open ocean
- Can withstand extreme conditions  
ex. Ephydriidae – petroleum
- HBI for species 0 - 10



# Diptera (True Flies)

- ✓ 29 aquatic families 3,500 species
- ✓ Complete metamorphosis
- ✓ Elongate, soft, and fleshy and resemble maggots
- ✓ Head may be capsule-like, separate structure with thick hard skin
- ✓ Head may be partially reduced on the rear margin, or may be greatly reduced to just mouth parts that protrude from the thorax
- ✓ No wing pads
- ✓ No segmented legs, may have prolegs
- ✓ Thorax and abdomen are entirely of soft, thin skin



# Crustacea

Gammaridae (scuds)



FBI = 6

HBI for species = 4 - 6

fast swimmers

resemble shrimp

Asellidae (sow bugs)



FBI = 8

HBI for species = 8

slow crawlers (do not swim)

resemble terrestrial sow bugs

# **Decapoda**



# Mollusca

Gastropoda (snails)



Pelecypoda (clams)



FBI = 7

HBI for species = 5 – 8

usually small in size

FBI = 6

HBI for species = 6 - 8

can become large



# Oligochaeta

FBI = 9

HBI for species = 5 – 10

Resemble typical earth worm



# Hirudinea

Leeches

FBI = 7

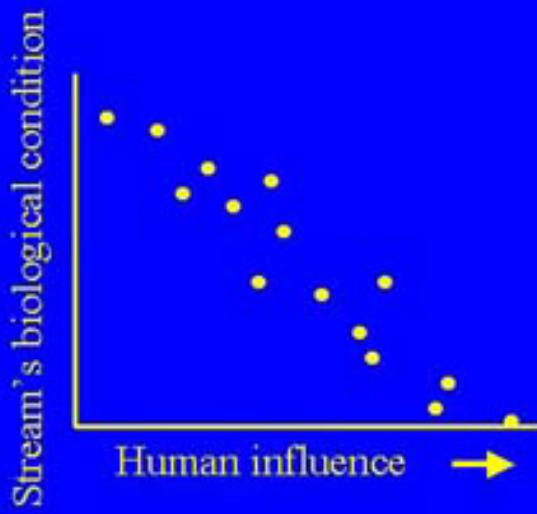




STREAMS AND RIVERS AQUATIC MACROINVERTEBRATE DATA ENTRY SHEET																			
Level II - Identify to Family (primarily)																			
Site # : Beaver R 4, downstream of dam										River/Stream: Beaver River									
Sample Date: 8/19/04										Sampler Name/s: Guillot, Aube, Urso									
Date of Lab Work: 8/30/04										Ave. # Organisms	39			# squares on tray:	1				
										# of replicates:	3	1	1	1	<- # squares picked each replicate				
Replicate #	1	2	3							Replicate#	1	2	3			1.0 average :			
Families in Major Group	T	D	D	D	D	Avg.	T x Avg.	D	FFG	Richness	Families in Major Group	T	D	D	D	Avg. D	T x Avg. D	FFG	Richness
<b>EPHEMEROPTERA (Mayflies)</b>										<b>TRICHOPTERA (Caddisflies)</b>									
Baetidae	4	1				0.3	1.3	GC/SC	0.3	Brachycentridae	1	1	1	1	0.3	0.3	FC/GC	0.3	
Baetiscidae	3					0.0	0.0	GC	0.0	Glossosomatidae	0			1	0.3	0.0	SC	0.3	
Caenidae	7					0.0	0.0	GC	0.0	Helicopsychidae	3				0.0	0.0	SC	0.0	
Ephemerellidae	1					0.0	0.0	GC/SC	0.0	Hydropsychidae	4	3	2		1.7	6.7	FC	0.7	
Ephemeraidae	4					0.0	0.0	GC	0.0	Hydroptilidae	4				0.0	0.0	GC/SC/SH	0.0	
Heptageniidae	4	1		2		1.0	4.0	SC/GC	0.7	Lepidostomatidae	1				0.0	0.0	SH	0.0	
Leptophlebiidae	2					0.0	0.0	GC	0.0	Leptoceridae	4				0.0	0.0	GC/SH/PR	0.0	
Metretopodidae	2					0.0	0.0	GC	0.0	Limnephilidae	4		1		0.3	1.3	SH/SC/GC	0.3	
Oligoneuriidae	2					0.0	0.0	FC	0.0	Molannidae	6				0.0	0.0	SC	0.0	
Polyimitarcyidae	2					0.0	0.0	GC	0.0	Odontoceridae	0	3	24	4	10.3	0.0	SH	1.0	
Potamanthidae	4					0.0	0.0	GC	0.0	Philopotamidae	3		2		0.7	2.0	FC	0.3	
Siphlonuridae	7					0.0	0.0	GC	0.0	Phryganeidae	4				0.0	0.0	SH	0.0	
Tricorythidae	4					0.0	0.0	GC	0.0	Polycentropodidae	6				0.0	0.0	FC/PR	0.0	
						0.0	0.0		0.0	Psychomyiidae	2				0.0	0.0	GC	0.0	
						0.0	0.0		0.0	Rhyacophilidae	0			4	1.3	0.0	PR	0.3	
<b>Subtotal Ephemeroptera</b>					1.3	5.3			1.0	Sericostomidae	3				0.0	0.0	SH	0.0	
<b>PLECOPTERA (Stoneflies)</b>															0.0	0.0	0.0		
Capniidae	1					0.0	0.0	SH	0.0						0.0	0.0		0.0	
Chloroperlidae	1					0.0	0.0	GC/PR	0.0	<b>Subtotal Trichoptera</b>				15.0	10.3		3.3		
Leuctridae	0	4	3	1		2.7	0.0	SH	1.0	<b>DIPTERA (True Flies)</b>									
Nemouridae	2					0.0	0.0	SH	0.0	Athericidae	2				0.0	0.0	PR	0.0	
Peltoperlidae	0					0.0	0.0	SH	0.0	Blephariceridae	0				0.0	0.0	SC	0.0	
Perlaidae	1	2		3		1.7	1.7	PR	0.7	Ceratopogonidae	6				0.0	0.0	PR	0.0	
Periodidae	2					0.0	0.0	PR	0.0	Chironomidae	7				0.0	0.0	ALL	0.0	
Pteronarcyidae	0					0.0	0.0	SH	0.0	Empididae	6				0.0	0.0	PR	0.0	
Taeniopterygidae	2					0.0	0.0	SH	0.0	Simuliidae	6				0.0	0.0	FC	0.0	
						0.0	0.0		0.0	Tabanidae	6				0.0	0.0	PR	0.0	
						0.0	0.0		0.0	Tipulidae	3	6	10	9	8.3	25.0	GC/PR/SH	1.0	
<b>Subtotal Plecoptera</b>					4.3	1.7			1.7	OTHER					0.0	0.0		0.0	
<b>Key to Column Headings:</b>										<b>Subtotal Diptera</b>									
T = Family Pollution Tolerance Value											8.3	25.0			1.0				



METRICS Summary		<i>Expected response to impact</i>
Org. Density / sample	39	
Taxa Richness	10	Decline
EPT Richness	6	Decline
% Predators	24.4	Decline
% Shredders	46.3	Decline
% Oligochaeta	0.0	Rise
% Diptera	21.6	Rise
% Chironomidae	0.0	Rise
Family Biotic Index	1.84	Rise
% Filters	6.5	Rise
% Contrib. Dom. Taxa	26.7	Rise
% Hydropsych. of Trich	11.1	Rise
% Trichoptera	38.8	Decline
% model affinity	0.38	Decline
EPT/Chironomid	#DIV/0!	Decline
Scrapers/Filterers	1.24	Decline
% Gatherers	14.8	
% Scrapers	8.0	Decline



## Multimetric Indices

- graphical analysis of biological response to human disturbance
- uses local or regional reference streams
- combines several community characteristics into one score

## Multivariate Models

- computer model interpretation of physical and biological stream characters
- uses a large database of reference streams to generate a score comparing the macros that were observed to what macros the model expected

(each axis = physical stream characters)

