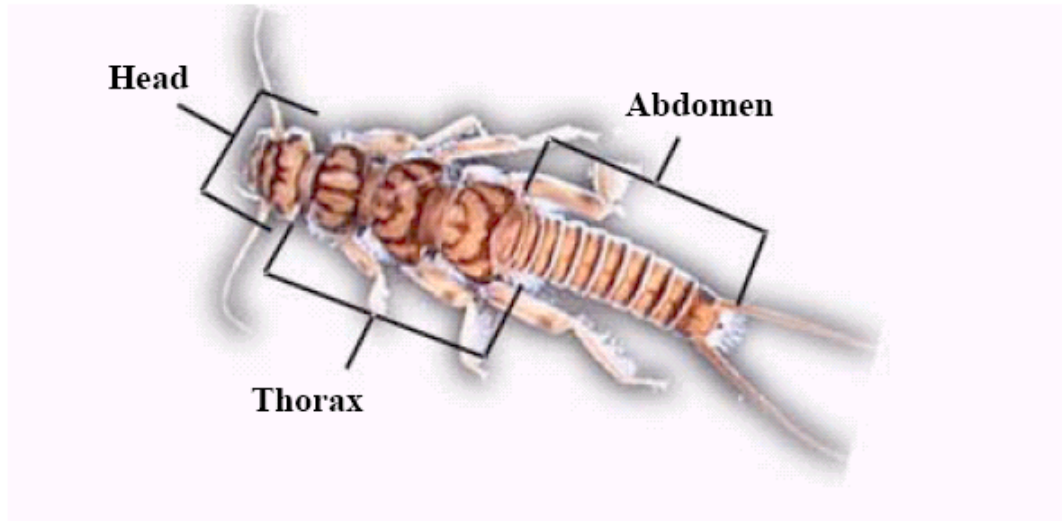


Aquatic Benthic Macroinvertebrates

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 Metamorphosis

egg



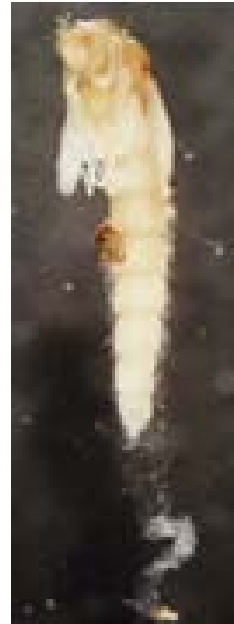
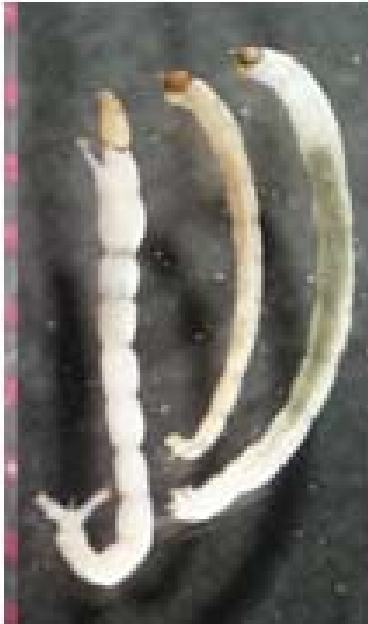
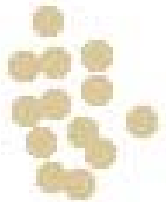
larva



pupa



adult



Incomplete Metamorphism

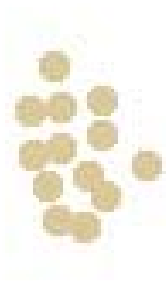
egg



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
- Odonota (Dragonflies) 1-3
(Damselflies) 5-9
- Megaloptera (Dobsonflies) 0-4
- Diptera (True Flies) 2-10
- Coleoptera (Beetles) 2-5
- Crustacea (Crayfish, Scuds, Sowboughs) 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)



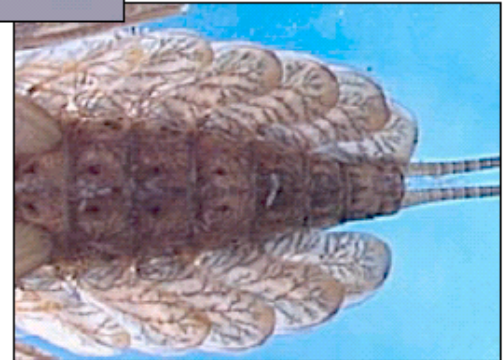
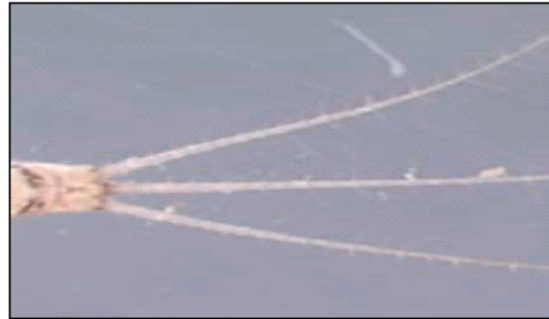
Ephemeroptera (Mayflies)



Ephemeroptera

Identification

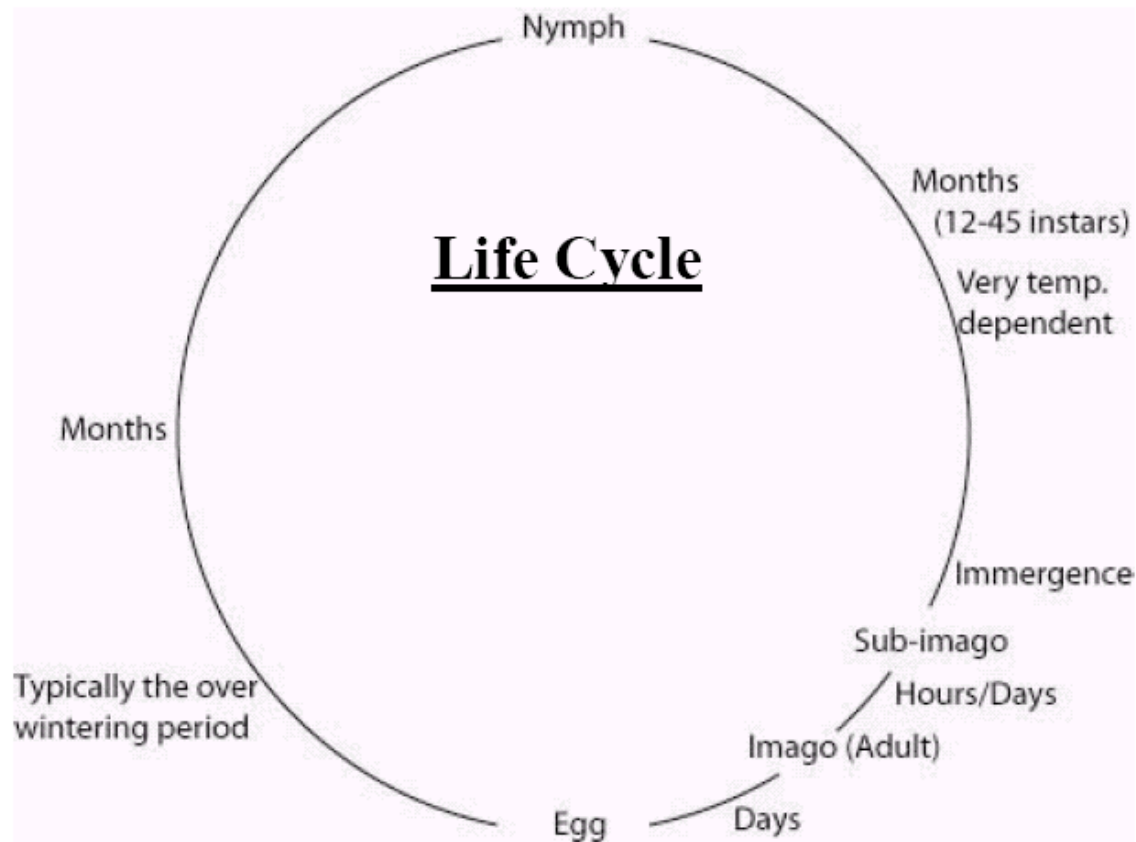
- 3 caudal filaments
- combination of gills
- one tarsal claw
- developing wing pads



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)

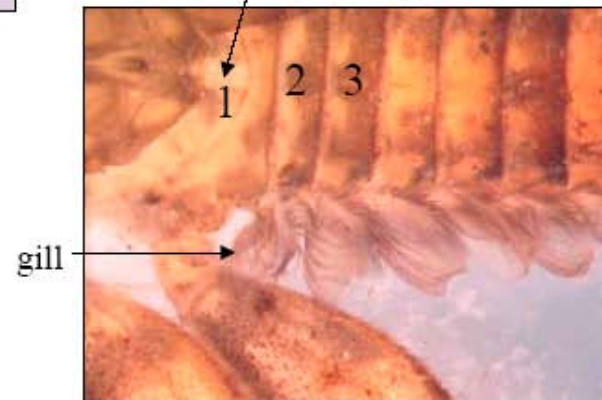
Ephemeroptera



Heptageniidae



Gills start on
abdominal segment 1



Ameletidae



Baetidae



Plecoptera (Stoneflies)

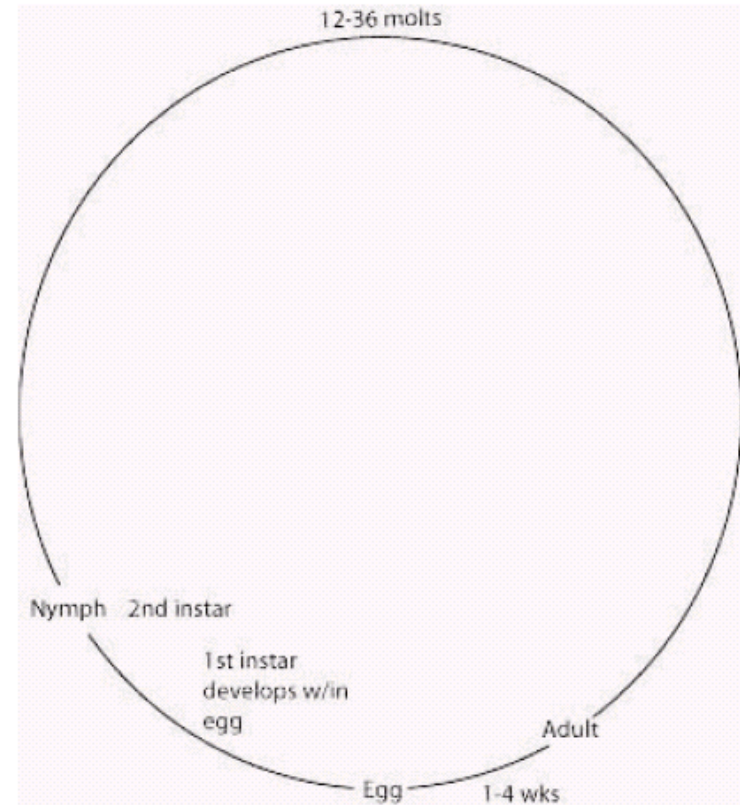


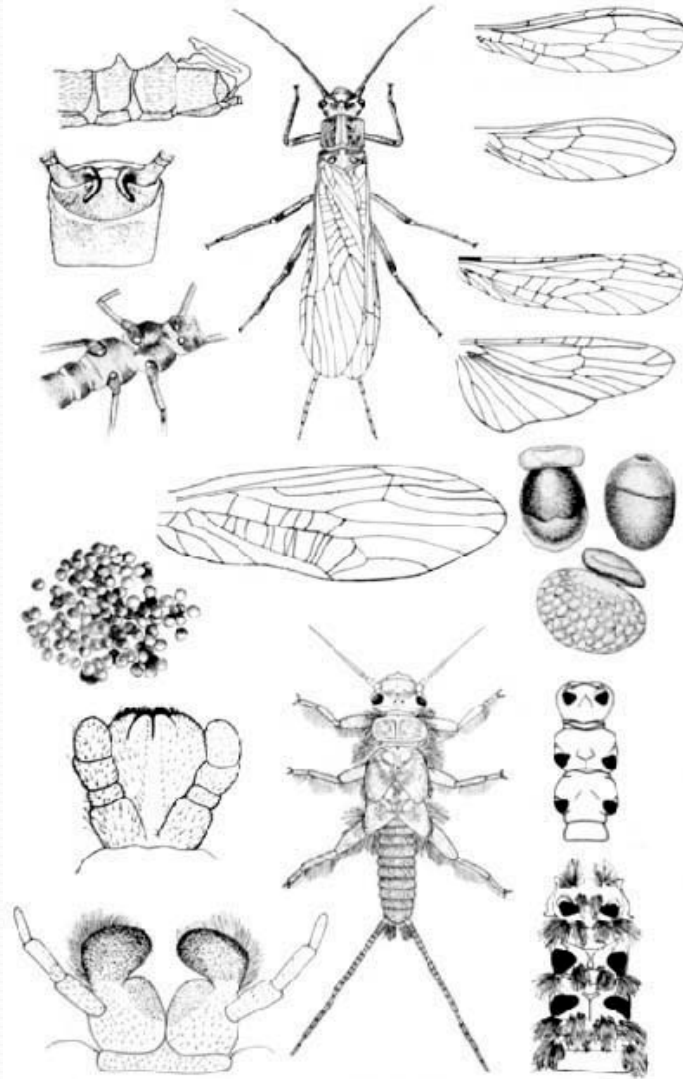
Plecoptera

General Info.

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

Life Cycle





University of Illinois Department of Entomology

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



Perlidae





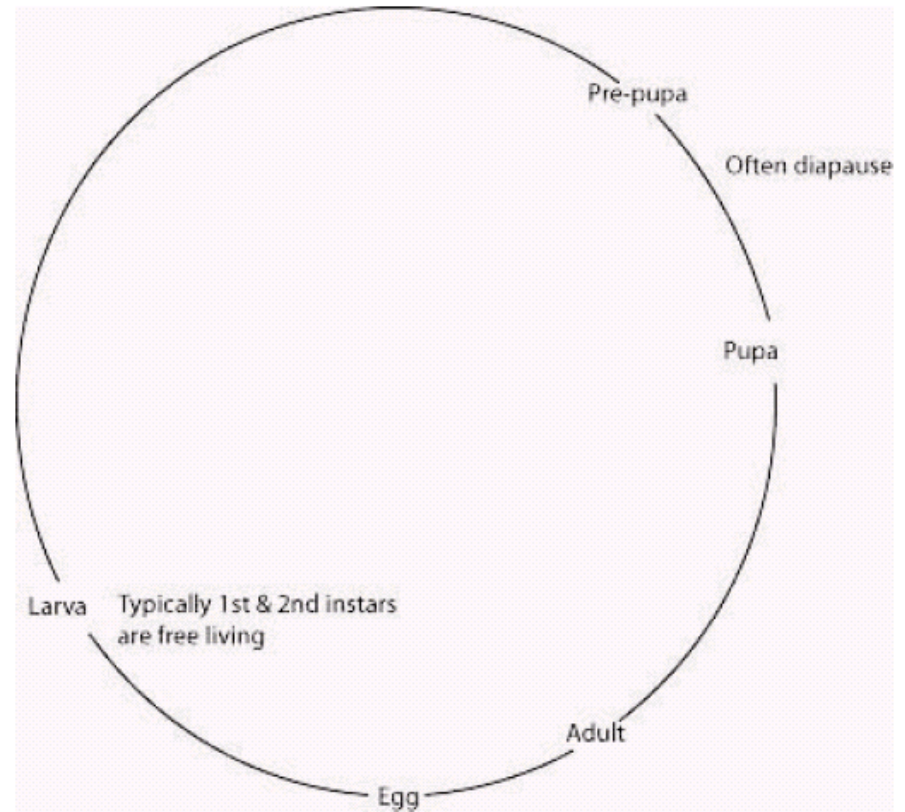
Trichoptera (Caddisflies- Netspinners/Casemakers)

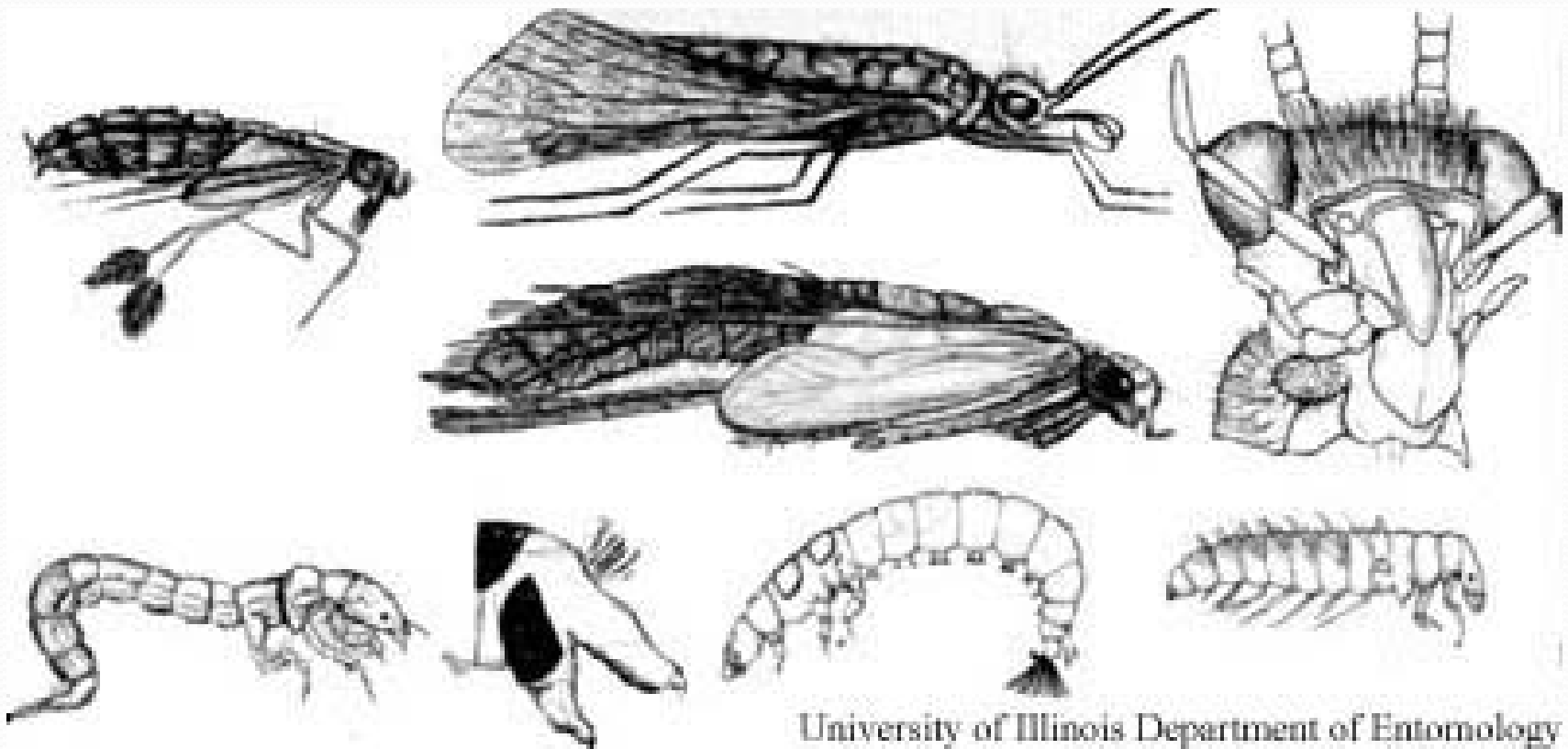
Trichoptera

General Info.

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

Life Cycle





University of Illinois Department of Entomology



University of Illinois Department of Entomology

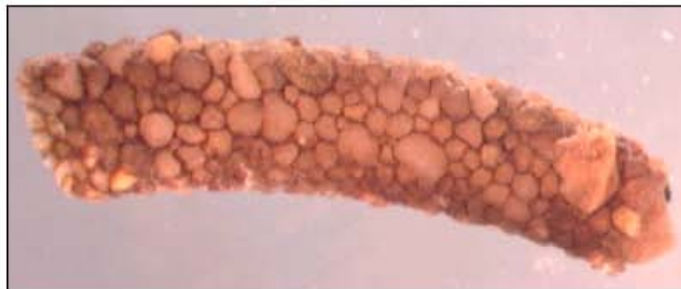
Trichoptera (Caddisflies) (1400 Species)

- ☞ Netspinners larvae use silk from their labial glands to construct retreats and nets, to filter or gather food such as algae, detritus,
- ☞ Netspinners or freelifving 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

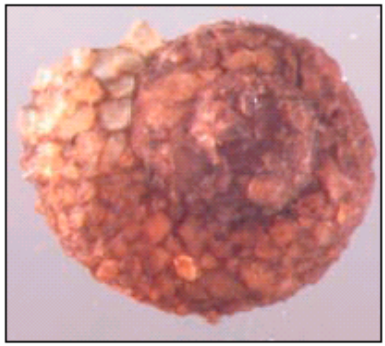
Casemakers Limnephilidae



Odontoceridae



Helicopsychidae



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

Netspinners

Hydropsychidae



Odonata

Paleoptera

Anisoptera - Dragonflies



Zygoptera - Damselflies

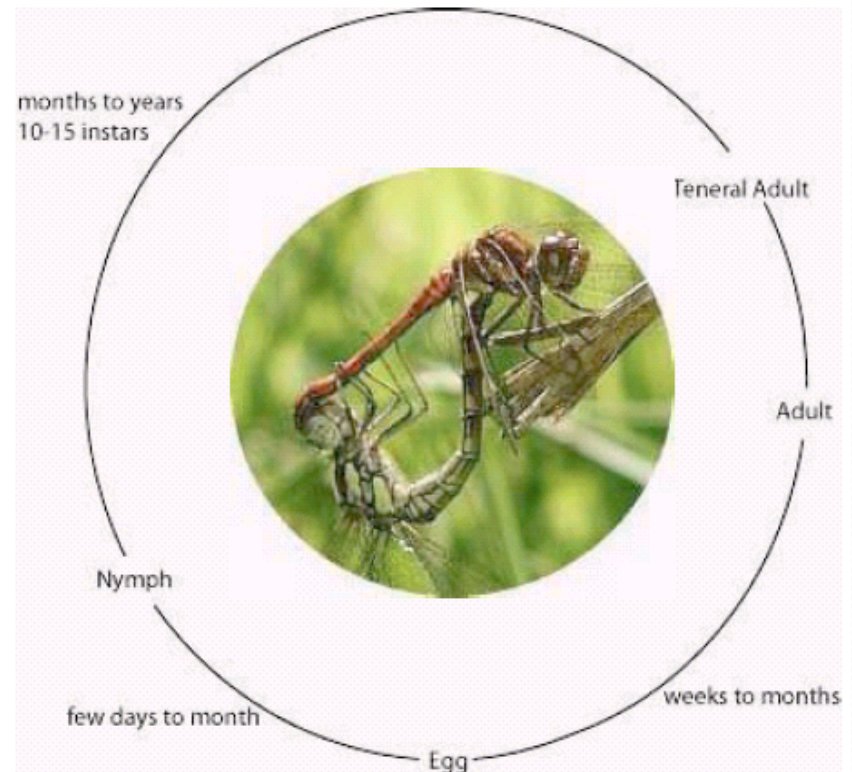


Odonata

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)

Life Cycle

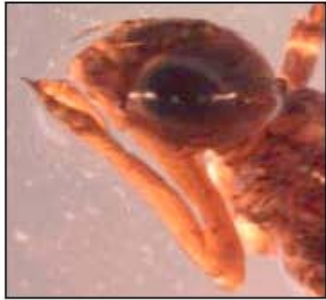


Odonata (Dragonflies/Damselflies)

- ☞ 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)

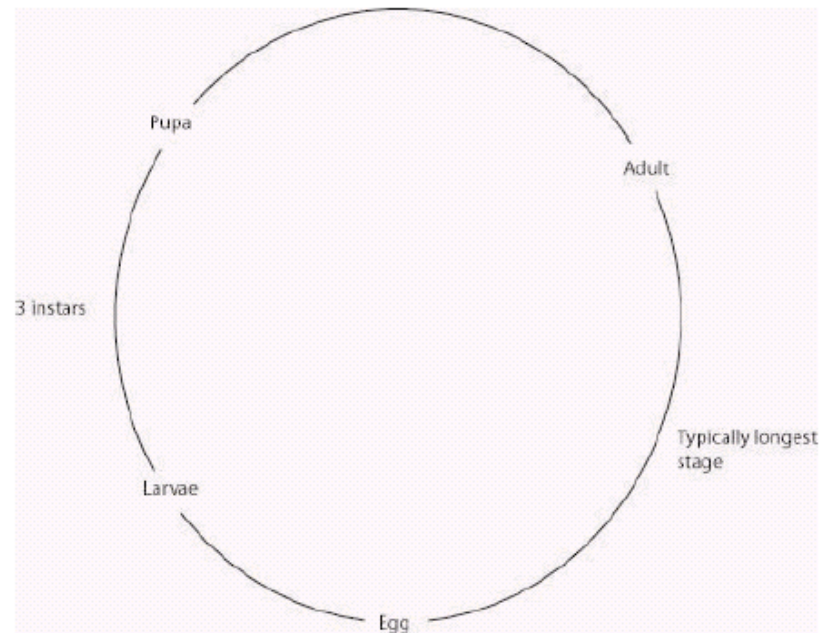
- ☞ 20 aquatic families and 1,000 species
- ☞ Head has thick hardened skin
- ☞ Thorax and abdomen of most kinds have moderately hardened skin, but the abdomen has thin, soft skin in some kinds
- ☞ No wing pads occur on the thorax
- ☞ Three pairs of segmented legs extend from the thorax in most kinds, 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

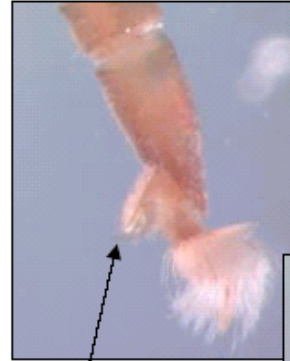
General Info

- 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

Life Cycle



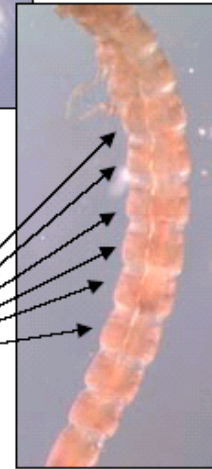
Elmidae



W/ moveable
ventral
operculum

&

6 lateral
pleurites



Psephenidae

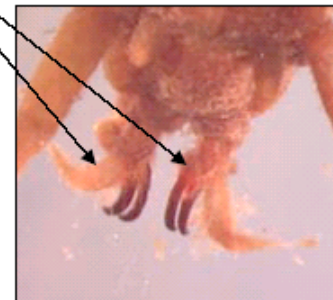
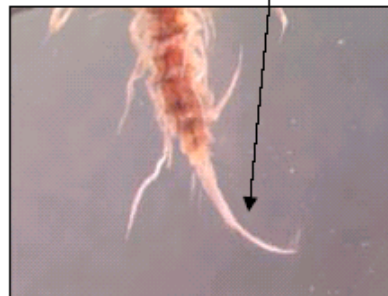


Megaloptera

- 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)

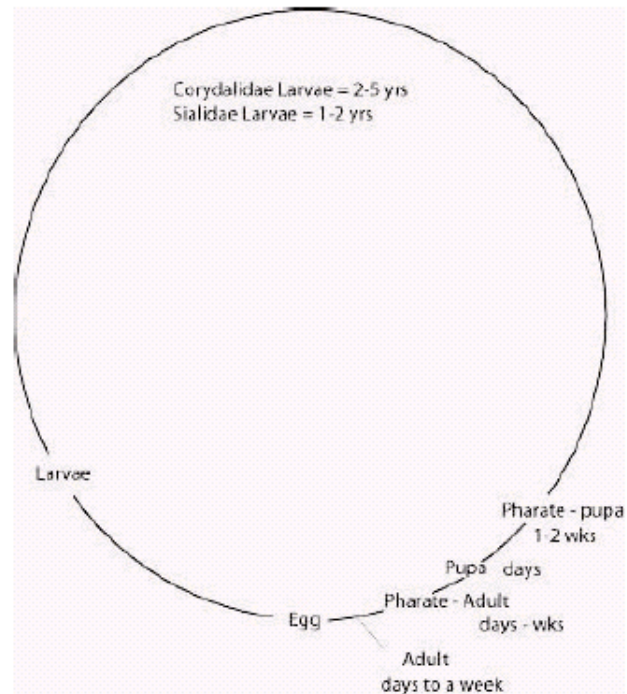
- ☞ 2 families 46 species
- ☞ Head and thorax have thick, hardened skin, while the abdomen has thin, soft skin.
- ☞ Prominent chewing mouthparts project in front of the head.
- ☞ No wing pads occur on the thorax
- ☞ Three pairs of segmented legs extend from the thorax
- ☞ Seven or eight pairs of stout, 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

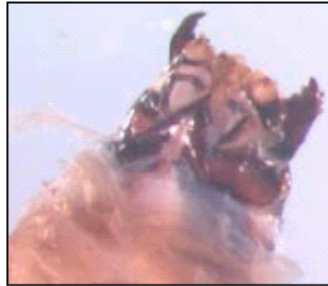


Diptera

Brachycera



Nematocera

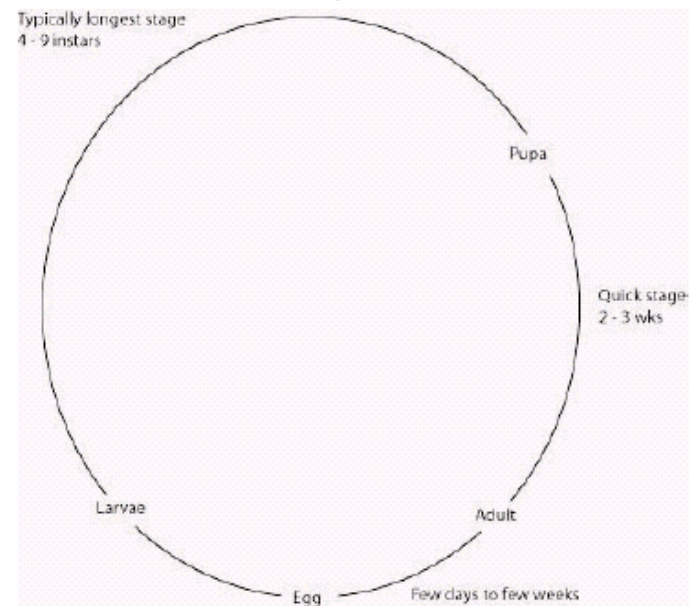


Diptera

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

Life Cycle



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)



FBI = 7

HBI for species = 5 - 8

usually small in size

Pelecypoda (clams)



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

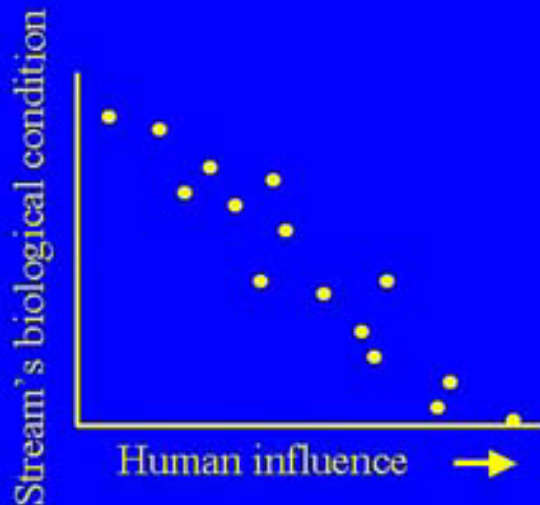




STREAMS AND RIVERS AQUATIC MACROINVERTEBRATE DATA ENTRY SHEET																	
Level II - Identify to Family (primarily)																	
Site #:	Beaver R 4, downstream of dam					River/Stream:	Beaver River										
Sample Date:	8/19/04					Sampler Name/s:	Guillot, Aube, Urso										
Date of Lab Work:	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					Avg. D	T x Avg. D					Avg. D	T x Avg. D					
Major Group	T	D	D	D		FFG	Richness					FFG	Richness				
								Group	T	D	D	D					
EPHEMEROPTERA (Mayflies)							TRICHOPTERA (Caddisflies)										
Baetidae	4	1			0.3	1.3	GC/SC	0.3	Brachycentridae	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
Ephemereillidae	1				0.0	0.0	GC/SC	0.0	Hydropsychidae	4	3	2		1.7	6.7	FC	0.7
Ephemeridae	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	Leptoceiridae	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
Polymitarcyidae	2				0.0	0.0	GC	0.0	Odontoceridae	0	3	24	4	10.3	0.0	SH	1.0
Potomanthidae	4				0.0	0.0	GC	0.0	Philopotamidae	3		2		0.7	2.0	FC	0.3
Siphonuridae	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
Subtotal Ephemeroptera					1.3	5.3		1.0	Sericostomidae	3				0.0	0.0	SH	0.0
PLECOPTERA (Stoneflies)							Subtotal Trichoptera										
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						0.0	0.0		0.0
Leuctridae	0	4	3	1	2.7	0.0	SH	1.0	Subtotal Trichoptera					15.0	10.3		3.3
Nemouridae	2				0.0	0.0	SH	0.0	DIPTERA (True Flies)								
Peltoperlidae	0				0.0	0.0	SH	0.0	Athericidae	2				0.0	0.0	PR	0.0
Perlidae	1	2		3	1.7	1.7	PR	0.7	Blephariceridae	0				0.0	0.0	SC	0.0
Perlodidae	2				0.0	0.0	PR	0.0	Ceratopogonidae	6				0.0	0.0	PR	0.0
Pteronarcyidae	0				0.0	0.0	SH	0.0	Chironomidae	7				0.0	0.0	ALL	0.0
Taeniopterygidae	2				0.0	0.0	SH	0.0	Empididae	6				0.0	0.0	PR	0.0
					0.0	0.0		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
Subtotal Plecoptera					4.3	1.7		1.7	Tipulidae	3	6	10	9	8.3	25.0	GC/PR/SH	1.0
									OTHER					0.0	0.0		0.0
														0.0	0.0		0.0
Key to Column Headings:																	
T = Family Pollution Tolerance Value																	
									Subtotal Diptera					8.3	25.0		1.0

Replicate #		1	2	3					Replicate#		1	2	3				
Families in					Avg.	T x Avg.			Families in Major					Avg. D	T X Avg. D		
Major Group	T	D	D	D	D	D	FFG	Richness	Group	T	D	D	D			FFG	Richness
MEGALOPTERA (Dobsonflies, alderflies, fishflies)									ISOPODA (Sowbugs)								
Corydalidae	0			1	0.3	0.0	PR	0.3	Asellidae	8				0.0	0.0	SH/GC	0.0
Sialidae	4				0.0	0.0	PR	0.0						0.0	0.0		0.0
					0.0	0.0		0.0						0.0	0.0		0.0
					0.0	0.0		0.0						0.0	0.0		0.0
Subtotal Megaloptera									Subtotal Isopoda								
0.3									0.3								
LEPIDOPTERA (Moths)									DECOPODA (Crayfish)								
Pyralidae	5				0.0	0.0	SH	0.0	Cambaridae	6				0.0	0.0	GC	0.0
					0.0	0.0		0.0						0.0	0.0		0.0
					0.0	0.0		0.0						0.0	0.0		0.0
Subtotal Lepidoptera									Subtotal Decapoda								
0.0									0.0								
COLEOPTERA (beetles)									OTHER (non-families w/tolerance values)								
Dystiscidae	8				0.0	0.0	PR	0.0	Class Oligochaeta	8				0.0	0.0	GC	0.0
Elmidae	4	6	6	6	6.0	24.0	GC/SC/SH	1.0	Class Hirudinea	10				0.0	0.0	PR	0.0
Psephenidae	4				0.0	0.0	SC	0.0	Class Gastropoda	7				0.0	0.0	SC	0.0
Gyrinidae	4				0.0	0.0	PR	0.0	Class Pelecypoda	7				0.0	0.0	FC	0.0
Hydrophilidae	8				0.0	0.0	PR	0.0	Order Hemiptera	8				0.0	0.0	PR	0.0
Subtotal Coleoptera									Subtotal Other non-family								
6.0									1.0								
ODONATA (Dragonflies, damselflies)									TOTAL								
Aeshnidae	3		2		0.7	2.0	PR	0.3	All Organisms					Density	Tx av.D	richness	
Calopterygidae	5				0.0	0.0	PR	0.0	Functional Feeding Group Totals:								
Coenagrionidae	9				0.0	0.0	PR	0.0	Total Predators					9			
Cordulegastridae	3				0.0	0.0	PR	0.0	Total Shredders					18			
Corduliidae	5				0.0	0.0	PR	0.0	Total Filterers					3			
Gomphidae	1	1	4	3	2.7	2.7	PR	1.0	Total Gatherers					6			
Lestidae	9				0.0	0.0	PR	0.0	Total Scrapers					3			
Libellulidae	9				0.0	0.0	PR	0.0	Total all Feeding Groups					39			
Macomiidae	3				0.0	0.0	PR	0.0									
					0.0	0.0		0.0									
					0.0	0.0		0.0									
Subtotal Odonata																	
3.3									4.7								
AMPHIPODA (Scuds)																	
Gammaridae	4				0.0	0.0	GC	0.0									
Talitridae	8				0.0	0.0	GC	0.0									
					0.0	0.0		0.0									
					0.0	0.0		0.0									
Subtotal Amphipoda																	
0.0									0.0								

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)

