

## Toward an online digital teaching collection of aquatic macroinvertebrates using interactive, gigapixel technology (Ephemeroptera, Plecoptera, and Trichoptera)

John Wenzel, Carnegie Museum of Natural History

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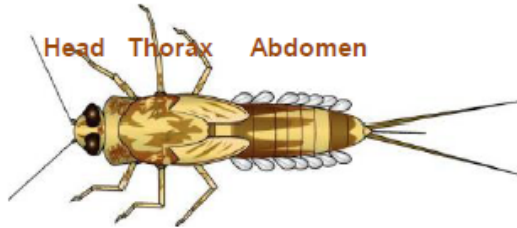
John C. Morse, Clemson University

Beginner's challenge in learning to ID insects is to eliminate everything but the correct association. Experts focus quickly on diagnostic features.



# Most available tools are pictorial guides, flash cards, or dichotomous keys

## WV Save Our Streams' Benthic Macroinvertebrate Field Guide



Small minnow mayfly

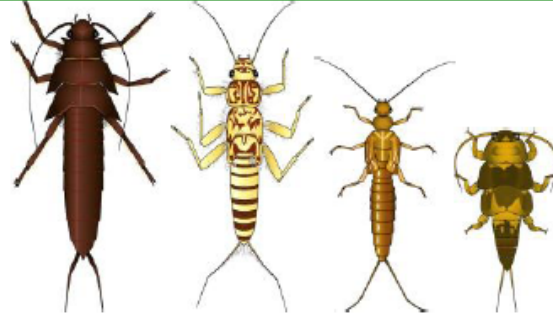
**What is an insect?** An insect is an invertebrate (an animal with no spine) that has three-pairs of legs (except Diptera) and three body divisions; the head is the location of the mouth, antenna and eyes; the thorax is the attachment site for the legs and wing pads; and the abdomen, which often has a variety of structures attached including filaments gills and tails. Gills are usually leaf-like, plate-like, or thin filaments. Tails can be long and thin, hairy, webbed or paddle-like. Most of the **benthic macroinvertebrates** you will encounter during stream surveys are aquatic larva or nymphs of insects. Most adult stages are not aquatic but beetles are the exception. The majority of the insects are described and illustrated on page one and the top of page two; non-insect group descriptions and illustrations begin on page two. Additional instructions are provided at the bottom of page two.

## Insect Groups



Mayflies

(Order **Ephemeroptera**): Three-pairs of legs with a single hook at the end; three some-times two tail filaments; gills attached to the abdomen,



Stoneflies

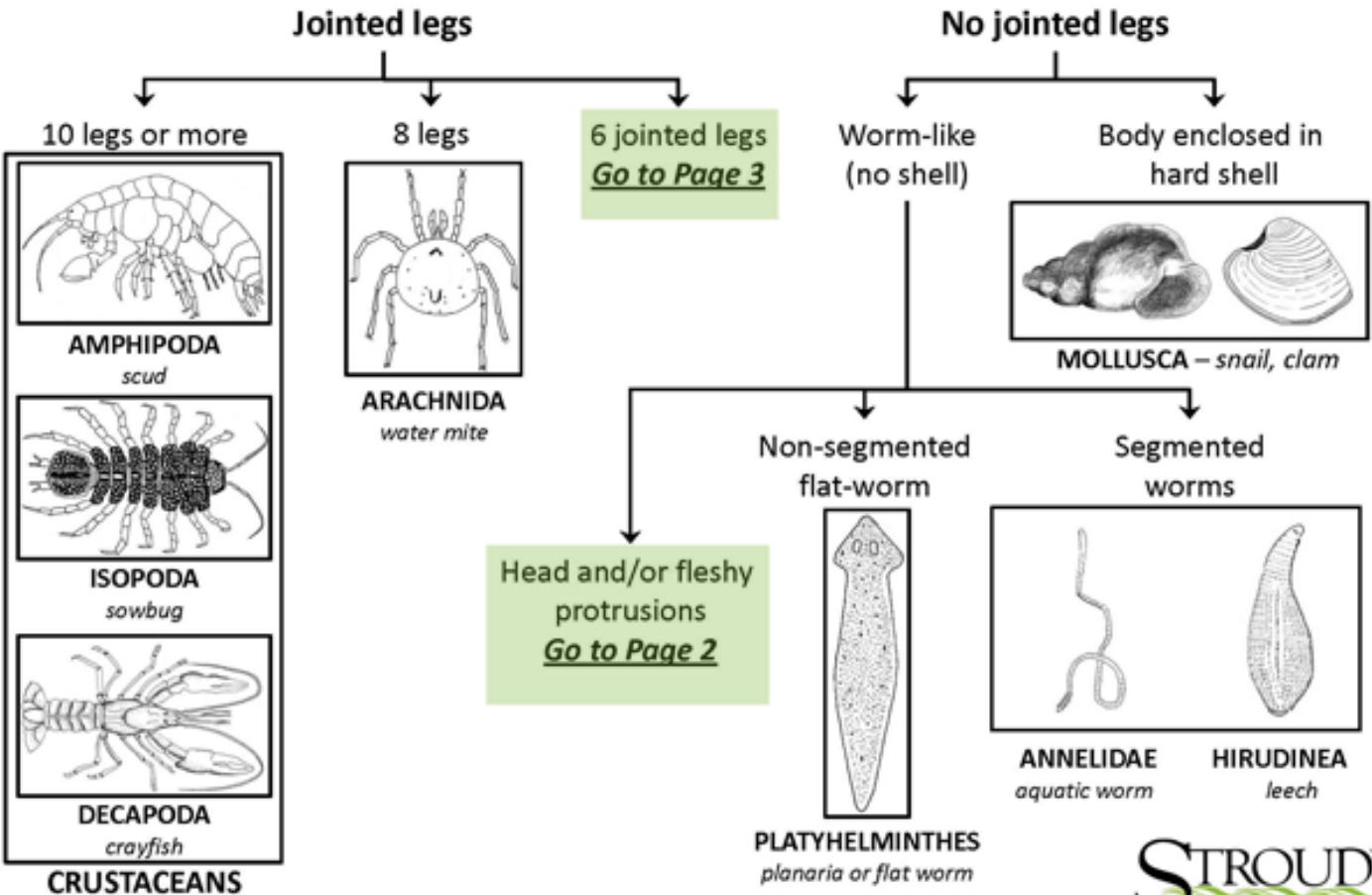
(Order **Plecoptera**): Three-pairs of legs with two-hooks at the end; two tail filaments; no gills attached to the abdomen but some kinds may



Case-building caddisflies

(Order **Trichoptera**): Grub-like soft body and a hard head; Three-pairs of legs located on the upper third of the body; tail is small and usually

# Identification Guide to Freshwater Macroinvertebrates



# Our tool opens with a general overview that beginners like

The screenshot shows a web browser window with the URL [macroinvertebrates.org/#/](http://macroinvertebrates.org/#/). The page header includes the Carnegie Museum of Natural History logo and the title "Aquatic Macroinvertebrate Collection" with the subtitle "An explorable resource for stream insect identification". A navigation menu is visible in the top right corner.

The main content area is divided into three vertical panels, each representing an insect order:

- Order EPHEMEROPTERA MAYFLIES**: This panel features a plus sign icon and displays five different specimens of mayflies, including nymphs and adults, showing their characteristic long tails and gills.
- Order PLECOPTERA STONEFLIES**: This panel features a plus sign icon and displays two specimens of stoneflies, including a large nymph with long antennae and a smaller nymph.
- Order TRICHOPTERA CADDISFLIES**: This panel features a plus sign icon and displays seven specimens of caddisflies, including various nymphs and pupae, some with prominent gills and others with different body shapes.

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# Clicking on mayflies expands that section, opens new information

Aquatic Macroinvertebrat x

macroinvertebrates.org/#/ephemeroptera

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## Aquatic Macroinvertebrate Collection

An explorable resource for stream insect identification

Order | EPHEMEROPTERA


### MAYFLIES

Family | Baetiscidae  
**Armored Mayflies**

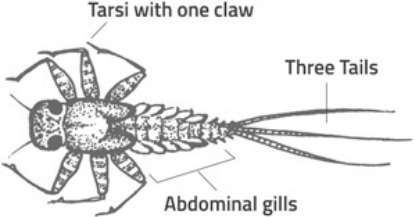
Family | Ephemerellidae  
**Spiny Crawler Mayflies**

Family | Heptageniidae  
**Flatheaded Mayflies**

Family | Leptophlebiidae  
**Prong-Gilled Mayflies**



**i**




Chronomidae Research Group

Mayfly nymph characteristics

#### ORDER EPHEMEROPTERA | Mayflies

Ephemeroptera: *ephemeros* 'short-lived' + *ptero* 'wings' (Greek)

Ephemeroptera spend most of their lives in the water as larvae. The adult flying insect stage is short-lived, and adults may only live a few hours to a few days to mate. Mayflies are usually pollution sensitive and can be "ecological indicators" of stream health. Mayfly larvae have one tarsal claw on the end of each leg, gills on their abdomens, and most have three long slender tails. Gill shape and position, and tarsal claw shape are used to tell mayfly families apart.



05:51

Video excerpt from Bugs of the Underworld / Ralph Cutter

# Clicking on a single family expands that information....

The screenshot shows a web browser window with the URL `macroinvertebrates.org/#/ephemeroptera/heptageniidae`. The page title is "Aquatic Macroinvertebrate Collection" with the subtitle "An explorable resource for stream insect identification". The main heading is "Flatheaded Mayflies" under the family "EPHEMEROPTERA Heptageniidae". Two tabs are visible: "Genus | Epeorus" and "Genus | Maccaffertium". Below these are two images of mayflies. A blue box with the letter 'i' is on the left. The page is divided into three columns: "FAMILY OVERVIEW | Heptageniidae" with a close-up image of an adult flat-headed mayfly and a descriptive paragraph; "CHARACTERISTICS" with a list of traits including "Pollution Tolerance Low (3)", "Primary Feeding Group Scraper", "Movement Clinger", and "Size Range Small to Medium (5-29mm)"; and "EXPERT INTERVIEW" featuring a video player with a play button, a progress bar at 0:52, and a speaker icon, alongside a photo of Dr. John Morse, Prof. Emeritus of Entomology at Clemson University. A small video player on the right shows a "Live Flatheaded Mayfly" with a play button and a 00:08 timer.

Aquatic Macroinvertebrate x

macroinvertebrates.org/#/ephemeroptera/heptageniidae

CARNEGIE MUSEUM OF NATURAL HISTORY

Aquatic Macroinvertebrate Collection

An explorable resource for stream insect identification

Family | EPHEMEROPTERA Heptageniidae

Flatheaded Mayflies

Genus | Epeorus

Genus | Maccaffertium

*i*

**FAMILY OVERVIEW | Heptageniidae**

The flatheaded mayfly is named for its distinctly flattened head and body with outspread legs. Their claws are shorter than the final tarsal leg segment. Gills on abdominal segments 2-5 are usually plate-like with basal gill tufts underneath. The family Heptageniidae are clingers found on submerged rocks and woody debris in currents of all kinds. Some are collectors (gatherers) and some species are even predators (engulfers).

**CHARACTERISTICS**

- Pollution Tolerance **Low (3)**
- Primary Feeding Group **Scraper**
- Movement **Clinger**
- Size Range **Small to Medium (5-29mm)**

**EXPERT INTERVIEW**

**Dr. John Morse**  
Prof. Emeritus of Entomology  
Clemson University

00:08

Live Flatheaded Mayfly


Clicking on a single genus opens the zoomable gigapixel image.  
Guitar pics identify characters diagnostic for Order, Family, and Genus.

← → ↻ [macroinvertebrates.org/#/ephemeroptera/heptageniidae/maccaffertium/dorsal](http://macroinvertebrates.org/#/ephemeroptera/heptageniidae/maccaffertium/dorsal) ☆ ☰

**CARNEGIE MUSEUM OF NATURAL HISTORY** Aquatic Macroinvertebrate Collection  
An explorable resource for stream insect identification

Genus | EPHEMEROPTERA Heptageniidae *maccaffertium*

↑ Maccaffertium











Dorsal

↑  
-

*i* 🔍

**DIAGNOSTIC CHARACTERS**

Category	Character	Image
ORDER	Three Tails	
	Abdominal Gills Present	
	Single Claw	
Family	Flat Head	
	Short Tarsal Claw	
	Straight-legged Appendages	
Genus	Slender Gill (ab seg 7)	
		

Natural History




Because the gigapixel image is 30 to 50 individual images stitched together on an axis, the screen becomes a powerful microscope. Zoom with touch screen, mouse, or +/- buttons

← → ↻ [macroinvertebrates.org/#/ephemeroptera/heptageniidae/maccaffertium/dorsal](http://macroinvertebrates.org/#/ephemeroptera/heptageniidae/maccaffertium/dorsal) ☆ ☰

**CARNEGIE MUSEUM OF NATURAL HISTORY** Aquatic Macroinvertebrate Collection  
An explorable resource for stream insect identification

Genus | EPHEMEROPTERA Heptageniidae *maccaffertium*

↑ Maccaffertium



Dorsal

+

-

*i* 🔍

**DIAGNOSTIC CHARACTERS**

- ORDER: Three Tails
- Abdominal Gills Present
- Single Claw
- Family: Flat Head
- Short Tarsal Claw
- Straight-legged Appendages
- Genus: Slender Gill (ab seg 7)

Natural History



# Aquatic Macroinvertebrate Collection

An explorable resource for stream insect identification

Genus | EPHEMEROPTERA Heptageniidae *maccaffertium*

## Maccaffertium

Insert box shows how zoomed image fits into general habitus, position and size



*i*

### DIAGNOSTIC CHARACTERS

Order   
 Family

# Aquatic Macroinvertebrate Collection

An explorable resource for stream insect identification

Genus | EPHEMEROPTERA Heptageniidae *maccaffertium*

## Maccaffertium



### DIAGNOSTIC CHARACTERS



DER



mily



Diagnostic characters are available by clicking on thumbnails.

macroinvertebrates.org/#/ephemeroptera/heptageniidae/maccaffertium/dorsal

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Aquatic Macroinvertebrate Collection  
An explorable resource for stream insect identification

Genus | EPHEMEROPTERA Heptageniidae *maccaffertium*

Maccaffertium

Dorsal

Click on thumbnail for automated diagnostics

DIAGNOSTIC CHARACTERS

- ORDER: Three Tails
- Abdominal Gills Present
- Single Claw
- Family: Flat Head
- Short Tarsal Claw
- Straight-legged Appendages
- Genus: Slender Gill (ab seg 7)

Program zooms to selected character, opens new information.

Aquatic Macroinvertebrat: x

macroinvertebrates.org/#/ephemeroptera/heptageniidae/maccaffertium/dorsal

CARNEGIE MUSEUM OF NATURAL HISTORY

# Aquatic Macroinvertebrate Collection

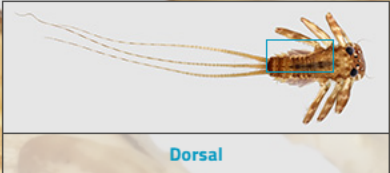

An explorable resource for stream insect identification

Genus | EPHEMEROPTERA Heptageniidae *maccaffertium*

## Maccaffertium

**Abdominal Gills Present**

Mayfly nymphs have flat, leaf-like gills which extend laterally (from the side) or ventrally (from the bottom) of the abdomen. Gill structure and shape is important in identifying mayfly groups.



Dorsal

**DIAGNOSTIC CHARACTERS**

ORDER

- Three Tails
- Abdominal Gills Present
- Single Claw

Family

- Flat Head
- Short Tarsal Claw
- Straight-legged Appendages

Genus

- Slender Gill (ab seg 7)

Natural History

Pull down menu allows user to move to another genus or support tool.

The screenshot shows a web browser window with the URL [macroinvertebrates.org/#/ephemeroptera/heptageniidae/maccaffertium/dorsal](http://macroinvertebrates.org/#/ephemeroptera/heptageniidae/maccaffertium/dorsal). The page title is "Aquatic Macroinvertebrate Collection" with the subtitle "An explorable resource for stream insect identification". The main content area displays the genus *Maccaffertium* with a taxonomic path: Genus | EPHEMEROPTERA Heptageniidae *maccaffertium*. A large image of a mayfly nymph is shown, with a blue pin highlighting a specific anatomical feature. A pull-down menu is open on the right side of the page, listing navigation options: MAYFLIES (orange), STONEFLIES (purple), CADDISFLIES (green), Glossary (grey), Resources (grey), and About (grey). Each of the first three options has a plus sign to its right. A text box on the left titled "Abdominal Gills Present" provides information about mayfly nymphs and includes a video player. At the bottom, a "DIAGNOSTIC CHARACTERS" section features a grid of images and labels for various morphological traits: Three Tails, Abdominal Gills Present, Single Claw, Flat Head, Short Tarsal Claw, Straight-legged Appendages, and Slender Gill (ab seg 7). The "ORDER" label is on the far left, and the "Genus" label is on the far right of this section.


# Jump to caddisflies....

macroinvertebrates.org/#/trichoptera

**CARNEGIE MUSEUM OF NATURAL HISTORY** Aquatic Macroinvertebrate Collection  
An explorable resource for stream insect identification

Order | TRICHOPTERA  
**CADDISFLIES**

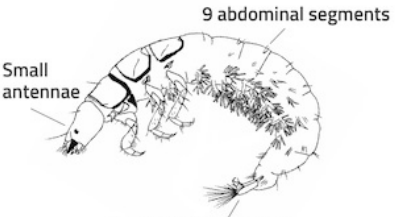
Family   Brachycentridae <b>Humpless Casemaker Caddisflies</b>	Family   Glossosomatidae <b>Saddle Casemaker Caddisflies</b>	Family   Philopotamidae <b>Fingernet Caddisflies</b>	Family   Thremmatidae <b>Autumn Mottled Sedges</b>
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**i**

**ORDER TRICHOPTERA | Caddisflies**  
Trichoptera: *trichos* 'hair' + *ptera* 'wings' (Greek)

Most caddisflies live in portable cases or retreats. Like moths and butterflies, they produce silk which is used to construct cases and retreats, spin nets to collect food, or anchor onto substrates, and form cocoons. Caddisflies are most abundant in flowing (lotic) water, and many are sensitive to pollution. Trichoptera larvae have a sclerotized (hardened horn-like) head, a soft abdomen ending in a pair of hook-bearing prolegs, and most have small antennae.

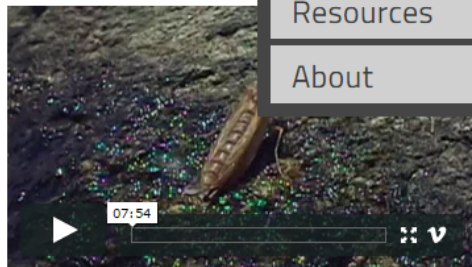


*Caddisfly larva characteristics*

Chronomidae Research Group

**MAYFLIES** +  
**STONEFLIES** +  
**CADDISFLIES** -  
Brachycentridae +  
Glossosomatidae +  
Philopotamidae +  
Thremmatidae +

Glossary  
Resources  
About



07:54

Video excerpt from Bugs of the Underworld / Ralph Cutter

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# Jump to Glossosomatidae...

Aquatic Macroinvertebrate Collection


macroinvertebrates.org/#/trichoptera/glossosomatidae

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Family | TRICHOPTERA Glossosomatidae

## Saddle Casemaker Caddisflies

Genus | *Glossosoma*



**i**


**FAMILY OVERVIEW | Glossosomatidae**

The Saddlecase family of caddisflies is distinguished by the unique dome-shaped form of their cases which are made from pebbles. Unlike other types of case-maker caddisflies, Glossosomatidae do not build cylindrical cases; but rather have a tortoise-shell shaped case held underneath by a strap or belt of cemented sand. These caddisflies live in cold, clean stream and feed on diatoms, algae and detritus scraped off rocky surfaces.


**CHARACTERISTICS**

- Pollution Tolerance: **Intolerant (0)**
- Primary Feeding Group: **Scraper**
- Movement: **Clinger**
- Size Range: **Small to Medium (5-29mm)**

**EXPERT INTERVIEW**



**Dr. John Moore**  
Prof. Emeritus of Entomology  
Clemson University



**Glossosomatidae Cases**

**MAYFLIES** +

**STONEFLIES** +

**CADDISFLIES** -

- Brachycentridae +
- Glossosomatidae +
- Philopotamidae +
- Thremmatidae +

Glossary

Resources

About



*Glossosoma*: Click “I” to open more information...

Aquatic Macroinvertebrate Collection

macroinvertebrates.org/#/trichoptera/glossosomatidae/glossosoma/dorsal

CARNEGIE MUSEUM OF NATURAL HISTORY

An explorable resource for stream insect identification

Genus | TRICHOPTERA Glossosomatidae *glossosoma*

**Glossosoma**

+  
-  
Dorsal | Lateral | Ventral

**DIAGNOSTIC CHARACTERS**

**ORDER** Anal Hooks

**Family** 9 Segmented Abdomen

Mesonotum Membranous

Metanotum Membranous

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# Mesonotal membrane and John Morse commentary

Aquatic Macroinvertebrate Collection

macroinvertebrates.org/#/trichoptera/glossosomatidae/glossosoma/dorsal

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An explorable resource for stream insect identification

Genus | TRICHOPTERA Glossosomatidae *glossosoma*

## Glossosoma

**Mesonotum Membranous**

The mesonotum (2nd thoracic segment) is entirely membranous in some genera of the family Glossosomatidae; or has two or three sclerites in other genera.

**Dr. John Morse**  
Prof. Emeritus of Entomology  
Clemson University

0:46

DIAGNOSTIC CHARACTERS

ORDER

- Anal Hooks
- 9 Segmented Abdomen

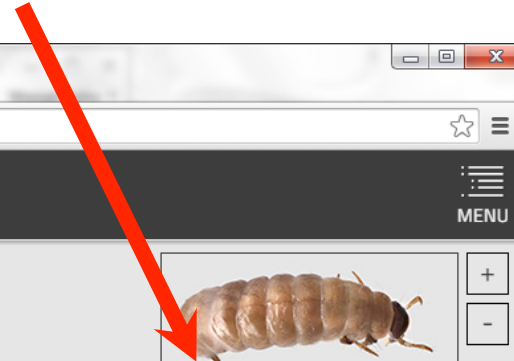
Family

- Mesonotum Membranous
- Metanotum Membranous

Dorsal | Lateral | Ventral

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User can switch between dorsal, lateral, and ventral views by clicking...



Aquatic Macroinvertebrate Collection

Genus | TRICHOPTERA Glossosomatidae *glossosoma*

# Glossosoma

**GENUS OVERVIEW**

*Glossosoma* is a widespread case-building genus found throughout North America. They are obligate scrapers on rock surfaces and cling to the rocks while encased inside a tortoise-like shelter. A key character that makes this genus recognizable is the pair of dark sclerotized lines on either side of their anal opening.

*Glossosoma* anal opening

**CHARACTERISTICS**

Taxonomic ID	117159	Movement	Clinger
Distribution	Widespread	Feeding Method	Scraper
Occurrence	Less Commonly Found	Habitat Type	Lotic-erosional
Pollution Tolerance	0	Size Range	Very Small to Medium (<5-29mm)

**SPECIMEN INFO**

Collected By  
Stephanie Sanner

Location  
USA, PA, Westmoreland Co.  
Loyalhanna Creek, 3km S. of Rector  
+40.16019891, -79.27180242

Date  
11/25/2012

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# Glossosoma ventral view

Aquatic Macroinvertebrat: x  
macroinvertebrates.org/#/trichoptera/glossosomatidae/glossosoma/ventral







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Aquatic Macroinvertebrate Collection  
An explorable resource for stream insect identification

Genus | TRICHOPTERA Glossosomatidae *glossosoma*  
↑ Glossosoma

Dorsal | Lateral | **Ventral**



**DIAGNOSTIC CHARACTERS**

ORDER	 Very Small Antennae	 Anal Hook	 9 Segmented Abdomen	Family	 Anal claw	 Tergum 9 Sclerite	Genus	 Anal opening
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# Thumbnail popup, diagnostic anal opening and information

Aquatic Macroinvertebrate Collection

Genus | TRICHOPTERA Glossosomatidae *glossosoma*

## Glossosoma

**Anal opening**

A distinctive character the *Glossosoma* genus is the dark sclerotized lines marking both sides of the anal opening.

Dorsal | Lateral | **Ventral**

**DIAGNOSTIC CHARACTERS**

- ORDER: Very Small Antennae
- Anal Hook
- 9 Segmented Abdomen
- Family: Anal claw
- Tergum 9 Sclerite
- Genus: Anal opening

Advantages:

Gestalt available from synoptic view

Responsive to level of inquiry

Different representational forms improve demonstration (video of gills moving)

Interview is more engaging than blocks of text.

Aquatic Macroinvertebrate Collection

macroinvertebrates.org/#/

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An explorable resource for stream insect identification

MENU

Order | EPHEMEROPTERA  
+ MAYFLIES

Order | PLECOPTERA  
+ STONEFLIES

Order | TRICHOPTERA  
+ CADDISFLIES

Museum of Natural History

## Trials with Allegheny College's *Creek Connections* program



Twenty-one 9<sup>th</sup> through 11<sup>th</sup> graders of mixed gender participated in the embedded assessment activity. Of these, 71% had done some sort of insect identification before. Students visit different stations and use different tools to ID specimens.

*Table 1: Accuracy of Insect Identification By Resource*

	Dichotomous Key	Flashcards	Digital Teaching Collection	Significance Level
Order	50%	100%	98%	.000*
Family	17%	38%	86%	.000*
Genus	N/A**	38%	87%	.000*

Students reported liking Digital Teaching Collection for the detailed images (52%), ease and efficiency of use (29%), and the way in which the insects were organized within the online interface (29%):

*“The digital one is really nice because of the touch screen and how easy it is to use. The pictures are also extremely good, so it is easy to compare the real specimen and the picture.”*



# Aquatic Macroinvertebrate Collection

An explorable resource for stream insect identification

Order | EPHEMEROPTERA

## + MAYFLIES



Order | PLECOPTERA

## + STONEFLIES



Order | TRICHOPTERA

## + CADDISFLIES

