Unit 6 - Non-pterygote Hexapoda

Open Entomology Project

13 September 2016

Introduction

Here we begin looking at taxa classified in **Hexapoda**. In most cases you will examine multiple families, most of which you will be tested on in lab practicals. You may be shown more families than are on the handout—primarily so that you can better grasp the diversity that exists—but you will not have to sight-identify these other families. Looking at these other families may help to you, though, in identifying specimens for your collection. Some characters might be impossible to see but are provided for future reference.

Materials

- Specimens (provided)
- Fine forceps, probes (provided)
- Sorting tray, watch glasses, gloves, safety glasses, glycerine, ethanol (provided)
- Pencil/paper for sketches

Safety

We will be working with sharp tools. Wear your personal protective gear at all times. Specimens are to be returned to their vials after lab, and glycerine and ethanol will be collected for proper disposal or reuse.

Methods

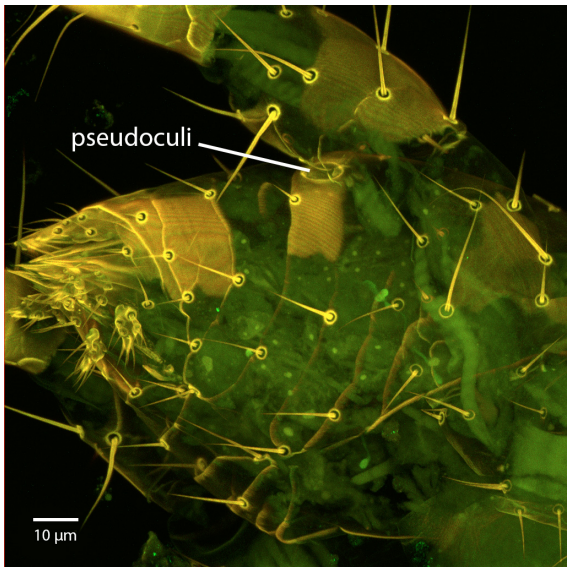
Working with a partner, organize your space, specimens, tools, and microscope. Use your probe and forceps to manipulate the specimen. In this lab, however, we will not be dissecting specimens (unless otherwise noted). You can start anywhere in the handout.

Hexapoda

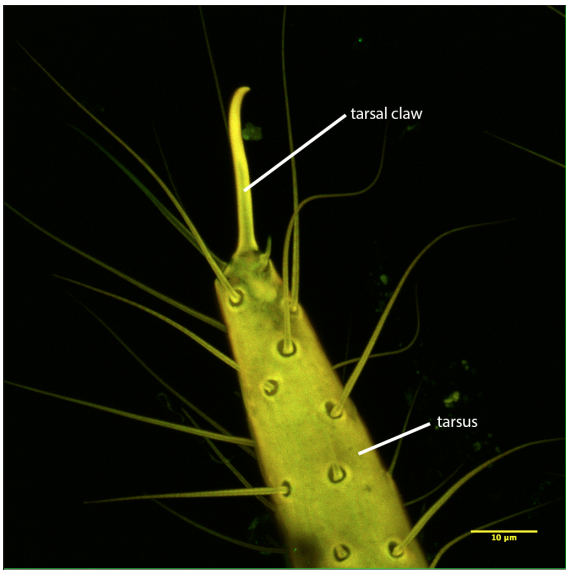
- 3 tagmata present: head, thorax, abdomen
- 3 pairs of uniramous thoracic appendages (legs) present

Entognatha

- Antennae, when present, truly segmented (*i.e.*, each segment has intrinsic musculature)
- Mouthpart concealed externally (Figure 1a)
- Tarsus not subdivided into tarsomeres (Figure 1b)



(a) CLSM volume rendered image showing proturan head (mouth region on the left-middle portion of the image) and base of fore leg. Photo (CC BY 2.0) by István Mikó



(b) CLSM volume rendered image showing proturan fore tarsus. Photo (CC BY 2.0) by István Mikó

Figure 1: Protura

1 Protura (coneheads)

Diagnostic characters: Antennae apparently absent (Figures 2, 3b); eyes absent; sensory organs (pseudoculi) present where one would expect eyes to be; mandibles without molar area (proximal flattened region for grinding food); body very small (<1.5 mm long); abdomen 11-segmented, cerci absent (Figure 3a).

Natural History: Proturans can be abundant in leaf litter and soil samples, but they are incredibly small and usually overlooked. More than 800 species have been described worldwide, and most are smaller

than 2 mm.

Question 6-1: How might the absence of antennae be adaptive for these hexapods? Where would you predict they live? Which structure functions as the primary anterior sensory appendage?

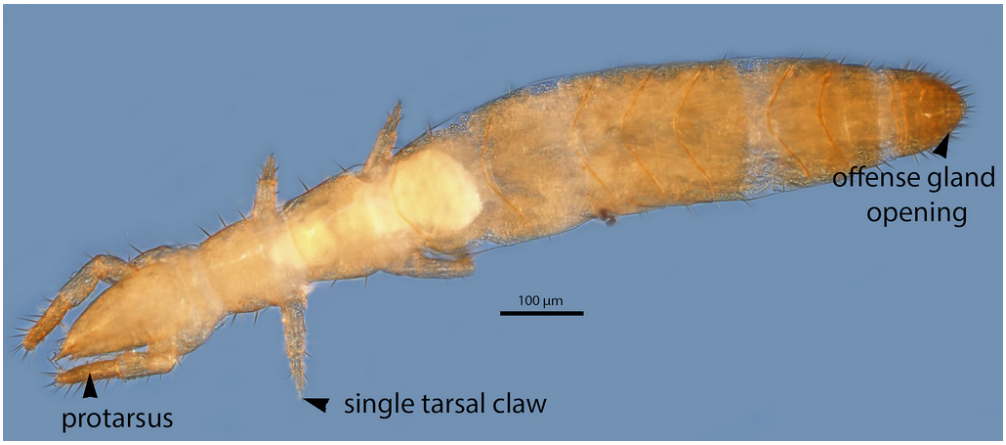
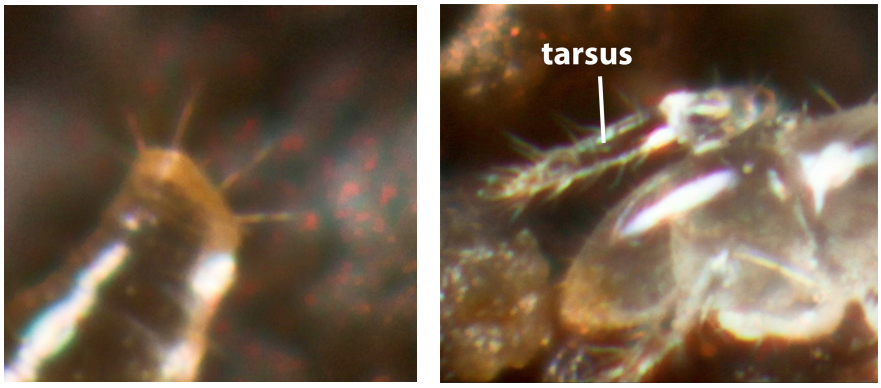


Figure 2: Proturan habitus. Photo (CC BY 2.0) by István Mikó `https://flic.kr/p/yCpxwp`



(a) Apex of abdomen. Photo (CC BY-SA 2.0) by Andy Murray `https://flic.kr/p/eaKZ2B`

(b) Head and prothorax. Photo (CC BY-SA 2.0) by Andy Murray `https://flic.kr/p/eaKZ2B`

Figure 3: Protura

2 Diplura (diplurans)

Diagnostic characters: Antennae filiform; eyes absent; pseudoculi absent; *mandibles without molar area*; body usually >3 mm long; cerci distinct; abdominal segments often with styli.

Natural History: These hexapods are quite common in Pennsylvania, especially under rocks and logs, at the interface between leaf litter and soil. Like Protura, there are approximately 800 species known

worldwide, but diplurans are generally much larger (up to 5 mm long in North America and up to 5 cm in the tropics).

Question 6-2: Compare **Japygidae** (Figure 4) to **Campodeidae** (Figure 5). What is your hypothesis for why the cerci vary phenotypically between families? What is their function?

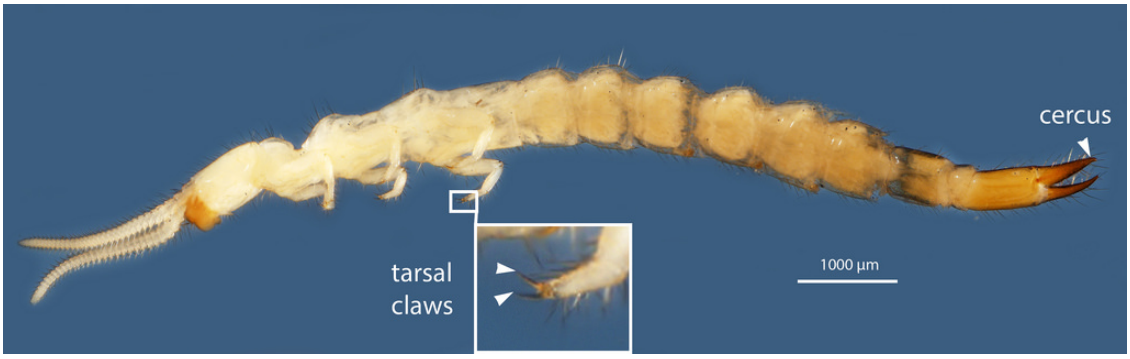


Figure 4: Japygidae habitus. Photo (CC BY 2.0) by István Mikó `https://flic.kr/p/yCo5BK`

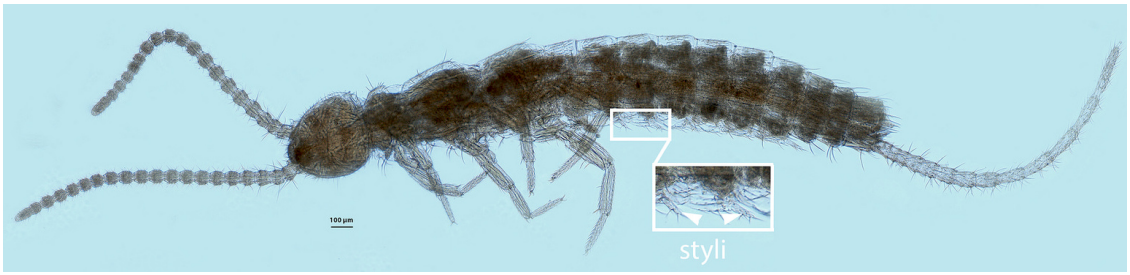
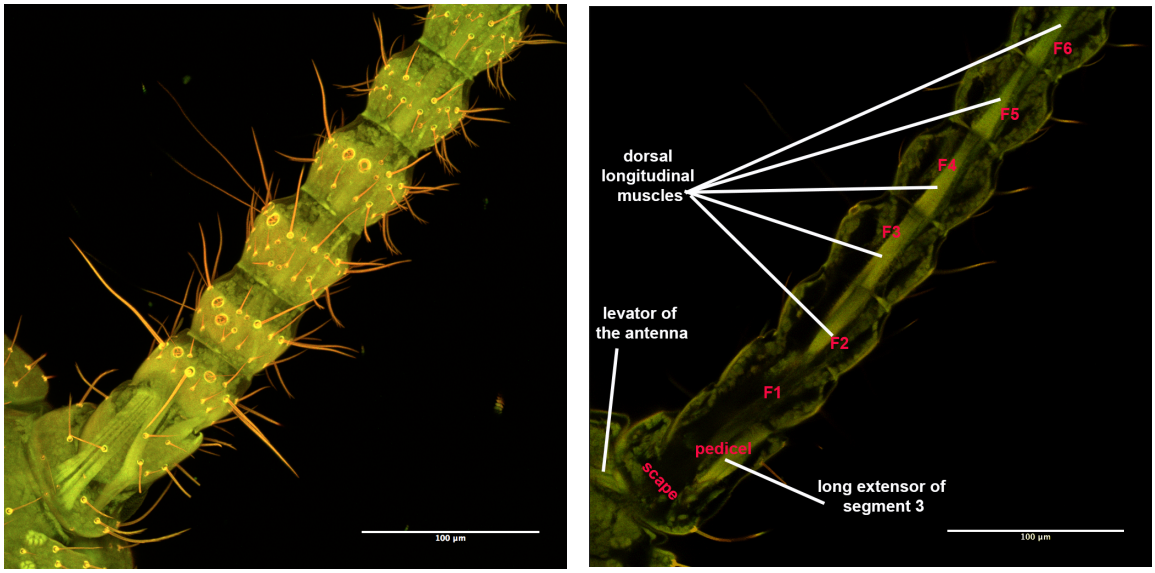


Figure 5: Campodeidae habitus. Photo (CC BY 2.0) by István Mikó `https://flic.kr/p/ykHVxt`

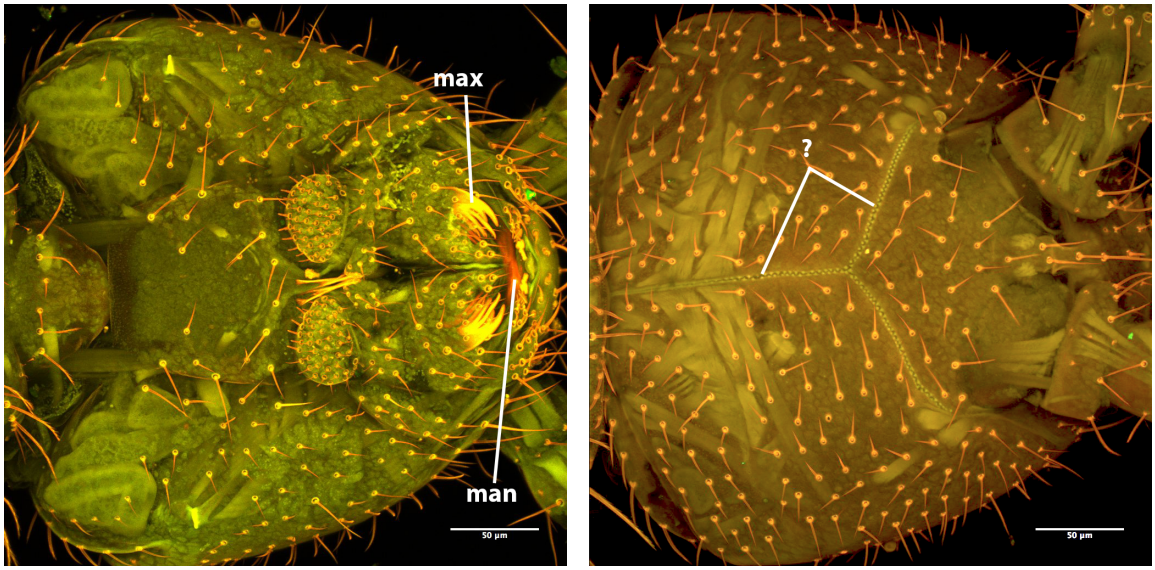
3 Collembola (springtails)

- Compound eyes present
- mandibles with molar area
- antennae usually ≤4 segments
- tibia fused with tarsus (tibiotarsus)
- abdomen with ≤6 segments: 1st segment with ventral tube (collophore), 3rd abdominal segment modified ventrally (retinaculum) to receive furculum, 5th abdominal segment with forked structure (furculum), usually folded under abdomen
- body length usually 1–3 mm



(a) External view **(b)** Internal view, with muscles

Figure 6: CLSM volume-rendered images, showing the antenna of Diplura. Photo (CC BY 2.0) by István Mikó.



(a) Ventral view **(b)** Dorsal view, revealing suture

Figure 7: CLSM volume-rendered images, showing the head of Diplura. Photo (CC BY 2.0) by István Mikó

3.1 Symphypleona (globular springtails, incl. Sminthuridae)

Diagnostic characters: Head typically hypognathous, anteroposteriorly flattened; antennae longer than head; prothorax indistinct dorsally, narrowly articulated with head; several abdominal segments fused dorsally.

Natural History: Biologically diverse. Symphypleona is subdivided into about 10 families. Some species are semiaquatic.

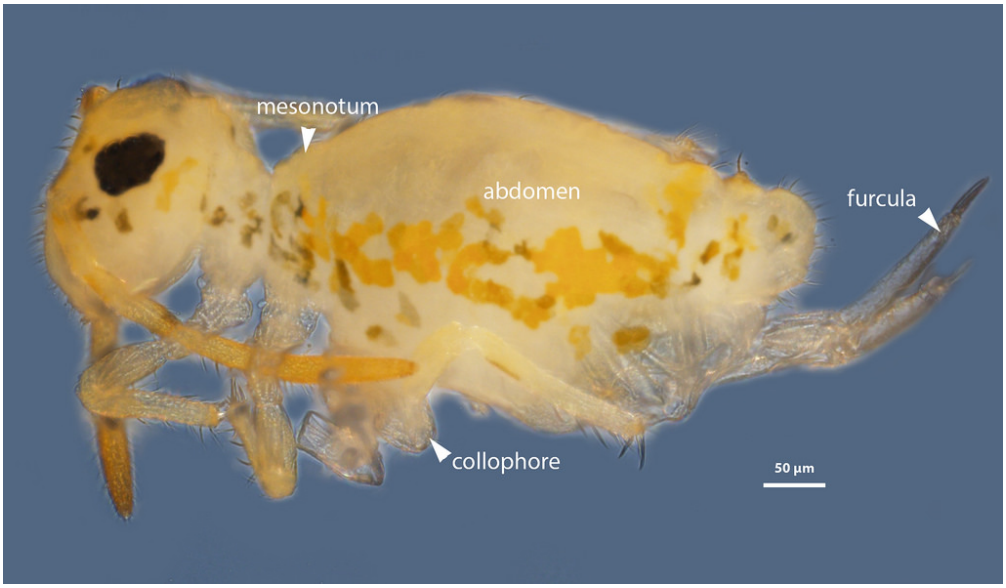


Figure 8: Sminthuridae habitus. Photo (CC BY 2.0) by István Mikó `https://flic.kr/p/xFw3ua`)

3.2 Poduromorpha (incl. Hypogastruridae, snowfleas)

Diagnostic characters: Head typically prognathous, not anteroposteriorly flattened; antennae usually shorter than head; prothorax distinct dorsally, broadly articulated with head; legs relatively short; abdominal segments 2–4 not fused.

Natural History: Like Symphypleona, these hexapods are biologically diverse, with many semiaquatic species. There are also about 10 families.

3.3 Entomobryomorpha (incl. Entomobryidae, Tomoceridae)

Diagnostic characters: Head hypognathous to prognathous, not anteroposteriorly flattened; antennae longer than head; prothorax indistinct dorsally, narrowly articulated with head; abdominal segments 2–4 not fused; body and legs relatively long, thin.

Natural History: There are about 8 extant families (Soto-Adames *et al.*, 2008).

Question 6-3: Lines similar to the one marked on Figure 7b occur on the epithelium of adult Entognatha. These structures are similar to human cranial sutures. What is their function? Winged insect adults do not have these lines, or at least they don't function in the same way. Why not?

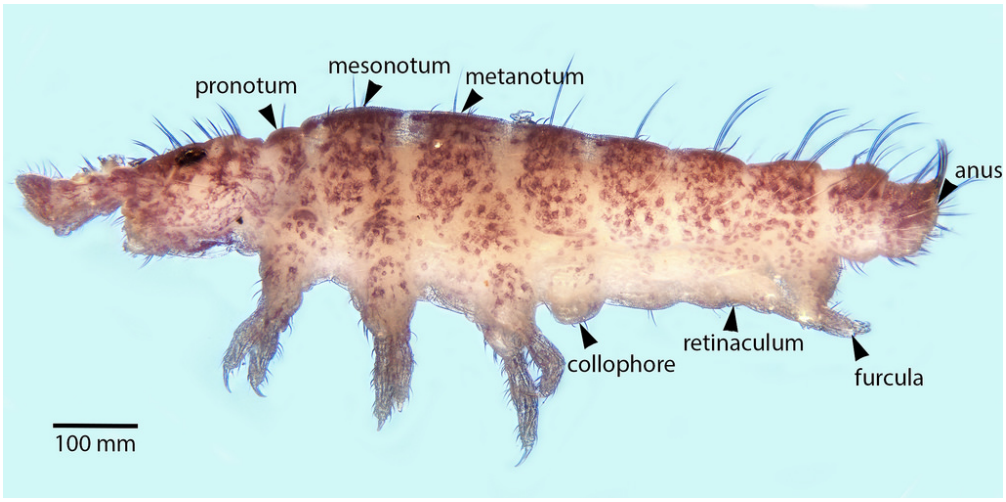


Figure 9: Hypogastruridae habitus. Photo (CC BY 2.0) by István Mikó `https://flic.kr/p/ykEeQC`

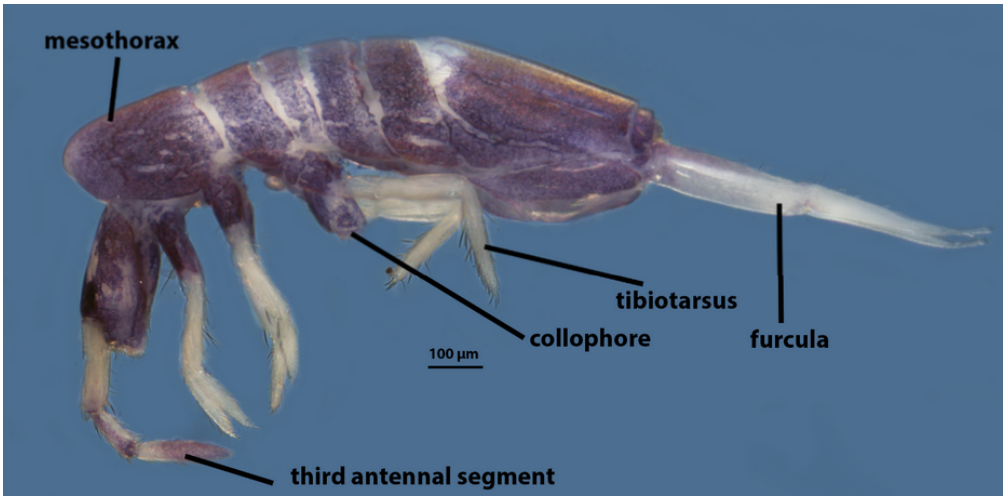


Figure 10: Entomobryidae habitus. Photo (CC BY 2.0) by István Mikó.

Insecta

The remaining arthropods we will examine in lab are true insects. In addition to many internal characters we won't examine (*e.g.*, Johnston's organ) insects can be recognized by:

- Antennae 3-segmented (*i.e.*, segments with intrinsic musculature), with apical segment (flagellum) usually subdivided
- Mouthparts not usually enveloped by cuticular evagination (*i.e.*, insects are *ectognathous*)
- Ovipositor present

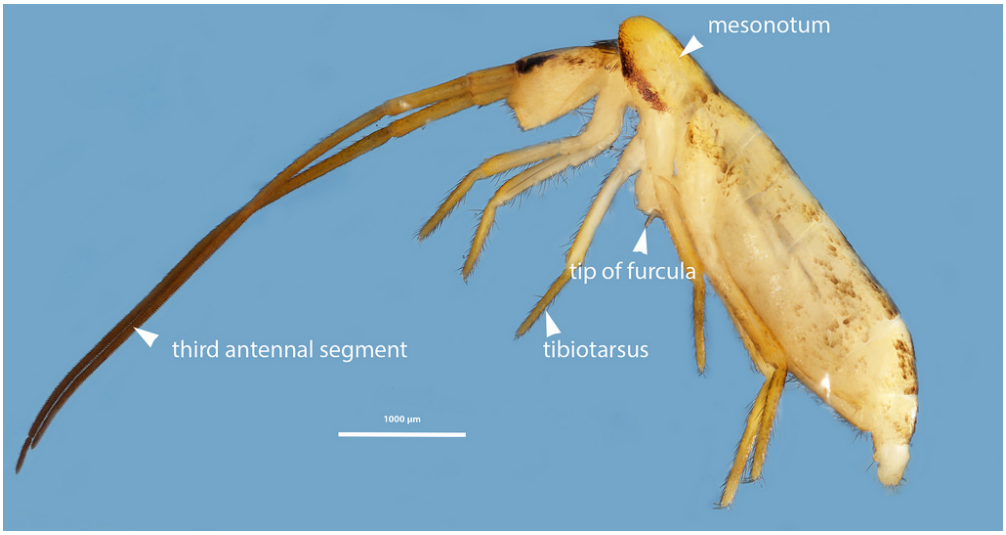


Figure 11: Tomoceridae habitus. Photo (CC BY 2.0) by István Mikó https://flic.kr/p/yCnGYz

4 Archaeognatha (Microcoryphia, bristletails)

Diagnostic characters: Compound eyes well-developed, adjacent dorsally; maxillary palps longer than legs, subdivided into 7 annuli; labial palps subdivided into 3 annuli; meso- and metacoxa with styli present; styli present on abdominal segments 2–9; abdomen with 3 scaly appendages present apically (2 cerci, 1 terminal appendage); body "humpbacked", scaly; paired eversible vesicles usually present on abdominal segments 1–7.

Natural History: These insects are frequently found on or around fallen logs and rocks, where they survive on algae, lichens, and decaying matter. There are about 350 known species, in 2 families.

Question 6-4: Which characteristics would you interpret as ancestral? Can you find evidence that insects are related to other pancrustaceans?

Question 6-5: Have you seen these insects move? Why do they have a "humpbacked" habitus? Can you find and draw the styli? What might these be remnants of?

5 Zygentoma (Thysanura, in part; silverfish, firebrats)

Diagnostic characters: Compound eyes small, widely separated; maxillary palps shorter than legs, subdivided into 6 annuli; labial palps subdivided into 4 annuli; styli on meso- and metacoxa absent, usually present on abdominal segments 2–9; abdomen with 3 bare appendages present apically (2 cerci, 1 terminal appendage); body dorsoventrally flattened, scaly; paired eversible vesicles usually present on abdominal segments 1–7.

Natural History: Zygentoma is about as diverse as Archaeognatha. Many species inhabit buildings,

Figure 12: Archaeognathan habitus. Photo (CC BY-NC-SA 2.0) by Kim Fleming `https://flic.kr/p/5pYjac`

Figure 13: Archaeognathan head and thorax. Photo (CC BY-NC-SA 2.0) by Shipher Wu `https://flic.kr/p/62T1m3`

where they can be pests (eating paper, glue, and other starchy products). Some species live in ant nests, and many can digest cellulose and lignin.

Figure 14: Zygentoman habitus. Photo (CC BY-SA 2.0) by Jean-Raphaël Guillaumin `https://flic.kr/p/4Cavhu`

Figure 15: Zygentoman head. Photo (CC BY-SA 2.0) by Jean-Raphaël Guillaumin `https://flic.kr/p/czicq1`

Epilogue

This handout is part of an open curriculum. Original files are available free for anyone to download, copy, modify, and improve at the Open Entomology GitHub repository (Open Entomology Project, 2016), which also provides a mechanism for reporting problems and other feedback: `https://github.com/OpenEntomology/InsectBiodiversityEvolution/issues`

Acknowledgments

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References

Open Entomology Project. Insect biodiversity and evolution. `https://github.com/OpenEntomology/InsectBiodiversityEvolution`, 2016. Accessed 19 August 2016.

Soto-Adames, F. N., Barra, J.-A., Christiansen, K., and Jordana, R. Suprageneric classification of collembola entomobryomorpha. *Annals of the Entomological Society of America*, 101(3):501–513, 2008. doi: 10.1603/0013-8746(2008)101[501:SCOCE]2.0.CO;2.