Unit 5 - Non-hexapod Arthropoda

Andrew R. Deans and István Mikó

24 February 2016

1 Lecture

In this unit we learn about major non-hexapod arthropod lineages—**Chelicerata** (spiders, mites, scorpions, and their relatives), **Myriapoda** (centipedes, millipedes, and their relatives), and some non-hexapod **Pancrustacea** (pillbugs, brine shrimp, and their relatives—including our collective understanding of their natural histories and hypotheses of their evolutionary history relative to other arthropods.

Taxa to know

Familiarize yourself with the following taxon names, which refer to organisms you are likely to encounter in the northeastern USA. Can you describe how these arthropods live (natural history) and roughly how diverse they are? Do you know how they're related to one another? Could you identify one by sight?

1. Acari
2. Amphipoda
3. Arachnida
4. Araneae
5. Chelicerata
6. Chilopoda
7. Diplopoda
8. Isopoda
9. Myriapoda
10. Onychophora
11. Opiliones
12. Pancrustacea
13. Pseudoscorpiones
14. Scorpiones
15. Xenocarida (no specimens)

Big picture questions

We covered more taxa than those in the list above. Was there one that stood out to you as especially compelling? Can you spell it correctly and describe its relevance to our understanding of evolution, behavior, and morphology?

What was the first terrestrial arthropod? How do we know it was terrestrial?

Revisit our discussion of the phenotypes that make an organism an arthropod. Now consider their diversity relative to other metazoans: vertebrates, annelids, nematodes, *etc.* What phenotypes would you consider "key innovations"? Why is Arthropoda orders of magnitude more diverse than its sister lineage?

2 Lab

Introduction

You should have a relatively firm grasp of arthropod anatomy at this point. It's time to start looking at specimens in the contexts of taxonomy and evolution. In this lab we will examine a few fossils, to get a sense of how much (or how little) information they provide. We will also look at specimens of velvet worms (Onychophora), the putative sister to Arthropoda, and non-insect arthropods. Based on your observations of their morphologies, how are insects related to these other arthropods? After this lab do you think you could recognize any of these taxa in the wild? We will focus primarily on arthropods you can find in Pennsylvania.

Materials

- specimens (provided)
- fine forceps, probes (provided)
- sorting tray, watch glasses, gloves, safety glasses, glycerol, 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.

2.1 Onychophora (velvet worms)

These organisms are thought to be sister to Arthropoda. Can you see any shared, derived characters (Figure 1) between onychophorans and arthropods? What features indicate that these creatures are definitely *not* Arthropoda (*i.e.*, how would you write the diagnosis)?

Figure 1: Photo (CC BY-NC-SA 2.0) by Yonatan Monk: `https://flic.kr/p/85z27d`

.

2.2 Chelicerata

These arthropods generally share the following characters:

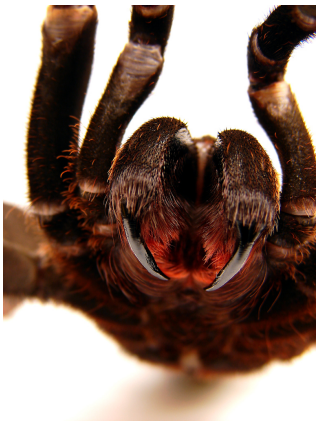
- antennae absent (though anteriormost pair of legs often antenniform)
- 6 pairs of uniramous appendages: chelicerae (mouthparts) + pedipalps + 4 pairs of legs
- 2 tagmata: prosoma (cephalothorax) and opisthosoma (abdomen)

The most diverse group of chelicerates is Arachnida, which includes all the terrestrial species of Chelicerata. We will examine specimens of the taxa listed below. Can you see the diagnostic characters clearly? If you saw any of these specimens in a lab practical could you name it (with correct spelling), describe a diagnostic feature, and/or describe its natural history?

Araneae (spiders)

- chelicerae fang-like (Figure 2a)
- anteriormost pair of legs not antenniform
- pedipalps not chelate (*i.e.*, pincer/claw-shaped), rarely stouter than legs
- opisthosoma not obviously segmented (except rarely)
- opisthosoma attached to prosoma via narrow constriction (Figure 2b)
- spinnerets present posteroventrally on opisthosoma, but no tail-like structure (telson)

Why do spiders have a constricted "waist"? What are fang-like chelicerae adapted for? Can you predict how they're used?



(a) Chelicerae. Photo (CC BY-SA 2.0) by Matt Reinbold: `https://flic.kr/p/2Bxryh`

(b) Ventral habitus. Photo (CC BY-SA 2.0) by James E. Petts: `https://flic.kr/p/fJqUsE`

Figure 2: Spiders (Araneae)

Acari (mites, ticks)

- opisthosoma not segmented (See Figure 3)
- opisthosoma broadly joined to prosoma, no tail-like structure (telson)
- young instars with 3 pairs of legs, adults with 4
- pedipalps not chelate, not thicker than legs
- mouthparts usually project anteriorly, chelicerae not chelate
- usually very small (0.08–10 mm body length)

The apparent lack of segmentation is a diagnostic character. Can you see any evidence that these arthropods have segments? Based on their body shape and size, and especially their mouthpart morphology, can you make predictions or generalizations about their natural history?

(a) Dorsal habitus. Photo (CC BY 2.0) by Mick E. Talbot: `https://flic.kr/p/55WxVw`

(b) Dorsal habitus. Photo (CC BY 2.0) by Mick E. Talbot: `https://flic.kr/p/6s36QX`

Figure 3: Mites (Acari).

Opiliones (harvestmen, daddy-longlegs)

- chelicerae chelate
- opisthosoma segmented, broadly joined to prosoma, without tail-like structure (telson) (Figures 4–5)
- body ovoid; body <7 mm long usually, with leg span up to 160 mm
- pedipalp morphology variable: usually thinner than legs, sometimes raptorial

Figure 4: Opiliones. Photo (CC BY-SA 2.0) by Gordon: `https://flic.kr/p/bVW3Yp`

Like all arachnids, Opiliones do not have antennae. Can you find an appendage that serves a similar function? Given the variation in pedipalp morphology across Opiliones, what would you predict is the function of these appendages?

Figure 5: Opiliones. Photo (CC BY 2.0) by Thomas Bresson: `https://flic.kr/p/6ytEzH`

Scorpiones (scorpions)

- chelicerae chelate
- pedipalps long, chelate, and usually at least as thick as legs (Figure 6)
- anteriormost pair of legs used for walking (*i.e.*, not antenniform)
- opisthosoma segmented, broadly joined to prosoma; tail-like posteriorly (tail = telson)
- telson with venom gland and sting present
- 2nd segment of opisthosoma with comblike organs (pectines) ventrally

Figure 6: Scorpiones. Photo (CC BY 2.0) by Clinton & Charles Robertson: `https://flic.kr/p/t52BX`

Some scorpion species have massive pedipalps and relatively small telsons, while others exhibit the opposite set of phenotypes (*i.e.*, massive telsons but small pedipalps); from a natural history

perspective what do you think is happening with these structures? Also, how do you think scorpions find prey?

Pseudoscorpiones (pseudoscorpions)

- chelicerae chelate
- pedipalps long, chelate, and thicker than legs (Figure 7)
- anteriormost pair of legs used for walking (*i.e.*, not antenniform)
- opisthosoma segmented, broadly joined to prosoma, without telson
- patellar segment absent on legs

Figure 7: Pseudoscorpionida. Photo (CC BY-SA 2.0) by Gilles San Martin: `https://flic.kr/p/5Nxymf`

Compared to the other arachnids we've seen, would you describe Pseudoscorpiones as being highly adapted for prey capture? What would you predict these arthropods eat?

Did you see all the phenotypes listed above in the specimens we have? Which characters seem to be evolutionarily significant and why?

2.3 Myriapoda

- antennae present as single pair
- appendages uniramous (*i.e.*, no branches)
- mouthparts mandibulate (*i.e.*, not chelicerate)

Diplopoda (millipedes)

- most (apparent) segments with 2 pairs of legs (Figure 8b)
- antennae usually 7-segmented, short
- 30+ pairs of legs present usually
- body usually round, tube-like; some species small, bristly (Figure 8a)

(a) Photo (CC BY 2.0) by Gilles San Martin: `https://flic.kr/p/dgF295`

(b) Photo (CC BY 2.0) by Brian Gratwicke: `https://flic.kr/p/dFP5Wu`

Figure 8: Millipedes (Diplopoda).

Chilopoda (centipedes)

- antennae usually with 14+ segments
- apices of anteriormost pair of legs (forcipules) modified into fang-like structures (Figure 10)
- most segments with 1 pair of legs; 15+ pairs of legs present usually (Figures 9–10)
- body usually dorsoventrally flattened (but see Figure 9)

Figure 9: Chilopoda. Photo (CC BY 2.0) by Brian Gratwicke: `https://flic.kr/p/ehk44m`

Figure 10: Chilopoda. Photo (CC BY 2.0) by Derrick Coetzee: `https://flic.kr/p/cF2Czu`

Based on your observations of the two myriapod taxa we have in lab, what would you say about their natural history? Where does each taxon typically live, and what does it eat?

2.4 Non-hexapod Pancrustacea (formerly "Crustacea")

- often with 2 tagmata: cephalothorax and abdomen
- many biramous (2-branched) appendages, usually with 2nd pair of antennae (antennules)
- mouthparts mandibulate

Isopoda (pillbugs, sowbugs)

- body with no carapace, usually dorso-ventrally flattened (Figures 11a–11b)
- 7 pairs of thoracic legs
- 2nd pair of antennae reduced

(a) Photo (CC BY 2.0) by Mick Talbot `https://flic.kr/p/6vEqLt`

(b) Photo (CC BY 2.0) by Mick Talbot `https://flic.kr/p/6jQM1g`

Figure 11: Isopoda

Amphipoda (scuds)

- no carapace, usually laterally flattened (Figure 12)
- fore legs often raptorial
- usually 6 or 7 pairs of thoracic legs

Given your observations of these "crustaceans", why do we have so few terrestrial and fresh water species, relative to insects?

Figure 12: Amphipoda. Photo (CC BY-NC 2.0) by Fred Snyder: `https://flic.kr/p/9vTru1`

2.5 Test your skills!

You've now seen a handful of arthropod taxa, from three groups that are not insects. While they are not the focus of this course, these organisms are incredibly diverse and remain relevant to understanding the evolution of Arthropoda. Take some time to observe specimens of taxa we are not covering, bask in the diversity of phenotypes, and see if you can classify them correctly. Are the chelicerates, myriapods, or pancrustaceans? Why or why not? Draw and/or describe features you think are diagnostic. Based on their morphology, can you predict their natural history?

Solifugae (Solpugida; camelspiders, sunspiders, windscorpions)

What group does it belong in and why?

What diagnostic characters separate it from the taxa above?

What do these arthropods eat, and how do they live?

Decapoda (crabs, lobsters, shrimp)

What group does it belong in and why?

What diagnostic characters separate it from the taxa above?

Figure 13: Solifugae. Photo (CC BY 2.0) by Maximilian Paradiz: `https://flic.kr/p/7J7B3r`

What do these arthropods eat, and how do they live?

Figure 14: Decapoda. Photo (CC BY 2.0) by Guenter Schuster: `https://flic.kr/p/njkdZ3`

.

Thelyphonida (Uropygi, Uropygida, vinegaroons, whipscorpions)

What group does it belong in and why?

What diagnostic characters separate it from the taxa above?

What do these arthropods eat, and how do they live?

Figure 15: Thelyphonida. Photo (CC BY-NC-SA 2.0) by StarWatcher307: `https://flic.kr/p/8hde2g`

Amblypygi (tail-less whipscorpions)

What group does it belong in and why?

What diagnostic characters separate it from the taxa above?

What do these arthropods eat, and how do they live?

Xiphosura (horseshoe crabs)

What group does it belong in and why?

What diagnostic characters separate it from the taxa above?

What do these arthropods eat, and how do they live?

Figure 16: Amblypygi. Photo (CC BY-NC-SA 2.0) by José Eugenio Gómez Rodríguez: `https://flic.kr/p/5hmWNS`

Figure 17: Xiphosura. Photo (CC BY-ND 2.0) NH Sea Grant: https://flic.kr/p/duEyis: `https://flic.kr/p/85z27d`

.

Copepoda (copepods, fish lice)

What group does it belong in and why?

What diagnostic characters separate it from the taxa above?

What do these arthropods eat, and how do they live?

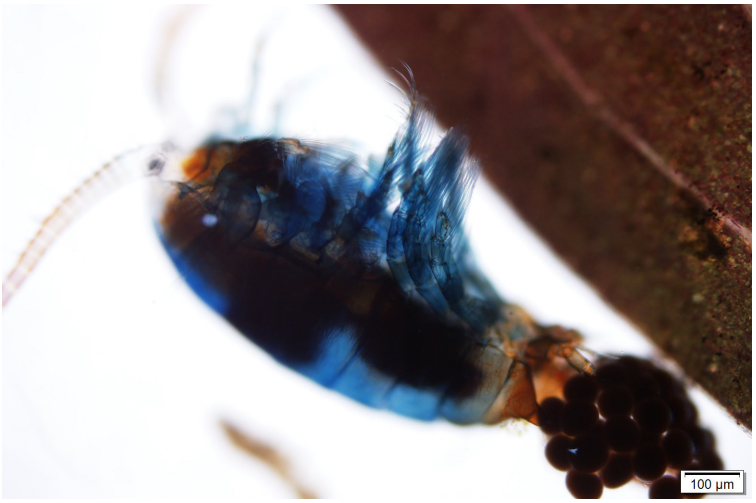


Figure 18: Copepod from Ten Acre Pond (Centre Co., Pennsylvania). Photo (CC BY 2.0) by Andy Deans: `https://flic.kr/p/nsJuJZ`

Symphyla (symphylans)

What group does it belong in and why?

What diagnostic characters separate it from the taxa above?

What do these arthropods eat, and how do they live?

References

[1] Greb, S. F., W. A. DiMichele, and R. A. Gastaldo (2006) Evolution and importance of wetlands in earth history. Geological Society of America Special Papers, 399:1–40 DOI: 10.1130/2006.2399(01)

[2] Dunlop, J. A. (2010) Geological history and phylogeny of Chelicerata. Arthropod Structure & Development, 39(2–3):124–142 DOI: 10.1016/j.asd.2010.01.003. Fossil Record and Phylogeny of the Arthropoda.

Figure 19: Symphyla. Photo (CC BY-SA 3.0) by Sonia Martinez: `http://bit.ly/1iRxA29`

[3] Miyazawa, H., C. Ueda, K. Yahata, and Z.-H. Su. (2010) Molecular phylogeny of Myriapoda provides insights into evolutionary patterns of the mode in post-embryonic development. *Scientic Reports*, 4(4127):1–9 DOI: 10.1038/srep04127.