Unit 9 - Acercaria

Open Entomology Project

10 October 2016

Introduction

Here we begin looking at taxa classified in **Acercaria**, a taxon characterized in part by their stylate laciniae. These three orders, Hemiptera, Psocodea, and Thysanoptera, may comprise a monophyletic lineage that is sister to Holometabola (the taxon with truly larval immature stages). Alternatively, based on genome-scale molecular data (Misof *et al.*, 2014), these taxa are related as ((Thysanoptera, Hemiptera),(Psocodea, Holometabola)). Acercaria share the following characteristics (Beutel *et al.*, 2013); do they represent synapomorphies?

- legs with ≤3 tarsomeres
- cerci absent
- labial palps relatively small or absent
- maxilla modified into stylet (maxillary laciniae are separated from the rest of the maxilla and are stylet-like)
- postclypeus relatively large, accommodates cibarial dilator muscles for sucking
- many species with inactive stage prior to adult

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 and insects on pins. Wear your personal protective gear at all times. Specimens are to be returned to their vials after lab, and glycerol 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.

1 Hemiptera (true bugs, scale insects, aphids, hoppers, etc.)

Diagnostic characters: antenna usually with 5–10 antennomeres, sometimes reduced; piercing/sucking mouthpart (mandible and maxillae rod-like stylets); labium elongate, multi-segmented and surrounds the stylets posteriorly (beak); prothorax is usually wider than long; fore wing is sometimes more sclerotized than hind wing (*e.g.*, Heteroptera); arolium (apicomedial membraneous area of pretarsus) balloon shaped, often exceeds tarsal claw apically, sometimes absent, not eversible; cercus absent.

1.1 Sternorrhyncha (psyllids, whiteflies, aphids, scale insects)

Diagnostic characters: tarsi 1- or 2-segmented; antennae filiform, sometimes absent labium arises from the head in between the procoxae when the head is in normal position, sometimes reduced; ovipositor reduced.

1.1.1 Psyllidae (plantlice)

Diagnostic characters: tarsi 2-segmented; antennae 5–10-segmented (usually 10); fore wings often more sclerotized than hind wing.

Natural history: More than 800 species of plantlice have been described worldwide, and several species are important pests (e.g., *Diaphorina citri* Kuwayama, 1908 and *Trioza erytreae* Del Guercio, 1918, which both vector the bacterium that causes citrus greening).

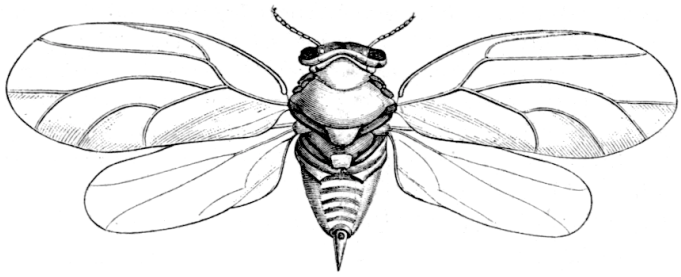


Figure 1: Psyllidae habitus (Schwarz, 1904, Fig. 10d)

1.1.2 Aphididae (aphids)

Diagnostic characters: tarsi 2-segmented, antennae usually 6-segmented; hind wing much smaller than fore wings; cornicles present near posterior end of abdomen (Figure 2).

Natural history: More than 4,000 species have been described worldwide, and at least 250 are known to be pests if the conditions are right. Diversity is higher in the temperate zone. These species have been studied extensively in the context of ecological and symbiotic interactions. They survive primarily as phloem-feeders.

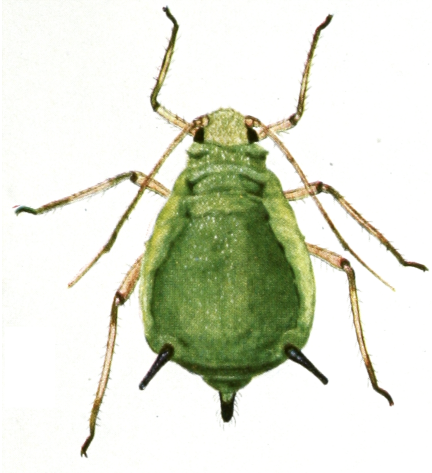


Figure 2: Aphididae habitus ((Snodgrass, 1930, Plate IIA)

1.1.3 Aleyrodidae (whiteflies)

Diagnostic characters: tarsi 2-segmented, antennae 7-segmented (Figure 3a); hind wing almost as large as fore wings; wings held horizontally over body while at rest; body and wings covered with white powder (depends on preservation) (Figure 3b).

Natural history: More than 1,500 species are known worldwide, including many pest species. The typical whitefly life cycle is, at least superficially, similar to holometabolous development. Indeed, the immature stages are often referred to as larvae, and the resting stage prior to eclosion of the adult is called the pupa or puparium (the resting stage resides inside the cast skin of an earlier instar).

Question 9-1: What is the function of the white "powder" that covers their bodies? How would you test your hypothesis?

The next four families are classified in **Coccoidea**, commonly referred to as scale insects. They share the following characteristics: adult males winged, 1-segmented tarsi (rarely 2), 1 pair of wings, no beak; females always wingless, sometimes legless or nearly so, often with a waxy or scale-like covering; first instar nymphs ("crawlers") are quite mobile and have distinct legs and antennae.

These insects also live primarily sedentary lives, with virtually no locomotion after the first instar or "crawler" stage (at least for females). As you examine these scale specimens, think about their adaptations to this kind of lifestyle.

(a) Dorsal habitus, nymph/larva. Photo (CC BY-NC 3.0) by David Cappaert `http://goo.gl/FvsQqt`

(b) Lateral habitus. Photo (CC BY-SA 4.0) by Amada44 `https://goo.gl/chHgyt`

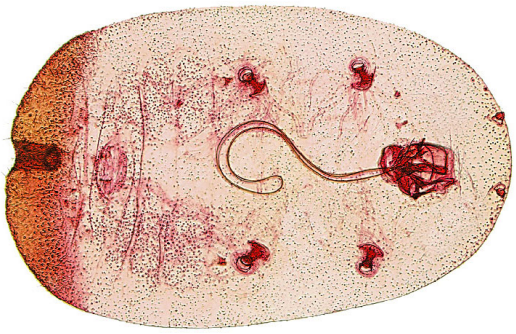
Figure 3: Aleyrodidae

1.1.4 Pseudococcidae (mealybugs)

Diagnostic characters: body ovular, usually with a powdery waxy coating; terminal abdominal segments, anal opening with setae; dorsal ostioles present; abdominal spiracles absent.

Natural history: More than 2,200 species have been described worldwide, and they vary quite a bit morphologically. When alive they can often be recognized by their waxy, powdery appearance.

(a) Dorsal habitus. Photo (CC BY-SA 3.0 AT) by D-Kuru `https://goo.gl/1tsXbc`



(b) Ventral habitus (image from Miller *et al.* (2014))

Figure 4: Pseudococcidae

1.1.5 Monophlebidae (giant scale insects)

Diagnostic characters: adult female flattened or spherical, often cylindrical or scalloped, with hard covering formed of wax and cast skins of earlier instars; abdominal spiracles present; female antennae short or long, up to 13 segments, no wings or legs.

Natural history: Approximately 240 species known worldwide, including the Cottony Cushion Scale (Icerya purchasi Maskell 1878), and important pest of many plants. Most species feed on trees or woody shrubs.

(a) Dorsal habitus. Photo (CC BY-SA 3.0) by Lucarelli `https://goo.gl/dQNTNy`

(b) Ventral habitus (image from Miller *et al.* (2014))

Figure 5: Monophlebidae

1.1.6 Coccidae (soft scale insects, wax and tortoise scales)

Diagnostic characters: adult female flattened and oval with smooth, hard exoskeleton or soft waxy covering (Figure 6b); antennae reduced or absent; legs often present but reduced; 2 triangular plates on anal opening; abdomen with anal cleft; abdominal spiracles absent.

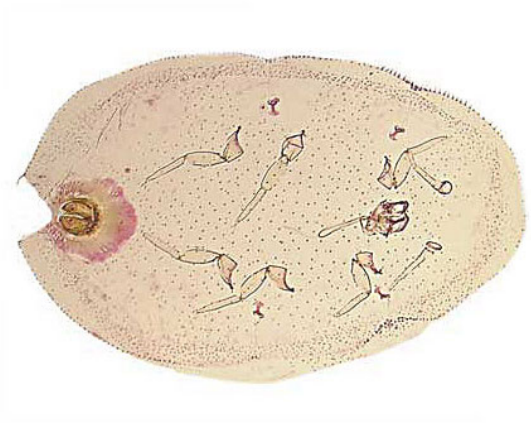
Natural history: Females smooth and dorso-ventrally flattened. More than 1,100 species have been described worldwide, including many economically important pests.

1.1.7 Diaspididae (armored scale insects)

Diagnostic characters: adult female flattened, disc-like with hard covering formed of wax and cast skins of earlier instars; antenna reduced to one segment; terminal abdominal segments form fused pygidium, anal opening without setae; legs absent.

Natural history: A diverse family of scale insects, with well over 2,500 described species. Exuviae from early instars, along with plant material and even frass, are often incorporated into a protective "shell" that can be quite tough. Like other scale families, this one includes some important pests.

(a) Dorsal habitus. Photo (CC BY 2.0) by Katja Schulz `https://flic.kr/p/qLWfyn`



(b) Ventral habitus (image from Miller *et al.* (2014))

Figure 6: Coccidae

(a) Dorsal habitus. Photo (CC BY 2.0) by Katja Schulz `https://flic.kr/p/CB5WCU`

(b) Ventral habitus (image from Miller *et al.* (2014))

Figure 7: Diaspididae

Question 9-2: Describe three adaptions you observed in these insects that allow them to live in one location for most of their lives. What challenges does this life history present? Given these challenges why don't they have many sclerites?

1.2 Auchenorrhyncha (cicadas, hoppers)

Diagnostic characters: head hypognathous, mouthparts arises posteroventrally from head; labium arises from the head anterior to the procoxae when the head is in normal position; antennae aristate; fore wing is not more sclerotized as hind wing; tarsi 3-segmented; presence of a complex tymbal acoustic system on abdominal segment I; ovipositor well developed.

1.2.1 Cicadidae (cicadas)

Diagnostic characters: relatively large (>2 cm); antennae arise between compound eyes that are widely separated (Figure 8); hind tibiae without large apical spur (*i.e.*, a moveable projection); hind tibia without robust lateral and apical spines; tymbals present.

Natural history: More than 1,300 species are known worldwide, and all are thought to be xylem-feeders (at least as immatures). Instars are subterranean, emerging only after several years' development. Imagoes are well-known for their courtship songs.

Question 9-3: Tymbals are present in all Auchenorrhyncha, but they are easy to see in Cicadidae due to their large size. Can you find and sketch them? Can you now find the hearing organ (tympanum)? Describe its location relative to the tymbal and think about why that might be.

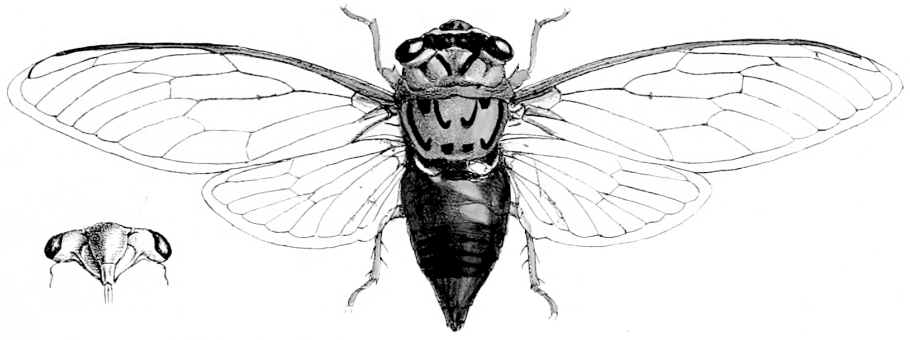


Figure 8: Cicadidae habitus (Waterhouse, 1880, Plate 100)

1.2.2 Membracidae (treehoppers)

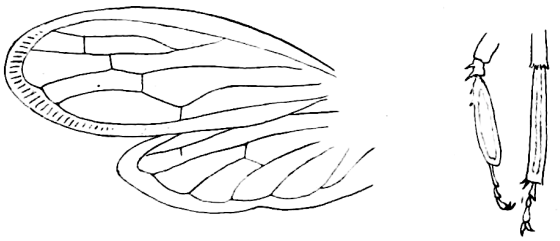
Diagnostic characters: Pronotum extends over abdomen; fore wing without many costal crossveins (Figure 9b; compare to Cicadidae); hind tibiae without large apical spur and without faint lateral spines.

Natural history: More than 3,000 species have been described worldwide, many of which have elaborate pronotal modifications. Treehoppers communicate with tymbals and often exhibit maternal care.

Question 9-4: Look at the variety of pronotal shapes in Membracidae. Can you think of at least three potential functions?

1.2.3 Cicadellidae (leafhoppers)

Diagnostic characters: Pronotum does not extend over abdomen (Figure 10); hind tibia with two rows of slender, elongate spines.

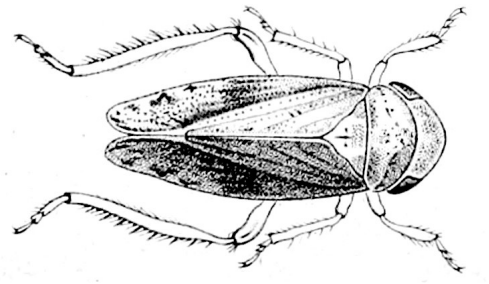


(a) Wings and legs (Buckton and Poulton, 1901, Plate I, Figs. 4c,4e)

(b) Habitus. Photo (CC By 2.0) by Brian Gratwicke `https://flic.kr/p/rGLMDm`

Figure 9: Membracidae

Natural history: Extraordinarily diverse group of auchenorrhynchans, with more than 22,000 described species, spanning from 2–30 mm in length. Leafhoppers also communicate with tymbals. Many species are important pests, including some that vector plant viruses and other disease-causing agents.



(a) Habitus (Fairmaire and Deyrolle, 1884, Plate 8, Fig. 16)

(b) Habitus. Photo (CC BY 2.0) by Andy Reago & Chrissy McClarren `https://flic.kr/p/xMeWGS`

Figure 10: Cicadellidae

1.2.4 Cercopidae (froghoppers, spittlebugs)

Diagnostic characters: hind tibiae with 1 or 2 robust lateral and numerous apical spines (Figure 11); fore wing usually more strongly sclerotized than hind wing.

Natural history: Approximately 1,500 species have been described worldwide, most of which are understood to be xylem-feeders (unlike most other auchenorrhynchans, which are phloem-feeders). Nymphs ensconce themselves in a frothy, bubbly matrix of waste ("spittle"), where they are protected from many threats.

Question 9-5: Can you find tymbals in the three families above? Where are they relative to in Cicadidae? From what structure(s) do you think the tymbal evolved? Think back on the morphology

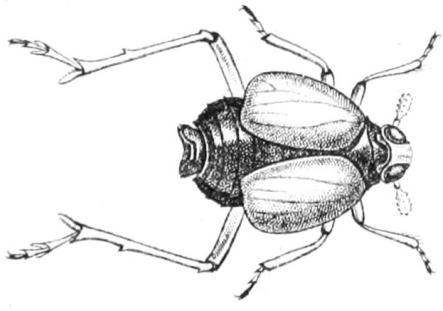
lectures earlier this semester.

Figure 11: Cercopidae habitus. Photo (CC BY 2.0) by Mick Talbot `https://flic.kr/p/5nSL3i`

1.2.5 Delphacidae

Diagnostic characters: Antennae arise below eyes on sides of head; median, emarginated area of the head present; fore wings without many costal crossveins; hind tibia with large apical spur (movable projection) (Figure 12).

Natural history: About 2,200 species have been described worldwide, most of which are grass-specialists. Many are important pests of grains/cereals.



(a) Habitus (Fairmaire and Deyrolle, 1884, Plate 7, Fig. 10)

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

Figure 12: Delphacidae

1.2.6 Flatidae (wedge leafhoppers)

Diagnostic characters: Antennae arise below eyes on sides of head; median, emarginated area of the head present; fork-like vein present on fore wing anal region; fore wings with many costal crossveins (Figure 13); body wedge-shaped, flattened from side to side, wings broad, triangular.

Natural history: Approximately 1,500 species are known worldwide, most of which are specialists of woody plants.

Figure 13: Flatidae habitus. Public Domain photo by Sam Droege `https://flic.kr/p/cuaaw5`

1.2.7 Issidae

Diagnostic characters: Antennae arise below eyes; median, emarginated area of the head present (Figure 14); fork-like vein present on fore wing anal region; fore wings without many costal crossveins (compare to Flatidae); fore wings often as long as or shorter than abdomen ; hind tibiae with 1 or 2 robust lateral and numerous apical spines.

Natural history: More than 900 species have been described around the world. Nymphs usually have long, straight wax filaments projecting posteriorly from their abdomens.

Figure 14: Issidae habitus. Photo (CC BY 2.0) by Katja Schulz `https://flic.kr/p/Baf2ZW`

1.3 Heteroptera

A suborder of Hemiptera commonly referred to as “true bugs”, which can be recognized by the following characters:

Diagnostic characters: Head prognathous, mouthparts arises anteriorly from head in lateral view, there is a distinct distance between the labium and the procoxae, compared to other hemipterans; antennae filiform; anterior part of fore wing is more sclerotized than posterior part of fore wing and the hind wing (hemelytra); tarsi with usually 3 tarsomeres, rarely 2 or 4; absence of a complex tymbal acoustic system on abdominal segment I; scent gland (sgo) on the metathorax usually present (but see Rhopalidae).

1.3.1 Enicocephalidae (unique-headed bugs)

Diagnostic characters: Body slim; ocelli present; antennae and beak 4-segmented; fore wings mostly membranous; front femur and tarsus relatively enlarged; mid and hind tarsus each 2-segmented.

Natural history: Approximately 400 species have been described worldwide, and most are between 2–4 mm long. They are often found in swarms, which gives them their other common name: gnat bugs. They are though to be predators of invertebrates that live in leaf litter and under logs. Specimens of this family, which is thought to be sister to the rest of Heteroptera, can be found in glycerol: `http://www.gigapan.com/gigapans/164037`.

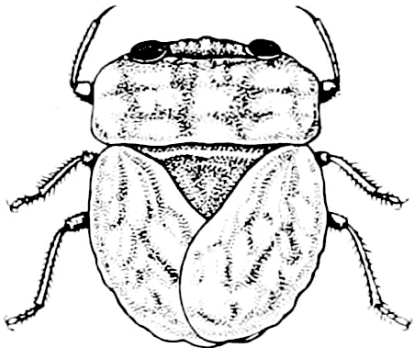
Figure 15: Enicocephalidae habitus. Photo (CC BY-NC-SA 3.0) by BIO Photography Group, Biodiversity Institute of Ontario `http://goo.gl/obSS2z`

Question 9-6: What makes the head of this bug unique, relative to other Heteroptera? Given their biology does this head phenotype offer any advantages?

1.3.2 Gelastocoridae (toad bugs)

Diagnostic characters: Body usually <10 mm long, toad-like, cryptic (camouflaged); antennae shorter than head, hidden; ocelli present; flattened, bulging eyes (Figure 16a); fore legs shorter than mid legs.

Natural history: Approximately 100 species are known worldwide, all of which are predators. Most species are found close to aquatic habitats (*e.g.* lake shores) and have cryptic coloration. The common name derives from their vaguely toad-like appearance and hopping locomotion.



(a) Habitus (Froggatt, 1907, Plate XXXII, Fig. 10)

(b) Habitus. Photo (CC BY-SA 2.0) by dr.scott.mills `https://flic.kr/p/efgMcq`

Figure 16: Gelastocoridae

1.3.3 Corixidae (water boatmen)

Diagnostic characters: Body flattened dorsally, with dark pattern of thin stripes; antennae shorter than head; ocelli absent; beak very short, appears 1-segmented (Figure 17); fore legs not raptorial, fore tarsi 1-segmented and scoop-shaped (Figure 17); hind legs elongate, oar-like, hind tarsi without claws.

Natural history: Around 500 species are known worldwide, all of which are aquatic. Often they occur in great abundance and are even harvested by people for food.

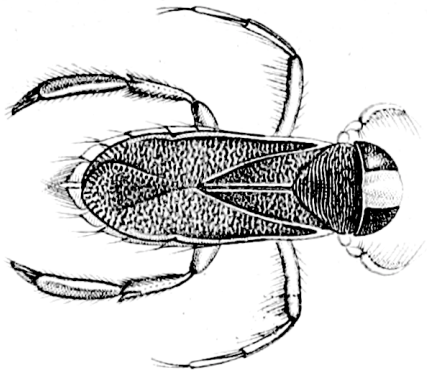


Figure 17: Corixidae dorsal habitus (Fairmaire and Deyrolle, 1884, Plate 7, Fig. 5)

Question 9-7: Compare the mouthparts of Corixidae to the other heteropterans. What do you think Corixidae eat, based on the morphology of the mouthparts? Hint: Check out their fore legs.

Question 9-8: Almost all corixids are patterned with stripes. What might their function be?

1.3.4 Notonectidae (backswimmers)

Diagnostic characters: Body convex dorsally, mottled, light-colored (Figure 18); antennae shorter than head; ocelli absent; fore legs not raptorial, front tarsi not scoop-shaped; hind legs elongate, oar-like, hind tarsi without claws.

Natural history: Approximately 400 species are known worldwide, all of which are predators. These insects can deliver a painful bite(!) when handled. They also communicate via stridulation, and scraper/file morphology can be diagnostic.

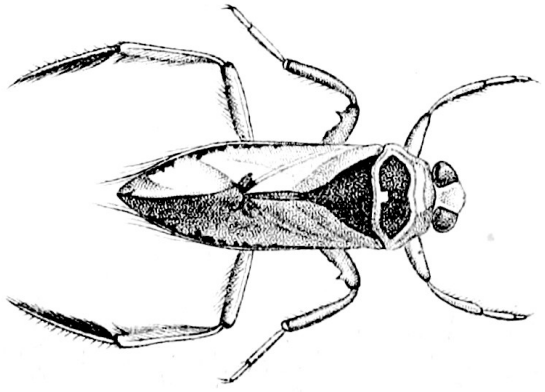


Figure 18: Notonectidae, dorsal habitus (Fairmaire and Deyrolle, 1884, Plate 7, Fig. 2)

Question 9-9: These insects swim upside down. How does their morphology vary from other heteropterans, given this behavior?

1.3.5 Nepidae (water scorpions)

Diagnostic characters: Body shape variable (Figure 19); antennae shorter than head; ocelli absent; tarsi each comprised of 1 tarsomere; fore legs raptorial; hind legs not oarlike, hind tarsi with claws; 2 long terminal abdominal appendages called "airstraps".

Natural history: Almost 300 species have been described worldwide. All are predators of other aquatic organisms, mainly invertebrates. They breathe through a snorkel-like structure, the air straps, located off the apex of the abdomen.

1.3.6 Belostomatidae (giant water bugs)

Diagnostic characters: Body large, dorso-ventrally flattened usually over >20 mm; antennae shorter than head; ocelli absent; fore legs raptorial (Figure 20); hind legs flat, oar-like, hind tarsi with claws; membrane of fore wing with veins.

Natural history: Almost 160 species have been described worldwide, all of which are aquatic predators. In some species the female lays her eggs on the male's dorsum, and he affords the clutch some level of paternal care. These insects are mostly found in lentic environments.

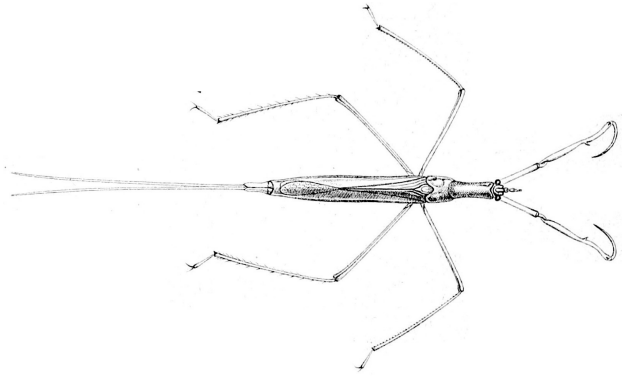


Figure 19: Nepidae, dorsal habitus (Fairmaire and Deyrolle, 1884, Plate 7, Fig. 3)

Figure 20: Belostomatidae, dorsal habitus. Photo (CC BY-NC 2.0) by Michael Jefferies `https://flic.kr/p/saEja`

Question 9-10: Describe some of the adaptations you see in the previous two families for predation. Can you predict how they hunt and capture prey?

Question 9-11: Look closely at the tarsi and the apex of each leg on the following two families. Do you see any adaptations that might be related to their semiaquatic lifestyle?

1.3.7 Gerridae (water striders)

Diagnostic characters: Body usually >5 mm; antennae longer than head; middle legs arising closer to hind legs than to front legs (Figure 21); hind femur longer than abdomen.

Natural history: About 750 species have been described worldwide, all of which are semiaquatic on slow-moving or still water. These insects forage on other invertebrates that fall in the water.

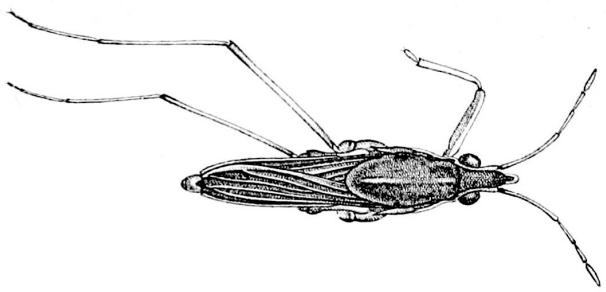


Figure 21: Gerridae, dorsal habitus (Fairmaire and Deyrolle, 1884, Plate 7, Fig. 12)

1.3.8 Veliidae (ripple or riffle bugs)

Diagnostic characters: Body relatively small, 1.6–5.5 mm; antennae longer than head (Figure 22); mid-legs arise midway between fore and hind legs; hind femur shorter than abdomen.

Natural history: Almost 1,000 species have been described worldwide, all of which are semiaquatic on still water or in lotic habitats. These insects likewise forage on other invertebrates that fall in the water.

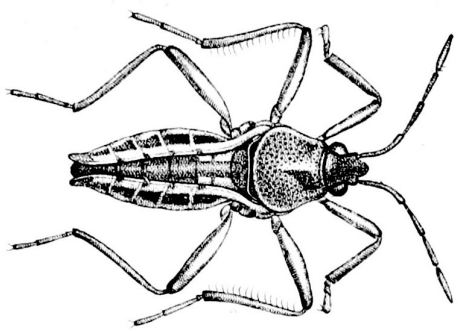


Figure 22: Veliidae, dorsal habitus (Fairmaire and Deyrolle, 1884, Plate 7, Fig. 11)

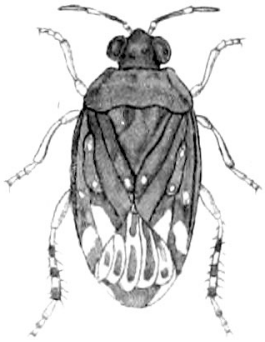
1.3.9 Saldidae (shore bugs)

Diagnostic characters: dorso-ventrally flattened, typically brownish; antenna with 4 antennomeres; labium with 3 sclerites; tarsus with 3 tarsomeres; membrane of fore wing with 4–5 long closed cells (Figure 23a–23b).

Natural history: The only family in Leptopodomorpha that occurs in our area (Northeastern USA). About 350 species are known in the world. They are frequently found near bodies of water (ponds, rivers, etc.), usually on stones or other substrates at the water's edge. They are predators.

1.3.10 Miridae (plant bugs)

Diagnostic characters: Antenna with 4 antennomeres; ocelli absent; labium with 4 sclerites; tarsus with 3 tarsomeres; trichobothria present on middle and hind femora; cuneus present (compare to taxon



(a) Dorsal habitus (Panzer and Sturm, 1793–1809, Fig. 13)

(b) Dorsal habitus. Photo (CC BY-NC 2.0, Perth Museum and Art Gallery) by Tristan Bantock

Figure 23: Saldidae

with cuneus absent, like Nabidae); membrane with 2 closed cells (Figure 24); wings wide, abdomen at most slightly exposed laterally.

Natural history: Worldwide there are >10,000 described species, and a majority are plant feeders (some are predators). Instars of many species have a eversible rectums that help these insects gain purchase on foliage.

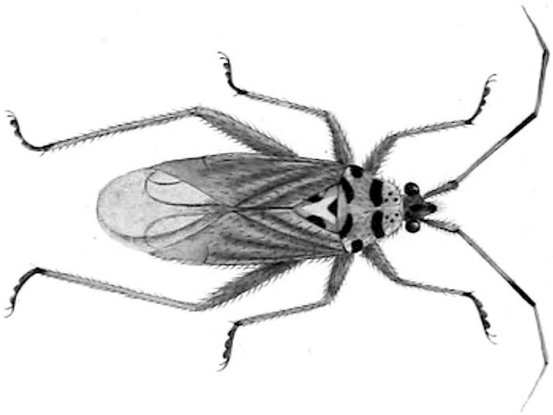


Figure 24: Miridae, dorsal habitus (Meyer-Duer, 1843, Plate II, Fig. 1)

1.3.11 Anthocoridae (minute pirate bugs)

Diagnostic characters: Antenna with 4 antennomeres; labium with 3 sclerites; ocelli present; tarsus with 2–3 tarsomeres; front legs not raptorial; cuneus present; membrane with no closed cells, with one or two usually rudimentary longitudinal veins; wings wide, abdomen at most slightly exposed laterally (Figure 25).

Natural history: Approximately 600 species are known worldwide, all of which are predators and (often) facultative parasites. This family is likely sister to Cimicidae, and both families exhibit "traumatic insemination".

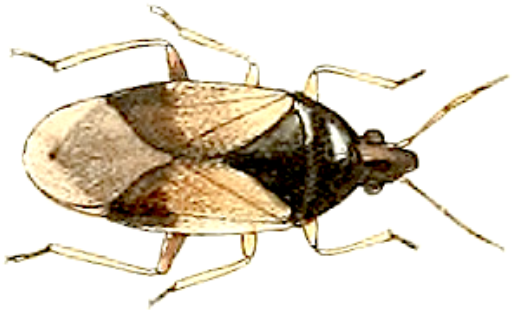


Figure 25: Habitus (Saunders, 1892, Plate 18, Fig. 10)

1.3.12 Cimicidae (bed bugs, bat bugs)

Diagnostic characters: Antenna with 4 antennomeres; labium with 3 sclerites; ocelli absent; number of tarsomeres: 2–3; wings absent.

Natural history: All 110 known species are parasites of birds and mammals (especially bats).

Question 9-12: In the previous two families can you see structures you think might facilitate traumatic insemination? How would such a mating strategy evolve? Note that some species in other heteropteran families, including Nabidae and Miridae, have also evolved this mating strategy.

Figure 26: Cimicidae habitus. Photo (CC BY-SA 2.0) by Gilles San Martin `https://flic.kr/p/a759C9`

1.3.13 Tingidae (lace bugs)

Diagnostic characters: body and wings with reticulate "lace-like" sculpture (Figure 27); antenna with 4 antennomeres; ocelli present; labium with 4 sclerites; each leg with 1–2 tarsomeres; cuneus absent; membrane venation obscured by reticulate sculpture; pronotum extends posteriorly obscuring mesoscutellum.

Natural history: More than 2,000 species are known worldwide, all of which are relatively small (2–10 mm). They are herbivores, mostly feeding on the underside of leaves. many species exhibit parental care.

Question 9-13: What do you think is the function of the elaborate integumental sculpturing of these bugs? What selection pressure would maintain such a structure?

Figure 27: Tingidae, lateral habitus. Photo (CC BY 2.0) by Brian Gratwicke `https://flic.kr/p/xWsqLL`

1.3.14 Nabidae (damsel bugs)

Diagnostic characters: Antenna with 4 antennomeres; labium with 4 sclerites; ocelli present; each leg with 2–3 tarsomeres; fore leg raptorial; cuneus absent; membrane with numerous closed cells or absent; wings wide, abdomen at most slightly exposed laterally.

Natural history: About 400 species have been described worldwide. All are predators of other insects, and some species have been cultivated for biocontrol of many pestiferous insects (lepidopteran larvae and eggs especially, but also leafhopper nymphs).

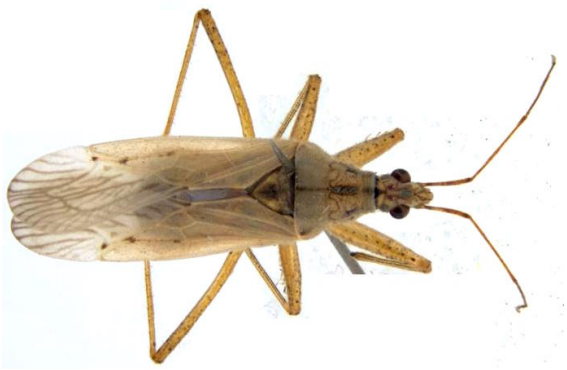


Figure 28: Nabidae, dorsal habitus. Photo (CC BY 3.0 Australia) by MAF Plant Health & Environment Laboratory `http://www.padil.gov.au`

1.3.15 Berytidae (stilt bugs)

Diagnostic characters: antenna with 4 antennomeres; apical antennomere spindle-shaped; labium with 4 sclerites; each leg with 3 tarsomeres; fore leg not raptorial; cuneus absent; membrane with no closed cells (usually with 5 longitudinal veins); wings wide, abdomen at most slightly exposed laterally.

Natural history: About 170 species are known worldwide, most of which are herbivores.

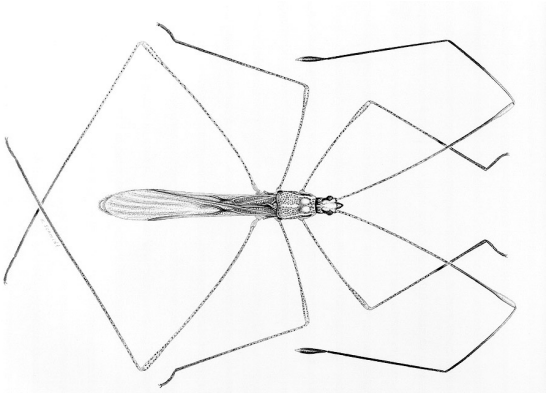


Figure 29: Berytidae, dorsal habitus. Illustration (CC0) by Kathleen Schmidt USDA-ARS

1.3.16 Lygaeidae (seed bugs)

Diagnostic characters: Head narrower than pronotum; antenna with 4 antennomeres; labium with 4 sclerites; each leg with 3 tarsomeres; fore leg not raptorial; cuneus absent; membrane with no closed cells; wings wide, abdomen at most slightly exposed laterally; abdominal spiracles 5–7 dorsally located.

Natural history: About 1,000 species are known, the vast majority of which are herbivores that specialize on seeds. The Milkweed Bug, *Oncopeltus fasciatus* (Dallas, 1852) frequently serves as a model for ecological research and evolutionary developmental (evo-devo) biology.

1.3.17 Geocoridae (big-eyed bugs)

Diagnostic characters: Head wider than pronotum (Figure 31); antenna with 4 antennomeres; labium with 4 sclerites; ocelli present; each leg with 3 tarsomeres; fore leg not raptorial; cuneus absent; wings wide, abdomen at most slightly exposed laterally; abdominal spiracles 5–7 ventrally located.

Natural history: Approximately 275 species are known worldwide, and most are 3–5 mm in length. They are predators of other insects and have been used in a biocontrol context.

Question 9-14: Take a look at the head shape in Geocoridae, and it compare to Lygaeidae; they used to be classified as one family. Do you see any differences that relate to their diets?

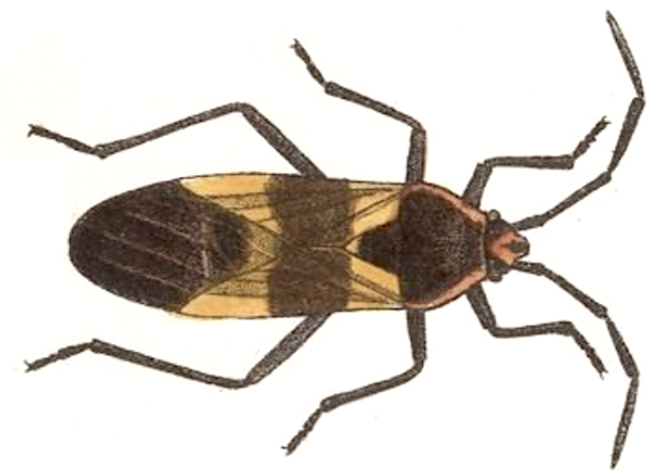


Figure 30: Lygaeidae habitus (Godman *et al.*, 1880–1893, Plate 16, Fig. 23)

Figure 31: Geocoridae, dorsal habitus. Photo (CC BY-ND-NC 1.0) by MJ Hatfield. `http://bugguide.net/node/view/884353`

1.3.18 Coreidae (leaf-footed bugs)

Diagnostic characters: Head narrower and shorter than pronotum; antenna with 4 antennomeres; labium with 4 labial sclerites; ocelli present; each leg with 3 tarsomeres; cuneus absent; wings wide, abdomen at most slightly exposed laterally; hind tibia usually widened, leaf-shaped.

Natural history: Almost 2,000 species have been described worldwide, and they tend to be large-bodied bugs (7–45 mm long). Evidence suggest they are all herbivores, and some species (*e.g.*, *Anasa tristis* (De Geer), 1773) are major pests.

1.3.19 Aradidae (flat bugs)

Diagnostic characters: Antenna with 4 antennomeres; number of labial sclerites: 4; ocelli absent; number of tarsomeres: 2; cuneus absent; fore leg not raptorial; wings wide, abdomen at most slightly

Figure 32: Coreidae habitus. Photo (CC BY-NC) by Laurence Livermore `https://flic.kr/p/a8m1dp`

exposed laterally ; hind tibia usually widened, leaf-shaped; head narrower and shorter than pronotum.

Natural history: Almost 2,000 species have been described worldwide, and they are thought to be fungivores or saprophages. They have incredibly long stylets, which are coiled inside the body when not in use for feeding (Spooner, 1920).

Figure 33: Aradidae habitus. Photo (CC0) by Alejandro Santillana `https://flic.kr/p/DgLMWB`

Question 9-15: Given their common name and their body shape, where do you think these live?

1.3.20 Reduviidae (assassin and ambush bugs)

Diagnostic characters: Antenna with 4 antennomeres; ocelli present or absent; labium with 3 sclerites; each leg with 1–3 tarsomeres; cuneus absent; fore leg raptorial; prothorax usually with a ventral, longitudinal scrobe accommodating the long and robust mouthparts; wings wide, abdomen at most slightly exposed laterally.

Natural history: As their common name implies these insects are mostly predators; some, however, have become parasites (including important species that vector human diseases, like trypanosomiasis). About 7,000 species are known worldwide, and they vary considerably in their habitus and size.

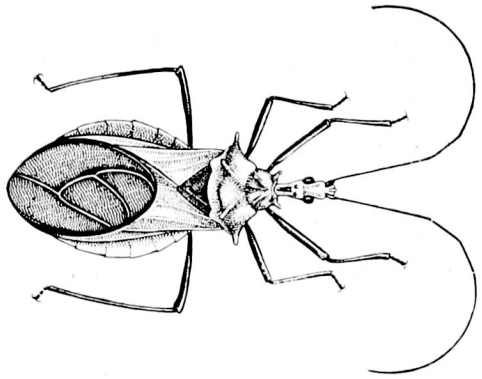
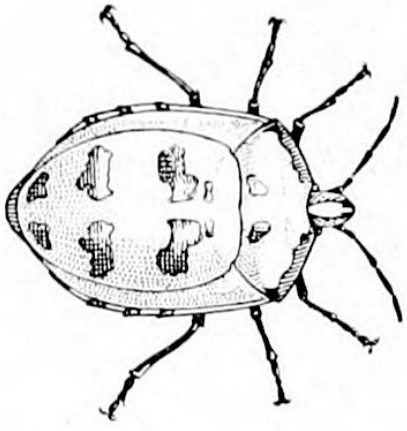


Figure 34: Reduviidae habitus (Froggatt, 1907, Plate XXXII, Fig. 12)

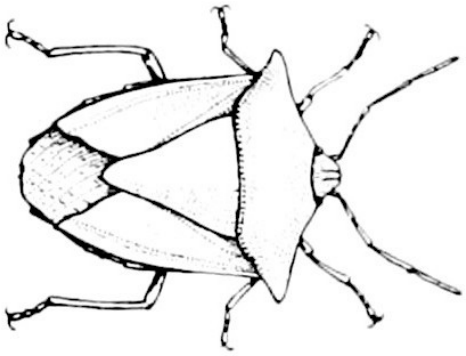
1.3.21 Scutelleridae (shield or shield-backed bugs)

Diagnostic characters: Antenna with 5 antennomeres; labium with 4 sclerites; each leg with 3 tarsomeres; cuneus absent; mesoscutellum extends posteriorly, obscuring most of abdomen (Figure 35a); wings wide, abdomen at most slightly exposed laterally.

Natural history: About 450 species of shield bugs have been described worldwide. All species are phytophagous, and some exhibit traumatic insemination.



(a) Scutelleridae habitus (Froggatt, 1907, Plate XXXI, Fig. 11)



(b) Pentatomidae habitus (Froggatt, 1907, Plate XXXII, Fig. 2)

Figure 35

1.3.22 Pentatomidae (stink bugs)

Diagnostic characters: antenna with 5 antennomeres (Figure 35b); labium with 4 sclerites; each leg with 3 tarsomeres; cuneus absent; mesoscutellum extends posteriorly but does not obscure most of

abdomen; fore leg not raptorial; wings wide, abdomen at most slightly exposed laterally.

Natural history: About 5,000 species have been described worldwide. Most species are herbivores but many predate on other insects and can be effective biocontrol agents.

Question 9-16: Why is the scutellum in each of the last two families enlarged (and quite large in scutellerids!)?

2 Psocodea (lice)

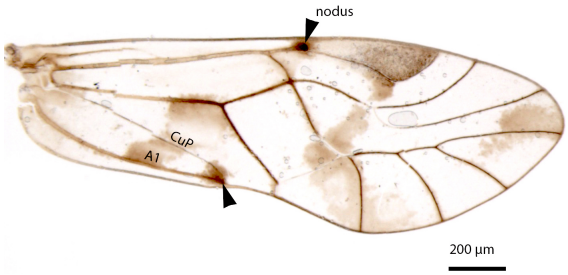
This lineage is comprised of three infraorders; we cover only two. Older classifications—Phthiraptera for parasitic lice and Psocoptera for bark lice, for example—resulted in at least one polyphyletic taxon. Synapomorphies of Psocodea include: Specialized water vapor uptake system (sitophore), which we won't see in lab; autotomic antennae (look for a line of weakness proximally); molecular data.

2.1 Psocomorpha (bark lice)

Diagnostic characters: Head usually with rounded vertex; antenna with 13 antennomeres; flagellomeres never annulated; labial palpus not subdivided; fore wing with nodus and thickened pterostigma (Figure 36b); CuP ending together with A1 at wing margin; tarsus subdivided into 2–3 tarsomeres.

There are 24 families classified in Psocomorpha. In lab we will look at only one: **Psocidae** (Figure 36a).

(a) Lateral habitus. Photo (CC BY 2.0) by James Niland `https://goo.gl/jr0D5W`



(b) Psocomorphan fore wing. Photo (CC BY 2.0) by István Mikó `https://flic.kr/p/z3Svuw`

Figure 36: Psocomorpha

2.2 Troctomorpha (book and parasitic lice)

Diagnostic characters: Head usually with relatively flat vertex; antenna with 15–17 antennomeres; tarsus subdivided into 2 tarsomeres.

There are 9 families classified in Troctomorpha. In lab we will look at four (see below), all of which are wingless and three of which are parasitic.

2.2.1 Liposcelididae (common book lice)

Diagnostic characters: Body usually yellow-brown in color; head prognathous; antenna relatively long, with 9–15 flagellomeres (Figure 37); tarsus subdivided into 3 tarsomeres; hind femora relatively large; wings absent in most species.

Natural history: These insects can frequently be found on books, in leaf litter, or as pests of stored products (grains, flour). Approximately 200 species are known worldwide, and several are closely associated with birds and mammals.

Figure 37: Liposcelididae. Photo (CC0) by S. E. Thorpe `https://goo.gl/Gd1yft`

2.2.2 Pediculidae (human head and body lice)

Diagnostic characters: Head usually narrower than prothorax (Figure 38); fore, mid, and hind legs roughly equal in size; tibial-tarsal complex adapted for grabbing; abdomen longer than width at base.

Natural history: These lice feed via piercing-sucking mouthparts and are classified in Anoplura (sucking lice). There are six described species worldwide, and all are parasites of Primates. This family include the human body and head lice species.

2.2.3 Phthiridae (human pubic louse, Gorilla louse)

Diagnostic characters: Head narrower than prothorax; mid and hind legs thicker than fore legs; abdomen about as long as its width at base, with prominent lobe-like structures (paratergites) laterally (Figure 39).

Natural history: There are only two described species in this family, which is also classified in Anoplura. One is *Phthirus pubis* (Linnaeus, 1758), the human pubic louse. The other species is a parasite of gorillas (*Gorilla gorilla* Savage and Wyman, 1847).

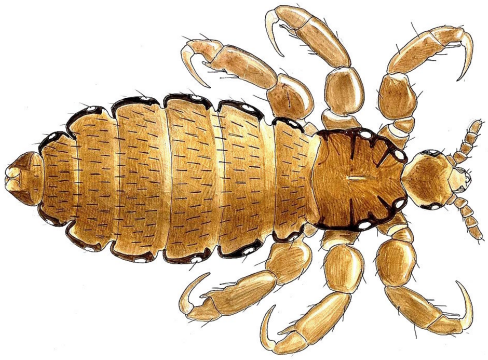


Figure 38: Pediculidae. Illustration by A. J. E. Terzi, CC BY Wellcome Trust `https://goo.gl/GByqFC`

Figure 39: Phthiridae. Photo (CC BY 2.0) by Frost Entomological Museum `https://flic.kr/p/znDT6y`

2.2.4 Trichodectidae (mammal chewing lice)

Diagnostic characters: Head as wide as or wider than thorax; mouthparts chewing (mandibulate) (Figure 40); antennae filiform, exposed, with 3 antennomeres; maxillary palpi absent.

Natural history: More than 400 trichodectid species have been described worldwide, all of which are parasites of mammals. They feed via chewing mouthparts and historically have been classified in a polyphyletic higher-level taxon "Mallophaga".

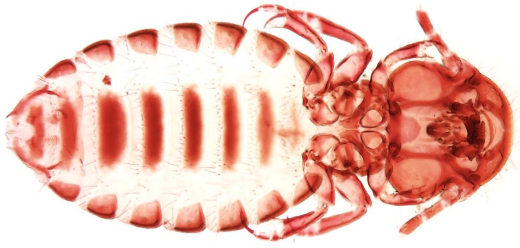


Figure 40: Trichodectidae. Photo (CC BY 2.0) by Emily Sandall `https://flic.kr/p/uQweJC`

2.3 Trogiomorpha

Diagnostic characters: Antenna with 22–50 antennomeres; forewing pterostigma is not thickened but rather is transparent to slightly opaque.

There are 7 families classified in Trogiomorpha, which covers at least 300 species worldwide. We have no specimens in our teaching collection, but the lineage is included here because several species are pests of stored products.

Question 9-17: Compare the parasitic psocodeans to those that live on bark or in leaf litter. What adaptations can you observe that you hypothesize are for parasitization? Compare head shape and size, between Trichodectidae and Anoplura. Why are they different?

3 Thysanoptera (thrips)

Diagnostic characters: Body very small (usually ~2 mm), with opisthognathous head; antenna with 7–9 antennomeres; piercing/sucking, asymmetrical (one mandible present) mouthparts; wings usually narrow with fringe composed of long setae; fore wing similar in size/shape to hind wing; tarsus with 1 or 2 tarsomeres; arolium (apicomedial membraneous area of pretarsus) balloon-shaped, eversible, exceeds tarsal claw apically.

Thysanoptera is subdivided into two suborders—Terebrantia (8 families, including Thripidae) and Tubulifera (1 family; Phlaeothripidae). Keep in mind that "thrips" is both singular and plural!

3.1 Terebrantia

3.1.1 Thripidae (common thrips)

Diagnostic characters: terminal abdominal segment divided ventrally, cone shaped, with strongly converging lateral margins; ovipositor present (Figure 41b), saw-like and curving ventrally; wing surface with acanthae (microtrichiae, or cuticular protuberances in the wing) and 2 rows of setae.

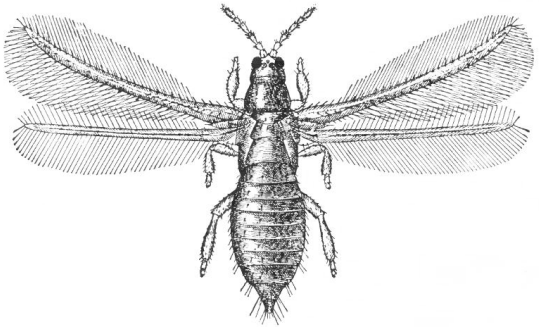
Natural history: More than 2,000 species have been described worldwide, including many pestiferous species. Most species survive as cryptophilous herbivores, feeding on plants with piercing-sucking mouthparts. As with many other kinds of thrips, some species are facultative parasites.

3.2 Tubulifera

3.2.1 Phlaeothripidae (tube-tailed thrips)

Diagnostic characters: terminal abdominal segment tubular, not divided ; ventrally, with parallel lateral margins (Figure 42b); ovipositor absent; wings with short, bare longitudinal veins and no acanthae (Figure 42b).

Natural history: Approximately 3,000 species have been described worldwide. This family includes many species that gallers, and many of them are eusocial. Other species survive as fungivores or

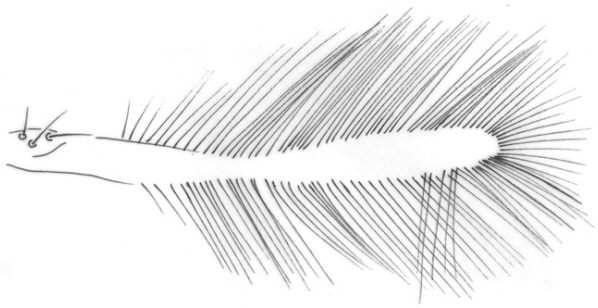


(a) Dorsal habitus (Fernald, 1921, Fig. 150)

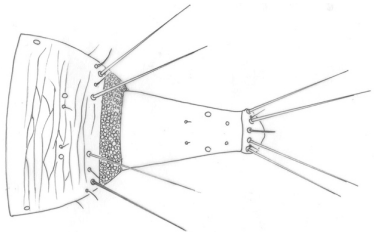
(b) Ventral view of abdomen and ovipositor (arrow). Photo (CC BY 2.0) by István Mikó `https://flic.kr/p/yNznf5`

Figure 41: Thripidae

herbivores.



(a) Fore wing (Minaei and Aleosfoor, 2013, Fig. 6)



(b) Dorsal view of abdomen apex (Minaei and Aleosfoor, 2013, Fig. 9)

Figure 42: Phlaeothripidae

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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