

Unit 14 - Amphiesmenoptera

Open Entomology Project

3 November 2016

Introduction

Amphiesmenoptera comprises two familiar orders, Lepidoptera (moths and butterflies; covered in section 1) and Trichoptera (caddisflies; section 2), whose close relationship is uncontroversial. To open this unit we'll discuss the evolutionary significance of two characteristics shared by these insects: silk production (from the labium) and hairy bodies (including wings).

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 and insects on pins. 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 carefully manipulate the specimen if necessary. Wing venation is especially useful for diagnosis, and one can see these characters more clearly in lepidopterans by placing one or two drops of ethanol on the wing. The wing color and pattern should remain unchanged after the ethanol evaporates. You can start anywhere in the handout.

1 Lepidoptera

Lepidoptera is one of the “big four” orders of insects, and with >157,000 described species and at least 350,000, probably many more, remaining to be described. These insects are commonly referred

to as moths and butterflies, and they remain one of the most recognizable groups of insects. Family-level diagnostics can be difficult, however, given that many characters are obscured by flattened setae called “scales”. The vast majority of species feed on plants as larvae (caterpillars), and adults live on liquid diets, imbibed through coiled, siphon-like mouthparts (proboscis, formed from the galeae). The hind wings of most species (*i.e.*, the taxon Heteroneura) are different in shape (usually shorter and more rounded) and venation from the fore wings.

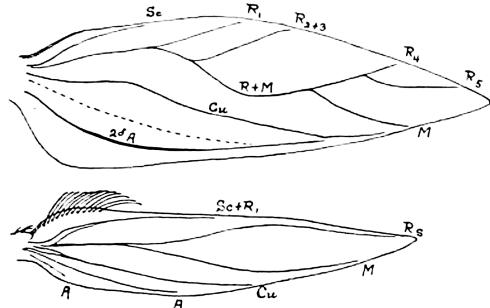
1.1 Non-dytrisian Lepidoptera (“Monotrysia”)

There is one family of commonly encountered moths whose species exhibit a single opening at the apex of its abdomen, through which copulation, oviposition, and defecation occur.

1.1.1 Nepticulidae (serpentine leafminer moths)

Diagnostic characters: Wingspan 3.5–10 mm, among the very smallest of moths; usually black and white, with a metallic band or gold speckles; antennae with an eye cap (Fig. 1b); maxillary palps well developed, long and folded; wing shape lanceolate; fore wing with relatively simple, branching venation (Fig. 1a).

Natural history: Larvae make thin, winding mines on the leaves of trees and shrubs. There are roughly 800 described species.



(a) Wings (Braun, 1917, Fig. 1)



(b) Habitus. Photo CC0 by M. Virtala <https://goo.gl/esgiwJ>

Figure 1: Nepticulidae

1.2 Dytrisia

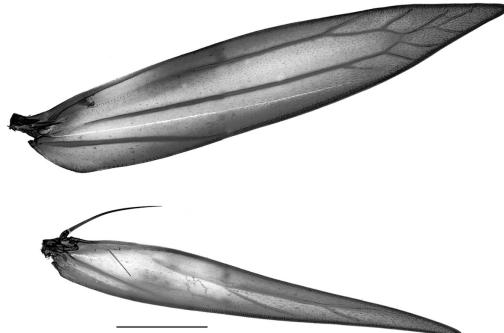
The remaining lepidopterans, >98% of all species, are classified in an unranked (sometimes a “division”), monophyletic taxon called Ditrysia. These insects have separate openings for copulation, oviposition, and defecation.

1.2.1 Gracillariidae (blotch leafminer moths)

Diagnostic characters: Minute to small in size (wingspan 5–20 mm); often brightly colored or metallic; maxillary palps usually absent; proboscis bare; wing venation reduced and elongate along proximal-

distal axis (Fig. 2a), wing fringe long (Fig. 2b); hind wing lanceolate.

Natural history: Most species develop as leaf miners on trees. Some species exhibit hypermetamorphosis, with early instars (flattened body shape, piercing mouthparts) feeding on sap and late instars (tubular body shape, chewing mouthparts) feeding on tissues. About 2,000 species have been described worldwide.



(a) Wings (Bai et al., 2016, Fig. 11, CC BY 4.0)



(b) Habitus. Photo (CC BY-NC 2.0) by Museum of Zoology, Lund University: Entomology <https://flic.kr/p/pfEv2z>

Figure 2: Gracillariidae

1.2.2 Gelechiidae (twirler moths, leaf tiers)

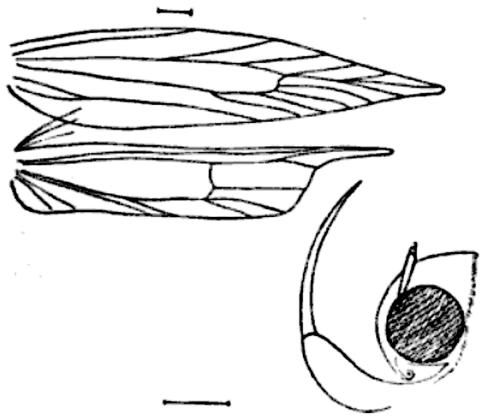
Diagnostic characters: Small (wingspan 7–25 mm); maxillary palps short, 4-segmented, located close to base of proboscis; labial palps long, upcurved, 3rd segment elongate and tapering (Fig. 3a); proboscis scaly; apical-posterior margin of hind wing concave (Fig. 3b).

Natural history: Diversely phytophagous family, whose >4,500 described species mostly are generally found feeding internally on plants (e.g., in leaf mines and galls). This lineage includes many pest species, as well as moths that are important biocontrol agents against weeds.

1.2.3 Tineidae (clothes moths and relatives)

Diagnostic characters: Small to medium-sized (wingspan 7–36 mm), usually gray or brown; head vesture bushy, mostly comprised of erect scales (Fig. 4b); antennae with a whorl of erect scales on each segment; maxillary palps usually present, folded; labial palps with sparse, elongate spines, usually very obvious; wing venation not so reduced as in above families (Fig. 4a).

Natural history: Unlike most lepidopterans, species in this lineage mostly do *not* feed on plants. Most species consume lichens, fungi, keratin (including feathers, mammal hair and horns), and detritus. About 3,000 species have been described worldwide.

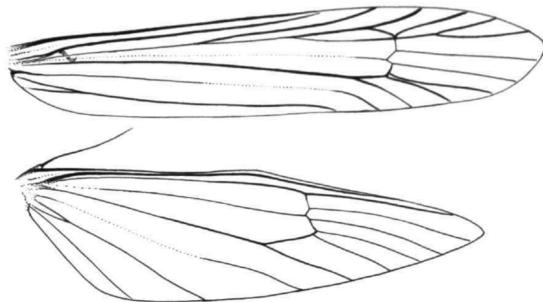


(a) Wings (left), head with palp (right) (Busck, 1903, Fig. 27)



(b) Habitus. Photo (CC BY 2.0) by Donald Hobern <https://flic.kr/p/o4Um8Z>

Figure 3: Gelechiidae



(a) Wings (Davis, 1998, Fig. 6)



(b) Habitus. Photo (CC BY 2.0) by Donald Hobern <https://flic.kr/p/eiZu6Y>

Figure 4: Tineidae

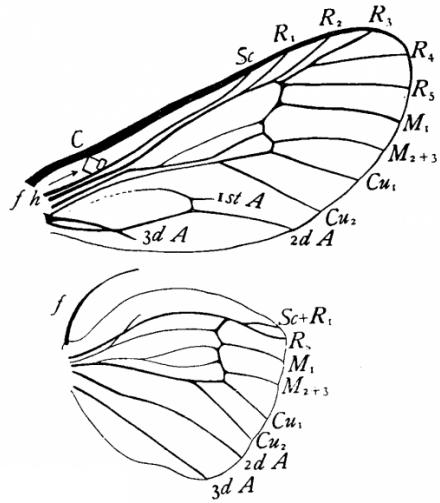
1.2.4 Psychidae (bagworm moths)

Diagnostic characters: Small to medium-sized moths (wingspan 12–36 mm); body usual black in North American species 5c; wings often absent or reduced in females, which remain in the silken bag (Figure 5b); male wings often (but not always!) mostly clear; setae hair-like, rather than scale-like.

Natural history: Larvae typically form bags constructed of silk and plant material. Females usually have only vestigial wings and often remain inside these cases after pupation. Males are winged and only rarely colorful. Almost 1,400 species have been described.

1.2.5 Sesiidae (clearwing moths)

Diagnostic characters: Small to medium-sized (wingspan 15–50 mm); transparent, scaleless “windows” usually present on wings; often wasp-like in shape and color (Fig. 6b); antennae widen apically, but narrow at the apex and are often somewhat hooked.



(a) Wings (Comstock, 1918, Fig. 46)



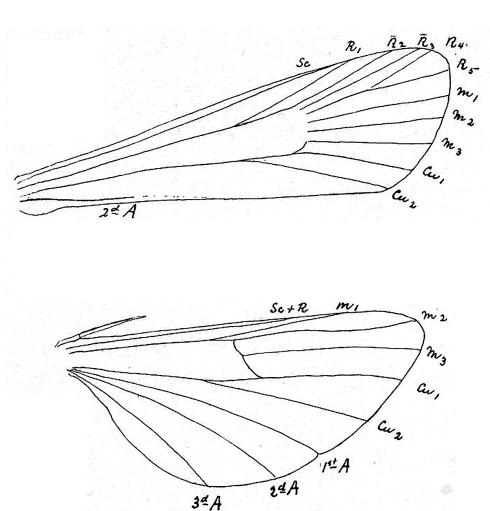
(b) Mature case.
Photo (CC BY 2.0) by Andrew C
<https://flic.kr/p/mhAUff>



(c) Habitus. Photo (CC BY 2.0) by Andy Reago & Chrissy McClaren <https://flic.kr/p/wZ8xCg>

Figure 5: Psychidae

Natural history: These moths are usually diurnal; can you guess why? Most species are wood or stem borers, and the taxon includes many pestiferous species. More than 1,300 species have been described.



(a) Wings (Beutenmüller, 1901, Fig. 8)



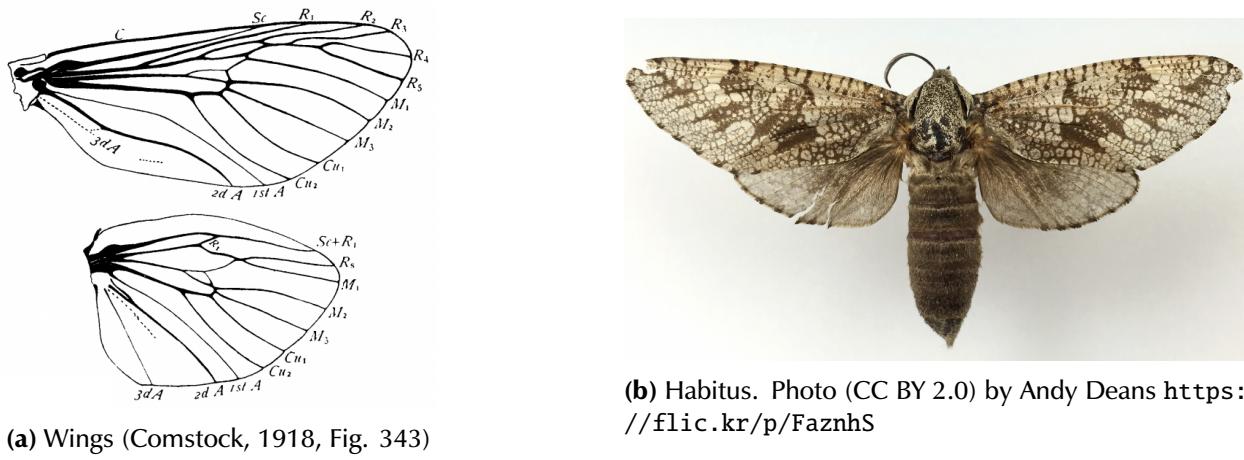
(b) Habitus. Photo (CC BY 2.0) by Katja Schulz <https://flic.kr/p/cjxZWU>

Figure 6: Sesiidae

1.2.6 Cossidae (carpenterworm moths)

Diagnostic characters: Relatively large (wingspan 40–100 mm), mottled gray and brown, heavy-bodied moths; male antennae bipectinate, females filliform; species in the U.S. usually black and gray, dull or with some orange; head is relatively small compared to the rest of the body (as opposed to Sphingidae) (Fig. 7b).

Natural history: There are almost 700 species worldwide, but only a handful occur in North America. Most species are borers, and a few are pests. About 700 species have been described worldwide.



(a) Wings (Comstock, 1918, Fig. 343)

(b) Habitus. Photo (CC BY 2.0) by Andy Deans <https://flic.kr/p/FaznhS>

Figure 7: Cossidae

1.2.7 Tortricidae (leafroller and fruitworm moths)

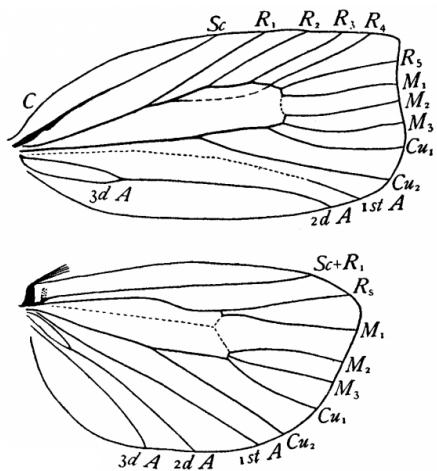
Diagnostic characters: Small to medium-sized moths (wingspan 10–33 mm); labial palps usually project forward (Fig. 8b), maxillary palps small; portions of scales on head often flattened; apical margin of fore wings usually distinctive, broad (Fig. 8a); fore wings with complex color pattern relative to hind wings.

Natural history: Diverse lineage, with >10,000 species, including many important pests. Larvae are diversely phytophagous, being leaf rollers, leaf tiers, fruit borers, gallers, etc. Well over 10,000 species have been described.

1.2.8 Limacodidae (slug caterpillar moths)

Diagnostic characters: Stout-bodied; usually brown and green or brown and silver (Fig. 9b); fore wing with 2 complete anal veins (Fig. 9a); Sc and R in hind wing separate at base, then briefly fused; hind wing with 3 anal veins.

Natural history: Larvae usually have reduced legs and prolegs and locomote with the assistance of silk. They are often defended by urticating setae. Cocoons are fashioned in a characteristic cup-shape. Adults often adopt bizarre postures when stationary on a surface. About 1,000 species have been described.

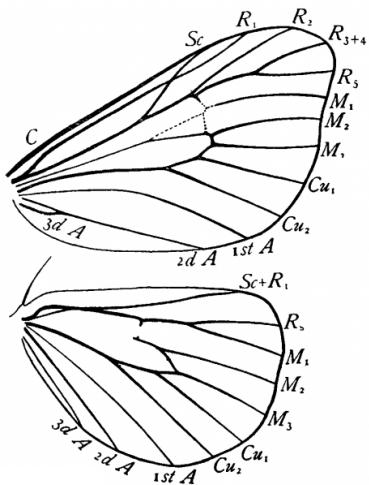


(a) Wings (Comstock, 1918, Fig. 353)



(b) Habitus. Photo (CC BY 2.5) Sander van der Molen <https://goo.gl/bjJa2B>

Figure 8: Tortricidae



(a) Wings (Comstock, 1918, Fig. 349)



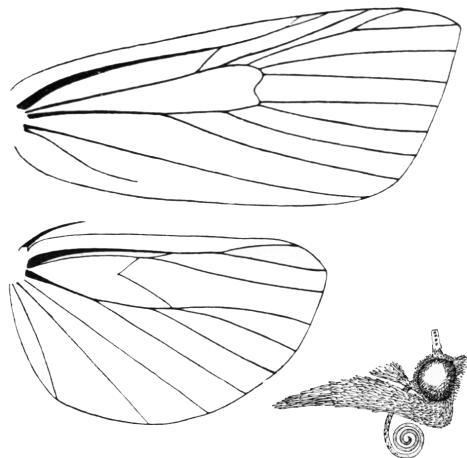
(b) Habitus. Photo (CC BY 2.0) by Andy Deans <https://flic.kr/p/FHd34h>

Figure 9: Limacodidae

1.2.9 Pyraloidea (snout moths and relatives)

Diagnostic characters: Fore wing usually elongate-triangular, hind wing more rounded and often broader (Fig. 10); palps often large and projecting forward (Fig. 10); proboscis scaly; tympana present on abdomen; Sc + R₁ and R₅ in hind wing fused beyond discal cell then separating (this character can be hard to see); hind wing with 3 anal veins.

Natural history: Large superfamily, with >15,000 described species and myriad life history strategies, including leaf miners, leaf rollers, borers, predators, coprophages, and aquatic species.



(a) Wings (composed from Fernald, 1896, Plate C)



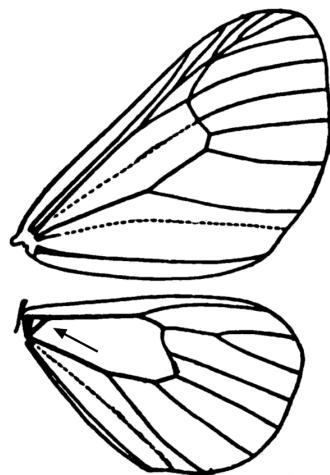
(b) Habitus. Photo (CC BY) by ©entomart <https://goo.gl/MvlacL>

Figure 10: Pyraloidea

1.2.10 Geometridae (inchworms, spanworms, loopers, etc.)

Diagnostic characters: Somewhat butterfly-like in shape, with broad wings; usually cryptically colored; geometric patterns on the fore wings often continue onto the hind wing (Fig. 11b); antennae thread-like or pectinate, not clubbed; proboscis bare; frenulum present, Sc in hind wing with an abrupt angle basally (arrow in Fig. 11a); tympana located at the base of the abdomen.

Natural history: Larvae often referred to as “inchworms”, due to arched habitus and measured locomotion. More than 35,000 described species, including some in Hawai‘i that are predators.



(a) Wings (Comstock, 1893, Fig. 20)



(b) Habitus. Photo (CC BY 2.0) by Andy Deans <https://flic.kr/p/FHd2FU>

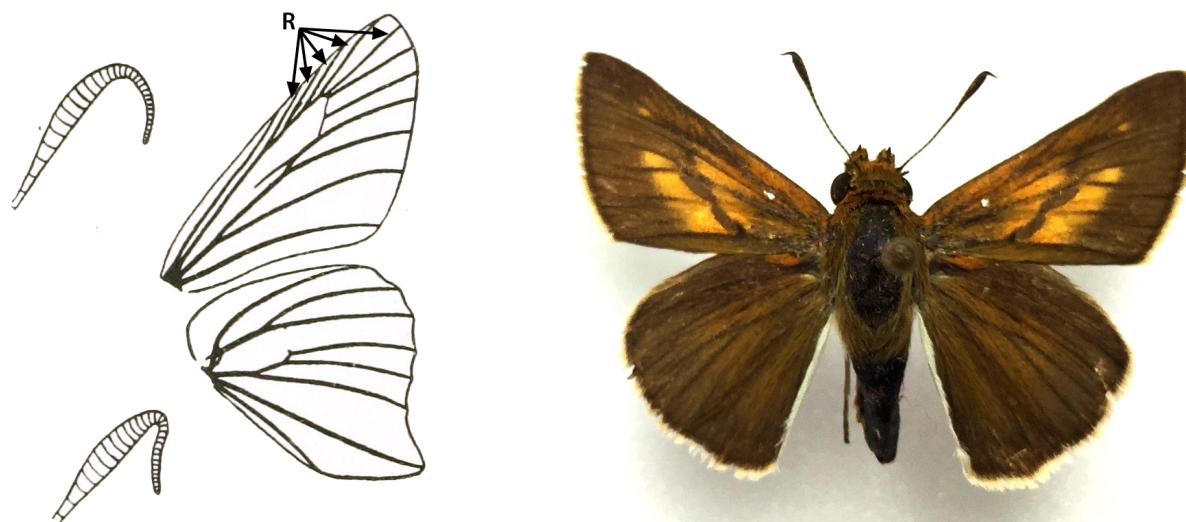
Figure 11: Geometridae

Rhopalocera (butterflies) The next five families are all commonly referred to as butterflies (although Hesperiidae is sometimes excluded). They can be recognized by the following characters: antennae knobbed/hooked at tip; ocelli always absent; body usually small relative to wings, wings usually broad; hind wing with only 1 or 2 anal veins.

1.2.11 Hesperiidae (skippers)

Diagnostic characters: Antennae clubbed but also hooked at tip (Fig. 12a); antennal insertions widely separated; R in fore wing 5-branched (Fig. 12a); fairly stout-bodied compared to butterflies, with large, broad heads (Fig. 12b).

Natural history: More than 3,500 species described worldwide. Larvae often live in shelters, e.g. leaf rolls, they construct for themselves. Adults are diurnal and have a characteristic darting flight.



(a) Wings (right) and apical flagellomeres (left) (Lindsey, 1921, Fig. 5)

(b) Habitus. Photo (CC BY 2.0) by Andy Deans <https://flic.kr/p/G2taKT>

Figure 12: Hesperiidae

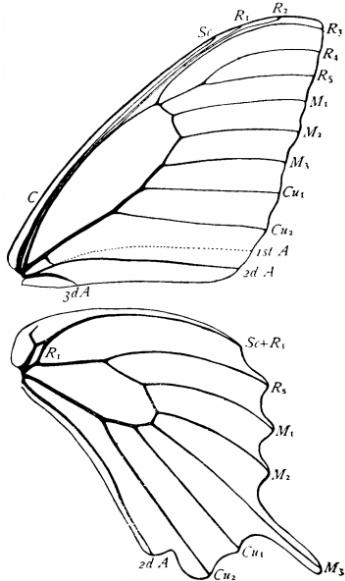
1.2.12 Papilionidae (swallowtails)

Diagnostic characters: Fore wing with R 5-branched; hind wing with 1 anal vein and usually with tail-like projection (Fig. 13a); 4 branches off Cu at bottom of discal cell; fore legs not reduced; usually brightly colored (black, yellow and other colors) (Fig. 13b) and large.

Natural history: More than 550 species worldwide, including the largest butterflies (the birdwings (Troidini) of southeast Asia). Larvae, which often mimic snakes, have a forked, defensive evagination (osmeterium) that can be exserted from behind the head.

1.2.13 Nymphalidae (brush-footed butterflies)

Diagnostic characters: Body size diverse; wings variable in color and shape; R 5-branched in fore wing (Fig. 14a); discal cell in hind wing often open or weakly closed; fore legs greatly reduced, lacking tarsal



(a) Wings (Comstock, 1918, Fig. 350)

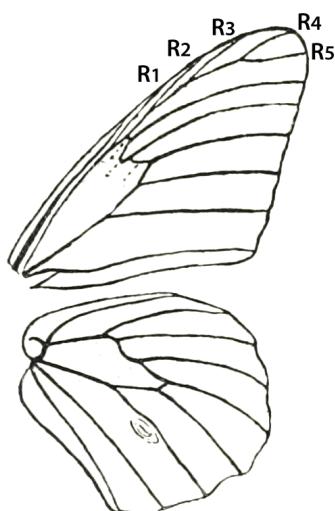


(b) Habitus. Photo (CC BY 2.0) by Andy Deans <https://flic.kr/p/Fd4fj4>

Figure 13: Papilionidae

claws (rarely normal sized).

Natural history: With more than 6,000 known species this is the largest family of butterflies; includes monarchs, satyrs, morphos, fritillaries, commas, and many other recognizable butterflies.



(a) Wings (Holland, 1899, Fig. 78)



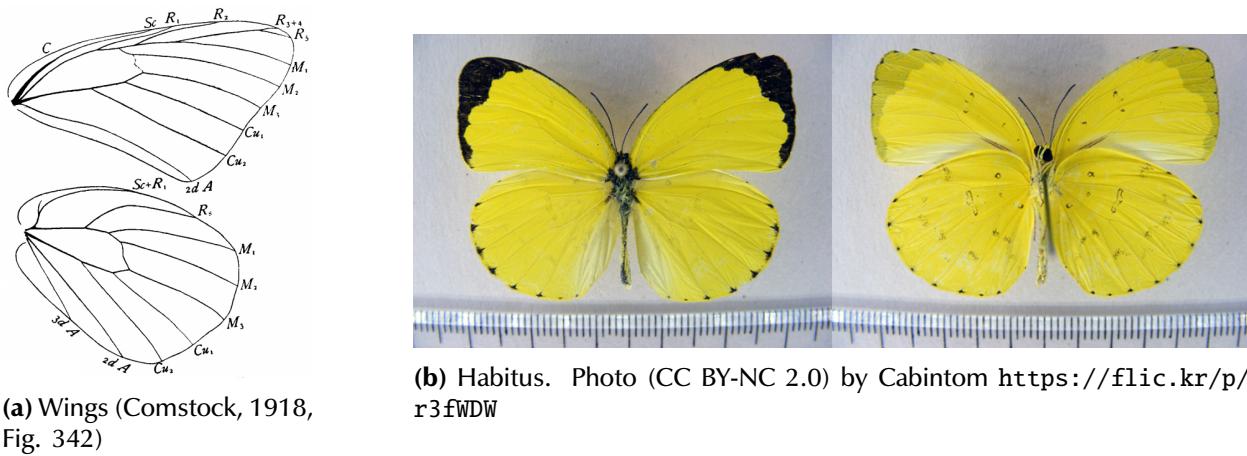
(b) Habitus. Photo (CC BY 2.0) by Andy Deans <https://flic.kr/p/G62zQj>

Figure 14: Nymphalidae

1.2.14 Pieridae (whites and sulfurs)

Diagnostic characters: Medium sized (wingspan mostly 40–60 mm) and usually white, yellow, or orange, often marked with black (Fig. 15b); fore wing R 3–5-branched; M1 of fore wing stalked with a branch of R near wing tip; hind wing with 2 anal veins and no tail (Fig. 15a); front legs not or only slightly reduced; tarsal claws bifid.

Natural history: Approximately 1,100 species described worldwide. They feed on a diversity of plants, especially Brassicaceae and Fabaceae, and many species are migratory.



(a) Wings (Comstock, 1918, Fig. 342)

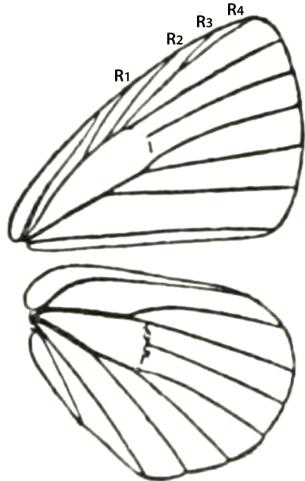
(b) Habitus. Photo (CC BY-NC 2.0) by Cabintom <https://flic.kr/p/r3fWDW>

Figure 15: Pieridae

1.2.15 Lycaenidae (blues, coppers, hairstreaks)

Diagnostic characters: Body small, delicate, and often brightly colored (but usually not white or yellow); antennae usually striped (Fig. 16b); fore wing R 3–4-branched; fore wing M1 very rarely stalked with a branch of R near wing tip; hind wing with 2 anal veins (Fig. 16a), occasionally with very tiny hair-like tail; male fore legs sometimes strongly reduced.

Natural history: Second largest group of butterflies, with >5,000 species that tend to be on the small side (wingspan <4 cm). Larvae are often closely associated with ants.



(a) Wings (Holland, 1899, Fig. 136)



(b) Habitus. Photo (CC BY 2.0) by Andy Deans <https://flic.kr/p/FcSvfj>

Figure 16: Lycaenidae

Macrolepidoptera (excluding Rhopalocera) The remaining families are moths that tend to be relatively large and generally share these characters: hind wing with only 1 or 2 anal veins; fore wing with 1 anal vein reaching margin.

1.2.16 Sphingidae (hawk moths)

Diagnostic characters: Body robust; head, including eyes, large (Fig. 17b); antennae spindle-shaped; ocelli absent; proboscis long, prominent; fore wings narrow, usually much larger than hind wings; hind wing with crossvein midlength in discal cell (arrow in Fig. 17a); abdomen often pointed.

Natural history: Larvae usually have dorsal, horn-like evagination on their posterior end, sometimes reduced or even absent. Adults are strong fliers. There are more than 1,400 described species.

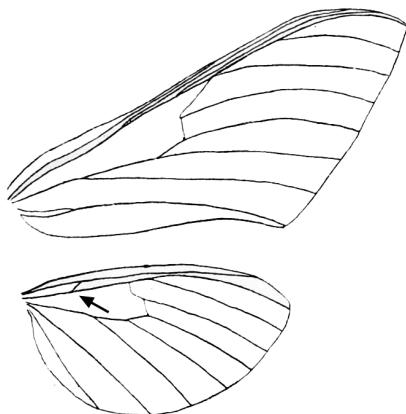
1.2.17 Saturniidae (giant silk moths)

Diagnostic characters: Antennae often bipectinate (Fig. 18b); proboscis reduced or absent; wings usually with translucent patches ("eye spots"; see Fig. 18b); fore wing M₂ arising closer to M₁ than M₃ (Fig. 18a); no basal areole in hind wing; hind wing Sc and Rs not fused; frenulum absent (wing coupling amplexiform); frenulum absent; medium-sized to large (wingspan up to 15 cm), with broad wings and short, thick bodies.

Natural history: Caterpillars diversely phytophagous, generally among the largest lepidopteran larvae. Most species pupate inside a silken cocoon. There are more than 2,300 described species.

1.2.18 Lasiocampidae (tent caterpillars, lappet moths, eggars)

Diagnostic characters: Antennae bipectinate; proboscis vestigial or absent; fore wing Cu₂ arising near wing base; basal areole present in hind wing; frenulum absent, humeral area of hind wing greatly

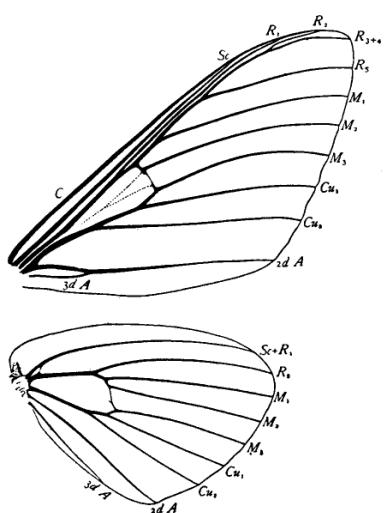


(a) Wings (Smith, 1888, Plate XIII, Fig. 3)



(b) Habitus. (Druce, 1881–1900, Plate 67, Fig. 4)

Figure 17: Sphingidae



(a) Wings (Comstock, 1918, Fig. 345)



(b) Habitus. (Druce, 1881–1900, Plate 19, Fig. 1)

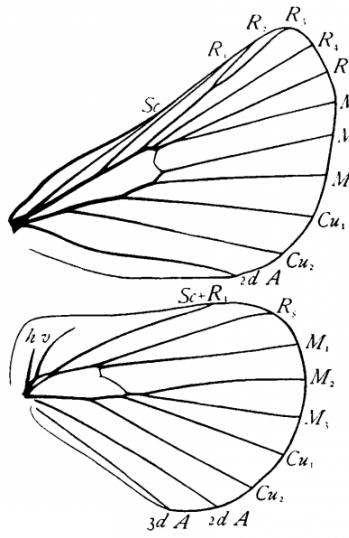
Figure 18: Saturniidae

expanded (Fig. 19a); fore wing M₂ arising closer to M₃ than M₁; relatively fat-bodied and hairy moths (Fig. 19b).

Natural history: Caterpillars diversely phytophagous but mostly on leaves of trees and shrubs. caterpillars setose, often with flattened evaginations (flaps or “lappets”) near prolegs. Some species live communally in tents during the larval stages. About 2,000 species have been described worldwide.

1.2.19 Notodontidae (prominents)

Diagnostic characters: Antennae usually bipectinate; tympanum on metathorax pointing ventrally; tympanal hood absent; no basal areole in hind wing; Sc and Rs in hind wing parallel, not usually fused; fore wing M₂ arising in midway between M₁ and M₃ (key character to separate from Noctuidae and



(a) Wings (Comstock, 1918, Fig. 69)

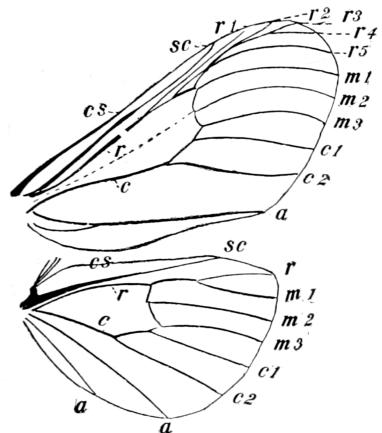


(b) Habitus. Photo (CC BY 2.0) by Andy Deans <https://flic.kr/p/G62zW1>

Figure 19: Lasiocampidae

Erebidae; see Fig. 20a); fore wing usually conspicuously longer than hind wing; body relatively stout, usually drab-colored (Fig. 20b).

Natural history: There are almost 4,000 species of prominents worldwide. Larvae typically feed on trees and have a distinctive habitus. Adults do not feed.



(a) Wings (Sanderson and Jackson, 1912, Fig. 443)



(b) Habitus. Photo (CC BY 2.0) by Andy Deans <https://flic.kr/p/G2taZk>

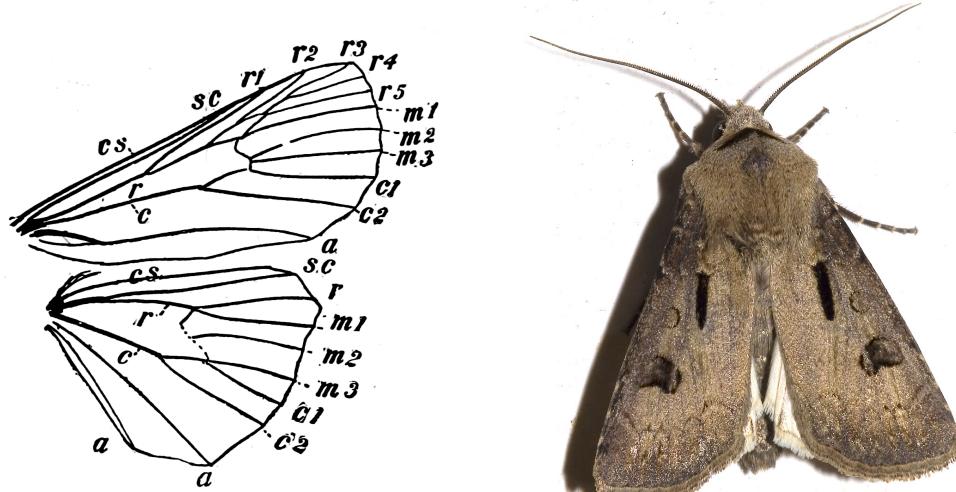
Figure 20: Notodontidae

1.2.20 Noctuidae (owlet moths)

Diagnostic characters: Antennae usually simple, occasionally bipectinate, sometimes swollen apically; labial palps usually long, upturned; ocelli sometimes present, medium-sized to large; fore wings usually

cryptic, sometimes with eye-like spots (Fig. 21a); hind wing cubital vein branches into 2 or 3 veins (hind wing trifine or bifine; see Fig. 21a); tympanum on metathorax pointing posteriorly or outwards; tympanal hood located posterior to spiracle; body color usually dominated by browns.

Natural history: Hugely diverse taxon, with tens of thousands of species; its taxonomic limits remain unsettled. Their natural history is difficult to generalize, but these moths are typically night-fliers. Larvae are diversely herbivorous and include many important pest species.



(a) Wings (Sanderson and Jackson, 1912, Fig. 445)

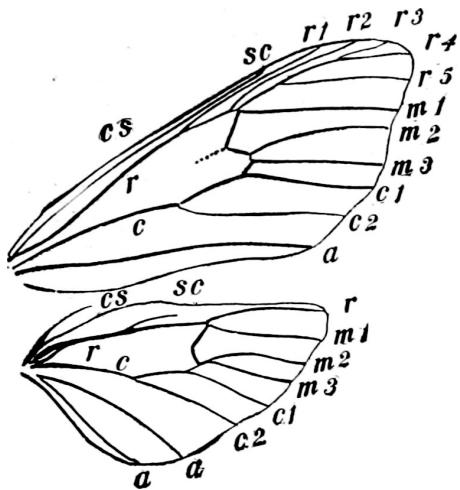
(b) Habitus. Photo (CC BY-SA 3.0) by Olaf Leillinger <https://goo.gl/zxic4M>

Figure 21: Noctuidae

1.2.21 Erebidae (includes Lymantriidae, Arctiidae, and several lineages that used to be in Noctuidae)

Diagnostic characters: Similar to Noctuidae but hind wing cubital vein branches into 4 veins: CU2, CU1, M3, M2 (i.e., hind wing quadrifine; see Fig. 22a).

Natural history: Like Noctuidae, this is a hugely diverse taxon, with tens of thousands of species. Their natural history is difficult to generalize, but these moths are typically night-fliers. Larvae are diversely herbivorous and include many important pest species.



(a) Wings (Sanderson and Jackson, 1912, Fig. 450)



(b) Habitus. Photo (CC BY-NC-SA 2.0) by Sunchild57 Photography <https://flic.kr/p/bPom3g>

Figure 22: Erebidae

2 Trichoptera

Trichoptera comprises approximately 13,000 species, the vast majority of which are aquatic as larvae. Larvae exhibit diverse life history strategies and serve as important indicators of environmental health. For these reasons, we'll be examining larval specimens alongside adults. Larvae use silk extensively, often constructing static or portable shelters. Adult mouthparts are diagnostic for the order, being highly reduced (haustellum) but with long palpi.

2.1 Hydroptilidae (micro-caddisflies)

Diagnostic characters: antennae short, mesoscutum without warts, fore tibiae with 1 spur, very small (usually less than 5 mm), usually mottled grayish or brownish and very hairy (Fig. 23a).

Natural history: These insects are among the smallest trichopterans, rarely measuring >5 mm as adults. Larvae are free-living until the final instar, which builds a silken structure referred to as a "purse case" (Fig. 23b). Larvae feed on filamentous algae and/or diatoms.

2.2 Hydropsychidae (net-spinning caddisflies)

Diagnostic characters: antennae long but usually less than 2× body; ocelli absent; maxillary palp 5-segmented, with apical segment longer than preceding segments; mesoscutum without warts (Fig. 24a); fore tibiae without preapical spurs.

Natural history: Larvae (Fig. 24b) construct trumpet-shaped retreats, attached to rocks in lotic environments. Detritus and invertebrates that get caught in these nets serve as forage for these caddisfly larvae.

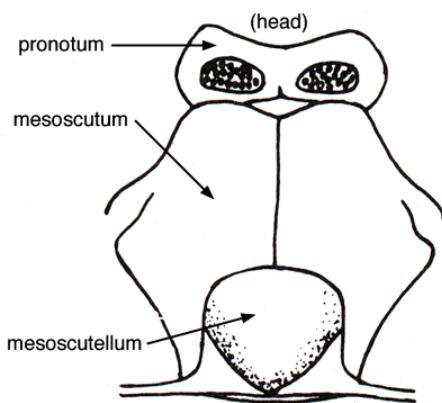


(a) Hydroptilidae. Photo (CC BY 2.0) by Donald Hobern
<https://flic.kr/p/eENe3d>

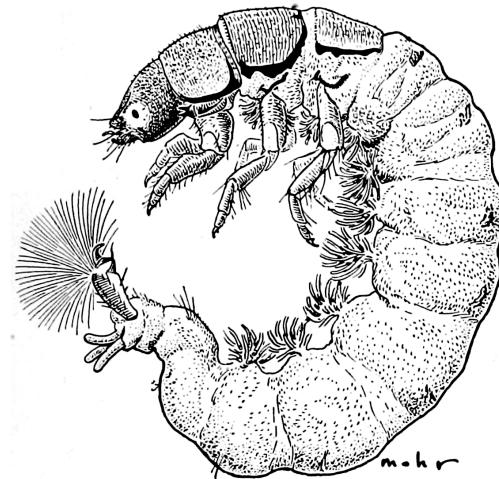


(b) Larval habitus. Photo (CC BY-NC 2.0) by Jon Sullivan <https://flic.kr/p/mpdUdv>

Figure 23: Hydroptilidae



(a) Dorsal view of thorax (Ross, 1944, Fig. 80)



(b) Larval habitus (Ross, 1944, Fig. 281)

Figure 24: Hydropsychidae

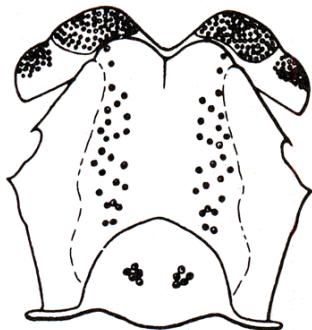
2.3 Leptoceridae (long-horned caddisflies)

Diagnostic characters: body slender, small to medium-sized; antennae hair-like, usually $2\times$ body length (Fig. 25b); ocelli absent; pronotum with a pair (or 2) of warts separated by notch; dorsal mesoscutum with 2 bands of setiferous punctures instead of setal warts (Fig. 25a).

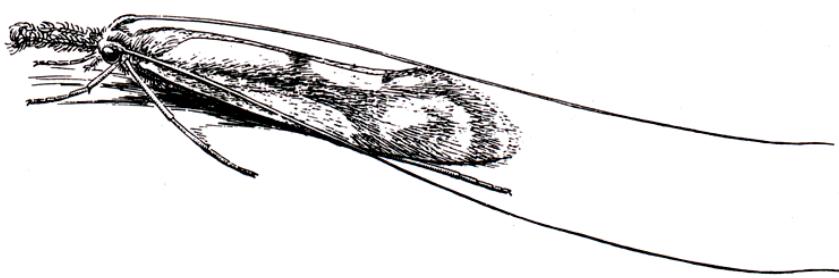
Natural history: Larvae mostly detritivorous shredders and algae (periphyton) scrapers; some species predators. Larvae, which also have relatively long antennae, typically construct tubular cases.

2.4 Phryganeidae (large caddisflies)

Diagnostic characters: Antennae usually about as long as body (Fig. 26a); ocelli present; fore tibiae with 2 or more spurs; middle tibiae with 4 spurs; male maxillary palp 4-segmented (Fig. 26b); among the largest caddisflies; often mottled and brown.



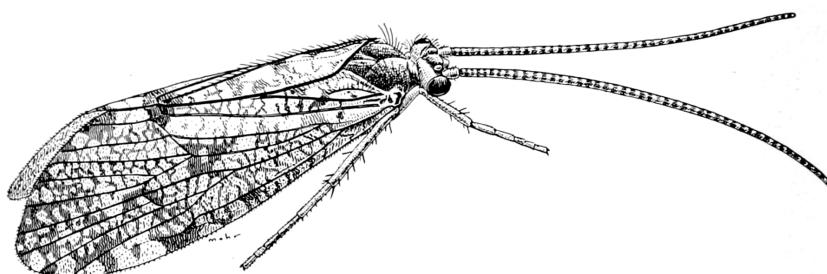
(a) Dorsal view of thorax
(Ross, 1944, Fig. 82)



(b) Habitus (Ross, 1944, Fig. 863)

Figure 25: Leptoceridae

Natural history: Larvae make portable cases from a diverse array of materials and can usually be found in cold, lentic environments. Larvae are mostly detritivores.



(a) Habitus (Ross, 1944, Fig. 591)



(b) Male maxillary palp
(Ross, 1944, Fig. 64)

Figure 26: Phryganeidae

2.5 Limnephilidae (northern caddisflies)

Diagnostic characters: Antennae usually about as long as body (Fig. 27a); ocelli present; fore tibiae with 1 spur or none; middle tibiae with 2 or 3 spurs; male maxillary palp 3-segmented (Fig. 27b), also often large; body usually brown with dark markings.

Natural history: Larvae make portable cases from a diverse array of materials, and they graze on algae or scavenge. This family also includes some unusual species that are terrestrial.



(a) Habitus. Photo (CC BY-NC 2.0) by Lynette <https://flic.kr/p/aTNQJZ>



(b) Male head
(Ross, 1944, Fig. 65)

Figure 27: Limnephilidae

Test yourself

What factors contribute to the overall diversity of Lepidoptera? Can you describe one or two characteristics that could be key innovations or opportunities?

Can you provide two examples of anti-predator adaptations, related to the modified wing setae?

What are the precursors of tympana? Do you think the “ears” on different body regions in different lepidopterans are homologous?

What trends do we see across the phylogeny of Lepidoptera, with respect to feeding biology, mouthpart morphology, and wing morphology?

Familiarize yourself with the following taxon names, which refer to organisms you are likely to encounter in the northeastern USA and/or which are phylogenetically relevant. 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? If you had to choose a family to study from the taxa below which one would it be and why?

1. Amphiesmenoptera
2. Ditrysia
3. Rhopalocera
4. Micropterigidae
5. Annulipalpia
6. Integripalpia

Trichoptera is the most diverse aquatic taxon. What factors contribute to their overall diversity, compared to Odonata, Ephemeroptera, and Plecoptera?

Can you describe one or two characteristics that could be key innovations or opportunities for Trichoptera?

With the mouthpart modification we see in Trichoptera, another vital, non-feeding function was lost. Can you describe how trichopterans solve some problems associated with mandible reduction?

What trends do we see across the phylogeny of Trichoptera, with respect to feeding biology and silk use?

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>

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