Lecture 2 2/02/2023

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Insect-Plant Interactions

Antagonistic interactions (+/-)

- ✓ Herbivory: Definition, types, taxonomic, distribution,
- ✓ Herbivory: Effects on plants
- ✓ Herbivory: Plant defence
- ✓ Herbivory: Tritrophic systems
- ✓ Herbivory: Specialisation, coevolution, diversification
- ✓ [Insectivorous, plants]

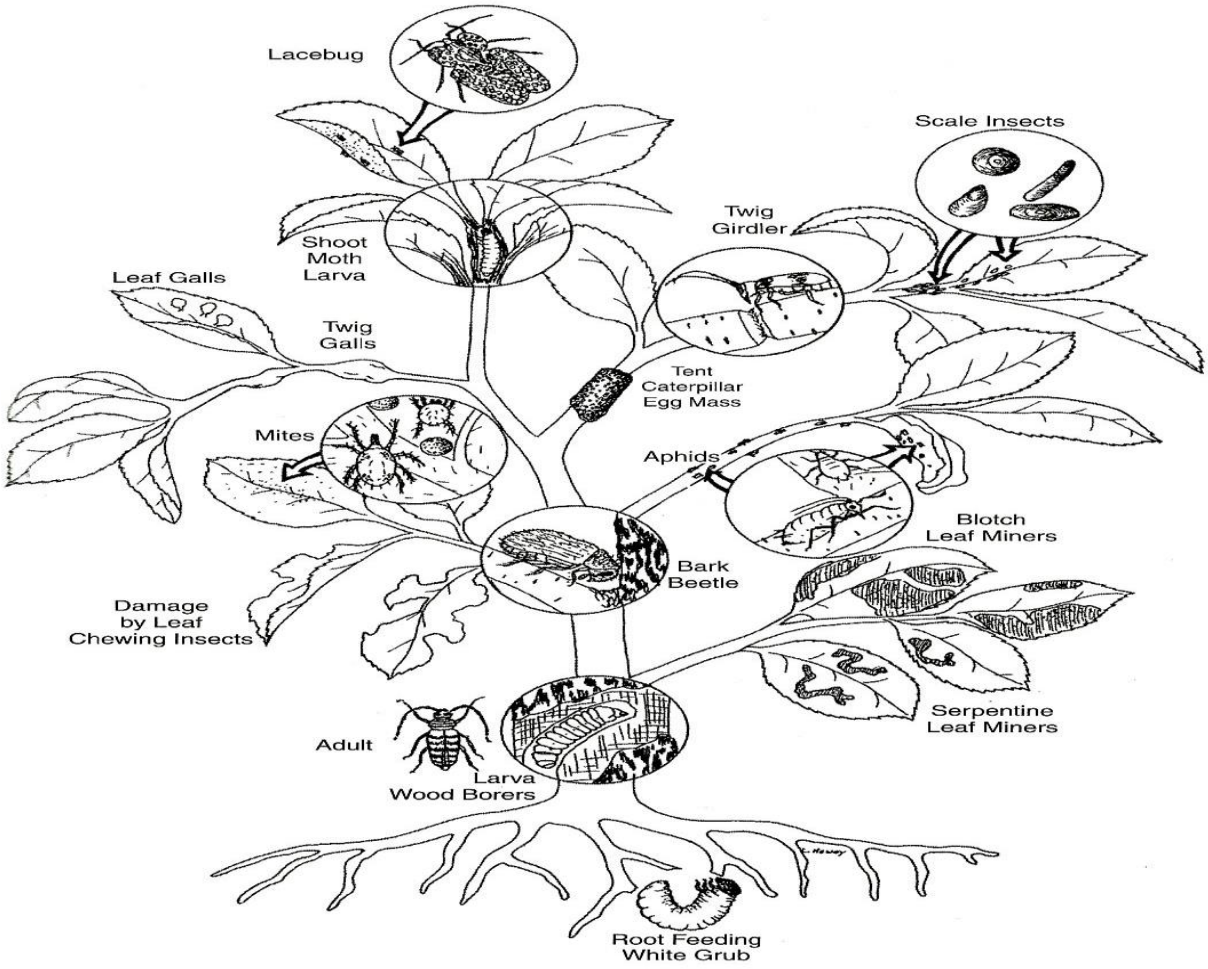
Mutualistic interactions (+/+)

- ✓ Pollination
- ✓ [Seed dispersal]
- ✓ Ant-plant interactions(ant-guards)
- ✓ [Phytotelmata]

An evolutionary approach:
Coevolution, specialisation–generalisation

PHYTOPHAGY (OR HERBIVORY)

- ✓ [Often used synonymously]
- ✓ Feeding on plants
- ✓ Herbivory more often used in vertebrates
- ✓ Phytophagy more often used in invertebrates
- ✓ Includes all forms of feeding on plants
  e.g. chewing leaves, sap sucking, stem boring, leaf mining, gall inducing, pollen, harvesting, nectar drinking,…



Herbivory=Predation

Predator…, Organism that consumes another organism (prey) Partly or entirely

„**True“ predators**…, …kill their prey and consume several to many prey individuals during their lifetime,

Grazers…, …consume several to many prey individuals but do not, kill them because they only eat parts of them

Parasites…, Consume only parts of *one* prey individual the so-called, host and live in close as sociation with that individual. The host is damaged but usually survives.

Parasitoids…, ….are parasites that kill their hosts obligatorily at the end of their development .

Insect herbivory: diversity and taxonomy

- ✓ >50% of the estimated 2-10 million insect species are herbivores!
- ✓ Is prominent in 9 insect orders, including the most speciose!
- ✓ Occurs in both hemimetabolous and holometabolous orders

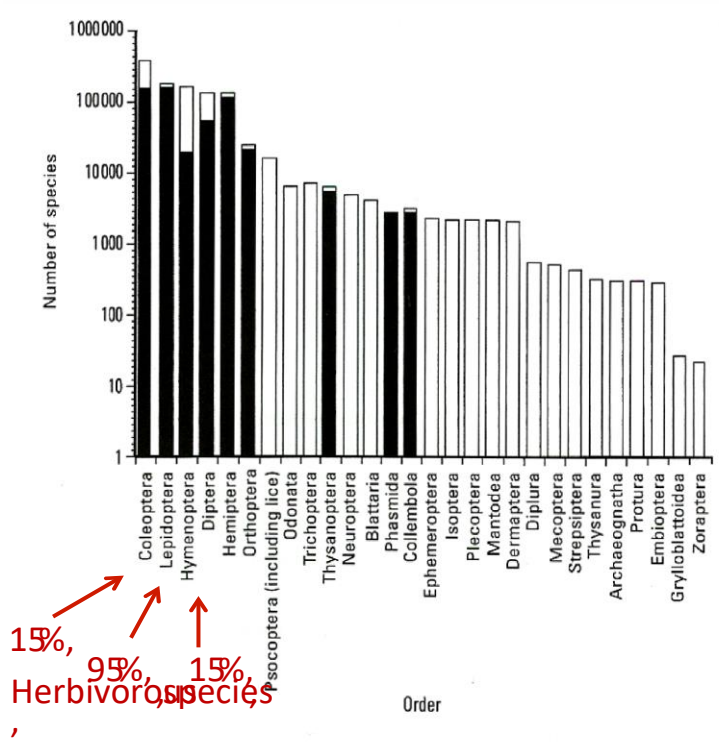


Figure 3.1 Insect orders that largely use live plant tissue are among the richest in species. Insect orders ranked by estimated species number in the world, with the proportion of plant-feeding species indicated by shading. Data for the proportion of herbivorous species give the proportion of herbivores in the fauna of the British Isles (Price 1997); the extent to which this reflects global patterns has yet to be explored.

Strauss & Zangerl (2002), Plant insect interactions in terrestrial ecosystems, In: Herrera & Pellmyr, Plant animal interactions, an evolutionary approach, Blackwell Pub.

Herbivory effects on plants

- ✓ Herbivores consume on average 18 % of terrestrial and 51 % of aquatic plant biomass;10 to 100 % of seeds are eaten
- ✓ Sometimes insect herbivores defoliate entire trees/forests,
- ✓ Effects on plant fitness (relative reproductive success) ranges from reduced growth over reduced seed production to individual death
- ✓ Experimentally removing insect herbivores from *Eucalyptus* trees by insecticide treatment for three years: Trees were 100% taller than controls
- ✓ Attack from multiple herbivore may have synergistic‘ detrimental effects
- ✓ Herbivores may reduce plant fitness by transmitting pathogens

- ✓ Massive outbreaks of herbivores occur in temperate and tropical forests, sometimes leading to the death of individual adult trees (in this case oaks)

spongy moth

Lymantria dispar

European oak leafroller and the green oak moth

Tortrix viridana

Leaf chewing

The damage caused by leaf-chewing insects is readily visible compared, for example, with that of many sap-sucking insects. Furthermore, the insects responsible for leaf-tissue loss are usually easier to identify than the small larvae of species that mine or gall plant parts. By far the most diverse groups of leaf-chewing insects are the Lepidoptera and Coleoptera. Most moth and butterfly caterpillars and many beetle larvae and adults feed on leaves, although plant roots, shoots, stems, flowers or fruits often are eaten as well. Certain Australian adult scarabs, especially species of *Anoplognathus* (Coleoptera: Scarabaeidae; commonly called Christmas beetles), can cause severe defoliation of eucalypt trees. Most methods rely on estimating leaf area lost due to leaf-chewing insects. This can be measured directly from foliar damage, either by once-off sampling, or monitoring marked branches, or by destructively collecting separate samples over time ("spot sampling"), or indirectly by measuring the production of insect frass (faeces).

Christmas beetles *Anoplognathus sp* (Coleoptera: Scarabaeidae)

Types of leaf chewing

1. Small hole ……larvae of Lepidoptera

2. Chewing leaf margins ……..grasshopper

3. Between veins …….. larvae of Lepidoptera

4. Leaf surface …….. flea beetle

Plant mining and boring

A range of insect larvae reside within and feed on the internal tissues of living plants. Some are miners, feeding just below the plant epidermis (the outermost protective tissue layer). Leaf-mining species live between the two epidermal layers of a leaf, and their presence can be detected externally after the area that they have fed upon dies, often leaving a thin layer of dry epidermis. This leaf damage appears as tunnels, blotches or blisters. Tunnels may be straight (linear) to convoluted, and often widen throughout their course as a result of larval growth during development. Generally, larvae that live in the confined space between the upper and lower leaf epidermis are flattened. Their excretory material, frass, is left in the mine as black or brown pellets or lines. The leaf-mining habit has evolved independently in only four holometabolous orders of insects: the Diptera, Lepidoptera, Coleoptera and Hymenoptera. The most common types of leaf miners are larval flies and moths. Leaf miners can cause economic damage by attacking the foliage of fruit trees, vegetables, ornamental plants and forest trees.

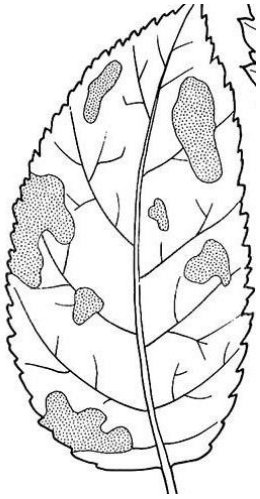
Shapes mines

1. Linear

   Serpentine …….. curving and twisting like a snake

   Linear blotch

   Trumpet
2. Blotch mines

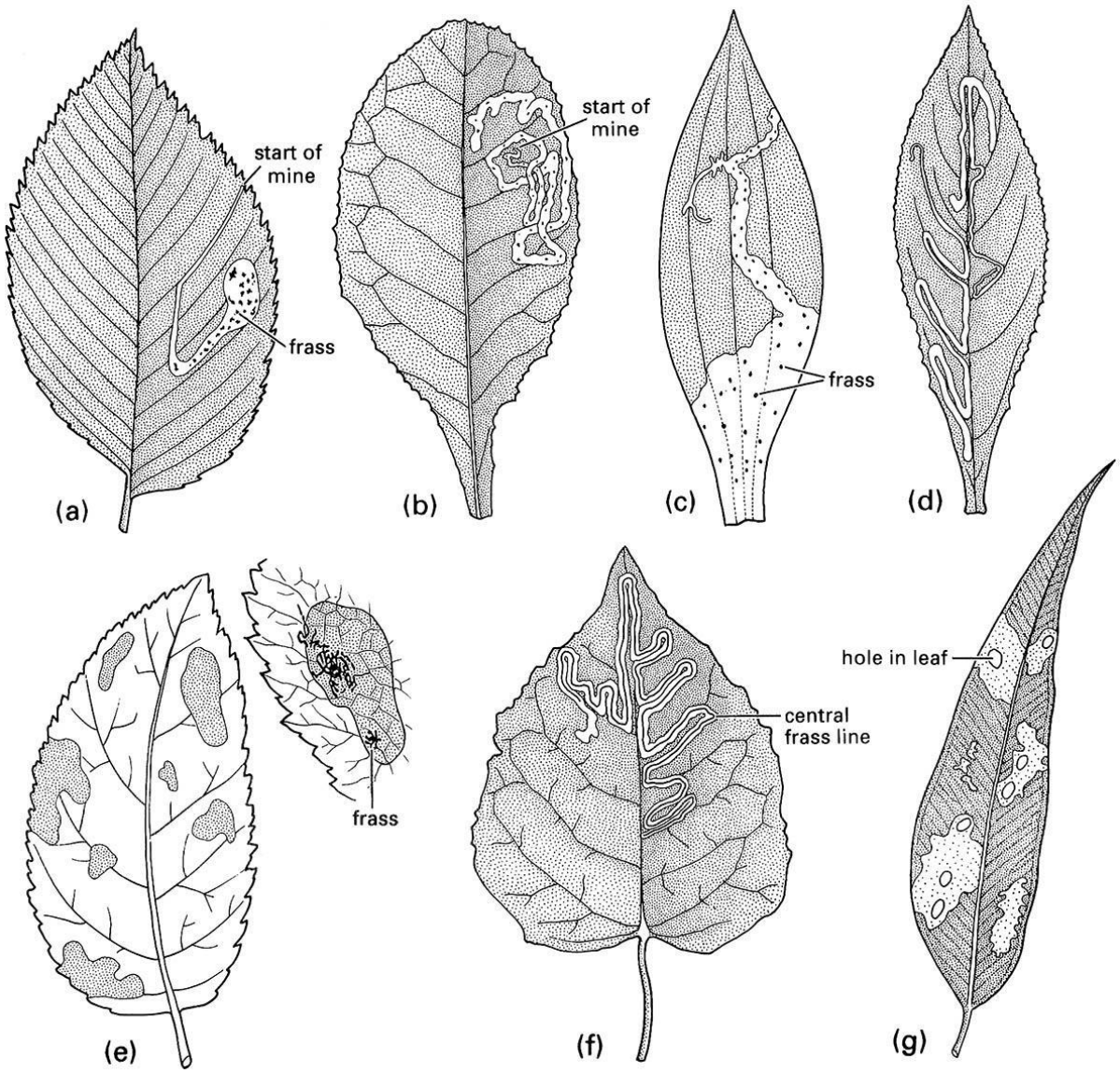


Digital mines

Tentiform mines 

Linear mine on poplar

Blotch mine on syringa



(a) linear-blotch mine of *Agromyza aristata* (Diptera: Agromyzidae) in leaf of an elm

(b) linear mine of *Chromatomyia primulae* (Agromyzidae) in leaf of a primula

(c) linear-blotch mine of *Chromatomyia gentianella* (Agromyzidae) in leaf of a gentia

(d) linear mine of *Phytomyza senecionis* (Agromyzidae) in leaf of a ragwort

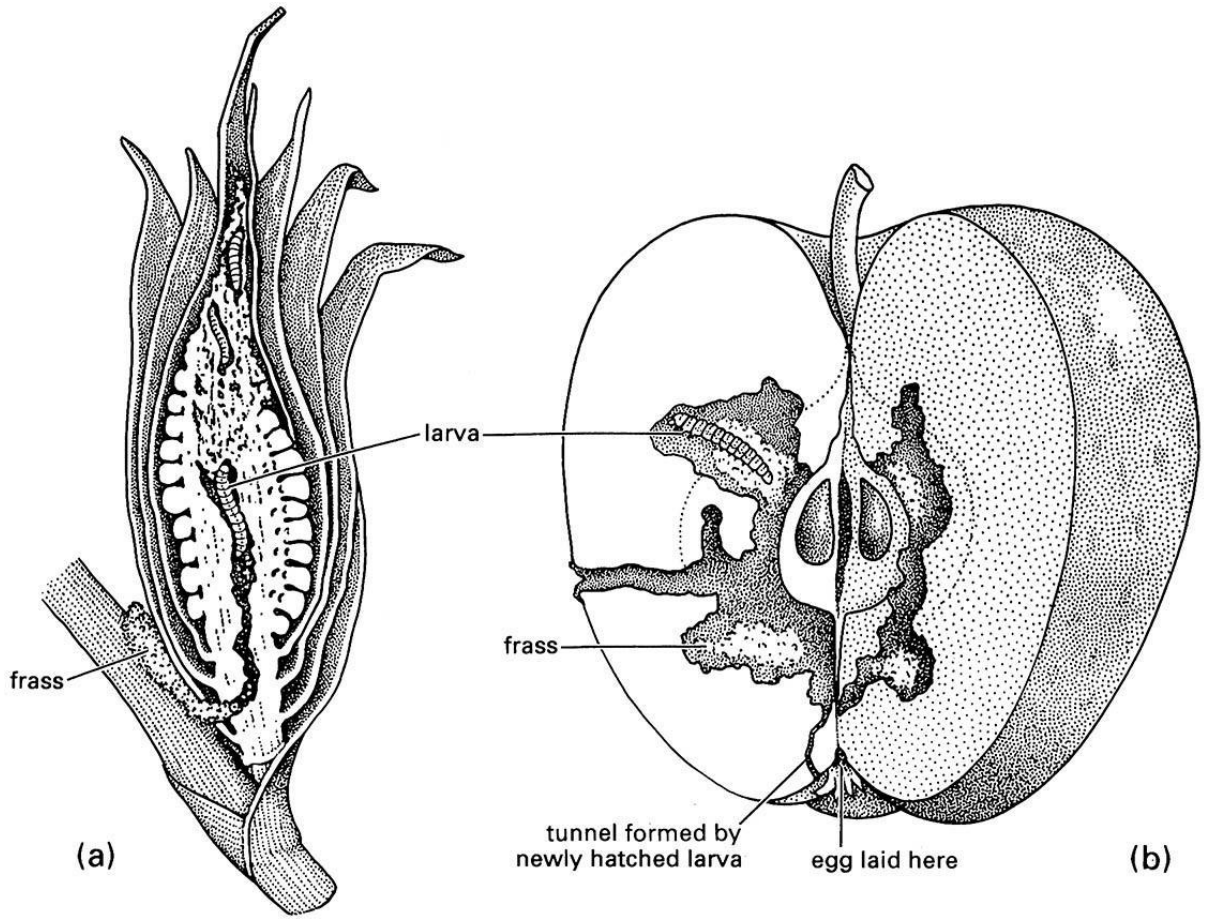
(e) blotch mines of the apple leaf miner, *Lyonetia speculella* (Lepidoptera: Lyonetiidae), in leaf of apple

(f) linear mine of *Phyllocnistis populiella* (Lepidoptera: Gracillariidae) in leaf of poplar

(g) blotch mines of jarrah leaf miner, *Perthida glyphopa* (Lepidoptera: Incurvariidae) *Eucalyptus marginata*

Stem boring is just one form of plant boring. which includes a broad range of habits that can be subdivided according to the part of the plant eaten and whether the insects are feeding on living or dead and/or decaying plant tissues. The latter group of saprophytic insects is. The former group includes larvae that feed in buds, fruits, nuts, seeds, roots, stalks and wood. Stalk borers, such as the wheat stem sawflies (Hymenoptera: Cephidae: Cephus species) and the European corn borer (Lepidoptera: Pyralidae: Ostrinia nubilalis), attack grasses and more succulent plants.

Wood borers feed in the roots, twigs, stems and/or trunks of living woody plants, where they may eat the bark, phloem, sapwood or heartwood. The wood-boring habit is typical of many Coleoptera, especially the larvae of longicorn (or longhorn) beetles (Cerambycidae), jewel beetles (Buprestidae) and weevils (Curculionoidea), and some Lepidoptera (e.g. Hepialidae and Cossidae) and Hymenoptera. The root-boring habit is well developed in the Lepidoptera, but moth larvae rarely differentiate between the wood of trunks, branches or roots. Many insects damage plant storage organs by boring into tubers, corms and bulbs.



(a) larvae of the European corn borer, *Ostrinia nubilalis* (Lepidoptera: Pyralidae), tunnelling in a corn stalk; (b) a larva of the codling moth, *Cydia pomonella* (Lepidoptera: Tortricidae), inside an apple.