Lecture 5

02/03/2023 Dr. Srwa Karim hamad

NSECTS AND PLANT REPRODUCTIVE BIOLOGY

Insects are intimately associated with plants. Agriculturalists, horticulturalists and gardeners are aware of their role in damage and disease dispersal. However, certain insects are vitally important to many plants, assisting in their reproduction, through pollination, or their dispersal, through spreading their seeds. Pollination Sexual reproduction in plants involves pollination – the transfer of pollen (male germ cells in a protective covering) from the anthers of a flower to the stigma. A pollen tube grows from the stigma down the style to an ovule in the ovary where it fertilizes the egg. Pollen generally is transferred either by an animal pollinator or by the wind. The benefits of insect pollination (entomophily) over wind pollination (anemophily) include: • **increase in pollination efficiency, including reduction of pollen wastage; • successful pollination under conditions unsuitable for wind pollination; • maximization of the number of plant species in a given area (as even rare plants can receive conspecific pollen carried into the area by insects)**. The major anthophilous (flower-frequenting) taxa among insects are the beetles (Coleoptera), flies (Diptera), wasps, bees and ants (Hymenoptera), thrips (Thysanoptera), and butterflies and moths (Lepidoptera). These insects visit flowers primarily to obtain nectar and/or pollen, but even some predatory insects may pollinate the flowers that they visit. Nectar

primarily consists of a solution of sugars, especially glucose, fructose and sucrose. Pollen often has a high protein content plus sugar, starch, fat, and traces of vitamins and inorganic salts. In the case of a few bizarre interactions, male hymenopterans are attracted neither by pollen nor by nectar but by the resemblance of certain orchid flowers in shape, colour and odour to their conspecific females. In attempting to mate (pseudocopulate) with the insect-mimicking flower, the male inadvertently pollinates the orchid with pollen that adhered to his body during previous pseudocopulations. Pseudocopulatory pollination is common among Australian thynnine wasps (Tiphiidae), but also occurs in a few other wasp groups, some bees, and rarely in ants. **Cantharophily (beetle pollination)** may be the oldest form of insect pollination. Beetle-pollinated flowers often are white or dull coloured, strong smelling, and regularly bowl- or dish-shaped. The major beetle families that commonly or exclusively contain anthophilous species are the Buprestidae (jewel beetles;), Cantharidae (soldier beetles), Cerambycidae (longicorn or longhorn beetles), Cleridae (checkered beetles), Dermestidae, Lycidae (net-winged beetles), Melyridae (soft-winged flower beetles), Mordellidae (tumbling flower beetles), Nitidulidae (sap beetles) and Scarabaeidae (scarabs).

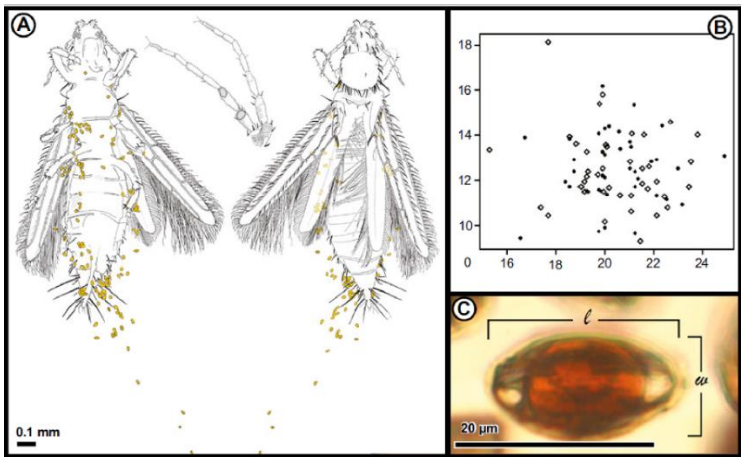
Myophily (fly pollination) occurs when flies visit flowers to obtain nectar, although hover flies (Syrphidae) feed chiefly on pollen rather than nectar. Fly-pollinated flowers tend to be less showy than other insect-pollinated flowers but may have a strong smell, often malodorous. Flies generally utilize many different sources of food and

thus their pollinating activity is irregular and unreliable. Both dipteran groups (Nematocera and Brachycera) contain anthophilous species. Major pollinator taxa are the Bombyliidae (bee flies), Syrphidae and muscoid families. Most members of the Lepidoptera feed from flowers using a long, thin proboscis. In the speciose Ditrysia (the "higher" Lepidoptera), the proboscis is retractile, allowing feeding and drinking from sources distant from the head. Such a structural innovation may have contributed to the radiation of this successful group, which contains 98% of all lepidopteran species. Flowers pollinated by butterflies and moths often are regular, tubular and sweet smelling. **Phalaenophily (moth pollination)** typically is associated with light-coloured, pendant flowers that have nocturnal or crepuscular anthesis (opening of flowers); whereas **psychophily (butterfly pollination)** is typified by red, yellow or blue, upright flowers that have diurnal anthesis. Many members of the large order Hymenoptera visit flowers for nectar and/or pollen. The Apocrita, which contains most of the wasps (as well as bees and ants), is more important than the Symphyta (sawflies) in terms of **sphecophily (wasp pollination**). Many pollinators are found in the superfamilies Ichneumonoidea and Vespoidea. Fig wasps (Chalcidoidea: Agaonidae) are highly specialized pollinators of the hundreds of species of figs. Ants (Formicidae) are rather poor pollinators, although **myrmecophily (ant pollination)** is known for a few plant species. Ants are commonly anthophilous (flower loving), but rarely pollinate the plants that they visit. Generally, bees are regarded as the most important group of insect

pollinators. They collect nectar and pollen for their brood as well as for their own consumption. There are almost 20,000 named species of bees worldwide and all are anthophilous. Plants that depend on **melittophily (bee pollination)** often have bright (yellow or blue), sweet-smelling flowers with nectar guides – lines (often visible only as ultraviolet light) on the petals that direct pollinators to the nectar. There is wide variation in the range of host plants visited, with most eusocial bees (such as honey bees and bumble bees) exhibiting **polylecty (collecting pollen from the flowers of a variety of unrelated plants) and most other bees being oligolectic (with specialized pollen preferences, often the pollen of one plant genus). Very few bee species are monolectic, specializing in collecting pollen from just one plant species.**

Pollination by Insects

- ✓ Pollen-eating insects were probably the first animal pollinators
- ✓ Thrips (Thysanoptera) from early cretaceous amber (~110 Mio ys), provide the first fossil evidence for animal pollination (of Gymnosperms, i.e. cycads)



- ✓ Angiosperm radiation was promoted or caused by coevolution with pollinating insects
- ✓ Today angiosperms reward insects for pollen transport with a diverse range of other resources, including…

floral oils, mating arenas, sleeping places……

✓ But not all plant-pollinator interactions are mutualistic: Pollination by deceit is common

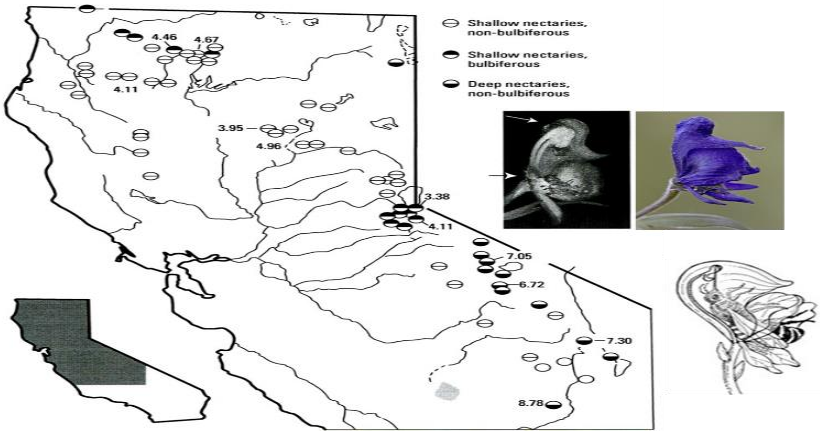
A case of a sexually deceptive orchid flower: A male of *Andrena sp*. (=solitary bee; "Sandbiene") pseudocopulating with the flower of *Ophrys lutea* (Orchidaceae: thereby removing the pollen packages (pollinaria).

The geographic context of coevolution

The geographic mosaic theory‘ of coevolution

Plants adapt to local pollinator assemblages

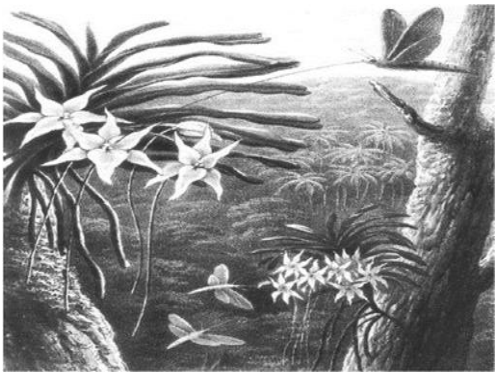
Longer spurs in mountain areas with longer-tongued bumblebees



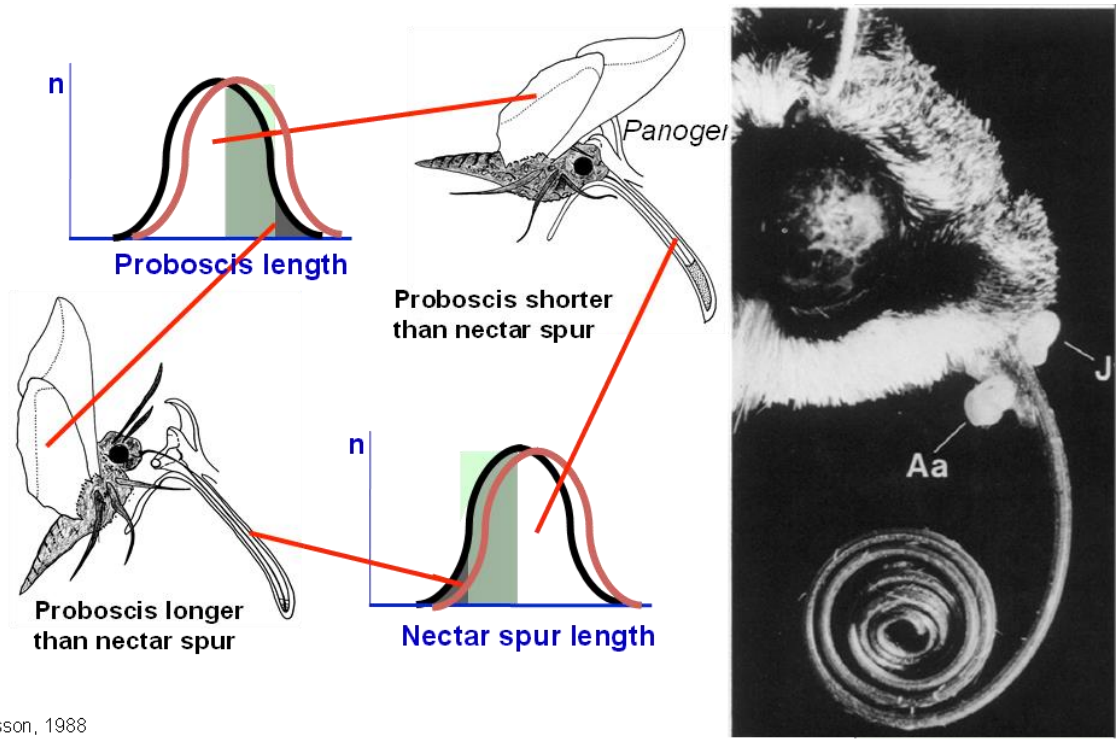
Example: Variation in spur length and asexual (bulbiferous) reproduction in Californian monkshood *Aconitum columbianum*(„Eisenhut“),

One-to-one coevolution inferred from floral morphology

- Charles Darwin,1862: *On the Various Contrivances by which Orchids are Fertilised by Insects*.“
- The Malagasy orchid, *Angraecum sesquipedale*, has nectaries at the bottom of 28.6 cm long spurs. Darwin predicted the existence of an equally long-tongued moth
- "It is,however, surprising that any insect should be able to reach the nectar: our English sphinxes have proboscis as long as their bodies; but in Madagascar there must be moths with proboscis capable of extension to a length of between ten and eleven inches



41ys. later: Rothschild and Jordan describe *Xanthopan morgani praedicta* (Sphingidae) with a proboscis of 25cm



Nilsson, 1988

Pollinator-Plant Coevolution

The most highly coevolved (specialized) systems are derived from parasitic interactions: fig wasp and yucca moth pollination

Larvae feed on developing seeds

Here the survival of larvae directly depends on the fertilization of plant ovules …..complete reciprocal dependence …..active pollination

Fig inflorescence with fig wasps

Yucca flowers, yucca moth

Fig trees and fig wasps

900 species of figs (*Ficus spp.*; Moraceae) are exclusively and specifically pollinated by +/- 900 species of fig wasps (Chalcidoidea: Agaonidae)

The fig is a monandrous inflorescence with female flowers maturing weeks earlier than male flowers

! Female wasp carrying pollen from another fig tree enter female phase inflorescences through ostiole lay eggs in ovules with ovipositor and actively pollinate flowers

! Larvae form galls and develop

! Flightless males hatch copulate with females still in the gall, bore emergence hole for the females, and die

! Females hatch, actively fill specialized structures on coxae with pollen, and leave to search for a female phase inflorescence guided by species-specific chemical cues

Females can only deposit eggs in the short -styled flowers, but pollinate all…. some flowers develop seeds

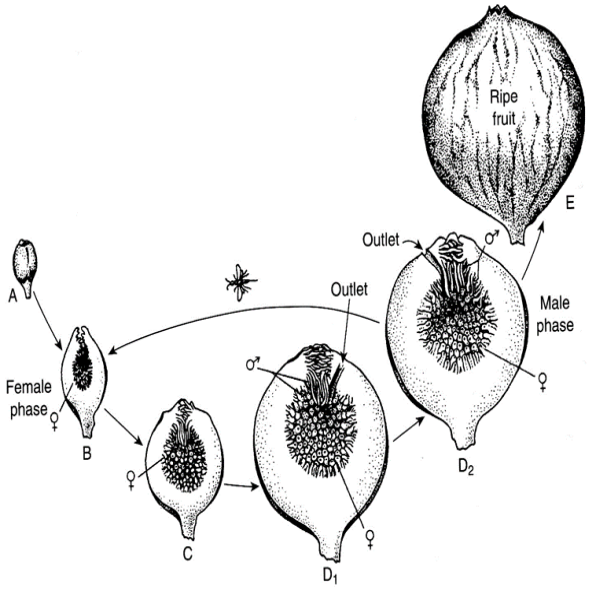


Fig inflorescence

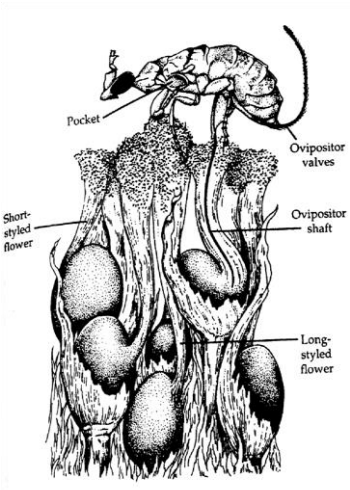


Figure 6.7 Female fig wasp, *Ceratosolen arabicus*, ovipositing in a short-styled flower of *Ficus sycomorus*, and extracting pollen from a pouch to fertilize the flower. From Galil and Eisikowitch (1969).

Pollen and bees: a special relationship

Bees (Hymenoptera: Anthophila; 20.000 species worldwide, they are wasps that have specialized on the consumption of floral pollen and nectar

Pollen is harvested as protein-rich larval food with specialized structures of branched hairs

Bees are derived from carnivorous hunting wasps (Sphecidae:, Crabroninae) in the early Cretaceous (100-120 mio ys. Ago)

Nectar is consumed by adults as sugar-rich‚flight fuel‘

They were not the first pollinators, but came to be the most important pollinator taxon and probably promoted the Angiosperm radiation

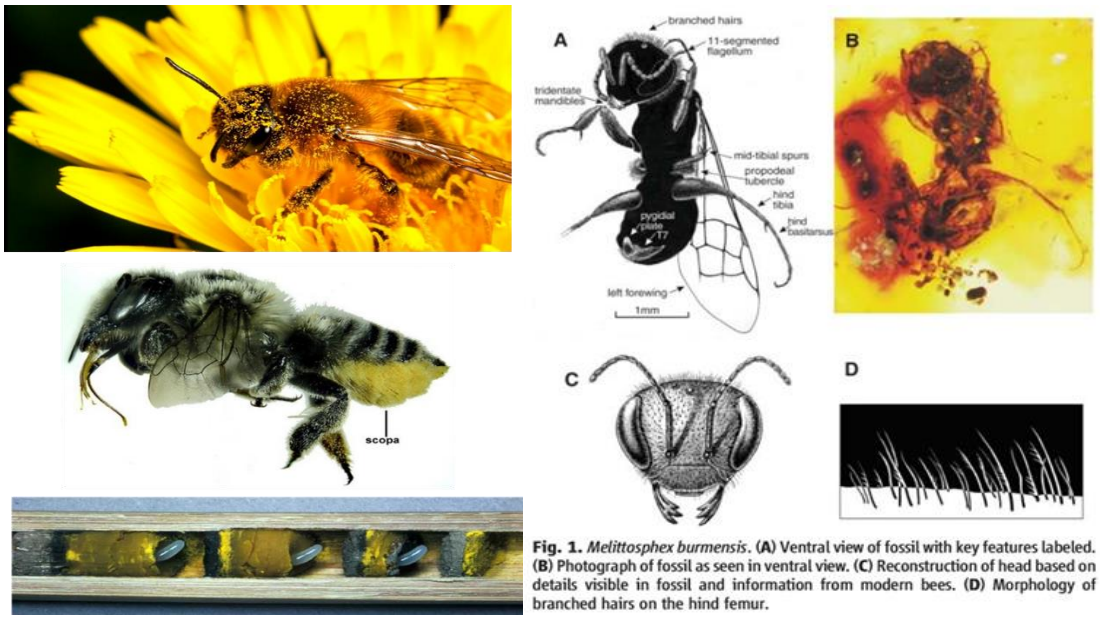


Fig. 1. *Melittosphex burmensis*. **(A)** Ventral view of fossil with key features labeled. **(B)** Photograph of fossil as seen in ventral view. **(C)** Reconstruction of head based on details visible in fossil and information from modern bees. **(D)** Morphology of branched hairs on the hind femur.