Melliferous plants and modern beekeeping management

dr Beata Michalska-Klimczak

Warsaw University of Life Sciences

Agricultural Institute

Department of Agronomy

room 3/101

e-mail: beata_michalska-klimczak@sggw.edu.pl

dr inż. Krzysztof Pągowski

Warsaw University of Life Sciences

Agricultural Institute

Department of Agronomy

room 3/105

e-mail: krzysztof_pagowski@sggw.edu.pl

Date	Schedule of lectures	Topics	Lecturers
2.03	The importance of pollinating insects in maintaining biocenotic balance. Mutual adaptation of insects and insect-pollinated flowers.		KP
9.03	Collection of cultivated plants, building 16A - Preparing a hotel for pollinators		KP/BMK
16.03	Characteristics of the honey bee and the basics of beekeeping. Bee pasture and products collected by bees: nectar, honeydew, pollen, bee glue.		KP
23.03	Nutritional needs of the bee colony. The development of the bee colony and its demand for nectar and pollen throughout the year.		KP
30.03	Characteristics of plants providing nectar and pollen, the so-called bee products (ultivated plants)		BMK
6.04	Collection of cultivated plants, building 16A sowing of melliferous plants		BMK/KP
13.04	Characteristics of plants providing nectar and pollen, the so-called bee products (wild plants)		BMK
20.04	Collection of cultivated plants, building 16A		BMK/KP
27.04	Characteristics of plants providing nectar and pollen, the so-called bee products (wild plants)		BMK
11.05	Collection of cultivated plants, building 16A		BMK/KP
18.05	Characteristics of plants providing nectar and pollen, the so-called bee products (wild plants)		BMK
25.05	Conditions for the full use of honeyflow: spring (including rape, maples), summer (such as black locust, raspberry, mustard, phacelia, linden, buckwheat) and late honeyflow (goldwood, heather and honeydew).		KP
1.06	Evaluation of the abundance of the bee pasture and the possibility of its enrichment, and the optimal size of the apiary.		KP
8.06	Bee products and their properties: honey, wax, propolis, royal jelly.		BMK
15.06	Test		BMK/KP

The importance of pollinators in maintaining biocenotic balance.

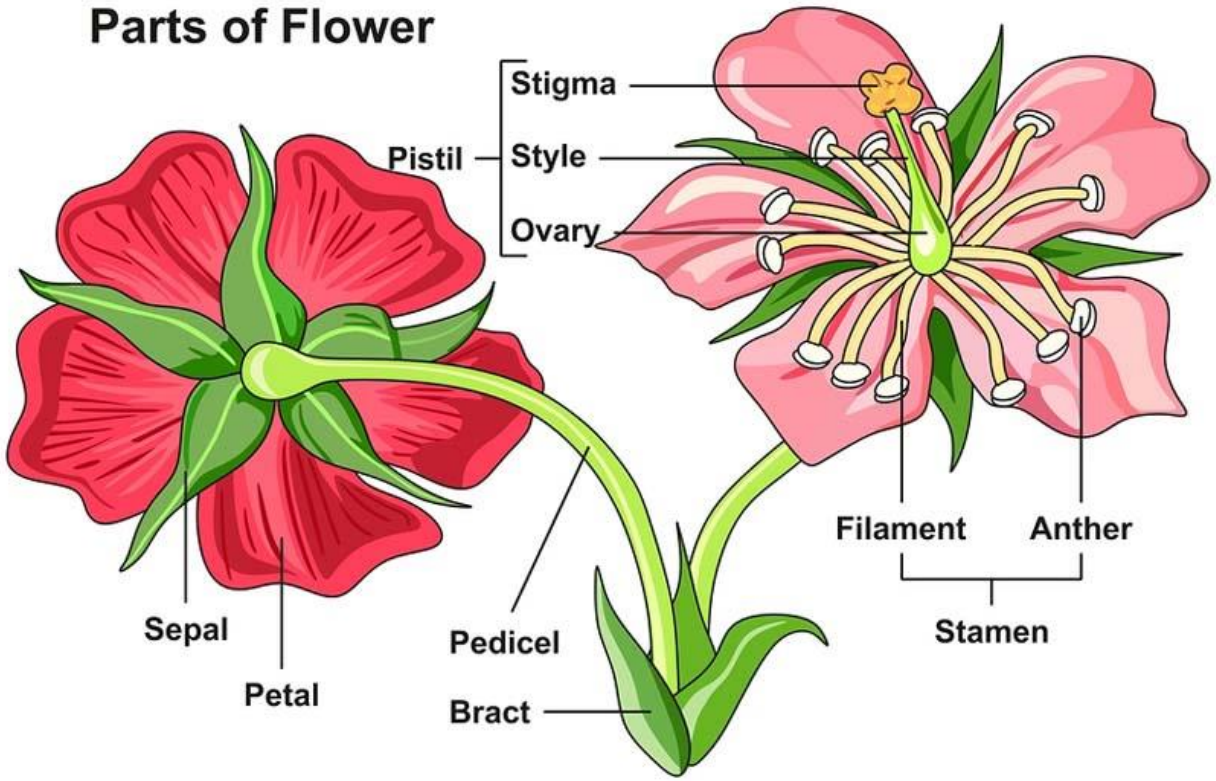
Mutual adaptation of insects and insect-pollinated flowers.

So many possibilities - which one would be the best choice for me.

Maintaining a balance in a biocenosis guarantees the organisms' **ability to reproduce**.

In the case of plants, effective pollination is necessary

Pollination: is defined as the transfer of pollen from the anther to the stigma.



There are many vectors for pollination

Anemophily or wind pollination is a form of pollination whereby pollen is distributed by wind. Approximately 12% of plants across the globe are pollinated by anemophily

Hydrophily is a **fairly uncommon** form of pollination whereby pollen is distributed by the flow of waters, particularly in rivers and streams.

Zoogamy, is a form of pollination whereby pollen is transferred by animals.

Entomophily or insect pollination is a form of pollination whereby pollen of plants, especially but not only of flowering plants, is distributed by insects.

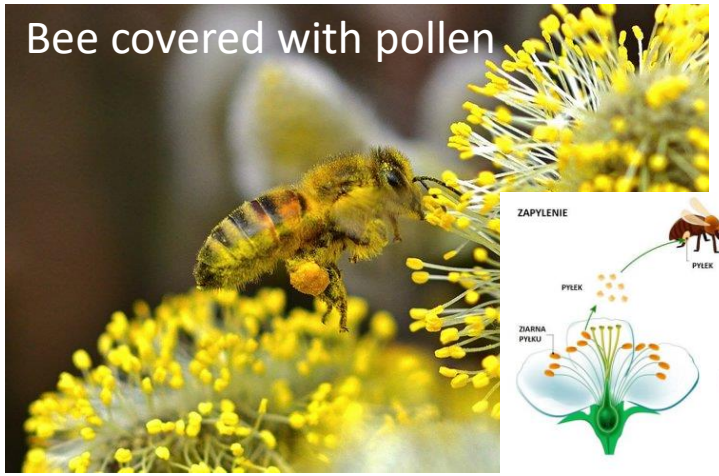
Lizard pollination

Ornithophily - bird pollination

Chiropterophily - bat pollination

Pollination by other mammals

There are benefits and costs associated with any vector.



Animal pollination:

- is beneficial because the process is more directed and often results in pollination
- is costly for the plant to produce rewards, such as nectar, to attract animal pollinators.

Abiotic (wind) pollinaton:

- not producing such rewards is one benefit of using,
- but a cost associated with this approach is that the pollen may be distributed more randomly.

Hazelnut pollen cloud

Pollination mechanisms

Cross-pollination, also called allogamy, occurs **when pollen is delivered from the stamen of one flower to the stigma of a flower on another plant of the same species.**

We need at least two plants of the same species to pollinate !!!!!!

CHERRIS

=

=

most varieties of:
- apples
- pears,

some varieties of:
cheries
plums.

Plants adapted for cross-pollination have several mechanisms to prevent self-pollination:

Dioecy, dioece - in plants, the presence of female and male reproductive organs (flowers) on different individuals.

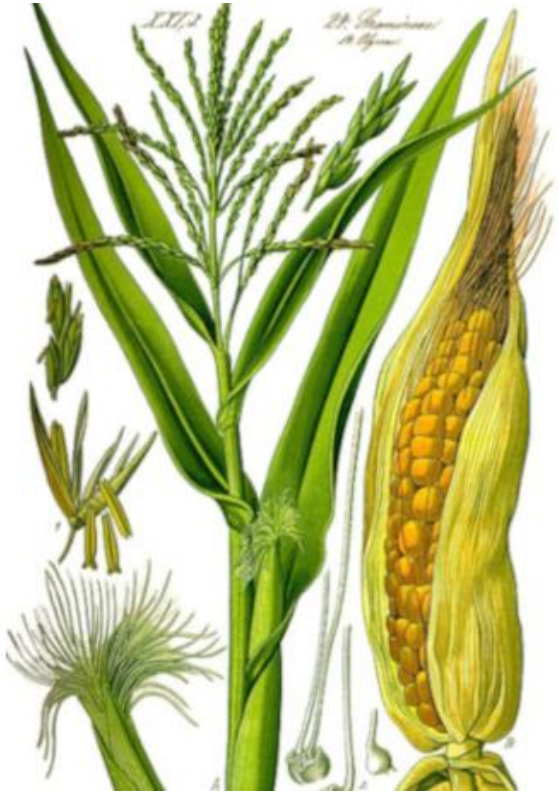
Separation of the sex of the generative organs between different individuals is observed for example in the **willow tree (**poplar, hemp, hops)

Male (flowers with anthers)

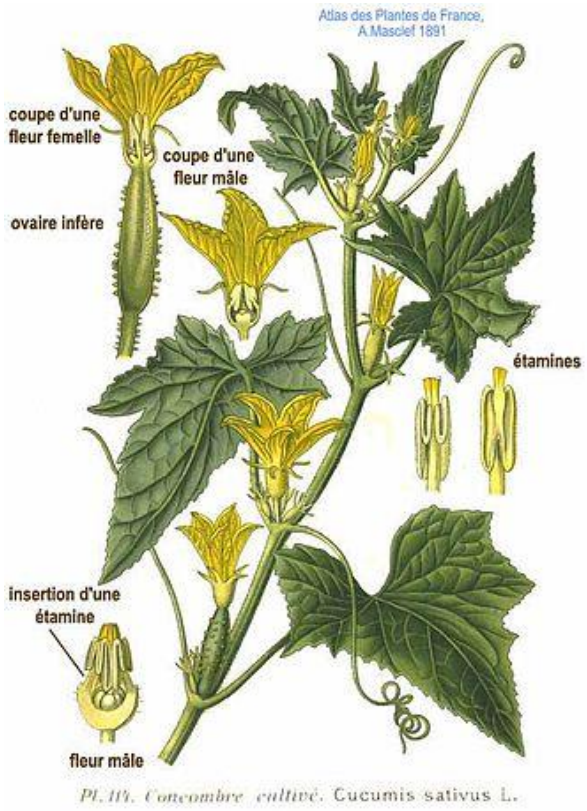
Female (flowers with pistils)

Plants adapted for cross-pollination have several mechanisms to prevent self-pollination:

Male and female flowers on the same individual
(corn, cucumber, pumpkin, walnut, hazel, oak, birch, pine)



Corn



Cucumber

Walnut

Plants adapted for cross-pollination have several mechanisms to prevent self-pollination:

Protandry - a phenomenon occurring in hermaphrodite flowers in some plant species.
It consists in the **earlier maturation of the stamens than the pistils.** Pollination with pollen from the same plant. In pre-stem flowers, only cross-pollination is possible - with pollen from another plant of the same species.
Very common in families Apiaceae, Asteraceae, Malvaceae

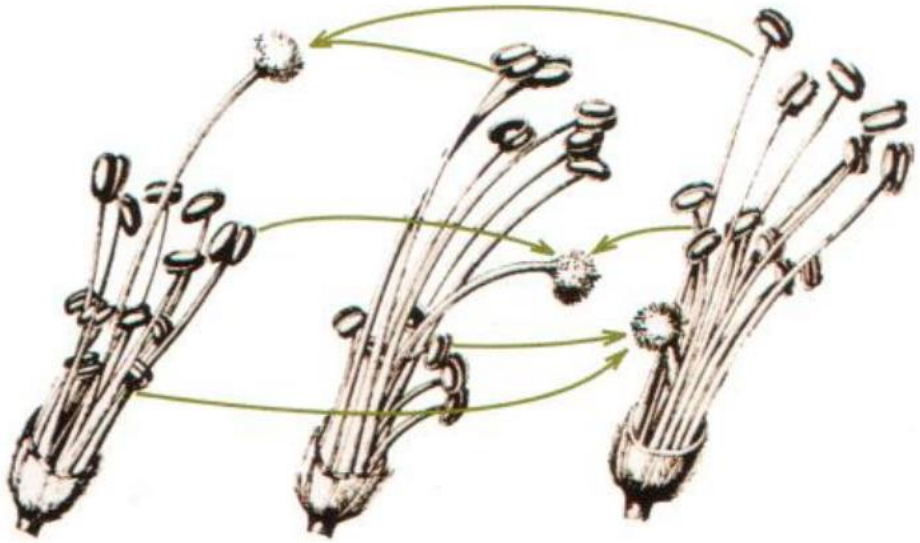
Protogyny - it consists in the earlier maturation of the pistils than the stamens.
This is one of the mechanisms preventing unfavorable self-pollination, i.e. pollination with pollen from the same plant.
(Scrophularia nodosa (figwort), apple tree, pear tree, plum tree)

Figwort

Different structure of flowers on the plant

Three types of flowers (*Lythrum salicaria L.)*

Pollen from the largest anthers pollinate the stigma of the longest pistil and e.t.c.



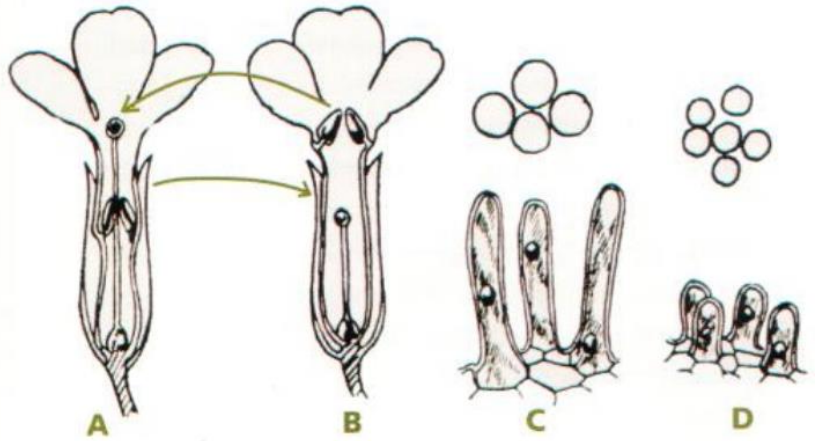
Rys. 14. Trójpostaciowe kwiaty krwawnicy pospolitej.
Prawidłowe zapylanie pokazano strzałkami (wg H. Meierhofera)

Two types of flowers (*Primula L.)*

Pollen from long anthers can develop only on the stigma of a long pistil and e.t.c.

The stigma of the pistil has a different surface

Pollen has a varoes size



Rys. 13. Dwupostaciowe kwiaty pierwiosnka:
A – kwiat długosłupkowy, B – kwiat krótkosłupkowy,
C – wyrostki na znamieniu długiego słupka kwiatu A i pyłek z długich pręcików kwiatu B, D – wyrostki na znamieniu krótkiego słupka kwiatu B i drobniejszy pyłek z krótkich pręcików kwiatu A (wg H. Meierhofera)

Plants adapted for cross-pollination have several mechanisms to prevent self-pollination:

Self-sterility - one of the mechanisms preventing pollination of the pistil of flowers by pollen from the same plant.

Self-sterility means that the pollen grain cannot germinate on the stigma of the pistil from the same plant, or it is very difficult to germinate.

There are different mechanisms of self-fertilization in different plants:

- For example, **in plants of the genus Cabbage**, a cuticle appears on the stigma of the pistil as soon as the petals open, which cannot be pierced by pollen grains from their own flowers, but can be pierced by pollen grains from flowers of the same species, but from another plant.

- In **red mustard or common rye**, **clover** there are chemicals on the stigma that prevent the germination of its own pollen.

In alfalfa, its own pollen grains germinate and even fertilization occurs, **but the seeds formed as a result of this fertilization die.**

Pollination mechanisms:

Self-pollination is undesirable, as it **leads to a reduction in the genetic diversity** of the offspring

S**elf-pollination** occurs when pollen from one flower pollinates the same flower or other flowers of the same individual.

Self-pollination may include:

- **autogamy**, where pollen is transferred from anther (male part) to the stigma (female part) **of the same flower**; (len)
- **geitonogamy**, when pollen is transferred from anther of a flower to stigma of another flower **on the same plant.** Plants adapted to self-fertilize often have similar stamen and carpel lengths. (Carrots, sunflowers, apricots, plums, peaches, cherries; but they need insects for this, we call them self-fertile and insect-pollinated..)

The least favorable is pollination within the same flower, more favorable from the most distant flowers on the same tree, but the most favorable is cross-pollination with pollen from another tree, plant.

Plants that can pollinate themselves and produce viable offspring are **called self-fertile.**

Pollination mechanisms:

Cleistogamy: is self-pollination that occurs before the flower opens. The pollen is released from the anther within the flower or the pollen on the anther grows a tube down the style to the ovules.
Some cleistogamous flowers never open. Cleistogamous flowers are by necessity found on self-fertile plants.
Although certain orchids and grasses are entirely cleistogamous, other plants resort to this strategy under adverse conditions.

Wheat

Pease

The importance of plants for pollinators

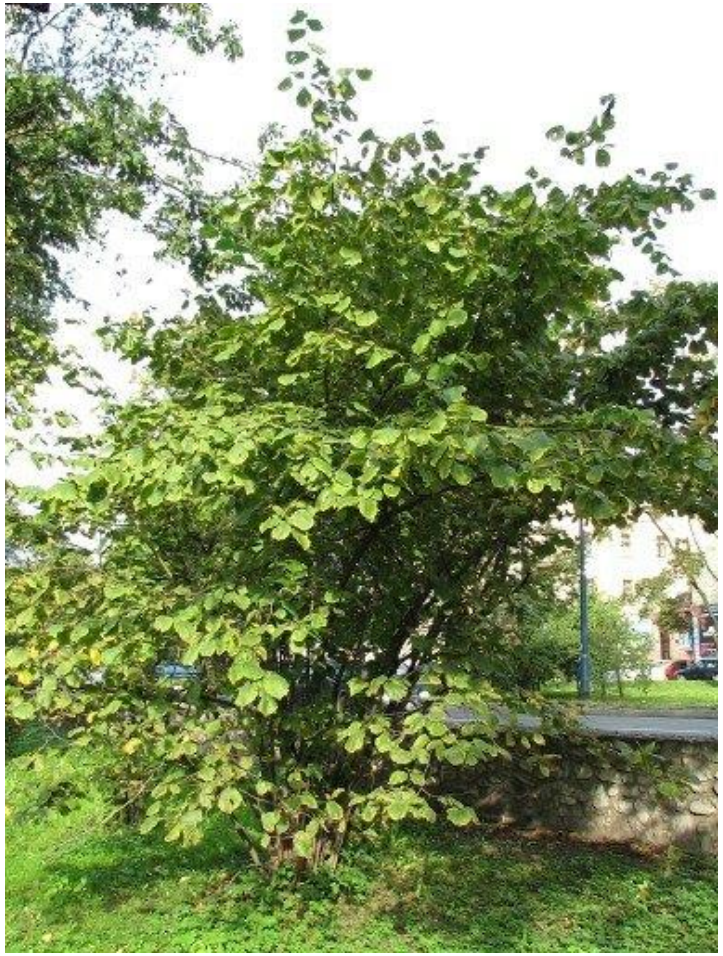
Importance of wind-pollinated plants for bees

Features of wind-pollinated plants

- The flowers are **small**, they **don’t smell** and **don’t have nectaries**.
- Their pollen is **fine, loose, light**, with air bubbles or wings (transmitted by the wind over long distances).
- They produce **very large amounts of male flowers and produce huge amounts of pollen.** (pine sprinkles pollen all over the forest)
- **Stigma is large** in the shape of a brush(catch pollen like a net).

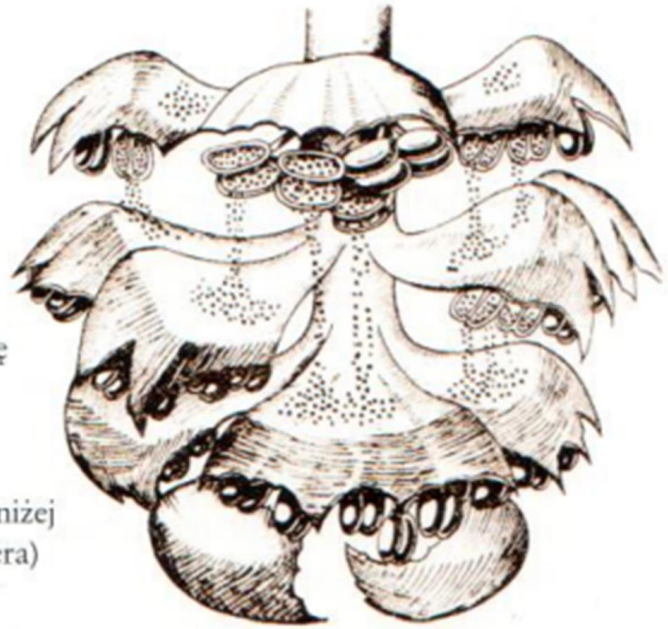
Importance of wind-pollinated plants for bees

Hazel

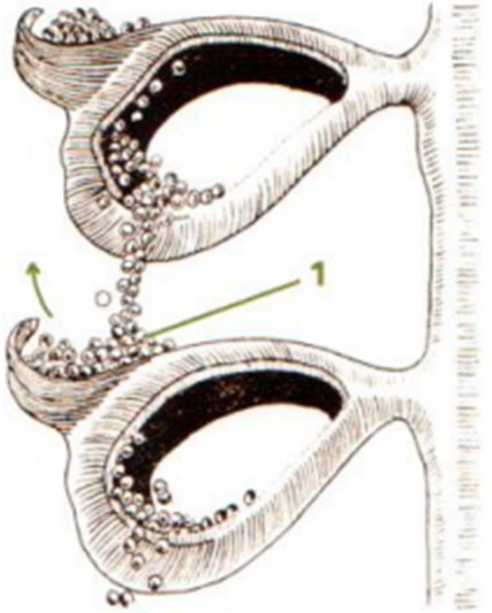


One of the first, very valuable sources of pollen for bees. It blooms in March

Protection of wind-pollinated plants against pollen waste.



Rys. 16. Dolna część kotki leszczyny. Pyłek wysypuje się na wgłębienie podkwiatka okrywającego pylniki położone niżej (wg H. Meierhofera)

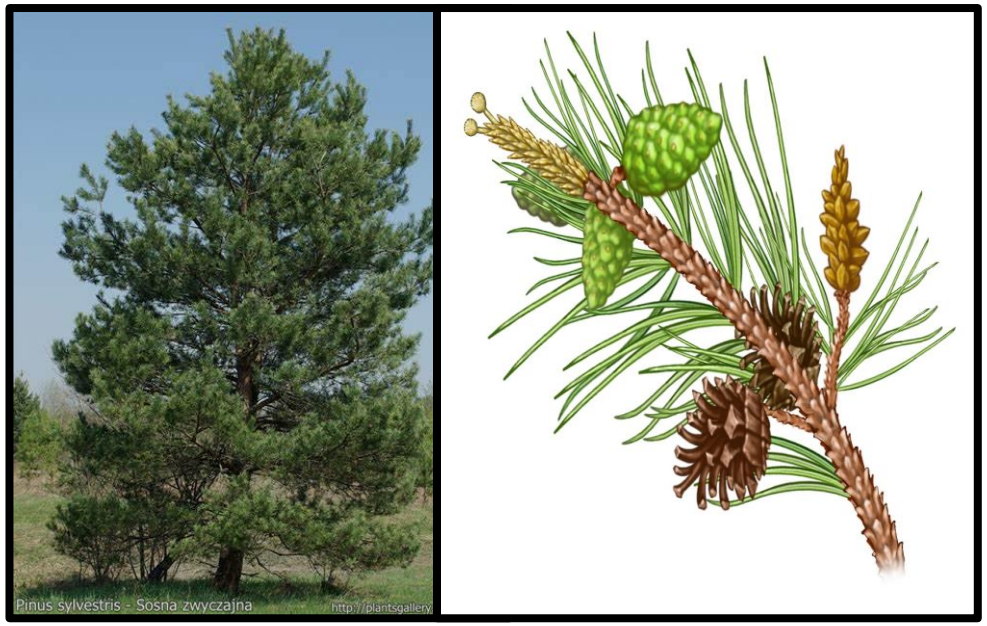


Rys. 15. Otwarte pylniki świerka. Pyłek (1) wysypuje się na pylnik położony niżej, skąd wiatr porywa go w kierunku strzałki (wg H. Meierhofera)

In hazel and spruce, pollen falls down into the holes under the flower.
During windless weather, it waits for better conditions.
Bees take advantage of the opportunity

Importance of wind-pollinated plants for bees

Coniferous trees



Pine

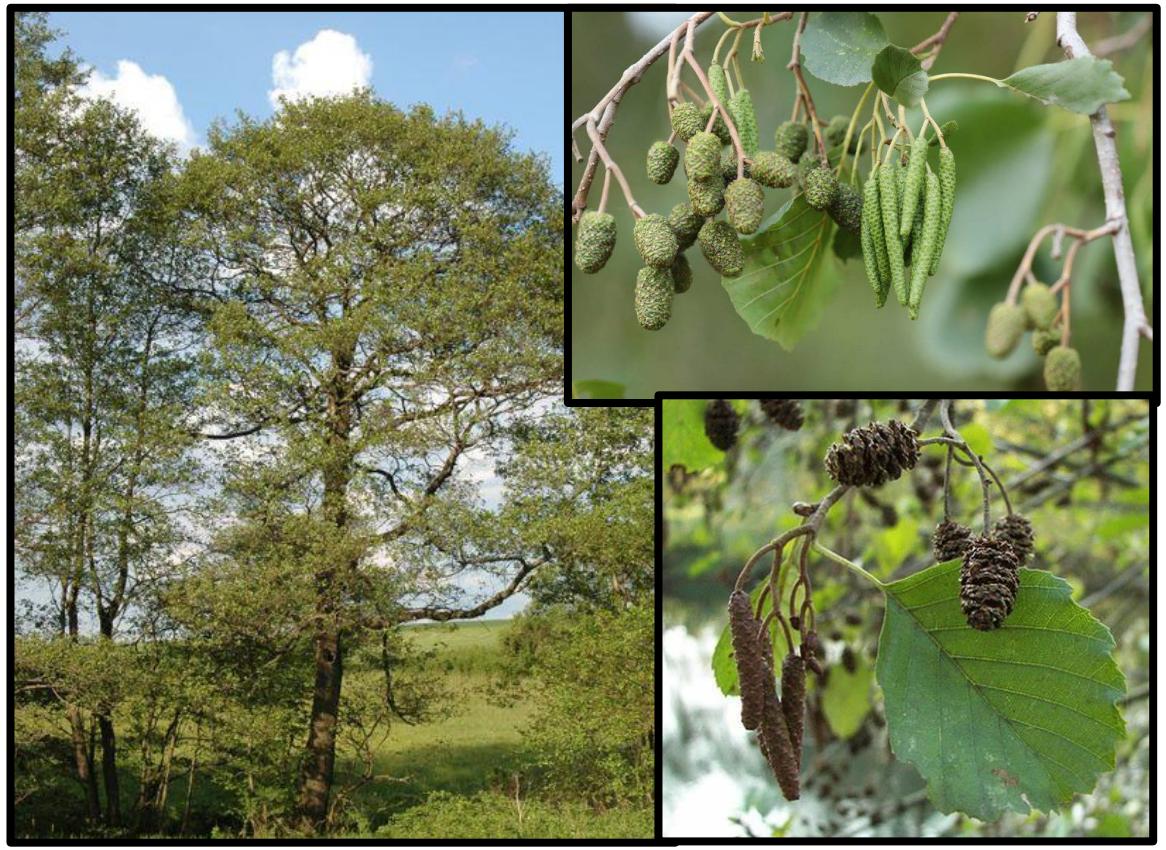
Spruce

Fir

Least important for pollinators. Pine pollens in late spring in mid-May

Importance of wind-pollinated plants for bees

Birch



Alder tree

Other examples of wind-pollinated plants

Hemp

Sorghum

Rye

Grasses including cereals

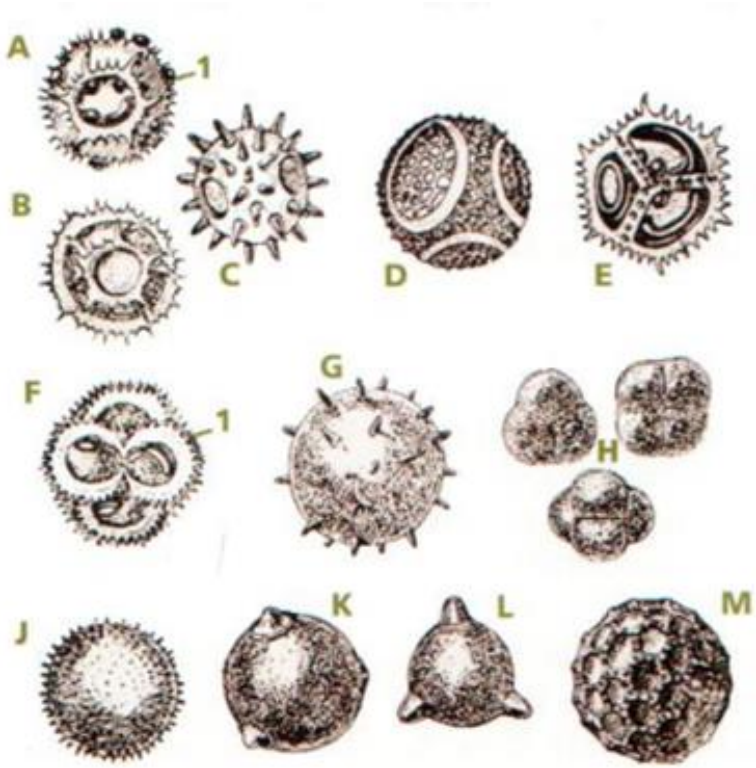
Features of plants pollinated by insects (entomophilous plants)

Pollen is:

- much larger and heavier than anemophilous,
- has a sticky or rough surface (it attaches more easily to the body of insects)

Plants produce less amount of pollen, but them **nutritional value is much greater** and bees are more likely to choose it.

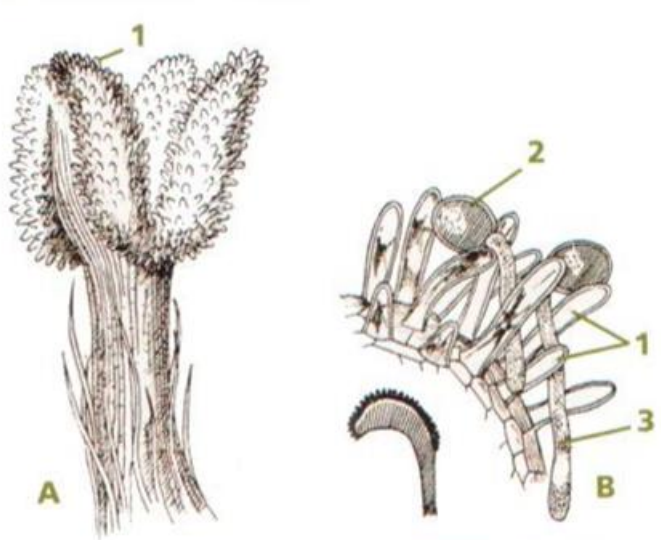
Various growths on the pollen surface are characteristic of individual species.



Rys. 18. Różne formy ziaren pyłku roślin owadopylnych:
A – kozibród łąkowy, B – mniszek pospolity, C – podbiał pospolity,
D – męczennica (*Passiflora*), E – sałatnik leśny, F – sałata,
G – ślaz, H – wrzos (pyłek w tetradach), J – grzybień biały,
K – dynia, L – czartawa pospolita, M – sępota (*Cobaea scandens*);
1 – kropelki tłuszczu (wg H. Meierhofera)

Features of plants pollinated by insects (entomophilous plants)

- The stigma is covered by growth that facilitate pollen retention and brushing of pollen from insects
- The stigma produces a sticky liquid, which makes it easier to stick pollen and stimulate germination



Rys. 19. Znamiona słupków roślin owadopylnych: A – wierzby iwy, B – zimowita jesiennego (w małym i dużym powiększeniu); 1 – wyrostki znamienia zatrzymujące pyłek, 2 – ziarno pyłku, 3 – łagiewka kiełkującego pyłku (wg H. Meierhofera)

Features of plants pollinated by insects (entomophilous plants)

Flowers attract, lure insects:

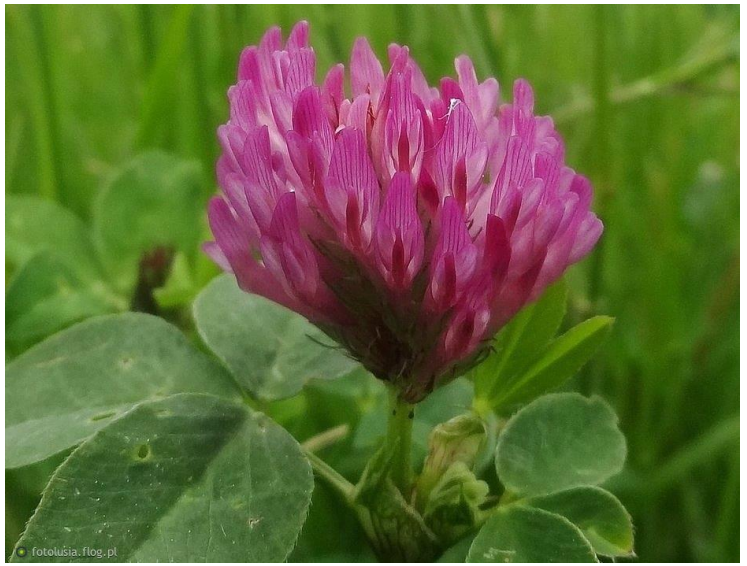
- they are usually of larger sizes
- are colorful, creating a clear contrast with the surroundings

Features of plants pollinated by insects (entomophilous plants)

Flowers attract, lure insects:

The visible wavelength of insects (bees) is shifted towards short wavelengths. They can see ultraviolet, but **red** and **green are synonymous with black** for them.

That is why red flowers, e.g. red clover, contain an admixture of blue



Features of plants pollinated by insects (entomophilous plants)

Lime tree (Tilia)

The smell is also important:

- It is especially important for plants with smaller, less colorful flowers. (lime tree)
- The essential oils that attract the bees are mainly found in the petals

Elder (Sambucus nigra)

The bee does not fly elder flowers with the smell of <u>ammonia compounds</u>

Mutual adaptation of flowers and insects:

In the process of evolution over millions of years, there have been many mutual adaptations of flowers and insects.

This adaptation provides:

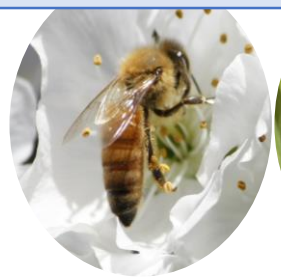
- cross-pollination for plants
- pollen and nectar for bees

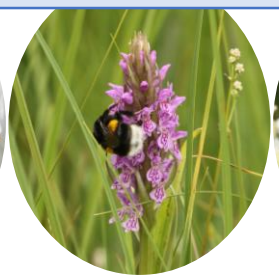
Some flowers are pollinated only by selected groups of pollinators

We still have a choice, but how long?

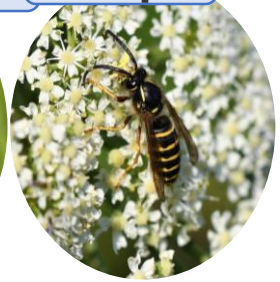
Pollinators

bees and bumblebees

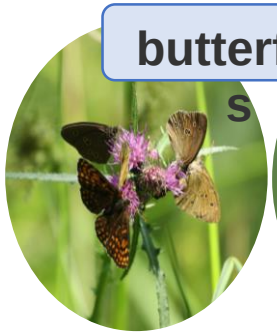


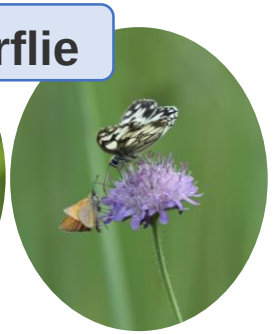


wasps



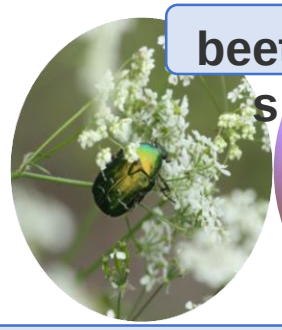
butterflies

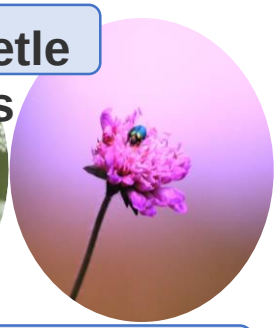




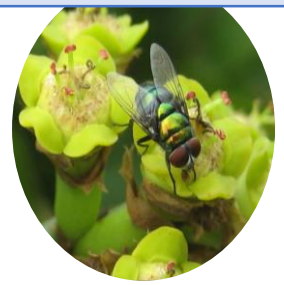
moths

beetles





flies and mosquitos



ants

or

Bees are the group of insects of greatest importance as pollinators.

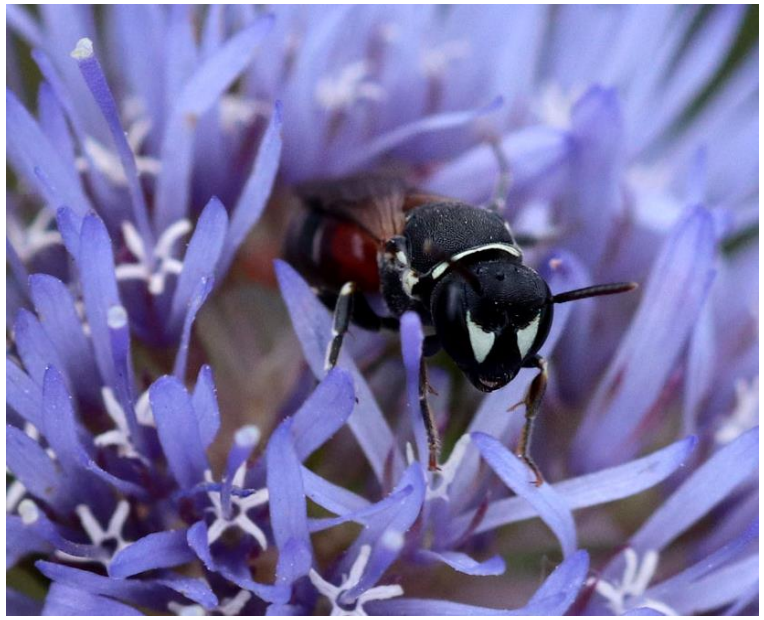
There are 20,000 species in the world, of which 2,000 species in Europe and 470 species in Poland.

Bees superfamily - Apoidea has been divided into 7 families:

- **Colletidae**
- **Andrenidae**
- **Halictidae**
- **Melittidae**
- **Megachilidae**
- **Apidae**
- Stenotridae

Representatives of the first 6 occur in Poland, the last of them only in Australia

Colletidae



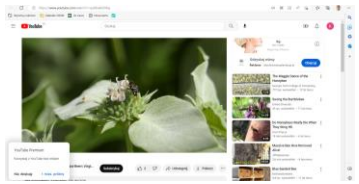
Hylaeus bees are solitary bees.

They are very sparsely haired. Lack of hairs used to carry pollen (brushes) in females.

In males, the bright "mask" is more developed than in females

Some species nest in earth burrows, others choose places such as empty insides of plant shoots.

Most species of solitary bees do not have any external structures to carry food into the nest. Both nectar and pollen are swallowed by the female and transported in to the nest.



Andrenidae

Andrena is a genus of bees with over 1,500 species, it is one of the largest genera of animals.
Andrena are generally medium-sized bees; body length ranges between 8 and 17 mm
Most are black with white to tan hair. **They carry pollen mainly on femoral scopal hairs**, but many Andrena have an additional propodeal corbicula **for carrying some pollen on their thorax.**

All Andrena are ground nesting, solitary bees. They seem to have a preference for sandy soils.

Andrena vaga visiting her nest

After mating, each female bee digs a burrow, collects pollen to form firm, round provisions for the larvae to eat and places them in cells lined with a shiny secretion.
Larvae do not spin a cocoon and they overwinter as adults.
They typically have one generation per year and adults are only active for a few weeks.

Many Andrena are host-plant specialists, in which a species visits flowers of only a single or a few closely related plants. Callandrena specialize on pollen from the plant family Asteraceae and have highly branched, fluffy scopal hairs to hold aster pollen.

Andrena are common in temperate regions of Europe, Asia, and North America

Halictidae

Megrims **nest mainly in the soil.**
They **choose areas** without the plants.
Some species **form large nest aggregations**. In most species, the construction of the nest is simple.

Among these bees there is both **solitary activity and a wide spectrum of social behaviors**. In eusocial species, **a family may contain from two to several hundred individuals**.

Spread
A cosmopolitan type, most numerously represented in the Mediterranean and Central Asia. **In Europe, 55 species have been found, of which 12 occur in Poland**

Melittidae

Family Melittidae - includes over **190 described species**.

They are single-generation solitary bees, producing **one generation per year.**

Pollen-collecting brushes are found in females **on the shins and first segments of the feet.**

The fertilized females **dig nests in the soil.** They consist of a main corridor and side corridors, at the bottom of which there are one or several brood cells.

Pollen is deposited into the cell, which is **formed into a lump, on top of which the female lays a single egg**. The larvae develop rapidly, consuming the entire lump in about 10 days. **The grown larvae overwinter** and pupate in the spring of the following year.

Some species with high specialization in relation to plants

This family originated in Africa and there it reaches the greatest diversity. **There are 11 species in Poland.**

Melitta leporina

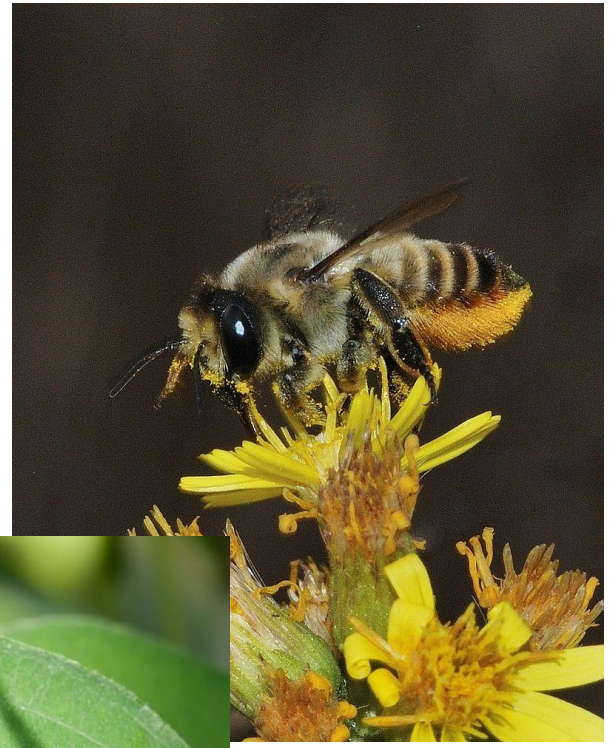
Melitta nigricans

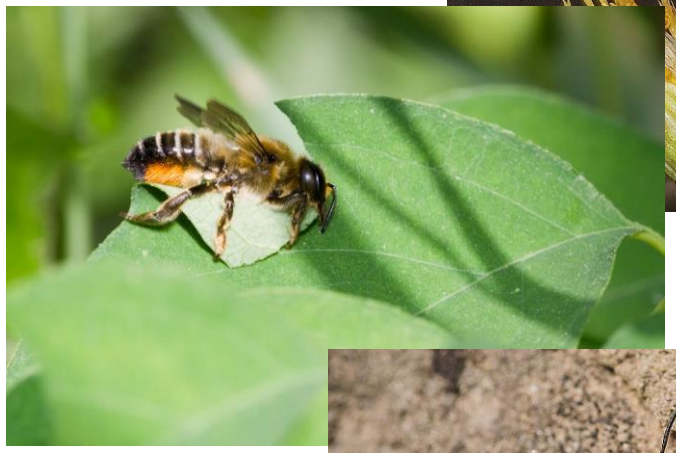
Megachilidae

The genus Megachile is a cosmopolitan group of **solitary bees** with **more than 1500 species.**
Bees in the family Megachilidae use **pollen-collecting hairs from their abdominal scopa.**

Megachile neatly cut pieces **of leaves or petal which they use to line the cells of their nests.** It is thought that the leaf discs help prevent the desiccation of the larva's food supply.

Nests are sometimes constructed within **hollow plant shoots or other similarly constricted natural cavities**, but often are in burrows **in the ground.**
Nests are typically composed of single long columns of cells. The female places an egg in each cell with a supply of food, generally pollen, sometimes mixed with nectar. She builds a cap and walls off the cell. The larva consumes the food supply. After moulting a few times, it spins a cocoon and pupates**, often after several months of hibernation as a prepupa.** It emerges from the nest as an adult. Males, which are typically smaller and emerge in advance of females, die shortly after mating, but females survive for another few weeks, during which time they build new nests.





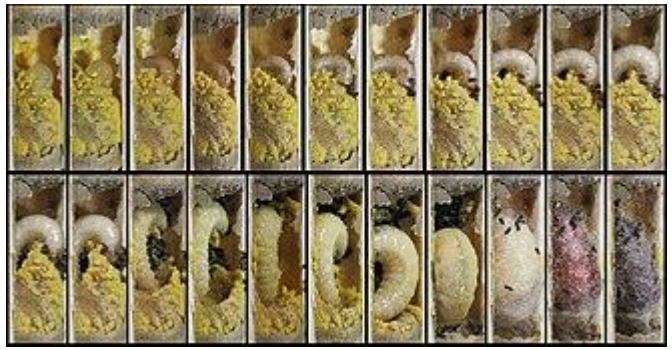
Megachilidae

- **Mason bee** is a name now commonly used for species of bees in the genus ***Osmia.***
- **Over 300 species** are found across the Northern Hemisphere. Most occur in temperate habitats.

In Poland, 18 species of this genus were found.

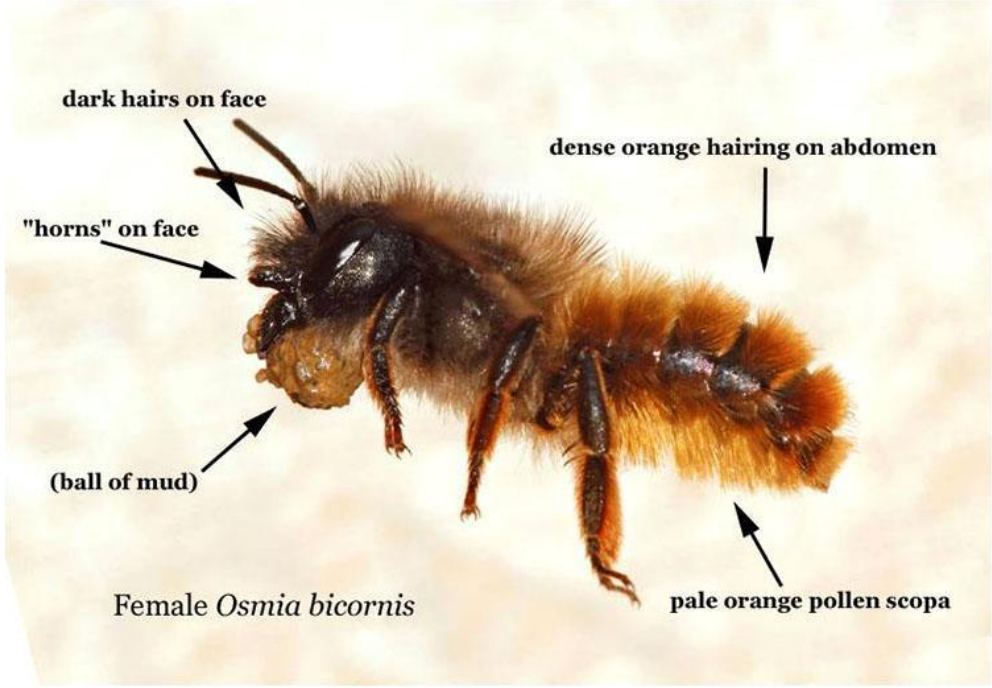
- **Osmia species are solitary; every female is fertile and makes her own nest, and no worker bees for these species exist.**
- When the bees emerge from their cocoons, the males exit first. When the females emerge, they mate with one or several males. The males soon die, and within a few days the females begin provisioning their nests.
- **Mason bees are named for their habit of using mud or other "masonry" products in constructing their nests, which are made in naturally occurring gaps such as between cracks in stones or other small dark cavities.** When available, some species preferentially **use hollow stems or holes in wood made by insects.**
- Within a few days of mating, the female has selected a nest site and has begun to visit flowers to gather pollen and nectar for her nests; many trips are needed to complete a pollen/nectar provision mass. Once a provision mass is complete, the bee backs into the hole and lays an egg on top of the mass. Then, she creates a partition of "mud", which doubles as the back of the next cell. The process continues until she has filled the cavity. Female eggs are laid in the back of the nest and male eggs toward the front.
- **Once a bee has finished with a nest, she plugs the entrance to the tube, and then may seek out another nest location.**
- Within weeks of hatching, the larva has probably consumed all of its provisions and begins spinning a cocoon around itself and enters the pupal stage, and the adult matures either in the fall or winter, hibernating inside its insulatory cocoon


Red mason bee

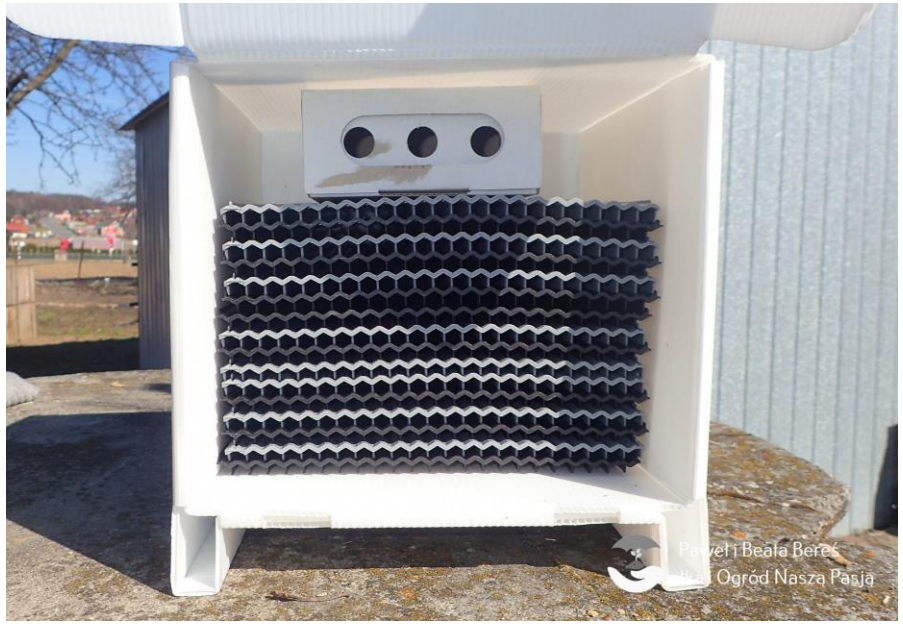


Pollination

- **Osmia can pollinate very efficiently, which is largely attributed to their anatomy and behavior.** Unlike most other bee species that collect pollen from their hind legs, female Osmia and other bees in the family Megachilidae **use pollen-collecting hairs from their abdominal scopa.** When Osmia transfer pollen to flowers, dry pollen falls from the scopa onto the flower's stigma, facilitating pollination at nearly every visit. Osmia typically pollinate early spring flowers in the family Rosaceae, and will even forage under poor weather conditions.



The species is commercially bred for pollination of crops.



Family Apidae - 5,800 described species.

The Anthophorini are a large tribe in the family Apidae. This species in this tribe are **often referred to as digger bees**. It contains over 750 species worldwide,
All Anthophorini species are solitary, **though many nest in large aggregations.** Nearly all species make nests in the soil, either in banks or in flat ground; the larvae develop in cells with waterproof linings and do not spin cocoons.

They are generally large (up to 3 cm) hairy bees
The abdomen is often banded, and in many Old World species of Amegilla, these bands are metallic blue.

The wings often appear disproportionately short compared to other bees.


Anthophora plumipes


Amegilla quadrifasciata

Family Apidae - 5,800 described species.

Xylocopa - a genus of bees with about 400 described species. **These are large bees** with a stout body, reaching from **13 to 30 mm in length.** The coloration, especially of the females, is **mostly very dark and shiny**. Males of some species may have intense yellow or brick red hair. The head of these bees has a fairly flat face, a short and partly strongly sclerotic sucker and and something like a piercing pin, **probably used to cut the long-crowned of tubular flowers.**

Usulaly nests in dead plant material. In most cases, females drill branched burrows in the dead, often hard wood. Smaller species nest in the **hollow, woody shoots of herbaceous plants**. The female lays about 10 eggs **and shows parental care** not only for the larvae, but also feeds young and maturing daughters' imagines

In Poland, only 2 species have been found: violet and black-horned

Family Apidae - 5,800 described species.

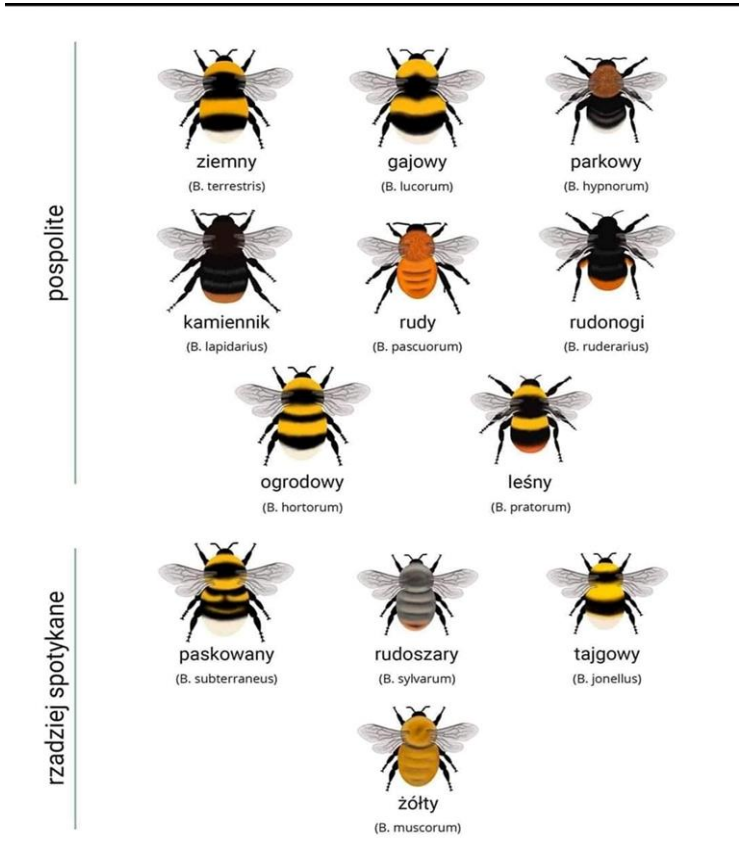
Bumblebee

A bumblebee is any of over 250 species in the genus Bombus, part of Apidae, one of the bee families. This genus is the only extant group in the tribe Bombini**.**

Bumblebees vary in appearance, but are generally plump and **densely furry**. They are larger, broader and stouter-bodied than honeybees, and their abdomen tip is more rounded. Many species have broad bands of colour, the patterns helping to distinguish different species.

Bumblebees have fewer stripes (or none), and usually have part of the body covered in black fur

They move slowly - in flight they reach a speed of about 10 km/h.



Bumblebees are effective and valuable pollinators.

Bumblebees have **relatively long tongues** and can pollinate long-crowned tubular flowers more efficiently.

They also have the ability to **vibrate pollination.**

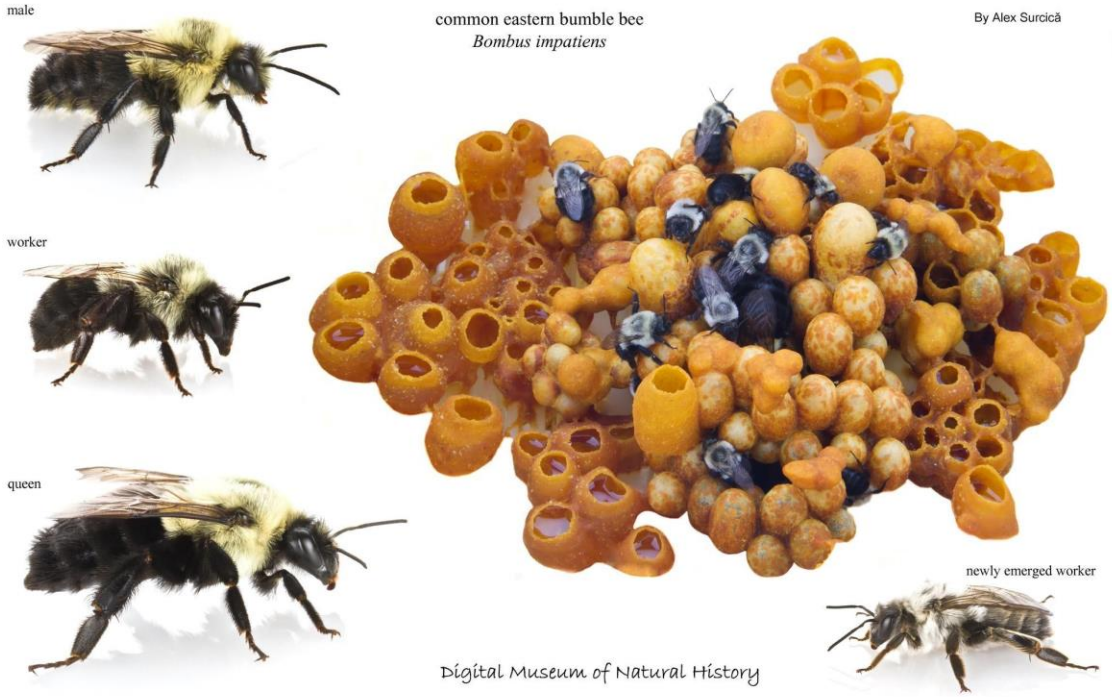
They feed at temperatures as low as **10 °C, and** the queens of some species living in cold climates can fly as low as **2 °C**

Temperate species are active from March to October, with the exact time range varying between species. Early-awakening and long-flying bumblebees include, for example, the ground bumblebee, while the high-mountain bumblebee is active for a shorter part of the year.

- Most bumblebees live in monogynous colonies. Their nest consists of the outer part - made of dry grass, moss and similar materials, often reinforced with wax, and the inner part, where the mother female builds a wax pot, into which she collects nectar from flowers. Then it builds the first cell of wax, a cradle, where it lays eggs, which it warms with the heat of its own body. Broods hatch from the eggs (the brood lasts up to a week), they are intensively fed, and after 2 weeks they form cocoons and pupate. Development from egg to perfect insect takes 28 to 36 days.

- In the temperate zone, from the eggs laid from the beginning of spring to mid-summer, worker bees hatch, helping the mother in expanding the nest and fulfilling all care functions in it. From August, males hatch, which feed on pollen, and finally young queens. In the autumn in the temperate zone, worker bees, males and old females die, while young females overwinter and establish their own colonies in the spring.

- The number of bumblebees gathered at one nest is, depending on the species and condition of the colony, **from several dozen to 500 individuals.**



Honey bee (Apis mellifera)

- The western honey bee or European honey bee (Apis mellifera) is the most common of the 7–12 species of honey bees worldwide. The genus name Apis is Latin for "bee", and mellifera is the Latin for "honey-bearing" or "honey carrying", referring to the species' production of honey.

- Like all honey bee species, the western honey bee is eusocial, creating colonies with a single fertile female (or "queen"), many normally non-reproductive females or "workers", and a small proportion of fertile males or "drones". Individual colonies can house tens of thousands of bees. Colony activities are organized by complex communication between individuals, through both pheromones and the dance language