

The importance of bees and wild pollinators in the protection of ecosystems and agriculture

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Lesson objectives

- Familiarization with the concept of pollinator
- Understanding the cause of the system flowering plant - pollinator
- Getting to know the species of pollinating animals
- Understanding the importance of pollinators in agriculture and ecosystem.

Introduction

Pollinating insects are irreplaceable guardians of each garden and agricultural crops. They provide adequate pollination of vegetables, trees, fruits and ornamental plants. They are therefore particularly important for the proper functioning of allotment gardens, orchards and also for natural ecosystems. Without pollinators, there wouldn't be a large part of the world's food but also would suffer biodiversity which is very important for the proper functioning of the biosphere. Today the relationship between plants and pollinating insects is called mutualism which was created in the process of coevolution.



Photo 1 Blueberry (J. Józefczuk)

Pollinators? What's that?

To propagate many plants, both cultivated and wild, need to be pollinated. Pollination is an important phenomenon occurring in flowering plants. It leads to the formation of seeds and thus the creation of a new plant. It involves transferring pollen grain on stigma. Most beneficial for plant is cross-pollination. It is a kind of pollination during which a pollen getting on pistil comes from flower stamen of the same species but coming from another plant. Because plants don't move, to fulfill this condition the plant must be „served” by pollinator - the animal that will bring this pollen. Presently, it was described more than 200,000 species of animals pollinating plants. It is estimated that every fifth species of animal is involved in pollination. These are mammals (bats, marsupials, primates), birds (sunbirds, hummingbirds), reptiles (iguanas, Skinks), arthropods and molluscs. However, the biggest group of pollinators are the insects, in particular four of their orders – Hymenoptera (sawflies, wasps, bees, ants), Diptera (true flies), butterflies and beetles.

Dlaczego powstały zapylacze?

For many millions of years plants used the wind and water in pollination process. About 100 million years ago appeared first plants producing flowers (photo 2). They were created not just to make our lives more enjoyable and allow making a nice gift to your loved one but to lure pollinating animals. They solved in this way the problem of the lack of mobility. The first plants that use animals were cycads and beetles ate their pollen. In our climate 20% of flowering plants still depend on the wind, their flowers are inconspicuous and odorless but worldwide 270,000 plant species is pollinated by animals. Flowers created a lot of adjustments to be attractive to pollinators and their flowers are perfect „advertising banner”. What are these adaptations?

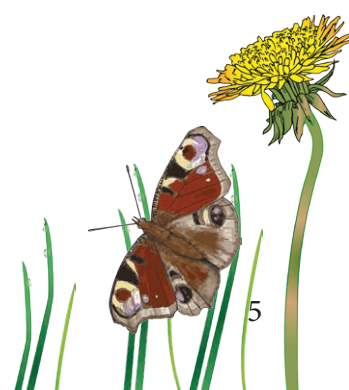
- Color vision in insects is different than a man - they see in the ultraviolet, so seemingly yellow flowers for bees are respectively yellow and purple, green leaves are gray with a yellowish coating. Bees don't distinguish between the red color of black, that's why in our flora red flowers are rare and the flowers of field poppy additionally reflect UV - for bees they are dark purple.
- Construction of flowers also is adapted to pollinators. Some species of plants use



Photo 2. Flowers of Chinese tree peony *Paeonia suffruticosa* (A. Smolis)



Fot. 3. Bezwonne kwiaty leszczyny są wiatropylne (J. Józefczuk)





Fot. 4. Willow flowers (J. Józefczuk)



Photo 5. Blooming Aesculus (J. Józefczuk)



Fot. 6. Orchid *Ophrys* spp. – based on Wikipedia - <https://it.wikipedia.org/wiki/>



Photo 7. Honeybee *Apis mellifera* on flowers (J. Józefczuk)

only one species of animals. An extreme case is the orchid *Darwin Orchidea*. When Charles Darwin received the plant wrote: „I have just received such a Box full from Mr. Bateman with the astounding *Angraecum sesquipedalia* with a nectary a foot long - Good Heavens what insect can suck it”. This orchid species has an exceptionally long nectary (reaches 20-43 cm in length) - epithet „sesquipedale” means „one and a half feet”. In 1903 Walter Rothschild and Karl Jordan described the subspecies *Xanthopan Morgani* (moth) having a particularly long suction trumpet (30 cm) able to reach the nectar of *Angraecum*.

- Another adaptation is production of rewards for pollinators in the form of food attractants. These are:

Pollen from it arise sperm cells of plants, in addition it is an important food of many organisms. It contains: proteins (eg. in willow more than 50% content of the dry mass, in a clover only 23%), carbohydrates (starch, in clover nearly 30%), fats and vitamins. Some plants produce large amounts of pollen for example: buckwheat (up to 400 kg / ha) or phacelia (over 1 tone / ha).

Nectar produced by nectaries usually located at the bottom of the flower. The nectar includes: solution of various kinds of sugars (glucose, fructose, sucrose) with the addition of a small amount of amino acids, vitamins, pigments and minerals. Sugar concentration is usually very high, usually specific for the plant species (in fritillaries approx. 5%, in Aesculus species up to 80%, photo 5) and the type depending on the species, eg. in rape are almost only simple sugars (monosaccharides) and in Rhododendron only saccharose. Sometimes nectar can be toxic, alcoholic and narcotic.

Other awards include small hair and edible flakes (eg. lady's slipper orchid), fatty oils and edible cells.

Bees and other pollinators in Poland

If ask a question about pollinating animals living in Poland, most of us have listed bees (photo 4). And yet honeybees which usually we associate with pollination, are only a small part of a very rich bee family. In Poland, there are 470 species of insects belonging to the family of bee, most of whom are solitary bees. Bees also include bumblebees. We have them in Poland about 30 species. In pollination also help butterflies, wasps, true flies and beetles. Wild pollinators are often more efficient pollinators than honeybees. These are smaller and less fussy, so fly over greater number of plants including those to which the nectar cannot reach by bees. And here is our pollinators.

Beetles - It is the richest in species animal order, one in four described species on earth belong to this group - in Poland there are over 6000 species. Their characteristic feature is the first pair of wings in the form of a sheath which protects the second pair of membranous wings. The most specialized in pollination are longhorn beetles and from *Protaetia* family (Photo 8).

Day and night butterflies (moths). Poland is represented by more than 3,000 species. (photo 9). eature distinguishes them is that the wings are covered with husks arranged like tiles and their mouthparts in the form of a long roll-up tube.

Flies (true flies) in Poland are represented by more than 7,000 species but still we discover new (photo 10). These insects have only one pair of wings, the other is converted into halteres (flies have the ability of suspended flight, the frequency of wing beats are up to 1000 times per minute) and mouthparts type of licking or piercing-sucking



Hymenoptera (sawflies, wasps, bees, ants) in Poland are represented by more than 6,000 species (some groups are poorly known), in the world live more than 120,000 species. Distinguishing feature of them are membranous wings connected together (one flying surface) and sting (restarted ovipositor). Scientific name *Hymenoptera* comes from the Greek hymen - membrane, pteron - wing or the Ancient Greek god of marriage, as these insects have „married wings” in flight. The biggest Hymenoptera have a wingspan up to 15 cm, the smallest (0.14 mm) can freely pass through the „needle’s eye”. Bees are the only Hymenoptera feeding her larvae with a mixture of nectar and pollen, sometimes secretion of salivary glands. Three species have been domesticated by man, it is Honeybee, Asian bee and in recent times - leafcutter bee. In the world live 16 000 species of bees, in Europe 1600 species and in Poland about 470 species and subspecies of bees. Fully social are the types of bee (*Apis*), bumblebee (*Bombus*) and *Halictus* (eg. *Lasioglossum*). Other types (90%) are usually solitary or lonely bees.

The honeybee is almost perfect pollinator: 10-20 000 workers fly out of the hive 10 times a day. Each worker visits during each flight 70 flowers, so one bee colony can pollinate 7-14 million flowers per day. But this „perfection” also has defects: short trumpet - about 6.3 mm so that can’t get into all the flowers, and avoiding some of the flowers (eg. lucerne) and flower fidelity which means a predilection for certain types of flowers.

Except the honeybee in Poland and in the world there is a large group of bees including species in which each female set up a separate nest and even a few nests, they are solitary bees. Female of those bees puts food into the nest, then eggs, shuts down it and dies, and the following year (or in the same if particular species produces two generations per year) hatch young males and females which set up a new nest.

Solitary bees include:

- nesting in the ground, so-called „diggers”: mining bee (*Andrena*), *Eucera*, *Melitta leporina*, *Rophitoides canus*;
- nesting in the wood or empty stems of the plants: some species of plasterer bees (*Colletidae*), mason bees (*Megachilidae*, *Osmia*), *Xylocopinae*;
- nesting in clay houses or natural uncovered earth, for example: *Anthophora parietina*.

Bumblebees (photo 12) after honeybee are the best pollinators of crops. They are particularly valued at pollination of some species of plants that produce flowers with the nectar hard to reach. These plants include a plurality of species which due to the specific construction of the flowers are reluctantly handled by bees. These include e.g. red clover, lucerne, birdsfoot (Lotus). These plants have flowers with long floral tube and therefore their nectar is not easily available for honeybees having a relatively shorter tongue. Bumblebees have a longer tongue than bees. The length of the bumblebees tongue can be up to 24 mm (while honeybees to 6.50 mm). Looking for food bumblebees put a flower in fixed-frequency vibration, thereby causing the spill of pollen through very small holes in anthers. This system is called vibrating pollination and is very effective with the pollination of many plant species eg. bilberries or tomatoes. Bumblebees collect less food per plant, so they must visit them more thus pollinating more plants. These insects doing very well, unlike bees, in adverse weather conditions. They fly out of the nest already at a temperature of about 11-12 °C and can fly even at low rainfall (drizzle) or in the fog, what can’t do bees. Young workers of bumblebees already after 1-2 days are able to exit after food and the maturation of worker bees is 21 days.



Photo 8. *Protaetia metallica* (A. Smolis)



Photo 9 Map *Araschnia levana* (J. Józefczuk)



Photo 10 Hoverfly from family *Syrphidae* (J. Józefczuk)





Photo 11 *Anthophora* spp. (J. Jóźefczuk)



Photo 12 Bumblebees (J. Jóźefczuk)

The importance of pollinators in agriculture

Most of the plants we eat requires pollination by insects, it is up to 1/3 of what we eat (photo 13).

Only in Europe 4000 varieties of vegetables depends on the work of pollinating insects. We owe them, among other: fruits - apples, oranges, tomatoes, pears, peaches, melons, lemons, strawberries, raspberries, plums, apricots, cherries, kiwi fruits, mango, currants, vegetables - carrots, onions, paprika, pumpkin, broad beans, zucchini, beans, eggplants, cucurbits, cucumbers, soybeans, industrial crops - cotton, rape, mustard, buckwheat, seeds and nuts - sunflower, almonds, chestnuts, spice plants - basil, sage, rosemary, thyme, coriander, cumin, dill, forage plants for animals - lucerne, clover, sweet-clover, plants producing essential oils - camomile, lavender, evening primrose. From crops pollinated by the animals we get 98% of vitamin C, 74% fat, 55% folic acid. Pollination by pollinators significantly increases yields in comparison with average yields. For example, yields of cucumbers 75-90%, and apples and pears 50-60%. Pollination is one of the most important ecosystem services, the value of yield obtained from 1 ha due to pollinator is 1500 \$, at a global scale this figure is \$ 200 billion. In Poland the yield value afforded by the honeybee is about \$ 350 million and by wild bees \$ -35 million. In Poland, we have 1 million bee families and our needs are almost twice as high. We observe even higher demand in the world, lack of pollinators will cost \$ 90 billion only in the US. Unfortunately, in the world we observe the phenomenon of mass dying of bee colonies CCD (Colony Collapse Disorder). Therefore, the hope for global agriculture can be a wild pollinators.

The importance of pollinators in the ecosystem

The benefits from the presence of bees in agriculture are appreciated not from today, but less is said about their role in the natural environment. It should be emphasized that the economic value of pollination by insect bees goes beyond agricultural production. Bees pollinate all plants, not just crops. The important role of bees is pollination of native species of plants that provide food to the wild animals, they provide biodiversity which ensures the proper functioning of the ecosystem.

Most of wild plants (from 60% to 90%) to be able to reproduce need animals mediation in the process of pollination - it means that other ecosystem services (and wild habitats they provide) are also dependent directly or indirectly on pollinators. Pollinating insects, particularly wild bees are considered a keystone species - a species with a large impact on the functioning of the ecosystem. They play a crucial role in maintaining the diversity of plants in almost all terrestrial ecosystems. In the coevolution process (jointly evolution of the species) have been created a strong interrelationship between flower plants and bees pollinating them. As a result, the local extinction of one species of pollinator may even lead to the disappearance of populations of certain species of plants. Ecosystems particularly dependent on the presence of pollinators are meadows, open and moorland. Due to the richness of species, their maintenance is one of the goals of modern protection of nature in Poland and Europe. In contrast to the forest environments, open spaces almost the entire season provide the right amount of nectar and pollen for pollinators, thereby in these environments is the biggest wealth of this group. In addition, open habitats offer favorable climatic conditions for those mostly thermophilic insects. In conclusion, the lack of pollinators means a threat to the functioning of these ecosystems and vice versa.

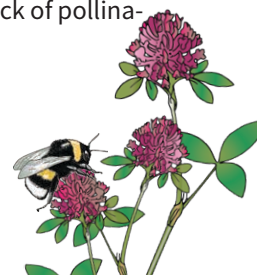




Photo 13 Fruit and vegetable market based on <https://pixabay.com/pl>

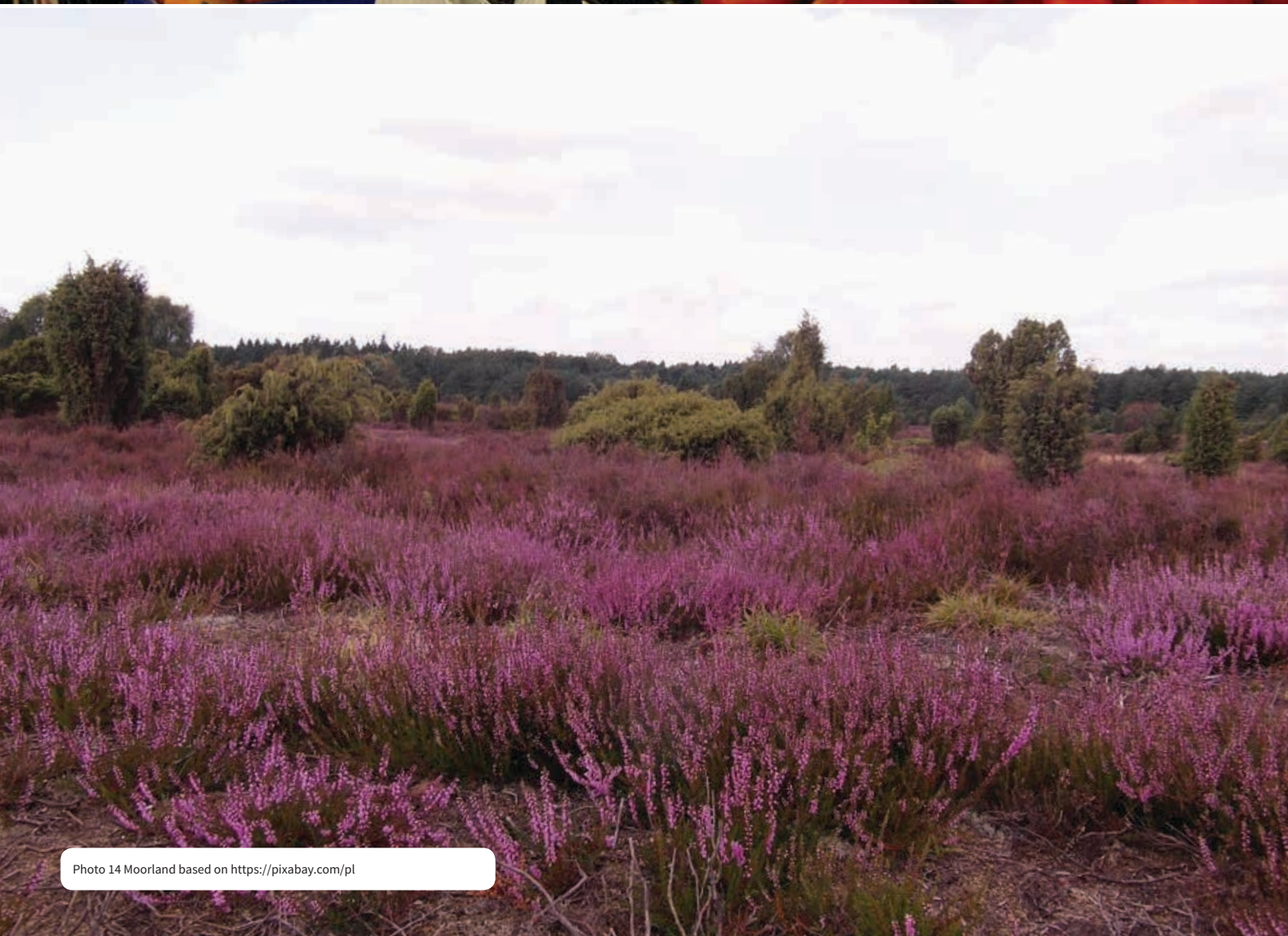


Photo 14 Moorland based on <https://pixabay.com/pl>



The importance of pollinators in agriculture

Thanks to the coevolution of flowering plants and pollinating animals, it is possible to maintain biodiversity in ecosystems and produce 1/3 of the world's food. The most important pollinators in our climate are four groups of insects: beetles, butterflies, wasps and flies. Thanks to the activity of pollinators human crop yields increase several times, and the lack of pollinating insects causing multimillion-dollar losses in agriculture. That's why it is so important today taking care of the good condition of pollinators in the world, because as the great evolutionist Charles Darwin said:

„If the bee disappears from the surface of the Earth, man will remain only four years of life. Since there will not be bees, will not be also pollination. There will be no more plants, then animals, and finally the time came for man ... „



Exercise

1. Cross-pollination is:

- a) transfer of pollen to the pistil from stamens of the flower of the same species but coming from another plant,
- b) pollinate with the help of insects,
- c) pollination of plants cross type,
- d) self-pollination.

2. Flowers were created to:

- a) make pleasant life for a man,
- b) lure pollinating animals,
- c) provide a food source for animals,
- d) make terrestrial ecosystems more attractive.

3. Most species belonging to bees in Poland include:

- a) bumblebees,
- b) hornets,
- c) solitary bees,
- d) social bees.

4. Bumblebees are in some cases more effective than bees because:

- a) bumblebees have a longer tongue than bees,
- b) they do well, unlike bees, in adverse weather conditions,
- c) young workers of bumblebees already after 1-2 days are able to pollinate,
- d) all answers are correct.

5. The importance of pollinators for human mainly consists of:

- a) honey production,
- a) pollination of human yields of crops,
- a) c) pollination of ornamental plants,
- a) d) production of nectar.

6. The importance of pollinators in ecosystems primarily consists of:

- e) maintaining biodiversity through pollination of plants,
- f) maintaining normal hydrological conditions,
- g) food production in the form of honey for animals,
- h) lack of correct answers.

Answers:
1. a
2. b
3. c
4. d
5. b
6. a

