LIFE 4 POLLINATORS

INVOLVING PEOPLE TO PROTECT WILD BEES
AND OTHER POLLINATORS IN THE MEDITERRANEAN

CITIZEN SCIENCE HANDBOOK

CITIZEN SCIENCE HANDBOOK

CREDITS

This handbook has been drafted during the implementation of the **LIFE18 GIE/IT/000755** co-financed by the LIFE Program of the European Union

Authors and contributors:
Marta Galloni; Marta Barberis; Giovanna Dante – BiGeA, Alma Mater Studiorum - Università di Bologna
Umberto Mossetti; Chiara Zagni – SMA, Alma Mater Studiorum - Università di Bologna
Fabio Sgolastra; Martina Parrilli – DISTAL, Alma Mater Studiorum - Università di Bologna
Laura Bortolotti; Marino Quaranta – CREA Centro Agricoltura e Ambiente (CREA-AA)
Theodora Petanidou; Jelle Devalez; Athanasia Chroni – University of the Aegean
Josè Maria Sanchez; Luis Navarro – Universidade de Vigo
Anna Traveset; Rafel Beltran Mas – Instituto Mediterraneo De Estudios Avanzados, IMEDEA- CSIC

Drawings:
Serena Magagnoli; Marta Barberis – Alma Mater Studiorum - Università di Bologna
Xavier Canyelles Ferrà – Instituto Mediterraneo De Estudios Avanzados, IMEDEA- CSIC

Graphics and editing: Elise Maria Keller – BiGeA, Alma Mater Studiorum - Università di Bologna

Translation: Helen Ampt

Coordinating Beneficiary: Alma Mater Studiorum - Università di Bologna
Bologna, Italy

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

www.life4pollinators.eu

INDEX

INTRODUCING POLLINATION AND POLLINATORS

Plant and animals are linked in many ways, one of them is pollination.

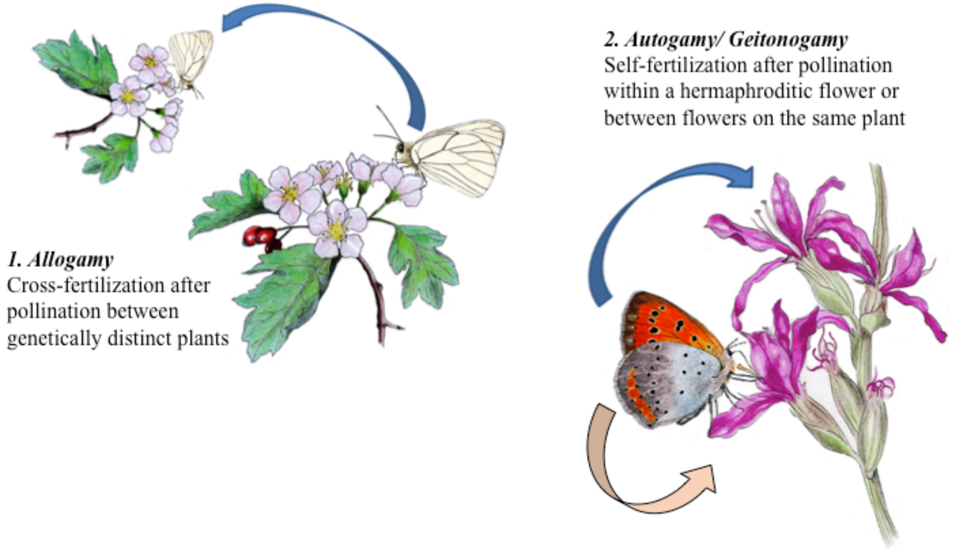


Illustration by Marta Barberis

WHAT IS POLLINATION?

Pollination is fundamental for the sexual reproduction of flowering plants (angiosperms). It involves the transfer of pollen (which contains the male gametes/genetic material) from the anthers (male flower part) to the stigma (female part) of flowers. Transfer may occur in the same flower or between flowers of the same or different plants. Once the pollen reaches the stigma it can germinate, launching the subsequent process of fertilization, which ends with the development of seeds and fructification.

Many plants require a pollination "service", meaning a vector that transfers pollen from one flower to another. In some cases, pollen is transported by wind (anemophily), more rarely by water (hydrophily), but for about 90% of known plant species, the vectors are animal pollinators (zoophily).

The pollination of flowers by animals implies a partnership between plants and pollinators, a partnership that determined their co-evolution. This is why the rapid diversification of angiosperms, since their appearance on Earth 135 million years ago, leading to their great current diversity (an estimated 300,000 species), largely depended on their co-evolution with pollinators.

All over the world, the major and most effective pollinators are insects: bees (Hymenoptera), wasps (i.e. aculeate Hymenoptera), flies (Diptera), beetles (Coleoptera), butterflies and moths (Lepidoptera), as well as certain bugs (Hemiptera). A special role is played by wild bees and syrphid flies. Besides insects, different species of vertebrates and other invertebrates can also act as pollinators: birds, mammals (including bats), snails and even reptiles (lizards, geckos and skinks).

WHY DO POLLINATORS VISIT FLOWERS?

All pollinating animals are attracted by flowers, where they often find a "reward", which may be food, such as nectar and pollen. As the pollinator collects the reward, pollen sticks to its body and it involuntarily "reciprocates" by transporting and depositing pollen on other flowers. This is a fully fledged exchange of goods and services between two organisms, which are therefore mutually dependent.

Apart from being indispensable for life, pollination is also an enormously important ecosystem service for humans, as agriculture and food production depend directly on this natural process. Up to 75% of major world crops (111) rely on pollination by insects. Gallai and colleagues (2009) estimated the world economic impact of this ecosystem service in 2005 at €153 billion and €15 billion per year in Europe (EU Pollinators initiative). Crops such as watermelons, pumpkins, melons, almonds and cherries depend on insect pollination for up to 90% of production.

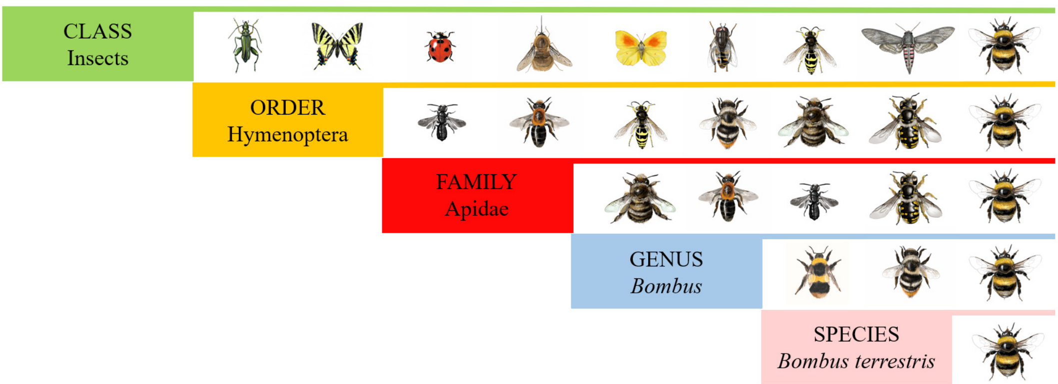
Since the end of the 20th century, there has been a decline in insect pollinator populations around the world. Habitat loss, land use change, intensive agriculture, use of pesticides and herbicides, introduction of invasive species and climate change are the main causes of this loss. The IUCN European Red List reveals that the populations of 37% of bee species and of 31% of butterfly species are declining, and that 9% of wild bees are threatened with extinction (Proposal for a EU Pollinator Monitoring Scheme: Potts et al. 2021[1]). The most worrying aspect, however, is that the conservation status of most pollinators is still not known, especially in the extremely diverse Mediterranean Region.

[1] Potts, S.G., Dauber, J., Hochkirch, A., Oteman, B., Roy, D.B., Ahrné, K., Biesmeijer, K., Breeze, T.D., Carvell, C., Ferreira, C., FitzPatrick, Ú., Isaac, N.J.B., Kuussaari, M., Ljubomirov, T., Maes, J., Ngo, H., Pardo, A., Polce, C., Quaranta, M., Settele, J., Sorg, M., Stefanescu, C., Vujić, A., Proposal for an EU Pollinator Monitoring Scheme, EUR 30416 EN, Publications Office of the European Union, Ispra, 2021, ISBN 978-92-76-23859-1, doi:10.2760/881843, JRC122225.

UNDERSTANDING THE CONTRIBUTION OF POLLINATORS

Today we are faced with an alarming decline in pollinators. Conservation measures are necessary to counterbalance this decline. However, this effort cannot be made unless people are properly informed about the threat. Recent opinion polls showed that stakeholders in the agri-food sector are generally unaware of the importance of wild pollinators and their decline. They apparently do not understand how great a risk is posed by intensive agriculture and pesticide use and they underestimate the importance of managing habitats in a pollinator-friendly way. On the other hand, European citizens care increasingly about food safety and environmental sustainability. A growing love of nature and appreciation of open-air activities means that more people are interacting with flowers and flower visitors. Perhaps a better understanding of the work of pollinators may come from direct experience?

Here is a brief guide to the insect pollinators one may encounter on a walk in the fields, a garden or a park. They are introduced with a general description based on taxonomic order or family (see BOX "TAXONOMIC CATEGORIES"), and notes on the biology of some flagship or charismatic species. The pollination service they provide is described.



LIFE STYLES

To protect pollinators and the ecosystem service they provide, we need to know their life cycle, not only their relation to flowers. Although visiting flowers is the activity important for pollination and supports fruit/seed production, all flower visitors need suitable conditions for nesting and feeding their progeny, so they can be constantly available in nature.

Pollinating insects, particularly bees, can be distinguished on the basis of their sociality. Social bees, such as honey bees, bumblebees and a few wild bees, build colonies of many individuals and raise many larvae at the same time. These insects need to forage pollen

and nectar on a grand scale, so abundant availability of flowers is important for the healthy growth and maintenance of their colony. Today, almost all honey bees are managed by beekeepers, who provide nesting conditions with artificial hives, but it is also possible to find feral colonies of honey bees (as for common wasps), in holes in trees and sometimes in the chimneys of houses. Bumblebees may colonize holes in the ground made by small mammals.
Like their social counterparts, wild bees also depend on pollen and nectar for themselves and their larvae. Especially in the Mediterranean, wild bees constitute a large fraction of the rich bee diversity, although their populations are much smaller than those of honey bees. Wild bees are mainly solitary, most living tunnels dug in bare soil, along trails in the countryside or in urban gardens. Their nest entrances may be simple holes in the ground. Although solitary, many females may sometimes nest close to one another. Other solitary bees build their nests in cavities in twigs or reeds. Ground- and twig-nesting species dedicate much time to nesting activities, cleaning and preparing the cells for their larvae and collecting pollen for the larvae. Many wild bees are specialists, visiting one or a few plant species; the variety of flowers available in an area is therefore very important.

Flies, butterflies, moths and beetles do not build shelters for their larvae, but may need particular plant species on which to lay their eggs. The eggs are usually attached to the underside the leaves of plants that will be food for the young caterpillars.

WHAT ARE THE MAIN INSECT POLLINATORS?

HYMENOPTERA

This is a large order that includes the well-known bees, wasps and ants. Although ants sometimes visit flowers for nectar, they are usually considered poor pollinators since pollen does not readily attach to or survive on their bodies.

Bees

Bees are the most important and probably the largest group of pollinators. All their food requirements come from flowers: nectar, especially rich in sugars, sustains the daily activity of adults; pollen, rich in proteins, is collected by females to feed the larvae. Since bees have evolved in close conjunction with flowers and their activity is focused on visiting flowers, their body is adapted to collect pollen and nectar, which are carried by specific body structures, or

[1] Ngo, H., Pardo, A., Polce, C., Quaranta, M., Settele, J., Sorg, M., Stefanescu, C., Vujić, A., Proposal for an EU Pollinator Monitoring Scheme, EUR 30416 EN, Publications Office of the European Union, Ispra, 2021, ISBN 978-92-76-23859-1, doi:10.2760/881843, JRC122225.

captured by different types of hairs in the case of pollen. Bees actually collect pollen to feed their larvae, but in the course of foraging, grains of pollen are inadvertently transferred to the flowers they visit. Bees are generally constant to a type of flower, an observation first made by Aristotle. This enhances the possibility of successful pollination and seed production of the plant in question. Besides being constant, bees may be numerous, especially those belonging to social species, their colonies providing an efficient pollination service in the area. Such social bees may visit a variety of plant species at different times of the day or season, and are therefore generalists, whereas other bee species visit one or few plant species during their lifetime, and are thus considered specialists.

European bee species can be divided into two main groups comprising six taxonomic families: long-tongued bees including the families Apidae and Megachilidae, and short-tongued bees including the families Andrenidae, Colletidae, Halictidae and Melittidae. As in the rest of the world, in Europe bees occur in all land habitats. Regarding numbers, the European continent hosts 2,051 of the 20,000 species of bees in the world. The highest species richness occurs in southern Europe, particularly in the Mediterranean, which hosts a large variety of bee species, many of them endemic. For example, Spain hosts >1100 species, Greece ~1200 and Italy ~1000.

The family Apidae, comprising about 30 genera and more than 550 species in Europe, is characterized by a great variety of sizes, shapes and colours. It includes the honey bee (*Apis mellifera*), almost entirely managed throughout Europe, and bumblebees (different species of the genus *Bombus*): both are well-known social species managed or reared and used for the pollination of crops. Many species of the family are rather large, furry, ground-nesting and solitary. Some resemble bumblebees, for instance species of the genera *Anthophora*, *Amegilla*, *Habropoda* and *Eucera*, almost all generalists. The family also includes carpenter bees *Xylocopa* (large) and *Ceratina* (small or tiny), which comprise solitary and social species: all are black and nest in aboveground cavities, often in dead wood and hollow stalks. This family also includes many "kleptoparasitic" bees (e.g. *Nomada*, *Melecta*, *Thyreus*, *Epeolus*, *Pasites*), commonly called "cuckoo bees", which like the cuckoo bird, lay their eggs in the nests of other bees.

Bees of the family Halictidae (also known as sweat bees) are commonly found on wild spring flowers like daises. Their appearance ranges from largely yellow and metallic-coloured, a few millimetres in size, as in the genera *Ceylalictus* and *Nomioides*, to average honeybee-sized bees (as in the genus *Pseudapis*). The most common genera are: *Lasioglossum*, black, almost hairless species resembling ants in shape and size; and *Halictus*, encompassing species that are larger than *Lasioglossum*, with a black and white banded abdomen. *Halictus* and *Lasioglossum* can be recognized in nature by observing the abdomen with a good lens while the insect plunges its head into a flower: females feature a furrow on the tip of the abdomen. The populations of some species of *Halictus* and *Lasioglossum* are often quite abundant because they are very social: indeed, sweat bees are the only group apart from honey bees, bumblebees and carpenter bees, which forms structured social colonies. These bees are commonly generalists, but there are also specialists regarding pollen preference. The family also includes kleptoparasitic species. For instance, the genus *Sphecodes* includes black and red cuckoo bees. Other interesting genera comprising few rare specialized species are *Dufourea*, *Rophites* and *Systropha*.

The large Andrenidae family includes bees of a variety of sizes, from very small to medium-large, most belonging to the genus *Andrena*. Females nest in deep tunnels in the ground, alone or in communal groups. This earns them, and other ground-nesting bee families, the name "mining bees". In the Mediterranean region, andrenids are among the most frequently encountered solitary bees in spring and early summer. Many species have a short period of activity and therefore specialise in the flowers of a plant family or genus. Besides *Andrena*, the family includes the genera *Melitturga*, with large eyes, a trait that makes them resemble flies, and *Panurgus*, small hairless black bees found almost exclusively on yellow, daisy-like flowers.

The family Colletidae contains only two genera: *Colletes*, medium-sized bees with an appearance similar to honey bees; and *Hylaeus*, small black hairless bees with yellow spots on the body and head, earning them the name of "yellow masked bees". *Colletes* species nest in the ground, lining their tunnels with an impermeable cellophane-like secretion, while those of *Hylaeus* nest in pre-existing cavities like the stems of plants or old nests of other bees.

The family Melittidae includes very specialized bees. They are ground-nesters and encountered in a restricted number of habitats. Individuals of the genus *Dasypoda* can be spotted in dry sandy habitats, transporting large masses of pollen attached to their hairy hind legs. The pollen is collected from daisy-like flowers. Bees of the genera *Melitta* and *Macropis* are typically found in marsh habitats or along streams where they specialize in pollen collection from flowers. Individuals of *Macropis* visit *Lysimachia* flowers to collect plant oils.

The family Megachilidae includes species known as builders of nests, mainly aboveground in pre-existing cavities and less frequently underground. They use various materials (such as plant fibres, leaves, resins, sand and mud) to plaster the walls of their nests. These activities earn them names like "mason bee" (*Osmia*), "leafcutter bee" (*Megachile*) and "wool carder bee" (*Anthidium*). Nests made from colourful flower petals (or even plastic bags) are not unusual! Members of this family are also known for nesting in hollows in objects ranging from snail shells to the key holes of doors. Females are easily spotted by the pollen they carry on their scopa, a thick layer of hairs on the anterior/ventral abdomen. They visit many species of plants, but some can be specialists. *Osmia* and *Megachile* species are now increasingly used to pollinate specific fruit crops, like apples, and clover or fodder crops, like alfalfa. By contrast, the genera *Coelioxys* and *Dioxys* include cuckoo bee species which attack the nests of *Anthophora* and other megachilids.

The term "wild bees" is very general: it indicates all bees that are not managed by man. Sometimes the term is also used for honey bees, indicating natural swarms of *Apis mellifera* that abandoned their hives or that still live free in nature, although the latter probably no longer exist.

Wasps

Wasps form a diverse group of insects with different life forms. Some species are eusocial and live in colonies, with different duties allocated to different castes, but most are solitary. There are also parasitoid wasps, which lay eggs in or on other insects (hosts) causing their death, and kleptoparasitic wasps, which lay their eggs in the nests of other wasps or bees, using the resources stored by the host to feed their larvae. There are many families and subgroups of wasps in the world. In the Mediterranean region, the most significant are the cuckoo wasps (Chrysididae), spider wasps (Pompilidae), scoliid wasps (Scoliidae), Sphecidae, ichneumon wasps (Ichneumonidae) and vespids (Vespidae).

Many wasps feed on pollen and nectar during their adult stage and are therefore also frequent flower visitors. Their larvae, however, feed on a variety of other foods as well, implying a much looser relationship with flowers compared to bees. Yet, unlike bees, wasps are not hairy and do not have specialized structures for pollen collection and transport. Pollen is therefore less likely to attach to their bodies when they visit flowers, and so they are generally less efficient pollinators than bees. However, there are exceptions, such as fig wasps, which are extremely specialized pollinators. Wasp pollinators are found in almost all Mediterranean habitats and tend to prefer sunny places. They nest in small holes in trees, walls, ruins or masses of dead plant material. Some species also nest on the ground, in mud or sand.

When threatened, social wasps emit pheromones that induce the hive to defend itself. Only female wasps have stingers. These can be used many times, unlike the stingers of bees. Wasps have a great capacity to control agricultural or forest pests due to their role as predators. That is why they are used as agents of biological control in some agricultural sectors.

Climate change, international trade and global travel have displaced many native species. When introduced into new territory, some may prove invasive, preying on, competing with and displacing native species of insects. A recent case in the Mediterranean has been introduction of the Asian wasp (*Vespa velutina*), a species that attacks the hives of the domestic honey bee and other populations of solitary hymenopterans.

DIPTERA

Flies are an insect guild, second only to bees in importance for pollination. In terms of species dependence on flowers and pollination efficiency, the group is very heterogeneous. Flies visit a variety of flowering species in nature and some of them are important pollinators of several plant crops, especially the carrot, mustard and rose families.

The most important family is the Syrphidae, also known as hoverflies or flower flies, the latter name highlighting their special relationship with flowering plants. In the Mediterranean region, the family includes more than 500 species with varying dependence on flowers and pollination efficiency. Only adults visit flowers for nectar and pollen, which implies that no hoverfly species is exclusively dependent on flowers, as the larvae may be predators, or feed on plants (phytophages), dead or decaying wood (saproxylics), or small particles (microphages). However, they can be regular flower visitors, occur on all continents, and are more common in wetter areas than in dry Mediterranean ones.

Syrphids tend to visit white or yellow, easy-to-handle, mainly open or bowl-shaped flowers in which nectar and pollen are easily accessible. Being slender animals with a very light exoskeleton, many resemble wasps. A species of interest is the (common) drone fly (*Eristalis tenax*), a migrant cosmopolitan species with a very high potential for crop pollination, and is therefore raised in several parts of the world. Another is the genus *Merodon* which includes species that are double-dependent on certain Mediterranean bulbous plants: their larvae feed on the bulbs and the adults visit the flowers for nectar and pollen.

Bee flies (Bombyliidae) have fewer species than hoverflies but are keen flower visitors and some are major pollinators. Their name reveals their appearance: they look like bees, due to their hairy body, and in fact some are bee mimics. Most species are parasitoids of other insects, so their larvae do not depend on flowers; however, the adults of many species have mouthparts, which may be four times as long as the insect's head and adapted for sucking nectar from deep flowers. The proboscis is therefore a distinctive feature of the insect, which along with the discrete colouring of the wing venation and the whirring sound they make in flight, make bee flies easy to spot and recognize.

There are few species in the family Nemestrinidae, but nemestrinid flies, also known as tangle-veined flies, can be found worldwide. They resemble bee flies in having a very long proboscis and wing venation, although they are much less hairy. Since the larvae are parasites of other insect groups, only adults visit flowers, especially deep ones and mainly for nectar.

Another dipteran family to be mentioned in the context of pollination is that of the Calliphoridae (blow flies), dull species with shiny metallic colouring. Though not great pollinators, they are remarkable because they are almost ubiquitous and feed on a variety of food sources, including flowers, thus acting as occasional relatively inefficient pollinators. As they frequent degraded and bee-depleted areas, they may be the only species carrying out pollination. The second reason they are mentioned here is because they can be successfully raised for use in large numbers as crop pollinators in greenhouses (e.g. onion farms).

LEPIDOPTERA

Almost all lepidopteran species have a tongue or proboscis adapted for sucking. Butterflies and moths have very long tongues, and are active by day and by night, respectively. They are typically guided to flowers by colour and fragrance. Moths visit plants with pale or white flowers; these usually diffuse abundant fragrance and offer dilute nectar. Moths do not always land on flowers: sometimes they suck nectar while hovering near them. They may also repose on flowers, landing on their surface. The bodies of moths are furry and attract pollen while reposing, or it sticks to their tongue during feeding.

The beautiful and graceful butterflies fly during warm weather and visit a wide range of flowers, preferring those with bright colours (red, yellow, orange). Butterflies recognize colours, sensing more wavelengths than humans; unlike bees, they can see the colour red. Since they are perch feeders, flowers need to offer them a landing pad. The butterfly's legs and tongue are long, keeping the insect away from the flower's pollen, so it loads less pollen than bees do. However, butterflies tend to visit a few flowers of one plant and then fly to another: this makes them good at transferring pollen, facilitating cross-pollination (i.e. pollination between different plants of the same species) and ensuring a good mixture of genes. Plants benefit from this increase in genetic diversity.

Butterflies live in many Mediterranean habitats, including forest, scrub, swamps, cultivated fields and even parks and gardens in big cities. They are very sensitive to temperature variations and some of them are known to migrate. This is why monitoring of butterfly populations is now normally included in studies on climate change. According to the latest IUCN assessment, the Mediterranean region hosts as many as 462 species of butterflies, 19 of which (5%) are at risk of extinction and 15 of which are endemic to the region.

COLEOPTERA

Beetles are considered to be primitive pollinators from two points of view. First, among the main pollinator guilds, beetles were the earliest in the history of Earth to systematically visit flowers and transfer pollen. They therefore have the longest mutualistic relationship with flowering plants. Second, since their primeval flower-related characters have changed little, their primitiveness is evident from their body anatomy and their flower-visiting behaviour. Beetles' mouthparts are mainly adapted for chewing rather than sipping; their wings (elytra or coleoí, hence the name Coleoptera) are adapted for protection more than for flying; their body is heavy with little hair. Likewise, their behaviour does not suggest high pollination efficiency, as beetles are pretty much sedentary, spend much time on a flower, seldom move between flowers and plants, and most are pollen consumers that treat flowers roughly, e.g. rose chafers (*Cetonia aurata*).

Beetles, however, have been important in the evolutionary history of pollination and continue to be an asset for the pollination services required today. There are several reasons for this: their diversity (they are the insect group with the highest diversity), their large populations, and the fact that they occur in nearly all habitats, from freshwater to very dry habitats and deserts. In the Mediterranean region, they are particularly present in the dry season, their massive presence on flowers denoting the onset of summer drought. The order includes generally polyphagous species, i.e. not exclusively dependent on flowers. They visit "primitive syndrome" flowers that are relatively easy to handle (open or bowl-shaped and inflorescences suitable for repose, with easily accessible floral rewards). Such flowers are large and mostly white, creamy or yellow in colour with a relatively functional smell ranging from sweet to fermented. For example, several Mediterranean *Arum* species are known to attract saprophilous flies and beetles through olfactory deceit: most emit a dung/urine-like smell that these insects find irresistible when searching for a place to lay their eggs.

Anthophilous (i.e. flower-visiting) beetles are a heterogeneous group including species spanning from "mostly consumers and poor pollinators" (e.g. the species *Mylabris quadripunctata* visiting a variety of flowers, sitting on them and consuming pollen, nectar and other flower tissues), to gentle legitimate pollinators (e.g. the eastern Mediterranean genus *Pygopleurus*). *Pygopleurus* species are very selective, visiting red bowl-shaped flowers of the anemone–poppy guild, for which they are very effective pollinators. Another significant Mediterranean anthophilous species with considerable pollination potential due to its large body size and ceaseless activity is the scarabaeid *Tropinota hirta* and species of the genus *Oxythyrea*, all of which visit a variety of flowers in late spring and summer. Some smaller beetles, like those belonging to the genera *Podonta* and *Variimorda*, are also notorious flower visitors, evident as many black dots on white daisy-like flowers.

FEAR OF STINGS

Many people of all ages are afraid of bees. Some are even terrified of them. Some know their importance, others certainly agree that their contribution is fundamental, but almost everyone prefers to maintain a safe distance.

What are people afraid of?
They are afraid of being stung.

When we ask where this phobia comes from, many remember childhood events: some squeezed a nest in their hands, others found themselves with a bee in their mouth, others running in the woods found themselves in a cloud of stinging insects. What these stories have in common is that all the insects were presumably wasps, and not bees. And in almost all cases, whether they were wasps or bees, they had to defend their nest or themselves from arbitrary attack.

Only female bees have a stinger. The stinger has a barbed tip: once it pierces the skin it lodges in the flesh and everything connected to it remains attached, from the poison sac to the stomach of the bee. This kills the bee, which is a good reason for bees not to attack for fun.

Wild bees are even less likely to sting: like their domestic relatives, they use the stinger only if they are annoyed, if you pinch or step on them (they prefer to move away rather than attack), or if someone destroys their nest (honey bees only sting when their nest is threatened).

Since people are taken to the emergency room every year for insect stings, it is legitimate to say that while „phobia“ may be an overreaction, the fear caused by stinging insects can be real, therefore it is useful to know real ways to prevent such stings:

- **Wear shoes, especially in grassy areas.**
- **Since stinging insects are attracted to sweetness, do not leave sweet drinks or food in accessible areas.**
- **Do not attempt to remove a nest on your own or swat at stinging insects; an aggressive reaction and repeated stinging may occur.**
- **Keep windows and doors properly closed if you have nests around.**
- **Promptly remove garbage and store it in sealed containers.**
- **If you react to a sting, seek immediate medical attention as reactions can be severe.**

Don‘t worry!

We can safely coexist with bees, observe them and grow plants that attract pollinators. By observing and respecting pollinators, we can all find ways to deal with and reduce our fear.

THE POWER OF “CITIZEN SCIENCE”

WHAT IS CITIZEN SCIENCE?

The Oxford English Dictionary defines Citizen Science as “scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions“.

Citizen Science projects involve citizens not only as recipients of outreach and educational activities, but also as active contributors to the scientific endeavour addressed to current urgent environmental challenges (European Citizen Science Association: https://ecsa.citizen-science.net/documents/2015), generating new knowledge, understanding and responsibility.

When Citizen Science projects address students, they engage a most receptive slice of the population: youngsters, with the additional value of giving them an idea of the scientific method and process.

THE ROLE OF SCHOOLS IN THE CONSERVATION OF POLLINATORS THROUGH ENVIRONMENTAL EDUCATION

Environmental education aims to make students aware of human impact on ecosystems. Environmental education brings students closer to nature, fostering an understanding of how ecosystems function and igniting awareness of the importance of preserving biodiversity. Environmental education covers many topics, including waste management, recycling, sustainable use of resources, climate change and biodiversity conservation.

Environmental education in schools brings many benefits:

- The activities involve practical and interactive learning, which is why they promote enthusiasm and creativity among students.
- Students are inspired to see the interconnectedness of social, ecological, economic, cultural and political problems, and are encouraged to apply this understanding in everyday life.
- Taking a class outdoors or bringing nature indoors provides an excellent backdrop or context for interdisciplinary learning.
- Exposure of students to nature and outdoor learning protects them from nature-deficit disorder.
- Communities are strengthened by community participation: when students set out to learn more or to improve their environment, they contact experts, volunteers and local bodies, bringing the community together to understand and address the environmental issues that affect them.

Schools are interesting places to promote and encourage Citizen Science projects due to their capacity to collect scientific data. Regarding pollinators, activities can be conducted where data, such as biodiversity inventories of specific habitats or records of observations of insects and visits to plants, is collected. If collected on a spatio-temporal scale using a well-defined method, this data can be used in scientific analysis, contributing to general knowledge about pollination in the Mediterranean region and helping define the risks and threats to pollinator populations.

The current context of the climate crisis and loss of biodiversity obliges schools and educational centres to incorporate these teaching strategies. Study of the loss of pollinating insects is not only mandatory in the environmental education curriculum, but also offers an opportunity for schools to play an active role in the conservation of pollinators.

WHAT CAN YOUR SCHOOL DO FOR POLLINATOR CONSERVATION?

- Include the roles of pollinators in natural ecosystems and food production in science and environment curricula (for example, Biology). Mention the loss of pollinator biodiversity as an aspect in all activities related to awareness about climate change.
- Implement a comprehensive environmental education program. It is essential to transmit the idea that pollinators are not hostile insects because they may sting. Very few species of pollinators can do any harm, and if they do, it is usually because they have been bothered or not treated with care. The misconception that pollinators are enemies must change. Pollinators are fundamental allies.
- If the school has gardens or green spaces, native plants that attract pollinators can be added. Insect hotels and drinkers for bees and other insects can also be installed.
- Promote school gardens. Gardens have great educational potential and are a good place to convey the importance of pollination for food production.
- Encourage the school canteen to provide seasonal organic food. Changes in land use due to conventional intensive agriculture and monocultures, where herbicide and pesticide use is systematic, are the major threat to pollinator populations.
- Invite beekeepers to the school to explain the art of caring for bees, obtaining honey and the importance of bees for the pollination of crops.
- Organize trips to botanical gardens, butterfly gardens and nature reserves that promote activities focusing on pollinators.
- Involve the school in citizen science events like Bioblitz. Some useful tools and suggestions can be found on the LIFE 4 Pollinators project website (**https://life4pollinators.eu/**).

"STUDENTS 4 POLLINATORS": THE LIFE 4 POLLINATORS CITIZEN SCIENCE PROJECT FOR SCHOOLS

A Citizen Science project for schools normally has three phases:

Phase 1) Preliminary lesson on theory, with pictures and/or other tools (e.g. 3D models): a lesson (1 or 2 hours) focusing mainly on the concept of pollination through practical examples relating to plant-pollinator interactions and the diversity of pollinators in the Mediterranean environment.

Phase 2) Practical activity, based on standard protocols (described below) and field-sheets to record plant-pollinator interactions.

Phase 3) Reporting and discussion (on-line if necessary): where the results of practical monitoring are presented and discussed.

ACTIVITY MANUAL FOR STUDENTS (AND TEACHERS)

BOTANICAL ACTIVITY: Plant-based fieldwork: field recording sheet no.1

Objective: to introduce students to the diversity and taxonomy of flowering plants. Through direct observation of plant diagnostic traits, they:

- become familiar with plant and flower morphology,
- learn to recognize (and appreciate) the variety of flower shapes and plant biodiversity in general,
- learn how to use taxonomic keys. (Optional – depending on age and teacher interest: herborization and preparation of herbarium specimens (exsiccata)).

Duration: 2(-3) hours

Useful equipment: hand lens

Activity

The activity can be performed by groups of 2-3 students, each having a specific role (i.e. observers and form filler). The form filler draws the flower and the leaf of a plant in the area (field sheet no. 1a). The group observes the flowering plant and records its features on field sheet no. 1b, with a view to determining its morphological group (LIFE 4 POLLINATORS field guide for plants) using the key for entomophilous plants (field guide or app). Observations are made using a hand lens.

LIFE 4 POLLINATORS

Flowers vary in shape, size and colour. In this activity, observe the characteristics of your chosen flowering plant and determine the morphological group to which it belongs to.

Group: Botanists	
School:	Grade:
Role	Name
Observer I	
Observer II	
Form filler	

DRAW THE FLOWER

DRAW THE LEAF

PLANT ASPECT

- tree
- shrub
- herb

LEAF SHAPE

- simple (1 leaf)
- divided into small leaflets

FLOWERS ASPECT

- small single flowers clumped together in inflorescence (use a lens!)
- single flowers easy to recognize, solitary or not

If you choose INFLORESCENCE:

- many little flowers aggregated in "head" (looks like a single flower)
- umbel-like
- spheric
- none of the above

STEM SECTION is:

- quandraqular
- circular

LEAF VEINS are:

- parallel
- not parallel

FLOWER SHAPE

- radial (more than 2 symmetry axes)
- bilateral (mirror symmetry)

How many STAMENS do you see?

- 3
- 4
- 5
- 6
- more than 6

POSITION of LEAVES on the stem:

- alternate
- opposite
- all basal

Is it aromatic?

- yes
- no

COROLLA with PETALS ...

- completely free (separated)
- fused only at the base (try to take off the petals)
- fused for more than half length

If PETALS are free, how many are they?

- 3
- 4
- 5
- 6
- more than 6

The plant has LATEX?

- yes (abundant)
- no

Does the flower have SEPALS?

- yes (free or fused)
- no

If SEPALS are present, how many are they?

- 3
- 4
- 5
- 6
- more than 6

FLOWER COLOUR:

It belongs to morphological group:

ENTOMOLOGICAL ACTIVITY: Pollinator-based fieldwork: field recording sheet no.2

Objective: to familiarise students with the various insect guilds. A simple pollinator census enables them to identify common pollinator species and realise their importance in ecosystems. Through direct observation of plant-pollinator interactions and by estimating the diversity of pollinators in a specific area, they:

- learn about insect guilds and species,
- gain an understanding of pollinator preferences for plants,
- learn to use taxonomic keys.

Duration : 2(-3) hours

Useful equipment: mobile phone, camera, stopwatch

Activity

The activity can be performed by groups of 3-4 people, each with a specific role (i.e. observer, form filler and photographer). First a study area is identified. Weather conditions and the habitat are recorded using field sheet no. 2a. The group observes a plot (or pot!) with a chosen plant species. For an hour, four plants (of the same or different species) are observed (15 minutes each). Observations are made at a distance of approximately one meter from the plant and the information is recorded on field sheet no. 2b.

Before starting the observation, the name of the plant is entered on the form (morphological group or family or genus or species if known) and the area of the plot in square meters.

The observers follow any insect entering the plot and:

1. describe insect characteristics with a view to identifying its guild (bee, wasp, hoverfly, bee fly, butterfly, moth, beetle) and name using an entomology field guide;
2. describe insect behaviour when interacting with flowers (e.g. collecting pollen, feeding on nectar, resting/mating on flowers);
3. count the number of flowers visited by the insect;
4. take a close-up photo of the pollinator on the flower, recording the time of the photo.

At the end of observations, the flowers can be examined more closely, and additional pictures taken.

Then all the data is shared with other groups and compared to assess the diversity of pollinators on each plant species and figure out the plants visited most and by whom.
The photo and the information collected can be uploaded to the database on the website:
www.life4pollinators.eu/en/submission

LIFE 4 POLLINATORS

Pollinators belong to various guilds. In this activity, observe a plot/pot of your chosen plant species and record the pollinators. How many can you identify?

Group: Entomologists	
School:	Grade:
Role	Name
Observer I	
Observer II	
Form filler	
Photographer	

DATE, TIME & LOCATION

Date:	
Start time:	End time:
Place (postcode or lat/long):	
Location:	

HABITAT

- ○ scrubs
- ○ grassland
- ○ agroecosystem
- ○ forest
- ○ gardens, parks & urban areas
- other:

WEATHER CONDITIONS

Temperature

Check your mobile and fill measurement (o C)

Cloud cover

Observe the sky and write down the cloud cover (few clouds, light cloud cover, many clouds, heavy overcast)

Wind

Determine wind speed by observation (calm, light breeze, moderate breeze, strong breeze)

Plant:

Area: m²

Duration of observation per plant: 15 min

Insects	Insect guilds							Name	Insect behaviour	Photo time
	Bee	Wasp	Hoverfly	Bee-fly	Butterfly	Moth	Beetle	(try to identify the insect with the LIFE4POLLINATORS entomological field guides and write the name of it or describe it)	Does the insect interact with the flowers? What do you think the insect is doing? (e.g. feeding, collecting pollen, resting, mating, patrolling, other)	
Insect 1	◯	◯	◯	◯	◯	◯	◯			:
	Number of flowers contacted in each visit									
Insect 2	◯	◯	◯	◯	◯	◯	◯			:
	Number of flowers contacted in each visit									
Insect 3	◯	◯	◯	◯	◯	◯	◯			:
	Number of flowers contacted in each visit									
Insect 4	◯	◯	◯	◯	◯	◯	◯			:
	Number of flowers contacted in each visit									

Upload your photos here: https://life4pollinators.eu/en

POLLINATION ACTIVITY: Interaction-based fieldwork, field recording sheet no.3

Objective: to learn how to monitor plant-pollinator interactions and assess their importance in ecosystems

Location: the activity can be carried out in the school garden or other garden with flowering plants, possibly in an open sunny area (avoiding ornamental plants if possible), or in natural areas.

Duration: two observation intervals of 15 minutes (total 30 minutes)

Activity

Groups of three students choose their monitoring area (which should include different species of plants in flower) which may be a plot 1 m x 1 m, or a transect 50 m long (to observe twice = total length of 100 m).

Weather conditions and habitat are recorded on field sheet no. 2a, then the group fills in field recording sheet no. 3:

1. List all the plants blooming in the plot (or along the transect) by name (morphological group, genus or species if known), using the field-guide or other identification tools.
2. Indicate the abundance of flowers for each species.
3. Observe plant-pollinator interactions: each time an insect visits a flower, record insect guild (bee-fly, hoverfly, bee, wasp, butterfly, moth, beetle) and score a bar for each visit to the same plant species.

LIFE 4 POLLINATORS

Pollinators belong to various guilds. In this activity, observe a plot/ transect and record the pollinators. How many can you identify?

Group: Entomologists	
School:	Grade:
Role	Name
Observer I	
Observer II	
Form filler	
Photographer	

DATE, TIME & LOCATION

Date:	
Start time:	End time:
Place (postcode or lat/long):	
Location:	

HABITAT

- ○ scrubs
- ○ grassland
- ○ agroecosystem
- ○ forest
- ○ gardens, parks & urban areas
- other:

WEATHER CONDITIONS

	Instructions	
Temperature	Check your mobile and fill measurement (o C)	
Cloud cover	Observe the sky and write down the cloud cover (few clouds, light cloud cover, many clouds, heavy overcast)	
Wind	Determine wind speed by observation (calm, light breeze, moderate breeze, strong breeze)	

Which monitoring method did you choose?

○ **Plot** 1x1 ○ **Transect** 1x50

Flowers Write the morphological group of each flower in your monitoring area	How many flowers do you see in the area? (many - few - rare)	Insect guilds: Bee	Wasp	Hoverfly	Bee-fly	Butterfly	Moth	Beetle	No visits Check the box below if there is no visits on the plant
									☐
									☐
									☐
									☐
									☐
									☐
									☐

IDEAS FOR OTHER EDUCATIONAL "POLLINATION" ACTIVITIES

MAKE YOUR OWN POLLINATION KIT

Objective: to create pollination kits consisting of a sample of seeds of wild plant species to sow in a garden or green area at school, a small insect shelter (mini bee-hotel) and a key to identify the most common pollinator species.

Material
- For the seed bags: paper bags to store the seeds and tweezers to handle them.
- For the shelter: short lengths of reed, bamboo, or plant material collected in the field to build the shelter. Recycled materials can also be used.
- For the identification key: notebook, pen, field magnifying glass, a regional insect field guide and an entomology collection if available. LIFE 4 Pollinators field guides can be very useful, too!

Duration and activity
The activity takes three days:

Day 1: Introduction and short theory class on pollinators and their importance in ecosystems. Collecting seeds in the field. Recognition of pollinator-friendly plants.

Day 2: Preparation of the pollination kit. Sort the seeds and store them in paper bags if they are not to be sown immediately. Construction of the insect shelter. Compilation of a simple identification key by the students themselves in the absence of external material (insect samples, entomology collection, photographs).

Day 3: Sow the plants in the garden and install the insect shelter. A bee drinker can also be installed. Decide on a method for monitoring pollinator visits and keeping a record of the insects that visit the garden. Take photos and upload them to the LIFE 4 Pollinator project website: www.life4pollinators.eu/en/submission

CONSTRUCTION AND MONITORING OF AN INSECT HOTEL
(Citizen Science activity)

Insect hotels are artificial structures, usually made of wood and plant materials, which have the function of offering shelter to insects, especially in degraded habitats. Insect hotels help convey the importance of pollinators to students, but their ecological efficacy has not yet been demonstrated due to a lack of scientific studies in this regard. The activity is focused on schools that have a garden or green area.

Objective: to construct and monitor the efficacy of insect hotels through citizen science data collection in schools, while raising awareness about the importance of pollinators.

Duration and activity

The workshop takes 2 days, while data is collected weekly for a period of 6 months.
Previous activity: Design an insect hotel that can be built by schools. It should be a simple inexpensive shelter that can be built by the students themselves using natural or recycled materials.

Day 1: Theory class on the importance of pollinators and start of construction of the insect hotel.

Day 2: Finish construction of the hotel and installation in the school garden. Make an inventory of the plants/flowers nearby.

Monitoring: The number of cells occupied by insects is recorded weekly to obtain the occupation percentage of the shelter. If insects are observed entering or leaving the shelter during the count, they are recorded (and if possible photographed). The monitoring is done once a week for 6 months. Any changes in the flora of the garden during the 6 months are recorded. The more schools build insect hotels, the more accurate the data will be!

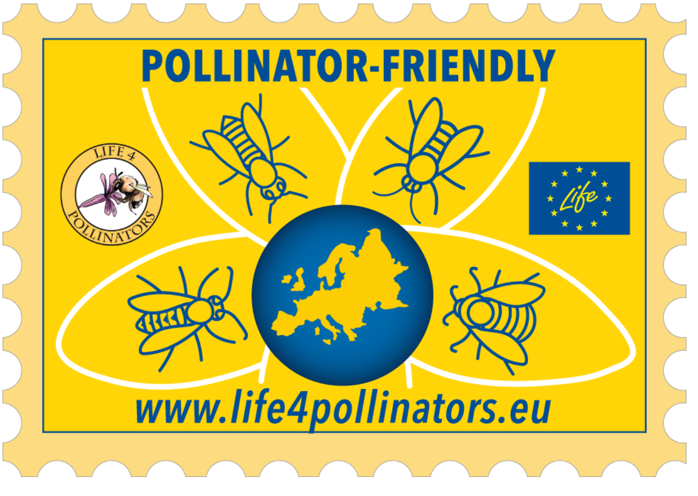
Note: Invasive species may occupy the insect hotel. Identifying and recording these species is valuable scientific information.

Bee hotel in Sóller Botanical Garden (Balearic Islands, Spain)

I DO MY PART: become a friend of pollinators!

Now that you have learnt how important pollinators are for nature and for human life, you can do your part to help them:

- Help them find food! Grow plants for pollinators in your garden or on your balcony .
- Help them find shelter! Create/install an insect-hotel in your garden or on your
- balcony.
- Provide them with water during dry weather. Pollinators need to drink too! Place a container with water that contains stones, pieces of wood, corks or any material that allows insects access to the water.
- Consume ethically! Read product labels and choose seasonal food produced locally in a sustainable way, possibly organic.
- Spread the word to your friends and family that pollinators are important, that we must take care of them, that they do not sting, and that we depend on them for our well-being. For instance, coffee and cocoa crops both depend on pollinators!
- Contribute to scientific knowledge! Upload your photos of pollinator to: **https://www.life4pollinators.eu/**. These records may be precious in the future!



LIFE 4 POLLINATORS

LIFE18 GIE/IT/000755