LIFE 4 POLLINATORS

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

MANAGEMENT OF URBAN GREEN AREAS

HANDBOOK FOR MANAGEMENT OF URBAN GREEN AREAS

CREDITS

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INTRODUCING POLLINATION AND POLLINATORS

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

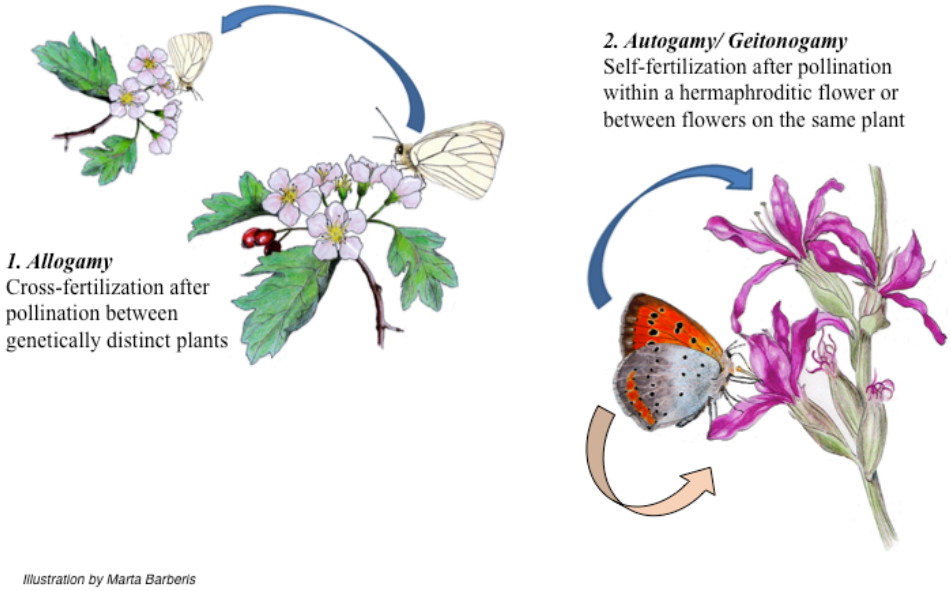


Illustration by Marta Barberis

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.

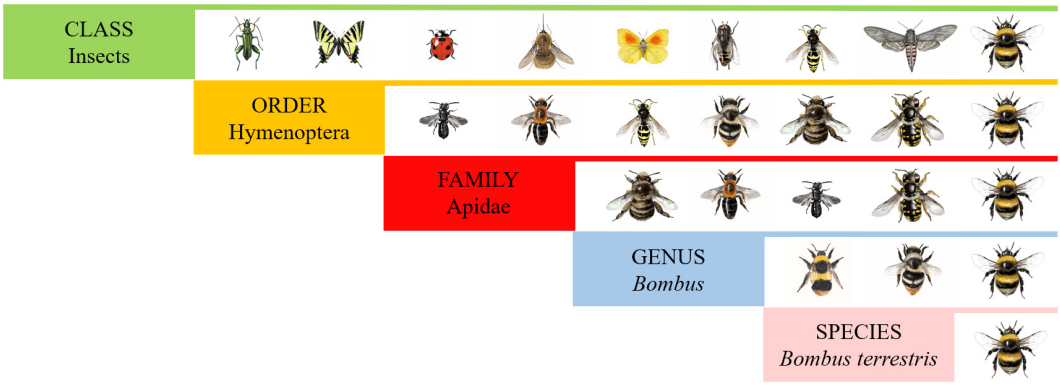
Since the end of the 20th century, there has been a decline in insect pollinator populations around the world. Habitat loss, land use change, intensive agriculture, use of pesticides and herbicides, introduction of invasive species and climate change are the main causes of this loss. The IUCN European 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.

URBAN GARDENING

OBJECTIVES

These guidelines for city dwellers, urban green planners/managers concern pollinator-friendly gardening and pollination services. They discuss possible new and best practices in urban gardening, the risks associated with the cultivation of plants (e.g. insecticides harmful to bees, parasite diseases, alien species), and possible mitigation measures.

REGULATORY FRAMEWORK

This handbook refers to rules, resolutions, recommendations and initiatives, often still in the phase of development. The main references at the date of publication are reported below. All the actions suggested in this handbook are based on the Sustainable Development Goals (SDGs), 17 interlinked goals to enable a better future for all people. The European Commission has adopted a series of documents for implementation of the SDGs, including the following:

- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Green Infrastructure (GI) — Enhancing Europe's Natural Capital. https://www.eea.europa.eu/policy-documents/green-infrastructure-gi-2014-enhancing
- Final Report of the Group Horizon 2020: EUROPEAN COMMISSION, Directorate-General for Research and Innovation, 2015: Towards a EU Research and Innovation policy agenda for Nature-Based Solutions & Re-Naturing Cities. http://ec.europa.eu/newsroom/horizon2020/document.cfm?doc_id=10195
- EU POLLINATOR INITIATIVE and the European Parliament resolution of 18 December 2019 on the EU Pollinators Initiative, https://ec.europa.eu/environment/nature/conservation/species/pollinators/policy_en.htm
- Directive on the sustainable use of pesticides (2009/128/EC) and the 2017 and 2020 Reports on its implementation https://ec.europa.eu/food/plants/pesticides/sustainable-use-pesticides_en
- Regulation (Eu) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species. https://www.eea.europa.eu/policy-documents/ec-2014-regulation-eu-no

WHY ARE GREEN AREAS IMPORTANT IN CITIES?

The world population is undergoing a dramatic shift from rural to urban living. In 1900, only 10% of people lived in cities; this number now exceeds 54% and is expected to increase to 66% by 2050[1]. Contrary to past views, cities are not ecological deserts: today it is recognised that nature is an integral part of them. Urban green spaces can host a rich diversity of species. Many cities retain a wealth of native flora distinct to their region (see box 2.1), despite a levelling trend due to selection of tolerant cultivated species, invasion of cosmopolitan aliens and the use of insecticides and pesticides. Most plant species in cities are natives and a fair proportion are threatened. In fact, urban areas may host the only remnant populations (or seed banks) of certain plants. Extensive urban surveys are rediscovering species that were thought to be extirpated[2]. This is linked to the fact that urban landscapes are a mosaic of remnants of natural habitats, vegetation regenerating on abandoned land, and managed parks and gardens. Unfortunately, the islands of green habitat in cities are physically distant from each other and isolated by a hostile matrix of buildings and streets.

BOX 2.1 FLORISTIC DIVERSITY IN BOLOGNA (ITALY)

Bologna is a typical densely populated southern European city, situated in the southern part of the Po valley, close to the Apennine mountains. Between November 2014 and June 2016, a survey into plant species distribution, richness and diversity was conducted. The study area was the historical centre of Bologna inside the avenues encircling the last city walls (14th century). The many private courtyards, often inaccessible, were not considered, leading to an underestimation of urban species. Nonetheless, the study revealed high plant species diversity: a total of 477 species, including many rare and protected entities, such as *Orchis purpurea* Huds., *Cephalanthera damasonium* (Mill.) Druce, *Asplenium scolopendrium* L., *Euphorbia hirsuta* L. and *Galanthus nivalis* L..

The urban habitat therefore proved to have a shelter function for these species.

Knowledge of potential and actual barriers is crucial if we are to improve green infrastructure and ecosystem services in urban landscapes. Such knowledge makes it possible to develop

[1] United Nation Population Division. World Urbanization Prospects: The 2014 Revision. New York, USA (United Nations Publications, 2015).

[2] Salinitro M, Alessandrini A, Zappi A, Melucci D, Tassoni A (2018) Floristic diversity in different urban ecological niches of a southernEuropean city. Sci Rep 8(1):15110.

High-quality urban areas could support good populations of plants and pollinating insects, and act as important source areas, refuges and corridors of favourable habitat in a hostile environment, especially in regions where intensive farming is the dominant land use.

methods for assessing green infrastructure in urban planning, an important aspect of EU Biodiversity Strategy 2020[3], currently being implemented in various European countries. According to the Strategy, there is an urgent need to promote biodiversity-friendly cities: appropriately managed cities could enhance the conservation of wildlife and act as hotspots of pollination services of insects to wildflowers and crops grown in urban settings. Indeed, wild pollinators often use habitats in urban areas, such as parks, flower-rich disturbed sites, roadsides and flower-rich gardens[4]. However, city planners are often unaware of the importance of green infrastructure for pollinators, and city dwellers are rarely aware that the most important factors for the populations of flower-visiting insects are the availability of food and nesting resources.

DIFFERENT KINDS OF URBAN GREEN SPACES

PRIVATE GREEN AREAS These can constitute over a quarter of the land use in some cities: botanically diverse private gardens, terraces, balconies and gardens shared by apartment buildings in suburban landscapes have been found to host a surprising diversity of insect species. However, several factors make it difficult for gardens to support a diverse and abundant insect assemblage: many gardens are actively managed with pesticides, pruning, mowing and other disturbances that may limit their capacity to maintain rare or sensitive insect species. "What will the neighbours think?" is another important driver of garden design. Historically and socially, a "neat" garden with a lush, weed-free carpet of grass is a status symbol of upward mobility and conformity to aesthetic and social norms. The outcome is simplistic vegetation, maintenance of which may consume large volumes of water, fertilizers, pesticides, fuel and time. Although of limited size, urban gardens may be numerous and largely domestic, accounting for a significant proportion of urban green space. They therefore have potential for the maintenance of biodiversity within a city.

[3] European Commission. 2017. Green Infrastructure. http://ec.europa.eu/environment/nature/ecosystems/ index_en.htm
[4] Hall D.M., Camilo G.D, Tonietto R.K et al. 2017 „The city as a refuge for insect pollinators". Conservation Biology 31: 24-29 dos: 10.1111/cobi.12840

URBAN PARKS are the main focus of the urban ecological network. They are usually rich in trees and shrubs, which attract many animal species. In most cities, natural areas are largely fragmented, increasingly isolating city dwellers from the experience of nature. Parks and public green spaces can be used to increase connectivity and raise public awareness of the complexity and importance of environmental issues.

HISTORICAL GARDENS should be regarded as the "green monuments" of a city. Though focused on tourism and recreation, they are often historic, cultural and social elements of a city, incorporating historical buildings and constituting landmarks. Together with city parks, they are the major green areas for the conservation of biodiversity. The common presence of monumental trees makes the need for correct management of historical gardens more urgent.

QUARTER GREEN AREAS are generally small areas with high social value. Sometimes they are neglected or abandoned public areas that citizen have "adopted", managing and maintaining them. In some cases, after heated clashes with citizens, city councils have regularized these "adoptions" through memoranda of understanding or specific agreements. Since these areas have been created spontaneously by people, using recycled materials and seeds and plants from private gardens, it is important that the agreements indicate plants to avoid, especially invasive alien species, such as *Ailanthus altissima*. Unfortunately, this species is often already present, because councils have been negligent in their maintenance. If the land is also used for individual or common vegetable gardens, clear rules are needed, for example that pesticides and plastics are forbidden.

GREEN ROAD VERGES include tree-lined avenues, parking lots, road flowerbeds and roundabouts. Although they cannot be considered true ecosystems, they may act as corridors or steps, maintaining a link between larger and more natural green areas.

MANAGEMENT OF URBAN GREEN AREAS

We list the details of a few actions that can be taken to obtain attractive, ecologically managed, "natural" green areas. Ecological and aesthetic quality can be achieved in private or public gardens of any size by choosing the actions best suited to the situation. Remember that gardens may already have areas that are good for pollinators, which it is important to identify and protect: patches of wildflowers or flowering hedgerows as sources of food, bare

soil or dry-stone walls as shelters and so on. In these areas, pesticides or insecticides should never be used.

All urban green areas should be surveyed by type, biodiversity (actual and potential), role (including historical or social), possible measures to improve them and by how they can be integrated in a true urban ecological network.

The actions that can be taken to manage the different types of urban green areas are described. The ultimate aim is to create, wherever possible, efficient interconnected ecosystem networks that can improve the quality of city life, not just for pollinators and plants but also for people. The Millennium Ecosystems Assessment (MEA)[5] was the first attempt by the scientific community to describe and assess all the services that nature offers humans at global level. Twenty-four different ecosystem services, defined as "benefits that humanity obtains from ecosystems", were identified. MEA recognizes that "ecosystems in good conservation status and health are a priority for the aspirations of humanity today"; that "sustainable management of an ecosystem provides more net benefit than that possible from ecosystem exploitation" and that "measures for the conservation of natural resources have more chance of success if the local community is directly responsible for them, shares their benefits and is included in decision-making". Well planned and disseminated actions to manage urban green areas can improve quality of life, bring economic advantages, and increase awareness, participative support and involvement in environmentally responsible management policies.

TRAINING. The training of gardeners and town planners is very important. If you are in charge of managing any urban green area, train gardeners and town planners in how to manage them ecologically, not just aesthetically. The LIFE project offers scientific advice in this regard.

REDUCE MOWING. Manicured lawns are a preferred type of public green area for city dwellers, predominantly for aesthetic reasons. However, close or frequent mowing may have negative ecological and environmental effects. A well-maintained lawn hosts low plant and insect diversity and transforms lawn-dominated areas into 'sterile environments for biodiversity' as it offers poor conditions for many species. Intensively managed lawns are also costly in terms of money and contribute to greenhouse gas loadings. Slight management changes do not mean letting the landscape go wild but managing it in a more sustainable way. The most cost-effective way to improve the ecological quality of a garden is to reduce the frequency of mowing in some areas and allow wildflowers to bloom. Plants like bram-

[5] https://www.millenniumassessment.org/documents/document.449.aspx.pdf

bles, clover, thistles, ivy, nettles and dandelions provide an important source of food for all types of pollinators but cannot flower in an intensively mowed lawn. Consider keeping small areas where such plants are allowed to grow in strips or patches of long grass or consider cutting some areas less frequently. Thus, in marginal areas of big parks, it is worth creating areas where:

- spontaneous herbaceous plants can flower, mowing only once at the end of the summer or under specific good climate conditions, mowing once every two years.
- pesticides are not used.

BOX 2.2 INFORMATION PLAQUE FOR UNMOWED AREAS

"WHY ALL THESE WEEDS?"

Spontaneous herbaceous plants are important!

Tall grass hosts native species that grow spontaneously in our parks and are not useless weeds. Here all plants have a name: we have *Ranunculus*, *Trifolium*, *Lamium*, *Brachypodium* and many more!

Why do we care so much about herbaceous plants? Because they contribute to local natural biodiversity and attract useful entomofauna: pollinator insects!

They keep the soil cool, moist, porous and protected, promoting organic matter and favouring the penetration of water. This is a benefit for us because it increases water reserves and prevents flooding on small and large scales, in our parks and in the city as well.

Less trivial than it seemed?

So please use the mowed paths and help us preserve these little spots of biodiversity!

In some parts of the Mediterranean, roadside vegetation is removed to reduce the risk of fires during the summer drought. In these cases, the vegetation should not be mowed until late spring, when most wild plants have finished flowering.
Since certain green areas are intensely frequented, any intervention should be communicated (BOX 3.2) and whenever possible, local people should have a say in planning and management, for example using a participatory approach and Citizen Science to explain the importance of the intervention planned.

MIX FLOWER TYPES over a growing season to reduce or eliminate dearth periods when no plants are blooming and to provide balanced overlapping bloom throughout the year. From this point of view, exotic long-blooming garden plants, unless invasive or double-flowered, are important and at least as attractive/useful to insects as native plants.

- Traditional bedding plants like geraniums, begonias, impatiens and petunias have virtually no pollen or nectar and are of little value to pollinators, but many ornamental plants have been selected for their long blooming and large showy flowers and may provide exceptional forage over long periods.
- Bulbs, such as *Crocus*, *Muscari* and snowdrop, can be a valuable early-season pollen source for foraging insects. If you are planning to use these bulbs in your garden, consider that the grass must be managed so as not to damage the bulbs (i.e. postponing mowing until the foliage has had time to wither);
- in larger gardens, late winter flowering shrubs like Italian buckthorn can be a fundamental food source for pollinators when other sources of pollen and nectar are lacking.
- wind pollinated plants may also provide pollen forage for pollinators at critical times: willows, for example, are one of the first major spring nectar and pollen sources. Pollinators may gather large quantities of pollen from wind pollinated plants, especially early in the season before other plants begin to flower.
- if meadows have low plant species biodiversity, a mix of native flowers can be planted to ensure food throughout the year to beneficial insects.

CREATE NESTING HABITATS. Wild pollinators need safe nesting habitats which provide shelter, protect them from predators and allow next year's pollinators to grow and develop. Leaving a small area of a garden (public or private) to grow wild during the spring/summer will create habitats for bumblebee nests, while mining bees need access to bare soil in order to dig their nest, so the easiest action is to create earth banks or to expose bare ground in a drained, sunny location. A variety of ground conditions will attract different types of mining bees. Other pollinators are cavity nesters: reeds, brambles and logs or tree trunks in a sunny, well drained area can be useful. Stone walls may provide a nesting habitat for solitary bees. Remember, never use pesticides, herbicides or fungicides in an area destined for nesting. A non-excessively tended garden usually provides the necessary pollinator nesting habitats. If piles of branches and dead trees are a liability issue, natural habitats can be enhanced or replaced with manmade pollinators nests. In large parks, it is certainly suggested to leave some areas natural, limiting bee-hotel installations to educational activities, whereas in smaller or highly managed parks, where for instance at the end of the season all dead plants are removed, a bee hotel should be built using natural materials and choosing natural locations.

BOX 2.3 INSECT HOTELS

Insect hotels can be fun, educational, aesthetically pleasing, useful for ecological and behavioural studies and for outreach in citizen science and pollinator education campaigns. Their popularity is increasing, and the marketing of insect hotels to promote wild pollinator conservation is widespread and expanding. While insect hotels are usually designed to encourage different species to co-aggregate (e.g. by varying nesting tube/hole width or length), this may increase the risk of disease and parasitism due to unnatural, high density living conditions. In public parks it is certainly more appropriate to maintain a small area in a natural state, limiting the use of insect hotels to educational activities, but if you have a small or over-maintained garden, you probably clean up dead plant material in spring and cavity-breeding bees may not have anywhere in the garden to nest. In this case small insect hotels can be a benefit, but please remember: if you want to build a pollinator hotel, try to recreate natural conditions in terms of materials and position, and consider the following points:

Keep it small: large insect hotels with many compartments (insect condominiums) are very popular, but they artificially aggregate nesting sites, possibly attracting pests and diseases. In natural insect habitats, nests are small and separate, so multiple, small units work better than a single large one.

Use the right materials: do not use plastic or glass, since they do not let moisture out; reeds must be the right size and have a closed end; use untreated and unvarnished wood; whenever possible use recycled or natural materials from your garden.

Install it properly: place the hotel in full sun, facing south or south east, at least a meter above ground or higher to favour the presence of bees. In shaded conditions, an insect hotel will mostly host solitary wasps; they may be important as predators of pests but will compete with pollinators for nesting sites. Do not obscure the entrance to the holes with vegetation. Fix the hotel securely to prevent swaying in the wind. Provide an overhanging roof to keep it dry.

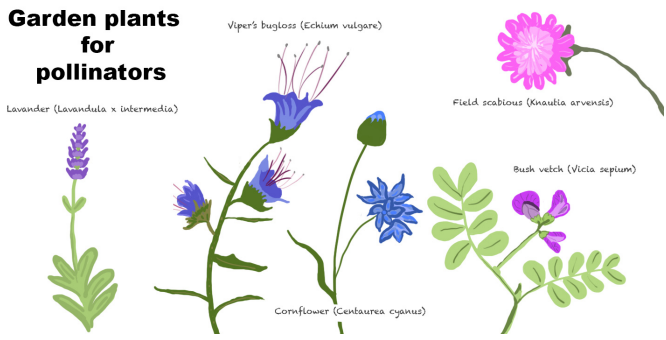
Look after it: remove dead cells at the end of the summer; replace the nesting sites if you notice mould or parasites; replace drilled wood blocks every two years. Maintaining an insect hotel is just as important as building it.

Act responsibly to minimize negative effects, so that these structures become truly useful tools for conservation.

MANAGING GREEN AREAS. In all urban green areas and especially in big parks and historical gardens, heritage trees and forest should be carefully managed. If safe, they can be allowed to evolve freely.
Depending on the size of the park, different environments may be created (meadows, hedges, grades, etc.) to improve biodiversity.
In the historical gardens, monumental trees, sometimes at the end of their life cycle, require monitoring and maintenance, using the best available technologies. In some cases, this can be done in front of the public: the main ecosystem service of a historical garden is socio-cultural; it is a perfect environment for labs, workshops, citizen science activities and public events.

CONNECTING GREEN AREAS. Small flower beds can be created wherever possible, in private gardens, on balconies or terraces, choosing appropriate plants, including some pollinator-friendly plants in window boxes, hanging baskets and other containers/pots, even where there is little outdoor space. These can help link up urban green spaces and create networks, offering habitats and corridors for the conservation of biodiversity.
City avenues and roundabouts, if well managed, play an important role in linking these habitats. Designing gardens with native plants rich in nectar and pollen can welcome and facilitate pollinator communities.
When creating a green area, appropriate flowering plants should be chosen, avoiding invasive exotics and plants dependent on pesticide treatments. See the list of invasive alien species of European concern below.

INVOLVING CITIZENS. Environmental education is a fundamental part of the naturalization and ecological integration of urban green areas. Parks and gardens should be understood as habitats of urban diversity, which host ecological processes such as pollination, not only as leisure spaces or urban decor. Encouraging activities for people of all ages in parks and urban green areas increases citizen awareness and appreciation of these areas. These activities may include planting orchards, pollinator gardens or green restoration. It is necessary to change the attitude that the streets must be "clean" of weeds and insects, and realise that cities are also habitats for animals and plants on which we depend (see Box 2.4).



BOX 2.4

INVOLVE SCHOOLCHILDREN IN THE CREATION OF POLLINATOR GARDENS AND THE PROMOTON OF URBAN BIODIVERSITY: A LOCAL PERSPECTIVE

In early 2020, the LIFE 4 Pollinators project with the City Council of Palma (Balearic Islands, Spain) and the European project BiodiverCities began a citizen project involving the creation of five pollination gardens in five city districts. These gardens will be created by elementary school students, who will also design and create insect hotels for them. The LIFE project will provide a list of plant species for the gardens, design proposals for insect hotels and educational material. Once created, these spaces will be cared for by the students themselves, and will be used to carry out pollinator biodiversity studies. Occupation of the insect hotels will be monitored and their effectiveness evaluated. Some environmental education workshops will also be held. The fact that it is the students who create and manage these urban spaces will increase environmental awareness of the need to conserve urban pollinator species.

A SPECIAL CASE: GREEN ROAD VERGES

Maintenance of green road verges is very expensive: trees have little space to grow and their root development is limited by underground services, making regular pruning and lightening of the canopy necessary. Road flowerbeds and roundabouts often host exotic ornamental species that only have aesthetic value and need to be constantly pruned to avoid interference with vehicle traffic. Recent studies show that incorrect spatial distribution of road trees can increase air pollution at ground level. It is therefore important to carefully choose the species to plant, especially in the case of trees, considering their environmental characteristics, aesthetic value and how much space is available. Road flowerbeds and roundabouts can be seeded with a carefully chosen mix of flowering plants. Too often exotic plants with large flowers are used which fail to produce enough seeds to spread. The effect is only beautiful for a short time, so that sowing has to be repeated. Spontaneous species are preferable, especially those that can resist long dry periods and that bloom over several months. The long lasting results keep maintenance costs low.

In recent years, the effects of urban lighting on pollinators became a topic of study. This is another aspect to consider when planning city parks and roads (see Box 2.5).

BOX 2.5 LIGHT POLLUTION

Light pollution is increasing all over the world and is another man-made environmental change that may affect pollinators in cities. Although the widespread use of public lighting at night has enhanced the quality of human life, the loss of darkness may have severe effects on the biosphere: artificial light can affect every level of biological organization from cells to communities. Moreover, conventional street lighting is being rapidly replaced by energy-efficient light-emitting diodes (LEDs), which are recognized as an emerging threat to biodiversity in urban ecosystems and agricultural areas, due to greater emission of blue light, up to levels never experienced before in nocturnal habitats. Several studies have demonstrated that artificial light at night may affect the physiology, phenology and behaviour of various animals and plants, possibly damaging nocturnal pollinators and the plants they pollinate. Ecologists recently showed that the negative consequences of disrupted nocturnal pollination may propagate to daytime pollinator communities.

Is it possible to mitigate the ecological impact of light pollution? A recent study investigated the effects of different types of street lighting and light regimes on the pollination success of a target species, and suggested that partial night-lighting regimes could be a way to reduce the influence of artificial light on nocturnal wildlife.

What can we do? The best thing to do, as Pete Strasser, technical director of the International Dark-Sky Association says, would surely be "to replicate nature and keep the lights off and out of your garden"! By doing this, you offer islands of darkness to the nocturnal habitat. If switching off the light completely is not a realistic solution, some tips for doing your part to reduce light pollution are suggested by sustainableamerica.org (Can Reducing Light Pollution Help Pollinators?). Local government and city planners should follow the same indications to keep artificial lightning in public gardens and city streets at sustainable levels.

- Use lights that shine down, not up. Use fully shielded, dark-sky friendly fixtures. That means lights shine down, not up.
- Only use lights when needed. Install timers and dimmer switches, and turn off lights when not in use.
- Use the right amount of light. Too much light is wasteful and impairs vision.
- Use long-wavelength light with a red or yellow tint to minimize negative health effects.

Suggested reading:

Bennie J., Davies T. W., Cruse D., Gaston K. J., Ecological effects of artificial light at night on wild plants. Journal of Ecology 104:611–620, 2016

Hoelker F., Wolter C., Perkin E. K., Tockner K., Light pollution as a biodiversity threat. Trends Ecol. Evol. 25, 681–682, 2010

Hoelker, F. et al. The dark side of light: a transdisciplinary research agenda for light pollution policy. Ecol. Soc. 15, 13, 2010

Manfrin, A., Singer G., Larsen S., Weiß, N. van Grunsven R. H. A., Weiß N.-S., Wohlfahrt S., Monaghan M. T., Hoelker F., Artificial light at night affects organism flux across ecosystem boundaries and drives community structure in the recipient ecosystem. Frontiers of Environmental Science & Engineering in China 5:61, 2017

Macgregor C. J., M. J. O. Pocock, R. Fox, and D. M. Evans., Pollination by nocturnal Lepidoptera, and the effects of light pollution: a review. Ecological Entomology 40:187–198, 2015

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Sasu Karttunen, Mona Kurppa, Mikko Auvinen, Antti Hellsten, Leena Järvi: Large-eddy simulation of the optimal street-tree layout for pedestrian-level aerosol particle concentrations – A case study from a city-boulevard Atmospheric Environment: X, 7 April 2020

2.6 URBAN BEEKEEPING

The popularity of urban beekeeping, the practice of keeping bee colonies in urban areas, is growing rapidly. In Paris, London and other European cities, there are hundreds of hives on rooftops, on balconies and in parks, and cities have begun to regulate urban beekeeping as responsible action to help pollinators.

Bringing hives into natural or urban areas can decrease bee exposure to agro-chemicals and increase the diversity of nectar sources for honey production and nutrition, but honeybees compete with wild bees for pollen and nectar, since they can forage over large, fragmented areas and visit thousands of flowers. Declines in foraging activity of native bees in proximity to honeybee colonies have been documented, especially at the end of the summer. Since increasing the number of honeybees in urban areas could have negative effects on city wild bee populations, placement of honeybee hives could be regulated more strictly near known locations of rare native pollinators species. Moreover, honeybees have viral, bacterial and fungal pathogens that can infect other insect species.

Apart from these ecological considerations, urban beekeeping is also considered a possible problem for public safety, mainly due to the risk of stings and swarming. Minimizing these risks needs to be a top priority when keeping bees in densely populated areas. This may be achieved by signs, fencing, strategic hive placement, and careful colony management. Technical best practices for urban beekeeping have been discussed comprehensively by various researchers (e.g. Melathopoulos A. et al., 2018. "Residential beekeeping: Best-practice guidelines for nuisance-free beekeeping in Oregon", Oregon State University Extension Service; Sponsler D B. and Bratman E.Z. 2020. "Beekeeping in, of, or for the city? A socioecological perspective on urban apiculture." EcoEvoRxiv. August 31). National regulations define, for example, distances and heights to observe, and municipal councils may add further constraints. Respecting these indications will help establish beekeeping as a form of environmental and social activism and an ecological citizenship practice.

How to help pollinators in urban context

Sown native wildflowers

1

Create nesting & refugee habitats for insects

2

Build Insect hotels

3

SOME INDICATIONS FOR LOCAL GOVERNMENT

Local government (including politicians and policy makers) and local planners, landscape architects, land managers, contractors and developers can play a leading role in addressing the decline of pollinators, since they can raise citizen awareness and promote pollinator-friendly management of urban spaces.

Raise awareness about pollinators locally:

- Map existing initiatives that can host actions for pollinators.
- Fund pollinator projects as examples of best practice.
- Identify pollinator-friendly habitats and explain their importance.
- Promote pollinator-friendly land management guidelines.
- Promote education and actions in local schools, youth groups, libraries, education centres.
- Fund a pollination award that recognizes local efforts.
- Inform citizens by organizing events and using information panels to explain pollinator-friendly land management.

Promote pollinator-friendly management of urban spaces:

- Develop and promote a local pollination strategy, including all stakeholders.
- Implement an ecological green space management plan.
- Make a formal commitment to pollinator conservation.
- Use non-chemical pest control and promote pollinator-friendly management of green areas.
- Ensure that pollinator conservation strategies are included in green infrastructure management and sustainable development strategies.
- Map existing pollinator habitats and connect them by green urban networks.

The context for local action is mainly set by the Convention for Biological Diversity (to which the EU and all member states are signatories), the Sustainable Development Goals (SDGs) and the EU Pollinators Initiative.

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ARTHROPOLOGIA, INRA PACA, 2014. Helping Wild Bees and Nature Find a Home in the City – Ecological Guidelines for Green Space Management in Urban and Peri-urban Areas (1st ed.), pp 128

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Matthew Shepherd, Mace Vaughan, and Scott Hoffman Black, 2008. Pollinator-friendly parks: how to enhance parks, gardens, and other greenspaces for native pollinator insects. The Xe-rces Society for Invertebrate Conservation, Portland, OR

Scottish Natural Heritage, 2019. Pollinators in Planning and Construction: A brief guide for the development sector

LIST OF ALIEN INVASIVE SPECIES OF EU CONCERN

SCIENTIFIC NAME	COMMON NAME
Acacia saligna (Acacia cyanophylla)	Golden wreath wattle
Ailanthus altissima	Tree of heaven
Alternanthera philoxeroides	Alligator weed
Andropogon virginicus	Broomsedge bluestem
Asclepias syriaca	Common milkweed
Baccharis halimifolia	Eastern baccharis
Cabomba caroliniana	Fanwort
Cardiospermum grandiflorum	Balloon vine
Cortaderia jubata	Purple pampas grass
Eichhornia crassipes	Water hyacinth
Elodea nuttallii	Nuttall's waterweed
Ehrharta calycina	Perrenial veldt grass
Gunnera tinctoria	Chilean rhubarb
Gymnocoronis spilanthoides	Senegal tea plant
Heracleum mantegazzianum	Giant hogweed
Heracleum persicum	Persian hogweed
Heracleum sosnowskyi	Sosnowsky's hogweed
Humulus scandens	Japanese hop
Hydrocotyle ranunculoides	Floating pennywort
Impatiens glandulifera	Himalayan balsam
Lagarosiphon major	Curly waterweed
Lespedeza cuneata (Lespedeza juncea var. sericea)	Chinese bushclover
Ludwigia grandiflora	Water-primrose
Ludwigia peploides	Floating primrose-willow
Lygodium japonicum	Vine-like fern
Lysichiton americanus	American skunk cabbage
Microstegium vimineum	Japanese stiltgrass
Myriophyllum aquaticum	Parrot's feather
Myriophyllum heterophyllum	Broadleaf watermilfoil
Parthenium hysterophorus	Whitetop weed
Pennisetum setaceum	Crimson fountaingrass
Persicaria perfoliata	Asiatic tearthumb
Prosopis juliflora	Mesquite
Pueraria lobata	Kudzu vine
Salvinia molesta (Salvinia adnata)	Salvinia moss
Triadica sebifera (Sapium sebiferum)	Chinese tallow

POLLINATOR-FRIENDLY MEASURES

PRIVATE GARDENS

PROVIDING AND INCREASING FORAGING HABITAT FOR POLLINATORS

1. Identify and protect existing sources of food for pollinators in your garden: patches of wildflowers; flowering hedgerows, trees, ect.
2. Reduce the frequency of mowing in some parts of your garden and allow wildflowers to bloom.
3. Mix flower types in order to ensure different flowering periods throughout the year.
4. Use entomophilous plants and avoid species with poor pollen and nectar production.
5. Exotic ornamental plants can be useful for their long blooming period and large flowers but avoid invasive species and double-flowered varieties.
6. Select and favour endemic plants with high pollen and nectar production.
7. Grow pollinator-friendly flowers wherever possible: window boxes, hanging baskets, pots, etc.

PROVIDING APPROPRIATE NESTING HABITAT AND INCREASING ECOLOGICAL CORRIDORS

1. Identify and protect existing nesting habitats for pollinators in your garden: bare soil, dry-stone walls, earth banks, etc.
2. When possible, let small areas grow wild.
3. Provide nesting-sites (e.g. bee hotel) for wild bees.
4. Never use pesticides in areas destined for nesting.

PUBLIC GREEN AREAS

PROVIDING AND INCREASING FORAGING HABITAT FOR POLLINATORS

1. Identify, map and protect existing sources of food for pollinators; manage and restore semi-natural habitats and their native plants.
2. Reduce the frequency of mowing to one cut per year in some areas; this allows wildflowers to bloom and provides undisturbed areas for nesting, while saving public funds and reducing greenhouse gas emissions.

3. Mix flower types to ensure different flowering periods throughout the year.
4. Choose entomophilous plants and avoid species with poor pollen and nectar production.
5. Exotic ornamental plants can be useful for their long blooming period and large flowers but avoid invasive species and double-flowered varieties.
6. Increase the number of native flowers and trees with high pollen and nectar production and of local provenance.
7. Grow pollinator-friendly flowers wherever possible: roadside and path verges, flowerbeds, roundabouts, etc.

PROVIDING APPROPRIATE NESTING HABITAT AND INCREASING ECOLOGICAL CORRIDORS

1. Identify, map and protect existing nesting habitats for pollinators, managing and restoring bare soil, dry-stone walls, earth banks, etc.
2. Leave small areas to grow wild wherever possible.
3. Provide nesting-sites (e.g. bee hotels) for wild bees.
4. Never use pesticides on areas destined for nesting; replace chemical fertilizers with organic products.

RAISING PUBLIC AWARENESS

1. Put up signs explaining the importance of pollinators and to demonstrate what is being done to support them.
2. Promote and distribute pollinator-friendly guidelines.
3. Facilitate training programmes on pollinators and how to take action to protect them Track and communicate all progress.

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