What biodiversity in the city ?

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Even if the urban environment imposes very strong constraints on the animals and plants that inhabit it, the biodiversity of our cities is rich in many diverse species. All these species form the urban ecosystem that provides valuable services to urban dwellers. We still need to make cities welcoming for fauna and flora.

1. The city, a place where many animal and plant species live

A city is an environment where a large human population is concentrated and which organizes its space according to needs and activities. The ecological characteristics of cities are quite particular due to the concentration of buildings of all kinds and the importance of human activities. In reality, these characteristics may vary according to the density of human populations, the geographical location and the type of activity (city centre, peri-urban districts, etc.). Nevertheless, the human presence is still more significant than in rural areas.

What are the consequences of the high human concentration in cities? Areas likely to support biodiversity are very small in size, and surrounded by buildings, streets, walls, structures that do not suit the lifestyle of a number of species because they cannot find food or shelter there... In fact, the isolation of these areas, within an inhospitable urban matrix, prevents most organisms from migrating from one area to another. The consequence of this isolation is a loss of viability of plant or animal populations through genetic impoverishment and inbreeding.

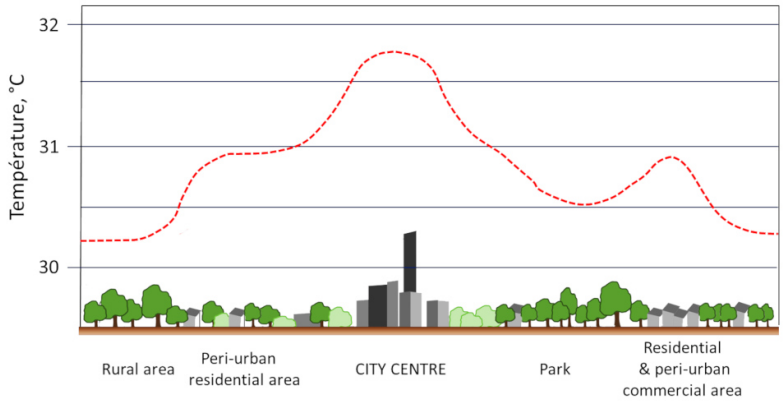

Figure 1. Schematic representation of an urban heat island. [Scheme adapted from Alexchris (Public domain)], via Wikimedia Commons]

Another particularity of the urban environment is its artificial microclimate, which is warmer and drier than its surrounding areas. This phenomenon called "urban heat island" (Figure 1) is due to human activities concentrated in cities, some of which produce a lot of heat, such as factories, vehicle engines, building heating, air conditioning, hot water circulating in sewers, etc. It is also the result of waterproofing urban soils that absorb solar radiation and then return it as heat, something that plant covered soils do not do.

Figure 2. Plant (young birch) growing in the crevice of a street surface. [Source: gcardinal from Norway [CC BY 2.0], via Wikimedia Commons]

Finally, organisms, animals and plants, like humans, are subject to urban pollution to which they are more or less sensitive. This pollution is the result of the emissions of various gases from road traffic, industrial activities and district heating. The main pollutants encountered are nitrogen oxides (NO and NO_2), carbon monoxide, volatile organic compounds, ozone formed by photochemical reaction in sunny weather and fine particles (see Air Pollution). All these molecules are absorbed by living organisms causing more or less damage (see What is the impact of air pollutants on vegetation?). Rainwater in cities is loaded with pollutants along its route, linked to car traffic and industrial activity. Polluted air and water as well as liquid or solid gaseous discharges from human activities also load the soil with toxic substances. These frequently reworked soils are a heterogeneous substrate that is not always ideal for the harmonious growth of a wide range of plants (Figure 2).

Other sources of pollution are light and noise pollution that cause serious damage to sensitive species (see What is the ecological impact of light pollution?). An example is bats, whose behaviour changes because of artificial light at night. Some very common species hunt insects attracted to the halos of streetlights. Other more rare species are very frightened and flee the cities for better preserved spaces.

In addition to the abiotic characteristics of the urban environment mentioned above, urban sites are subject to strong direct pressures due to the high concentration of urban dwellers on small areas: the soils are trampled and compacted. The concentration of animal and plant species in small areas leads them to more intense relationships, whether they are predation, competition, facilitation,... Epidemics are more violent and serious even if the microorganisms are less diversified in the city

centre.

2. Why preserve biodiversity in the city?

The growing literature on the subject clearly shows that the quality of life of urban dwellers and even their health is closely linked to the quality of biodiversity in the neighbourhoods in which they live.

Through the services they provide, urban plants help to improve the quality of air, water and soil. Trees in particular absorb significant amounts of pollutants. They play a significant role in the carbon cycle and have a significant impact on neighbourhood temperatures, especially in the event of severe heat waves. Indeed, the water taken by the roots of the trees and circulating (the sap) to the leaves evaporates thanks to the stomata. This conversion of liquid water into water vapour (evapotranspiration), which uses large amounts of solar energy [1], has a particularly appreciable local cooling effect during the summer months.

Nature in the urban environment provides psychological and physical benefits for urban dwellers when they live in neighbourhoods rich in green space. This is why many cities set up many parks or squares, so that each city dweller has a public garden within walking distance. Studies show that in greener neighbourhoods, urbanites are less prone to allergies, cardiovascular disease... Indeed, these spaces improve local air quality and their pleasant landscaping encourages residents to use them for walking or playing sports. As a result, they have a positive impact on the health of city dwellers.

Urban biodiversity also has cultural and educational virtues. It provides an opportunity to raise awareness of environmental issues among a wide audience, starting with children. A large proportion of small urban dwellers are in contact with nature only in the areas around their homes. The growing interest in associative initiatives whose objective is to show the nature of cities (nature festivals and other events around biodiversity for example) or the success of certain participatory science programmes (see focus on Participatory sciences) whose objective is to collect data on the functioning of biodiversity in cities (*Sauvage de ma rue* [2], *Lichen go* [3], garden biodiversity...) demonstrates the importance in preserving green spaces in the most central districts.

Figure 3. Apartment with flower and vegetable garden, in the city centre of Aretxabaleta (Spain). [Source : Vmenkov (CC BY-SA 3.0), from Wikimedia Commons]

Urban agriculture tends to be renewed in our cities. Whether for leisure or economic reasons, vegetable gardens are returning to the neighbourhoods (Figure 3). Fruit and vegetable production is based on good quality soils and water as well as pollinating or regulating organisms for crop pests.

In addition to these purely utilitarian arguments, preserving nature in cities means preserving part of the biodiversity of certain regions. Indeed, since urban territories are becoming increasingly large and urban sprawl sometimes takes place in areas rich in fauna and flora, preserving urban biodiversity is potentially a way to preserve certain species. Some examples found in the literature: very rare plants grow around Perth Airport in Australia [4] or a beautiful population of a lizard that is declining sharply throughout its range, lives on a greenway in Oklahoma City, USA [5].

Similarly, the preservation of areas dedicated to biodiversity in cities allows them to act as corridors for fauna and flora,

continuous or discontinuous for species likely to cross the city from peri-urban populations. In Brisbane, Australia, this is the case of a marsupial who occupies urban sites as soon as they are connected, even episodically, to populations on the fringes of the city.

3. What species in the city?

The major taxonomic groups are almost all represented in the city. As in many other terrestrial ecosystems, aquatic species suffer most from developments that are often at the expense of wetlands. For example, amphibians are often at high risk in urban areas. Otherwise, plants, herbivores or phytophages, carnivores may be found in cities. Apart from trees that have a special status, urban animal and plant organisms are of modest size. In French metropolitan cities, the largest animals are domestic or in captivity.

3.1. Cultivated and domestic species

Figure 4. Green wall and roof.. A (left), Plant wall of the Musée du Quai Branly (Paris); [Source © Patrick Blanc (CC BY 2.0), via Flickr] ; B, (right) Green roof of a building on the NIH campus (Bethesda, Maryland, USA) [Source © Djembayz (CC BY-SA 3.0), via Wikimedia Commons].

One of the characteristics of urban biodiversity is that it is composed of a large proportion of cultivated or domestic species. For the flora, we think of all the horticultural or vegetable species that populate houses, balconies, public and private gardens, flower beds in the streets... Several hundred species are mobilized to accompany us. Among the cultivated flora are species on the ground, on walls and on roofs and terraces (Figure 4). Due to the characteristics of these different structures, the plant communities are not identical: on the walls grow mainly plants that like shade and humidity. On roofs and terraces, it is the plants in upland areas that are most enjoyable.

Species come from a variety of geographical regions. Some are local, they have been part of the flora of our country for several hundred years, white stoneware (*Sedum album* L.) for example is used to green some roofs (Figure 5). Many others are exotic. The agapanthus (*Agapanthus praecox* Willd.), for example, which flowers nicely in many gardens, comes from South Africa (Figure 5).

Figure 5. A (left), White Stone Plant [Source Photo © Franz Xaver (CC-BY-SA-3.0), via Wikimedia Commons] ; B (right), Agapanthus flower [Photo © Pierre Mirosa (CC BY-SA 4.0), via Wikimedia Commons].

The alignment trees that line avenues and boulevards - including plane trees, horse chestnut trees and silver lime trees - are of

real importance in the urban environment. It has been demonstrated that a tree-lined urban environment contributes to improving the living conditions of urban dwellers. The 100,000 or so trees in the streets of Paris have many beneficial properties: they contribute to the urban green fabric by creating corridors for a number of species, regulating microclimates and influencing the water cycle. Indeed, they provide a beneficial summer shade during hot weather. Their evapotranspiration (see above, section 2) cools and hydrates the air. Their foliage modifies the air flows that contribute to aerate the city but also to reduce the force of turbulence.

Urban forests sequester some of the greenhouse gases, including CO_2, and produce oxygen owing to photosynthesis. They purify a fraction of air pollution, particulate and gaseous (CO, NO_X and NO_2, and some non-biodegradable toxic substances for example). Finally, the tree enriches the soil with bacteria and fungi that degrade complex organic pollutants (some pesticides, PAHs, organochlorines, etc.). Increasing the number of urban trees, and greening cities leads to a reduction in pollution.

Figure 6. Hollow rose flowers in the city (metro in Korea). [Source : Photo, CC0 Public Domain, via Max Pixel]

For animals, dogs and cats are extremely numerous. They have a strong impact on the urban ecosystem. Studies show that these animals are terrible predators, killing billions of birds, lizards and small mammals. They enrich the soil with their excrement.

Whether animal or plant, domesticated species are likely to establish and prosper in the urban environment. Examples include hollyhocks (*Alcea rosea* L., Figure 6) escaping from gardens or Florida turtles *(Trachemys scripta*) released into the urban wilderness, which can be found outside areas where they have been raised or cultivated.

3.2. Wild species on my street

Figure 7. A, Annual bluegrass plant [Source photo, Rasbak (CC BY-SA 3.0), from Wikimedia Commons]; B, Canada fleabane plant. [Source Photo © Phil Bendle (CC BY-SA 3.0 New Zealand License), via Kete New Plymouth]

Wild plant species are quite few wild plant species. The richness of natural communities depends on the diversity of the spaces that make up the urban ecosystem because each type of environment, which corresponds to a type of use, has its own set of species: lawns, wastelands, vegetable gardens, etc. Depending on management practices, we can move from grass to lawn,

meadow, wasteland or even urban forests. Naturalist databases report annual bluegrass (*Poa annua* L.), dandelion *(Taraxacum officinale* F.H. Wigg) or Canadian fleabane (*Erigeron canadensis* L.) as some of the most common species (Figure 7). In general, species are very common. For many of them, they are pioneer or ruderal species. They are well adapted to the disturbances linked to the activities of city dwellers, trampling, mowing or regular uprooting. There are about 1000 plant species in Paris intramuros.

The most threatened are wetland plants that have been largely drained during the urbanization phases. Some ferns in particular are protected because they are becoming scarce in the city.

Figure 8. Necklace parakeet in the Parc de Sceaux (Paris). [Source: Vianney Tran (CC BY-SA 2.0), via Wikimedia Commons]

Among all the plants living in cities, some species come from remote areas and have significant proliferation capacities. They are called invasive alien species (see Climate change and globalization, drivers of insect invasions & When invasive plants also wander in the fields). Many of them, coming from hot countries, find in cities the conditions favourable to their proliferation. The roads give them access to the hearts of cities.

On the wildlife side, the most visible are birds. Several dozen species populate our cities. House sparrows, blue tit, common starling, blackbird and black swift are among the most common species. Some species are exotic, such as the beetle pigeon or the collared parakeet (Figure 8). In the urban environment, adapted birds find nesting places and abundant feeding resources, so the abundances observed can be very high. The house sparrow remains common in the city. Its decline is mainly documented in rural areas. The window swallow finds its main nesting habitat in Western Europe in the city. In winter, the city loses some migratory species but also gains some non-breeding species such as alder tarin, which come to seek food and heat.

Figure 9. Fox on Ayres Street, Southwark (London borough). [Source: photo © Dun.Can (CC BY 2.0), via Flickr]

As far as urban mammals are concerned, there are only about ten species. In our highly urbanised European cities, the last references to large mammals, carnivores or herbivores, wolves, deer, etc. date back several centuries, even if wild boars are increasingly reported in some outlying districts. Hedgehogs, moles, martens, squirrels, rats and mice, rabbits or foxes (Figure 9) and some species of bats are about the only mammals found in urban centres. While most thrive thanks to a very adapted lifestyle (prolific reproduction, night life...), others suffer from too difficult conditions. Hedgehogs in particular are in sharp decline due to the increasing scarcity of insect or gastropod species on which they feed, killed by insecticides or slug pellets. Fencing between gardens in increasingly large urban areas that prevent genetic exchanges between populations, as well as deadly encounters with vehicles on the road, make them a highly threatened species.

Figure 10. Lonely bee species. A, Carpenter bee, Xylocopa violacea [Source Photo © Jacques Joyard) ; B, Horned osmie, Osmia cornuta [Photo © Bj.schoenmakers (CC0), via Wikimedia Commons].

The warm urban environment and the high availability of food resources also attract many small invertebrates. Beetles, for example, can be observed in many gardens. Studies have shown that the more gardens are connected to each other by hedges or other vegetated structures, the more small detritus feeders they contain. In general, the city appears to be a refuge for generalist insects, adapted to varying living conditions in highly disturbed environments. Butterflies often desert city centres but can be found in large numbers in gardens when they have a few unmanaged spaces and when the floral resource is quite abundant. Other pollinating species are also found in cities, especially solitary bees (Figure 10), which are responsible for most of the pollination of entomophilic plants in cities, or are not too competitive with honeybees from the many hives placed in certain areas.

Many insect species are poorly perceived by urban dwellers, such as bed bugs, food mites or cockroaches. These species find in the human way of life the ideal conditions for proliferation.

4. Welcoming more effectively biodiversity in cities?

The most important factor that governs the quality of biodiversity is the place it is given: vast green spaces, many gardens, connected to each other by vegetalized structures within the urban matrix. Buildings and other artificial surfaces can support vegetation as long as the planting was planned at the time of construction.

Management must be diversified according to spaces and uses. Pesticides must be banned for their toxicity to biodiversity and

dangerous to the health of urban dwellers. Mowing and pulling up must be spaced out over time to allow the species to complete their life cycle.

Figure 11. Garden in Bercy Park (Paris) [Source: Patrick GIRAUD (photo) Original uploaded by Calips (Transfered by Tangopaso) (CC BY-SA 1.0), via Wikimedia Commons]

In conclusion, preserving fauna and flora is necessary even in cities. Nevertheless, it is up to city dwellers to choose the species with which they want to live. Often it is a question of finding the best compromise between what is desirable for biodiversity, what is economically possible and what is compatible with the way of life and perception of urban dwellers.

Nevertheless, as part of climate change, our regions are increasingly subject to catastrophic events, floods, storms or heat waves (see Extreme Weather Events and Climate Change). It is by implementing effective urban renaturation policies that cities will have a chance to escape the worst. The abandonment of chemicals in public spaces is already beginning to yield results, since at the beginning of the 21st century, the urban environment is the only terrestrial environment that is seeing its biodiversity increase (Figure 11).

5. Messages to remember

The ecological characteristics of cities are quite particular due to the concentration of buildings of all kinds and the importance of human activities.

In cities, the areas likely to host biodiversity are very small in area, and isolated from each other by buildings. It is hot and dry. The air, water and soil are more polluted than elsewhere.

Nevertheless, there is sometimes an abundant biodiversity in the city, depending on the quality of the management and configuration of the city. Cultivated or domesticated animals and plants live alongside wild species.

The quality of biodiversity depends on the place it is given and the management applied to it. But in return, it provides city dwellers with many services and benefits that are essential to their quality of life and health.

References and notes

Cover image. Aerial view of Paris above the "Jardin des Plantes". Urban green spaces contain a large part of the biodiversity of

cities. Waterways or tree lines can provide ecological corridors for some animal and plant species. [Source: screenshot Géoportail © IGN]

[1] A large tree can evaporate hundreds of litres of water vapour, using 0.7 kWh/L of energy to convert liquid water into vapour.

[2] http://sauvagesdemarue.mnhn.fr/

[3] http://www.particitae.upmc.fr/fr/participez/suivez-les-lichens.html

[4] Close DC, Messina G, Krauss SL, Rokich DP, Stritzke J & Dixon KW (2006) *Conservation biology of the rare species Conospermum undulatum and Macarthuria keigheryi in an urban bushland remnant*. Australian Journal of Botany 54(6) 583-593

[5] Endriss DA, Hellgren EC, Fox SF & Moody RW (2007) Demography *of an urban population of the Texas horned lizard (Phrynosoma cohnutum) in central Oklahoma*. Herpetologica 63:320-331

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