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The role of biodiversity conservation in education at Warsaw University Botanic Garden

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Abstract: The Botanic Garden of Warsaw University, established in 1818, is one of the oldest botanic gardens in Poland. It is located in the centre of Warsaw within its historic district. Initially it covered an area of 22 ha, but in 1834 the garden area was reduced by 2/3, and has remained unchanged since then. Today, the cultivated area covers 5.16 ha. The plant collection of 5000 taxa forms the foundation for a diverse range of educational activities. The collection of threatened and protected Polish plant species plays an especially important role. The Botanic Garden is a scientific and didactic unit. Its educational activities are aimed not only at university students, biology teachers, and school and preschool children, but also at a very wide public. Within the garden there are designed and well marked educational paths dedicated to various topics. Clear descriptions of the paths can be found in the garden guide, both in Polish and English. Specially designed educational games for children, Green Peter and Green Domino, serve a supplementary role. On demand, the garden staff organize special tours on specific topics, such as “Plants of the Meadows and Forests of Poland”, and “Adaptations of Plants to Different Environments”. Each year there are also several exhibitions and shows aimed at presenting various plant groups. One of the most popular is “Plants, Insects and Honey”. A wide range of workshops is also available there. One of them is “Under the Ginkgo tree leaf”. The Botanic Garden of Warsaw University also serves as a place for the conservation of plants traditionally grown in Polish village gardens. For this purpose the Kurpie Border was created to familiarize visitors with the issues of the conservation of the biological diversity of the Polish countryside.

Keywords: garden collection, conservation, educational activities

Introduction

The Convention on Biological Diversity (Dz.U. 2002 no. 184 item 1532), adopted in 1992 and signed by Poland in 1996, points out the need for the conservation of biological diversity, the entire natural heritage, which is a common concern for humankind. This is the first of the three main goals established in the Convention, along with the sustainable use of biodiversity components, and the fair and equitable sharing of benefits arising from genetic resources. The principal method for the conservation of biodiversity is *in situ* preservation, i.e. on the site where a particular natural component is present. On such sites, protected areas are established, biodiversity of damaged ecosystems is restored, populations of valuable and threatened species maintained or restored, and the introduction of alien species or genetically modified organisms is prevented. Apart from these measures, traditional folk knowledge and practices promoting conservation and the sustainable use of biological diversity should be preserved. The *in situ* conservation is complemented by *ex situ* measures which serve for the preservation of biological diversity in places other than natural habitats, e.g. in botanic gardens. (https://www.mos.gov.pl/artykul/2959_materialy/10650_konwencja_o_roznorodnosci_biologicznej.html). Article 9 of the Convention, addressing the *ex situ* conservation of biodiversity components, stresses the importance of adopting conservation measures, preferably in the country of origin of such components. Hence, the enormous role of botanic gardens in the conservation of native flora and vegetation, including rare, protected and threatened species.

The first International Agenda for Botanic Gardens, prepared in 2000, indicated the role of botanic gardens in the conservation of plant biodiversity. This involves, for example, the documentation of the biodiversity; development, maintenance and verification of plant collections, which are readily available material for studies on biodiversity; making botanic gardens centres of reference for the identification of plants; establishing methods of plant cultivation; the registration of new cultivars, the implementation of programmes for the *ex-situ* and *in-situ* conservation of threatened species, and educational activities that explain the need for and ways to protect biodiversity (WERBLAN-JAKUBIEC & ZYCH 2007).

History of the Warsaw University Botanic Garden

The Warsaw University Botanic Garden was established in 1818 by Michał Szubert, a professor of botany. Up to 1834 it covered over 22 ha (about three times greater than today) between the Belvedere Palace and Łazienki Park, in the centre of Warsaw. In the early days of its operation, in 1819, the Garden published a plant list containing 5000 species, and another one, in 1824, with 10,000 taxa. Unfortunately, the historical circumstances in Poland led not only to a reduction in the Garden's size after the November Uprising (1834), but also to a significant depletion of plant collections in subsequent years. Successive guardians and directors of the Garden tried as much as possible to bring back

order in the Garden, but this happened only after the revival of Warsaw University in 1916. Before World War II, from 1919, when the Garden was managed by Professor Bolesław Hryniewiecki, there were significant changes: greenhouses were rebuilt, all plots rearranged, and a number of new plant groups and species were introduced. The Garden began to regain its former glory. A research laboratory and the Department of Plant Taxonomy were established at the Botanic Garden. This allowed for the on-site organization of lectures and presentations, and the sampling of plant material for workshops and scientific research. The Garden could now serve its purpose: to contribute to science, both in terms of creative research and by teaching university students, and to promote knowledge about flora among Polish society on a large scale (HRYNIEWIECKI & KOBENDZA 1932). Unfortunately, another war caused enormous damage in the Garden. At the beginning of the war, in 1939, two greenhouses were demolished, and in 1942, after the evacuation of the scientific staff and the closure of the Garden, the area was devastated. In 1944, during the Warsaw Uprising, all the buildings in the garden were destroyed. The Botanic Garden became totally derelict. The restoration of the Garden began after the war. Over several years garden facilities and greenhouses were rebuilt. The reconstruction and rearrangement of the park's plant collection and paths began, and an irrigation network was installed. New ponds with aquatic plants were created, and the New Alpinarium, a section of alpine plants, mostly originating from the Polish mountains, was established. From 1960, when research assistant Ludmiła Karpowiczowa became the Head of the Garden, new investments were made, plant collections were enlarged, and botanical knowledge was again promoted among the public. In 1965 the Botanic Garden was included in the List of Cultural and Scientific Heritage of the capital city of Warsaw. The years following the death of Ludmiła Karpowiczowa in 1973 were a period of inactivity, until the appointment of a new manager, Dr Hanna Werblan-Jakubiec, in 1987 (WERBLAN-JAKUBIEC 1991). Every year the Garden became more beautiful. Greenhouses were renovated and extended, and a number of plant sections were rearranged. The enrichment of the plant collections continues today, and the future presents new challenges to the Garden's staff, such as the redevelopment of educational and research facilities, the establishment of a museum, and many other initiatives.

Collections at the Warsaw University Botanic Garden

Currently, the collections at the Warsaw University Botanic Garden comprise over 7500 plants from over 5000 taxa in 22 sections (data from the Genesis database for 23 July 2015).

The park zone of the Garden consists of the following plant sections: The New Alpinarium (with species from the European mountains), The Old Alpinarium (with mountain species from outside Europe), the Arboretum (with a rich collection of trees and shrubs, including 23 monuments of nature), the Biology of Plants, the Carpathian Beech Forest (with species characteristic of a fertile Polish mountain beech forest), Polish Lowland Flora (with species characteristic

of different plant communities that are found in the Polish lowlands), Habitat Groups (with species from different habitats, e.g. dunes - inland and coastal, saline, steppe), Climbers, Gardens in Kurpie (with plants typical of old cottage gardens), Medicinal Plants, Cover Crops, Ornamental Plants, Crop Plants, Aquatic Plants, a Rose Garden, and Plant Taxonomy.

Visitors have access to greenhouses: Tropical, Subtropical (with a collection of crop plants), the Cold Greenhouse (with a collection of succulents and plants from the Mediterranean zone), and the Palm House.

A separate collection, grouping plants from different sections, is called Protected Plants of Poland and Endangered and Threatened Plants of Poland. Most of these plants are gathered in four sections: Habitat Groups, Aquatic Plants, Polish Lowland Flora, and the New Alpinarium. Protected plants of Poland are represented in the Garden by 165 taxa and 357 specimens. The Garden has a collection of 110 plant species threatened or endangered in Poland, including: extinct in Poland (EX) – 4, extinct in the wild (EW) – 2, critically endangered (CR) – 21, endangered (EN) – 5, vulnerable (VU) – 40, least risk/concern (LR or LC) – 9, data deficient (DD) – 29 (MIREK et al. 2006, KAŹMIERCZAKOWA et al. 2014).

Information on sections, collections and plants are stored in the Genesis electronic database. This serves not only as a record of the collected taxa, but also allows users to enter detailed information on individual plants or introduced specimens. The most valuable species in the Garden are taxa collected from natural habitats. Polish Lowland Flora is a particularly valuable collection as natural habitats have been documented for almost all plants from this section. This aim was adopted at the beginning of the creation of the collection and during its restoration in the post-war period in the 1950s. *Osmunda regalis* is one of the oldest plants in this section. Collections of Habitat Groups and the New Alpinarium also include plants of known origin documented from the late 1980s. The collection of protected and threatened plants of Poland mainly gathers plants from known sites in Poland, but some species come from other countries, not only in Europe. This was possible through the international exchange of seeds (*Index Seminum*), and sometimes plants, between botanic gardens around the world.

Aims and activities of the Warsaw University Botanic Garden

Botanic gardens primarily serve as venues for scientific activity (in particular the creation and extension of plant collections), teaching, popularization of knowledge, and recreation (as a place of rest available on specific terms to the general public). In addition, as specified in Article 69 of the Act on the Conservation of Nature (Dz.U.2004 no. 92 item 880), the Warsaw University Botanic Garden, like all botanic gardens in Poland, is obliged to carry out a series of activities aimed at protecting species, including those threatened with extinction. The entire operation of the Garden has been oriented towards its main role, which is the conservation of biodiversity.

Since the Warsaw University Botanic Garden is small, and is located in the centre of a big city, it is unsuitable for typical research on biodiversity or the *ex situ* conservation of species. The extensive plant collections, including protected and endangered species, serve for educational and popularization purposes. Taxa gathered in sections reflect the diversity of flora, but also serve to preserve it for future generations, as well as for scientific research.

Many educational activities are carried out in the Garden: These include:

1. Classes for students from the Institute of Biology, Warsaw University, on botany, horticultural botany, practical botany, educational botany, conservational botany and dendrology. There are also lectures on the fundamentals of plant biology, the biology of pollination, succulents of the world, and seminars organized by the Botanic Garden, for example "Contemporary problems in nature conservation".
2. Classes for students of Postgraduate Studies for Natural Science Teachers, e.g. on “Organisms in the natural environment”, and workshops on the conservation of plant species.
3. Workshops for younger and older children from primary schools: “Under the Ginkgo tree leaf” (http://www.ogrod.uw.edu.pl/edukacja/gry_edu.htm), “Winged worlds” (http://www.ogrod.uw.edu.pl/aktualnosci/skrzydlaty_swiat.pdf), and “Small worlds” (http://www.ogrod.uw.edu.pl/aktualnosci/WARSZTATY_info.pdf).
4. Classes on natural science and botany for children from kindergartens, and primary and secondary schools. These classes address the following topics: Threatened and protected species in the collections of BGWU, Plants of Polish meadows and forests, Adaptation of plants to different environments, Trees and shrubs of Polish flora, The most interesting trees and shrubs in the Botanic Garden, Plant species native to Poland, Identification of leafless trees and shrubs, Gymnosperms, Historic and contemporary flowerbed plants, Roses in our gardens: care, growing and protection, Perennials and their use, Seed dispersal strategies, Pollination strategies, Plants in religion, culture and art, Useful plants, Plant adaptations to growth in humid tropical forests, Different types of traps in carnivorous plants, Tropical crop plants, Epiphytes – growth and cultivation, and Race for light – climbers and lianas.
5. Educational paths are designed in a way enabling each visitor unassisted tours around the garden. The following paths have been created: Monuments of nature, Protected plants of Poland, Who benefits from flowering plants?, Journeys of plants, Plants from different environments, Useful plants, Tropical crop plants, Climbers – what are they? A number of relevant folders and leaflets have been prepared for specific paths.
6. A guide to the Botanic Garden, with description of sections and educational paths. A Mobile Guide to the Botanic Garden for Android and iOS systems was prepared recently.
7. Educational games: Green Peter – presenting pairs of a crop plant and material obtained from it, and Green Domino, where players have to match

plants and their natural habitats. These games, intended for the youngest members of the public, are additional elements accompanying the educational paths.

8. The Botanic Garden is a venue for research carried out by students writing Bachelor's, Master's or doctoral theses.
9. Each year the Botanic Garden organizes "Meetings with nature at BGUW" and accompanying events; for example, in 2015 these were:

   9-10.05 Magnolias, lilacs and azaleas – a walk around the Garden
   16.05 The Night of Museums at the Botanic Garden – Light performance on "Wonderful plants"
   16-17.05 Exhibition of carnivorous plants
   20-21.06 Exhibition of cacti
   27.06 Warsaw full of flowers
   27-28.06 Exhibition of African violets
   11-12.07 Festival of roses
   5-6.09 Plants, insects and honey – a family educational event
   12-13.09 Days of orchids
   13.09 The Day of the Warsaw Escarpment
   19-27.09 Festival of Science.

Our event "Plants, insects and honey" has always been the most popular among visitors. In 2014, from June to October, a survey was carried out, aimed, among other things, at identifying the special events most popular among visitors to the Botanic Garden. As many as 78% of respondents were most enthusiastic about "Plants, insects and honey". During the festival members of the public have an opportunity to learn about beautiful and interesting species of pollinators, and to find out how to help them. In 2015 the Garden plans to organize a play for families entitled "How to watch insects", workshops on making and painting houses for wild bees, horticultural presentations and consultations, "True tales about insects" for the youngest visitors, a presentation of pollinator species native to Poland, a walk with an entomologist, pollination games, origami workshops, face painting, and a fair of honey and other bee products.

The most interesting collections at the Warsaw University Botanic Garden

As mentioned earlier, one of the most important collections in the Warsaw University Botanic Garden is that of Polish lowland flora. Now it consists of more than 350 taxa characteristic of different plant communities found in the Polish lowlands. Before World War II this section occupied a much larger surface area, and plantings were organized in a taxonomic order, on regular plots intersected with narrow paths. The Polish flora section was destroyed during the war, along with the whole Garden. In the 1950s it was not restored to its previous layout, but reduced in size and thoroughly transformed. Plants were grouped in two plots on irregular beds, separated by narrow grass paths. The aim of this arrangement was to create the most naturalistic section possible in the Garden

(KARPOWICZOWA 1967). Plant species were grouped in families. The pre-war practice was continued, and species native to Poland were grown here, brought directly from natural habitats by the staff of the Garden after expeditions and trips. After the war the curator of this section, Pelagia Podlecka, MSc, organized a special register wherein information on plant origin, collection date and name of collector was stored. Later on, from the 1970s until the mid-1980s, this section was somewhat neglected, as was the entire Garden. Fortunately, when the new head of the Garden, Dr Hanna Werblan-Jakubiec, was appointed, a new young and eager curator, Izabella Kirpluk, MSc, of this section was employed. It was now possible to revive the exemplary and valuable principles of the scientific approach to the management of the collection, and to collect plants from natural known sites in Poland. This approach to the management of the collection was also used in other sections of the Garden: Habitat Groups, the New Alpinarium, Aquatic Plants, the Carpathian Beech Forest and, recently, to a large extent, to the sections of Plant Taxonomy and the Old Alpinarium.

The section of Polish lowland flora gathers species characteristic of dry parts of forests, thickets and grasslands (e.g. *Dianthus arenarius, Jovibarba sobolifera, Salvia vertcillata, Scabiosa ochroleuca*), species of wet meadows and thickets (e.g. *Dactylorhiza majalis, Dianthus superbus, Gladiolus imbricata, Inula salicina, Iris sibirica, Succisa pratensis, Veronica longifolia*), species of ruderal habitats (e.g. *Artemisia absinthium, Ballota nigra, Leonurus cardiaca*), and segetal species (e.g. *Anchusa officinalis , Consolida regalis, Fumaria officinalis, Papaver rhoeas*). In 2013 a special plot was created in the section of Polish lowland flora, and it was sown with seeds of segetal species, so the next year a subsection of "Wild flowers" was formed by colourful annual weeds frequently found in old times among cereal fields. Wild flowers are represented by *Agrostemma githago, Centaurea cyanus, Consolida regalis, Matricaria maritima* subsp. *inodora, Papaver rhoeas, Thlaspi arvense, Vicia cracca,* and *Vicia hirsuta*. Some of them have the status of rare segetal species (WARCHOLIŃSKA 1994).

Plant Taxonomy is another noteworthy section. It is the largest and the richest in species section of the Garden, covers 0.7 ha, and gathers over 700 taxa. Individual adjacent beds are occupied by plants representing specific genera from the same botanical family. Families of plants are grouped into orders. The regular arrangement of beds helps to notice and learn the relationships between subsequent plant families Until recently, plants in the section of Plant Taxonomy were arranged based on the classification established in late 19th and early 20th centuries by Adolf Engler (1844-1930). This system was abandoned by botanists long time ago, but for many years it was kept here for historical reasons. In recent decades, with the strong contribution of advanced phylogenetic methods and the use of molecular techniques, an entirely new classification system known as APG (Angiosperm Phylogeny Group) (CHASE & REVEAL 2009, SOLTIS et al. 2011) was established, and it allows for the very accurate identification of links between various groups of plants. The APG system, unlike many other classification systems based on morphology and anatomy, very accurately

reflects the actual relationship between plant species resulting from shared evolutionary history. Therefore, when a new eager curator, Dr Wojciech Podstolski, was appointed to manage the Plant Taxonomy section, a decision was made to rearrange and modernize this section in line with the APG system. Because many families have changed their position with respect to the previous classification system, this process was scheduled to take many years. Many new species representing families are introduced into the collection. These also include some miniature or column forms of trees and shrubs, that can fit in the limited space available.

The Plant Taxonomy collection gathers species from 151 families out of 413 angiosperm families identified in the newly adopted APG system; of these 83 were introduced during the rearrangement that began in 2009.

The Plant Taxonomy section is divided into three plots - Taxonomy I, II, III - which correspond with relevant phylogeny groups.

Taxonomy I starts with a collection of the most primitive vascular plants, represented by ferns (Pteridophyta). Interesting species can be found here, such as *Equisetum hyemale*, *Osmunda regalis* and *Adiantum pedatum*. Gymnosperms are represented only by a single genus, *Ephedra*. The next group gathers the most primitive angiosperms, represented, for example, by genera *Schisandra* (Schisandraceae), *Asarum* (Aristolochiaceae), *Houttuynia* (Saururaceae), *Magnolia* (Magnoliaceae) and the rarely found *Asimina triloba* (Annonaceae) and *Sassafras albidum* (Lauraceae). *Laurus nobilis* (Lauraceae) is put outdoors from the greenhouse for the summer season.

A new group was formed in this section by monocotyledons (Monocotyledoneae) moved from another site. It starts with *Acorus calamus* (Acoraceae) and representatives of subsequent families, i.e. Araceae and Dioscoreaceae. Interesting plants in this section include *Trilium chloropetalum* (Melanthiaceae), *Bletillia striata* (Orchidaceae), and *Ensette* (Musaceae), *Chamaerops humilis* (Arecaceae), *Ananas comosus* (Bromeliaceae), put outdoors from the greenhouse for the warm season. The collection of monocotyledons is completed with grasses ordered according to a detailed classification system.

Grasses are followed by numerous representatives of early evolutionary lineages, know as lower dicotyledons, i.e. the families Papaveraceae, Ranunculaceae, Lardizabalaceae, and Berberidaceae, as well as Buxaceae. The family Proteaceae is represented by *Grevillea* plants, put outdoors for the summer season. This group is completed with *Gunnera manicata* (Gunneraceae).

The last group in this section, gathering more advanced dicotyledons, is the order Caryophyllales, represented by such families as Plumbaginaceae, Tamaricaceae, Polygonaceae, Caryophyllaceae, and even Cactaceae or Aizoaceae.

Other representatives of the hierarchically organised families of more advanced dicotyledons can be found in the sections Taxonomy II and III.

Taxonomy II gathers plants classified to the clade of Rosids, a large group of families related to the family Rosaceae. This section starts with representatives of more primitive families Paeoniaceae with *Paeonia delavayi*, Hamamelidaceae (e.g. *Parrotia sinensis*) and numerous representatives of the family Saxifragaceae. These are followed by families Euphorbiaceae, Fabaceae, Rosaceae, Urticaceae and Moraceae represented by *Ficus carica*, wintering under cover. Another interesting element of this section is a small collection of dwarf species and varieties from the family Fagaceae (*Quercus ilicifolia*, *Fagus silvatica* 'Felderbach'), Betulaceae (*Betula nana*) and Nothofagaceae (*Nothofagus antharctica*) from the order Fagales, dominated by numerous, usually large-size tree species. This section also includes representatives of the Geraniceae and Oenotheraceae families.

Taxonomy III includes plants from a large group of Asterids (related to the family Asteraceae). It starts with a flowerbed of plants representing the families Cornaceae (*Cornus canadensis*) and Hydrangeaceae (*Hydrangea villosa*, *Deinathe caerulea*). This is followed by families from the order Gentianales (Rubiaceae and Apocynaceae*)*, and from the order Solanales (Solanaceae and Convolvulaceae). The family Convolvulaceae is represented by an interesting parasitic species *Cuscuta europaea* found on host plants - *Urtica* and *Humulus*. A new flowerbed was created here with species from the family Oleaceae (*Fraxinus ornus* and *Abeliophyllum distichum*). The families Lamiaceae and Asteraceae are represented by an extensive number of species, with a very interesting giant *Dahlia imperialis* (Asteraceae). This section is completed with species from the family Araliaceae, for example, *Aralia elata* and *Hedera rhombaea*, and specimens of *Hedera colchica* obtained from natural habitats. The sister family Apiaceae will be moved to this section in subsequent years.

Summary

The Warsaw University Botanic Garden has an almost 200-year-long tradition, and impressive collections of plants grouped in many sections and greenhouses. The garden occupies relatively small area in the centre of the capital city of Warsaw. With a convenient location and valuable collections this Botanic Garden is a place that everyone can easily reach and, regardless of age and knowledge already possessed, where everyone can gain more information on the world of plants and its splendid diversity.

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