INTERNATIONAL PROGRAMMES FOR SEED PRESERVATION OF EUROPEAN NATIVE PLANTS

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SUMMARY

About 21% of Europe's vascular plants are listed as threatened with extinction according to IUCN threat categories. Therefore a big attention was paid to the so called *ex situ* conservation of rare and endangered plants, native for Europe, in botanical gardens and in gene banks. According to the "European Plant Conservation Strategy", published in 2002 as a result of the 3rd Planta Europa Conference, 80% of the genetic diversity of 50% of regionally and nationally threatened European species should be stored in gene banks until the year 2010. To achieve this target several European Union projects were prepared. Among them the most important is the project ENSCONET (European Native Seed Conservation Network) carried out as the 6th framework project of the EU since November 2004. The project was initiated by the staff of the Millennium Seed Bank, a unit of the Royal Botanic Garden Kew located in West Sussex County (U.K.) at Wakehurst Place. The members of the project are 19 institutions from 12 EU countries, especially botanical gardens holding seed banks collections of rare and endangered plants of the European flora. Other EU projects also devoted to seed banks of regionally native plants are: REDBAG for the flora of Spain, BASEMAC - a special project for the unique flora of Macaronesian Islands (Canary Islands, Azores and Madeira) and GENMEDOC for the Mediterranean flora.

INTRODUCTION

It is estimated that the numbers of species of flowering plants in whole world may vary from 250.000 to 300.000 (WCMC, 1992). This number could be even higher, because many new species have not yet been discovered and identified. But among them 60.000–80.000 species are threatened with extinction worldwide (Zedan, 2000). In the "Gran Canaria Declaration", called in 2000 by 16 representatives of the world's botanical gardens it was written: "As many as two-thirds of the world's plants species are in danger of extinction in nature during the course of the 21st century, threatened by population growth, deforestation, habitat loss, destructive development, over consumption of resources, the spread of alien invasive and agricultural expansion" (BGCI, 2000). Because of such big threat of plant diversity on the global and regional scale the "Convention on Biological Diversity" was adopted by 187 parties represented by various countries during the Earth Summit, which was held in Rio de Janeiro in June 1992 (Zedan, 2003). The Convention on Biological Diversity included a special article No. 9 devoted to ex situ conservation, where botanical gardens were indicated as the major practitioners of ex situ conservation for plants (CBD Secretariat, 2003). Following the "Convention on Biological Diversity" the "Global Strategy for Plant Conservation" was published in 2000 with a list of targets to achieve by the year 2010. Among them a special target No. VIII was called: "60 per cent of threatened plant species in accessible *ex situ* collections, preferably in the country of origin, and 10 per cent of them included in recovery and restoration programmes" (CBD Secretariat, 2000). In Europe also "The European Plant Conservation Strategy" was published by the Council of Europe and the Planta Europa in 2002 based on the texts adopted by the participants of the 3rd Planta Europa Conference on the Conservation of Wild Plants. held in June 2001 in Průhonice (Czech Republic) (Smart et al. 2002). In this document 21% of Europe's vascular plant species are classified as threatened according to IUCN threat categories, 50% of Europe's 4700 vascular plant endemics are considered to be in danger of extinction and 64 have already become extinct (Smart *et al.*, 2002). "The European Plant Conservation Strategy" has listed the rules, targets and terms for implementation in European countries before the year 2010. Four targets were devoted to *ex situ* conservation of plants (Nos. 1.9, 2.5, 2.8 and 2.11), being even more strict for the European flora, than for the world's flora in the "Global Strategy fo Plant Conservation". In target No. 2.5 it was defined that 80% of the genetic diversity of 50% regionally and nationally threatened plant species should be stored in gene banks by the year 2010 (Smart *et al.*, 2002).

The botanical gardens have prepared several programmes related to their activity in plant diversity conservation. The first one was "The Botanic Gardens Conservation Strategy" published in 1989 by the IUCN Botanic Gardens Conservation Secretariat and the WWF (Heywood, 1984), where the rules for *ex situ* conservation by the botanical gardens seed banks were defined. Later the Botanical Gardens Conservation International has become an independent, world leading organization for botanical gardens, practically coordinating all their activities, especially in the areas of biodiversity conservation and environmental education. In 2000 they published the "International Agenda for Botanic Gardens in Conservation" (Wyse Jackson & Sutherland, 2000). This document very precisely described the tasks and priorities for ex situ conservation of various endangered plants, paying a special attention to seed storage as the important conservation method. The botanical gardens in the countries - members of the European Union have established a special organization at their own called the European Botanic Gardens Consortium, which also prepared a document named "Action Plan for Botanic Gardens in the European Union" (Cheney et al., 2000). Among 35 precise objectives 3 of them were related to ex situ conservation activities also including efforts on seed and tissue storage of rare and threatened plant taxa as well as of the genetic resources of economic plants.

The seed banks in botanical gardens

The long-term seed storage started to be used for the conservation of the germplasm of cultivated plants in the year 1926, when the first plant gene bank was organized by Nikolai Vavilov in Leningrad (Ford - Lloyd & Jackson, 1986). Later after World War II many new seed banks were organized in whole world, but their goal was to preserve the genetic resources of economic plants mainly (Plucknett et al., 1987). Thanks to the development of modern seed storage techniques, offering the possibility of prolongation of storage period without loosing seed viability for more than 50, or even 100 years, the seed banks were organized in the botanical gardens for native plants occurring in the natural habitats (Eberhart et al., 1997; Hawkes *et al.*, 2000). According to the survey made by Laliberté (1997) 152 botanical gardens have seed banks, where more than 250.000 accessions of germplasm are stored, and most of them hold plant species that are rare or endangered. It means, that in 1.846 world's botanical gardens the living plant collections are the most dominant and preferable method for ex situ conservation of endangered plants. But the following advantages of seed banks in comparison to living plant collections can be indicated (Puchalski, 2000):

- 1) less hazard for changes of the genetic structure of populations induced by mutations, recombinations or natural selection,
- better safety by lack of damages risk caused by pests, diseases, animals or harsh weather conditions,
- 3) good possibility of the preservation of high number of individuals in small space and volume,
- 4) higher genetic representativity of sampled or collected plants,
- 5) elimination of genetic drift,
- 6) lower costs of collection maintenance,
- 7) approximately long period of genetic diversity preservation in uniform conditions.

All these advantages were taken into consideration by the Botanical Garden of the Polish Academy of Sciences in Warsaw, where in 1991 a seed bank for rare, endangered and protected species of the Polish flora was organized (Muranyi *et al.*, 1995). For the long-term seed storage the cryogenic technique was chosen which involves the seed preservation in the vapor of liquid nitrogen in the temperature ca. -160° C. This technique, however more complicated than storage in standard cold temperature of about -20° C, offered the prolongation of life span of stored seeds, probably for the period longer than 100 years. Our seed bank plays the role of the National Seed Bank of the Polish Flora and presently 78 species represented by 280 populations of plants collected from the natural localities in Poland are preserved there (Muranyi, 2003, 2004) (Fig. 1 a, b, c).

Among the European countries it is Spain that has the broadest network systems of seed banks for native plants. The first seed bank for collections of wild plants in European botanical gardens was created in 1966 by Professor César Gómez-Campo at the Department of Vegetal Biology of the Polytechnical University in Madrid (Gómez-Campo, 1997). It was especially devoted to the wild species of the tribe Brassiceae (Brassica, Raphanus, Sinapis, *Eruca*) occurring in the western Mediterranean area. This seed bank was a pioneer for other Spanish seed banks, which were organized in many regions of Spain to cover almost the whole territory of the country. Of particular importance in the region of Canary Islands with the richest endemic flora was seed bank in the "Viera y Clavijo" Canarian Botanical Garden located in the vicinities of Las Palmas on Gran Canaria Island. For the Balearic Islands a seed bank for local flora was also created by the Sóller Botanical Garden on Mallorca. Several seed banks were also organized in different parts of the Iberian Peninsula. For the flora of Andalusia the modern seed bank was opened in the Botanical Garden of the University of Cordoba. The University of Valencia and the Regional Valencian Government also started a project for seed banking of local flora at the Botanical Garden of Valencia. The seed bank in Valencia has elaborated methods for the longterm storage of seeds as well as for spores of ferns and mosses.

The first seed bank of native plants in Italy was organized by the Botanical Garden of the University of Palermo on Sicily. The main goal of this bank was the preservation of the unique flora from the Mediterranean Region. In the last few years a seed bank was also created at the Trident Museum of Natural History in Trento dealing with the alpine flora of northern Italy, especially from the Lombard Region.

The French botanical gardens have established a special network system for native plant conservation called the National Botanical Conservatories (Conservatoires Botaniques Nationaux) where, besides the living plant collections, seed banks were also organized. Such botanical gardens – conservatories were located in various regions of France for example in Brest, Porquerolles, Bailleul, Nancy, Gap-Charance, Mascarin and for the Massif Central. But the leading seed bank for the French native flora was created by the National Museum of Natural History in Paris.

Seed banks for wild plants were also established in the botanical gardens in Belgium (in the National Botanical Garden in Meise) and in Ireland (in the Trinity College Botanical Garden in Dublin).

But among the world's botanical gardens the biggest efforts for seed banking of native plants were put by the Royal Botanic Gardens Kew, which were called the Millennium Seed Bank Project (Linington, 1997). Thanks to big financial support from the Royal Government of the United Kingdom big resources of 80 million British pounds were invested to build a very modern seed bank in southern England (West Sussex County) at Wakehurst Place (Fig. 2). This Millennium Seed Bank was opened in November 2000 and was called also the Noah's Ark of the 21st century. The main contribution to this huge project originated from the funds of U.K.'s national lottery and from grants of Wellcome Trust and Orange plc. The Millennium Seed Bank project is devoted to the flora of British Islands, but also to the flora of various unique plant areas in the world (Tenner, 2003). The capacity of this seed bank is big enough to preserve about 10% of the world's vascular flora and about 93% of the higher plant flora of the United Kingdom. The Millennium Seed Bank project aims to collect, research and conserve over 24200 plant species, principally from arid and semi-arid regions of the world by the year 2010 (Tenner, 2003). Therefore the strong collaboration in seed collecting and preservation was established with the botanists from various regions in the world: North and West Africa, Southern Africa and Madagascar, East Africa, the Middle East, India, Australia, North America and Latin America.

The Millennium Seed Bank has very good facilities for seed testing and for research on seed biology. The seeds are stored in glass or



Fig. 1. The seed bank in the Botanical Garden of the Polish Academy of Science in Warsaw
a) general view with freezing cabinets and cryogenic containers for the long-term seed storage
b) big cryogenic vaults (capacity 500 l) for seed and tissue storage in liquid nitrogen
c) the seed samples of wild plants preserved in the vapor of liquid nitrogen (temperature ca. -160°C)

(Photo J. Puchalski)



Fig. 2. The general view of the Millennium Seed Bank at the Royal Botanic Gardens Kew at Wakehurst Place (United Kingdom). (Photo J. Puchalski)

aluminum containers in the controlled cold chambers in the temperature of ca. -20°C. All laboratories at Wakehurst Place are accessible for public visitors (Fig. 3). The staff of the MSB also provides training courses for scientists and conservationists from many countries in the areas of seed biology and long-term seed storage.

European projects for seed banking of native plants

The Millennium Seed Bank (MSB) was also a promoter of the collaboration among the seed banks of wild flora run by the botanical gardens in Europe within the framework of a special European project. The initiative to organize the European network of seed banks for native



Fig. 3. The laboratories for seed testing at the Millennium Seed Bank - opened for public visitors. (Photo J. Puchalski)

plants was called by staff of the MSB in 2002. On June 25-30, 2002 they invited botanists from 8 countries to the Wakehurst Place to prepare the draft project called ENSCONET -European Native Seed Conservation Network. The main aim of the project was the coordination of botanical garden's activities in the ex situ conservation of native plants through longterm seed storage. During the next 2 years a group of botanists from 19 institutions, representing 12 European Countries, has prepared the final version of the ENSCONET project, which was submitted to the European Commission (EC) as a proposal for financing as the EU's 6th framework project. After negotiations with the EC, the ENSCONET project was approved and officially started on November 1st, 2004. The project is designated for 5 years and the members are: Royal Botanic Gardens Kew (U.K.) as the coordinator of the project, 5 botanical gardens and seed banks from Spain (Cordoba, Valencia, Gran Canaria and Sóller botanical gardens and the Polytechnical University in Madrid), 3 institutions from Italy: Trident Museum of Natural History in Trento, University of Pavia and Botanical Garden of the Pisa University, 2 institutions from Greece: National and Kapodistran University of Athens and Mediterranean Agronomic Institute in Chania (Crete), and single institutions from: France (National Museum of Natural History in Paris), Belgium (National Botanic Garden in Meise), Austria (Institute of Botany and Botanical Garden of the Vienna University) and Ireland (Trinity College in Dublin). The new member countries of the EU are represented by: Slovak Republic (the Institute of Botany of the Slovak Academy of Sciences in Bratislava), Hungary (Budapest Zoo and Botanical Garden), Cyprus (Agricultural Research Institute in Lefkosia) and Poland (Botanical Garden – Center for Biological Diversity Conservation of the Polish Academy of Sciences in Warsaw). The ENSCONET project is divided into 4 activity groups devoted to various targets of the project:

N2 – Seed collecting (coordinator: Canarian Botanical Garden, Las Palmas)

N3 – Seed curation (coordinator: Botanical Garden – CBDC of the PAS, Warsaw)

N4 – Data Management (Trinity College, Dublin)

N5 – Dissemination (Botanical Garden of the University in Valencia)

The whole activity of the network and the realization of ENSCONET project is steered by the management team of 8 persons, activity groups coordinators and specialists:

Mr. Roger Smith (RBG Kew, MSB Wakehurst Place, UK) – project chairman

Mr. Steve Alston (RBG Kew, MSB Wakehurst Place, UK) – secretary

Dr. David Bramwell (Canarian BG, Las Palmas, Spain) – leader N2: Seed Collecting

Dr. Jerzy Puchalski (BG-CBDC, PAS, Warsaw, Poland) – leader N3: Seed Curation

Dr. Steve Waldren (BG of Trinity College, Dublin, Ireland) – leader N4: Data Management

Dr. Elena Estrelles (BG of the University of Valencia, Spain) – leader N5: Dissemination

Prof. Dr. Esteban H. Barméjo (BG of the University of Cordoba, Spain) – liaison person 1 (plant conservation initiatives)

Prof. Dr. Costas Thanos (NK University of Athens, Greece) – liaison person 2 (seed science and research development).

The results of the project will be presented during 5 annual meetings held for evaluation and discussion on the reports. Also, 5 field trips will be organized as botanical expeditions for local flora exploration and for seed collecting each year in various countries: 2004 - Greece (Crete), 2005 - Spain (Valencia), 2006 -Poland (Warsaw), 2007 – Spain (Gran Canaria) and 2007 - Italy (Trento). Such distribution of field trips will give a good possibility for getting acquainted with different floristic regions of Europe (Mediterranean, temperate, alpine/boreal and Macaronesian zones).

The ENSCONET project will serve as the collaboration platform for seed banks of native plants on European scale. But 3 other EU projects were also designated for seed banking of regional flora. The project called GENMEDOC (An inter – regional network of Mediterranean Seed Banks) is the oldest one in Europe, especially devoted to the *ex situ* conservations of Mediterranean endangered plants. There are 10 members of the network from Spain, France, Italy, Greece and Tunisia. The coordinator of the project is the Forest Seed Bank of the Valencian Government in Valencia.

For the conservation of the flora of Spain including the Iberian Peninsula, the Canary

Islands and the Balears, a Spanish Network of Seed Banks was established within the framework of the EU project called REDBAG. The project started in 2002 and included 10 botanical gardens and their seed banks from Madrid, Gran Canaria, Cordoba, Valencia, Mallorca, Maritmurta (Blanes, Gerona), Malaga and Alcala de Henáres. This project was prepared by the members of the Iberomacaronesian Association of Botanic Gardens in Spain. The leading institution for the coordination of the project is the Botanical Garden of Cordoba University and the Andalusian Seed Bank.

The Macaronesia is the area on the Atlantic Ocean, west of Africa and Europe, with the archipelagos of Canary Islands (territory of Spain) and the Azores and Madeira - islands belonging to Portugal. The Macaronesia is a region with a very rich flora, being one of the world's most important centers of biodiversity represented by 3.900 species of vascular plants. The Macaronesian Islands present the highest rate of endemism in Europe. There are 925 species of endemic plants in these three archipelagos and 418 of them were listed as threatened with extinction. Therefore, for the conservation of this unique flora in seed banks a special EU project BASEMAC (Banco de Semillas de Macaronesi) was also established. The coordination of BASEMAC project and the main conservation activity is run by the Canarian Botanical Garden "Viera y Clavijo" in Las Palmas (Gran Canaria). The Portuguese members of the network are: the Botanical Garden of Madeira in Funchal and the Botanical Garden of Azores in Faial (Bramwell, 2004, unpublished).

It could be concluded that all these 4 European Union projects on seed banking of native plants in Europe will be essential for the implementation of the targets of the: "Global Strategy for Plant Conservation" and the "European Plant Conservation Strategy" up to the year 2010.

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