

Botanic gardens as introduction centres for plants of economic importance – a reappraisal

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'Germplasm collection should be done under a multi-discipline approach that involves characterization, conservation and preservation, maintenance, and distribution, as well as adequate evaluation of existing collections of germplasm', USDA Woody Landscape Plant Germplasm Repository (2007)

Introduction

Over the centuries botanic gardens have occupied many different roles (Heywood 1987) but in the last 20–30 years plant conservation has become a major focus for many gardens, encouraged by organizations such as BGCI, the Center for Plant Conservation and IABG, and a great deal of effort has gone into devising guidelines and protocols so as to improve the quality of the conservation actions they undertake.

The aim of this paper, however, is to consider another area in which botanic gardens have historically been major actors, namely plant introduction. Some gardens still maintain the introduction of new ornamental species to the trade as a significant function, and plant exploration for this purpose remains active, for example, in the United States and the United Kingdom, while the cultivation and domestication of medicinal plants is being undertaken by a number of gardens in China and India for example. But it is perhaps time to revisit this whole area of plant introduction and today's needs, especially in the light of global change, develop a coherent policy and assess what role the botanic garden community might play.

Plant introductions

Plant introduction had its origins in earlier civilizations such as the Chinese, Greek, Roman and Egyptian (Del Tredici 2000). The earliest recorded plant collecting expedition was that of Queen Hatshepsut of Egypt who sent an expedition to the Land of Punt in 1493 BC. In China the first recorded plant hunter was Chan-Chien who brought back alfalfa and grapes in 126 BC during his tenure as Ambassador of the Han dynasty to the "Western Territory" (Sheng 1980).

The introduction of wild species into cultivation for ornament began in several civilizations not long after the first domestications of plants for agriculture. In China, for example, unimproved wild species were used for ornament in the Xia dynasty (2100 BC – 1600) BC) and possibly before then. The first cultivar known in China (long before the term cultivar was introduced into the Horticultural Code in 1953), was possibly the Jiahua (*Chrysanthemum*) as evidenced by a poem of Tao Qian (355~ 417), and it is reported that the yearly income of one who cultivated a thousand mu of gardenia was equal to that of a marquis who collected taxes from a thousand families (Wang and Zhang 1993), while the cost of a tree peony with deep red flowers was equivalent to the taxes paid by ten middle class families. And this is many centuries before the development of tulipomania in the Netherlands!

The deliberate introduction of plants from one continent, region or country to another has been a critical element of our social, economic and agricultural development. As the St Louis Declaration on Invasive Plant Species notes, 'Plant introduction and improvement are the foundation of modern agriculture, yielding diversity to our supply of plants used for food, forestry, landscapes and gardens, and other purposes'. Most civilizations have engaged in a two-way traffic of introduction and export of plant (and to a lesser extent animal) resources. Since the 15th century the acquisition and introduction of new crops was almost a defining

characteristic of the colonization process as Calestous Juma noted in *The Gene Hunters* (1989): ‘... the acquisition of colonies was not enough unless linked with the availability and of labour and plant genetic resources’.

Much has been written about the vital part played by botanic gardens in the introduction and diffusion of economically important plants such as coffee, tea, rubber, oil palm, bread fruit, cassava, vanilla as part of the colonial process although it should be noted that the initial post-Columbian exchange during which crops such as potato, maize, beans (*Phaseolus*), tomatoes and peppers were introduced from the Americas to Europe, took place before the first European botanic gardens had been created in the middle of the 16th century. It was only in the 17th and 18th centuries that botanic gardens became key players in the introduction process, both in Europe in countries such as Spain, Portugal, France the Netherlands and the United Kingdom, and in their colonial territories, and often acclimatization gardens were established. This continued through to the 19th and early 20th centuries although responsibility for introductions gradually transferred to agricultural stations or Departments of Agriculture, as in the United States where the renowned plant explorer David Fairchild had the splendid title of ‘Agricultural Explorer, in Charge of Foreign Explorations’ (Fairchild 1906).

The initial focus of introductions was on plants that could add to the agricultural wealth of the country or those of medicinal value although ornamentals were also included as gardening gradually became a leisure pursuit with the increase in wealth.

Today, however, those gardens that are engaged in plant introduction direct most of their efforts at plants of horticultural merit as in the case of North American botanic gardens and arboreta such as the US National Arboretum, University of British Columbia Botanical Garden, and the consortium of six major botanic gardens and arboreta which form the Plant Collecting Collaborative, although expeditions organized by these gardens also provide plants of other interest, such as medicinal plants for study by ethnobotanists, rare and endangered plants studied for conservation purposes and food plants. In China, however, from 1954 onwards plant introduction was scientifically organized and a major function of the newly established botanic gardens was ‘the exploitation of wild plant resources, introduction of indigenous and exotic, economic plants, breeding of new varieties so as to enrich the resources of cultivated plants’.(Sheng 1980).

Increasingly countries are looking to their native flora as a source as potential ornamental crops, notably Australia (Plummer et al. 2000), Israel (Halevy 2000), South Africa, and E. Asia (Okhawa 2000) and in Latin America, Boyle (1991) has described the genetic resources of the native herbaceous ornamental crops as vital to commercial horticulture. A special Ornamental Plant Germplasm Center was created in the U.S.A. in conjunction with the U.S.D.A. National Plant Germplasm System and Ohio State University (Tay 2003).

The introduction process today

The process of plant introduction has remained largely unchanged over the past 400 years (Reichard and White 2001). Yet, despite its acknowledged importance, why is it that with a few exceptions such as the above mentioned Plant Collecting Collaborative, plant introduction is often, *ad hoc*, poorly organized, insufficiently collaborative, badly publicized and inefficiently followed through? In fact, plant introduction is undertaken on a very much *ad hoc* basis, usually by individual national institutions such as Departments of Agriculture, botanic gardens and arboreta and it is difficult to discern any general coherent policy lines. While the botanic garden system is conducive to and has mechanisms for the sharing or exchange of germplasm, especially seeds through the Index Seminum system, this does not always obtain and all too often rare accessions are grown as single individuals in greenhouses and at the mercy of the changing staffing of the facility, with no duplicates in other gardens.

Even when material is distributed, the subsequent survival of the collections may be hazardous as in the case of germplasm from the 1980 Sino-American Botanical Expedition to the Shennongjia Forest District, Hubei Province, China, where after 22 years, although of the original 621 collections, 258 are represented by plants

growing in at least 18 different botanical institutions, 115 of them are represented by a single accession growing in a single location (Dosmann and Del Tredici 2003) suggesting that 'the plant introduction process is much more tenuous than has been generally assumed'.

Of course not all introductions are exotic. In Australia, for example, the Centre for Biodiversity Research, a joint venture of CSIRO Division of Plant Industry the Australian National Botanic Gardens, notes that because of their adaptation to local conditions and their integration into our natural ecosystems, Australian native plants form a valuable source of genes that could be utilized to improve agricultural and industrial productivity.

Expanding the introduction mission of botanic gardens

If botanic gardens are to recover at least part of their earlier role as testing places for new introductions of economically or socially important plants, some of the key issues that need to be addressed are:

1 Broadening the plant introduction and exploration mission so that botanic gardens can respond to some of the demands for new germplasm in addition to that for ornamental horticulture. Botanic gardens should consider working more closely with the agricultural and genetic resources communities in areas such as collection and conservation of:

- crop wild relatives (Heywood et al. 2007) for which there will be an increasing demand in the face of global change;
- economically and socially valuable wild species such as those which contribute significantly to nutrition and health (Grivetti and Ogle 2000; Heywood 1999, 2006); and
- minor and underutilized crops (IPGRI 2002).

Another group of plants with which some botanic gardens are already engaged is medicinal and aromatic plants (Hamilton 2004). Conservation of germplasm of these plants is still very much neglected despite their major socio-economic importance in many parts of the world Heywood (2002). A critical global look at the part that botanic gardens might play is needed.

2 Closer cooperation with agricultural genebanks. Botanic gardens and agricultural genebanks have different strengths and missions but they are complementary and there are obvious opportunities for synergies which will further both the mission of plant introduction and the global conservation effort (Heywood 1999b; Maunder 1994; Engelmann & Engels 2002).

- Forging agreement(s) between botanic gardens and the agricultural sector on precisely which species/species categories/genepool should be their conservation responsibilities so as to avoid duplication and gaps (Engelmann & Engels 2002)
- Improving the quality and sampling of accessions. Although great advances have been made in recent years by some gardens, many botanic garden accessions do not meet minimal requirements. Consideration should be given to defining rigorous standards with the genetic resources sector for collecting, conserving and documenting activities, including sampling procedures, seed and in vitro storage conditions, viability testing procedures, accession sizes and adopting and adapting ecogeographical survey techniques and sampling protocols.
- Proper evaluation and assessment of the introduced material. As Lighty (2000) has rightly pointed out, getting the plants into the country is not the most important part of the introduction programme but the first step.

- Information on the accessions of introduced plants and their fate and its dissemination. The essence of any botanic garden is the plant collections that it grows and globally botanic garden accessions which represent an astonishing 80–100,000 species constitute a major but much undervalued and certainly underutilized biodiversity resource (Dosmann 2006). Despite the best efforts of BGCI and other bodies to assemble data on botanic garden holdings, it remains remarkably difficult to find out what is out there in the collections of the world's gardens, let alone any details of the accessions, their state of health, which gardens hold duplicates, and so on. As Raven noted (2004) 'Without knowing who has what ... the maintenance and assembly of collections cannot be efficient, and in fact most of what botanical gardens do is wasted or replicated effort, unknown to others and generally not available'. Develop the proposal by Engelmann and Engel (2002) to cooperate in the establishment of a comprehensive information management system(s), including a common database of accessions maintained (possibly on a regional level).
- A critical reassessment should be made of the concept of acclimatization, the function of acclimatization gardens and societies and the part that the botanic garden community might play.
- A major problem is the lack of effective and well-resourced botanic gardens in areas of high biodiversity and it is precisely in such areas that the socio-economic need for new introductions is probably greatest. Aid agencies might be more inclined to fund the establishment of new gardens in developing countries if one of their functions was to contribute to poverty alleviation through new plant introductions.

Introductions as invasives

While the majority of plant introductions have had a positive result in terms of human welfare (Mack 2005), and indeed few countries could have survived and developed by relying on their native germplasm, inadvertently some of the introduced species have proved to have characteristics that make them invasive in some regions. It is considered, for example, that horticultural escapes have provided the greater part of the naturalized flora of many countries from which many of their invasive plant species have been derived (Reichard and White, 2001; Dehnen-Schmutz et al., 2007). This raises many social, economic, ethical, scientific and technical issues which have to be taken into account when addressing the introduction process. Invasive species are now recognized as one of the major threats to biodiversity today and this is being addressed by a number of global, regional and national initiatives and codes of conduct have been proposed for botanic gardens (and will not be considered further here). These risks do not, however, in any way negate the key role of plant introduction for the world's economy/

References

- Ault, J.R. (ed.) 2000, Plant Exploration: Protocols for the Present, Concerns for the Future. (Symposium Proceedings, March 18-19, 1999). Chicago Botanical Garden, Glencoe IL.
- Boyle, T.H. 1991, The genetic resources of Latin America's herbaceous ornamental crops— vital to commercial floriculture. *Diversity* 7: 50–51.
- Dehnen-Schmutz, K., Touza, J., Perrings, C. and Williamson, M. 2007, The horticultural trade and ornamental plant invasions in Britain. *Conservation Biology* 21: 224–231.
- Del Tredici, P. 2000, Plant exploration: a historic overview. In: Ault, J. R. (ed.), Plant Exploration: Protocols for the Present, Concerns for the Future. (Symposium Proceedings, March 18-19, 1999), Chicago Botanical Garden, Glencoe, IL.
- Dosmann, M. 2006. Research in the garden. *The Botanical Review* 72 (3): 207–234.

- Dosmann, M. and Del Tredici, P. 2003, Plant introduction, distribution and survival: a case study of the 1980 Sino-American botanical expedition. *BioScience* 53: 588–597.
- Drayton, R. 2000. *Nature's Government. Science, Imperial Britain, and the 'Improvement' of the World.* Yale University Press, New Haven and London.
- Engelmann, F. and Engels, J.M.M. 2002, Botanic gardens and agricultural genebanks: building on complementary strengths for more effective global conservation of plant genetic resources. *Plant Genetic Resources Newsletter* No. 131: 49–54.
- Fairchild, D. 1906, Our plant immigrants. *The National Geographic Magazine* 17(4): 179–201.
- Fay, K. (ed.) 2002, Linking Ecology and Horticulture to Prevent Plant Invasions. *Proceedings of the Workshop at the Missouri Botanical Garden*, St. Louis, Missouri, 1-4 December 2001. Appendix A. Missouri Botanical Garden, St Louis, Missouri.
- Grivetti, L.E. and Ogle, B.M. 2000, Value of traditional foods in meeting macro- and micronutrient needs: the wild plant connection. *Nutrition Research Reviews* 13:31–46.
- Hamilton, A.C. 2004, Medicinal plants, conservation and livelihoods. *Biodiversity and Conservation* 13: 1477–1517.
- Halevy, A.H. 2000, *Introduction of native Israeli plants as new cut flowers.* 541:79-82.
- Heywood, V.H. 1987, The changing role of the botanic garden. In Bramwell, D., Hamann, O., Heywood, V. and Synge, H. (eds), *Botanic Gardens and the World Conservation Strategy*, pp. 3–18. Academic Press, London.
- Heywood V.H. 1993, Broadening the basis of plant resource conservation. In: Gustafson, J.P. Appels, R., Raven, P. (eds), *Gene Conservation and Exploitation*, 1–13. Plenum, Press, New York.
- Heywood, V.H. 1999a, Use and Potential of Wild Plants in Farm Households. Farm Management Series 15. FAO, Rome.
- Heywood V.H. 1999b, The role of botanic gardens in ex situ conservation of agrobiodiversity. In: Gass, T., Frese, L., Begemann, F., Lipman, L. (compilers), *Implementation of the Global Plan of Action in Europe. Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. Proceedings of the European Symposium on Plant Genetic Resources for Food and Agriculture, Braunschweig, Germany, 30 June-4 July 1998.* International Plant Genetic Resources Institute, Rome, Italy, pp. 102-107.
- Heywood, V.H. 2002, The Conservation of Genetic and Chemical Diversity in Medicinal and Aromatic Plants. Chapter 2 in: Sener, B. (ed.), *Biomolecular Aspects of Biodiversity and Innovative Utilization*, Proceedings of the 3rd IUPAC International Conference on Biodiversity (ICOB-3), November 3-8, 2001, Antalya, Turkey, Kluwer Academic/Plenum Publishers.
- Heywood, V. 2003, Conservation and sustainable use of wild species as sources of new ornamentals. In: Düzyaman, E. & Tüzel, Y. (eds), *Proceedings of the International Symposium on Sustainable Use of Plant Biodiversity to Promote New Opportunities for Horticultural Production Development, Acta Horticulturae* Number 598P: 43–53.
- Heywood, V.H. 2006, Human use of plant resources - the knowledge base and conservation needs. In: Ertug, Z.F. (ed.). *Proceedings of the IVth International Congress of Ethnobotany (ICEB 2005)* pp. 365–372. Ege Yayınları, Istanbul, (2006).

- IPGRI. 2002, Neglected and Underutilized Plant Species: *Strategic Action Plan of the International Plant Genetic Resources Institute*. International Plant Genetic Resources Institute, Rome, Italy.
- Lighty, R.W. 2000, An assessment of ornamental plant introduction in the not-for-profit sector. In: Ault, J.R. (ed.), *Plant Exploration: Protocols for the Present, Concerns for the Future*. (Symposium Proceedings, March 18-19, 1999) Pp. 14–22. Chicago Botanical Garden, Glencoe IL.
- Mack, R.N. 2005, Predicting the identity of plant invaders: future contributions from horticulture. *HortScience* 40: 1168–1174.
- Maunder M. 1994. Botanic gardens: future challenges and responsibilities. *Biodiversity and Conservation* 3:97-103.
- Okhawa, K. 2000, Flower industry in Northeast Asia: development and introduction of new crops. *Acta Hort.* 541:125-133.
- Plummer, J.A. Considine, J.A., Yan, G., Hall, D., Alford, T., Seaton, K., Growns, D., Newell, C. and Webb, M. 2000, New developments from the Centre for Australian Plants. *Acta Hort.* 54:37- 47.
- Raven, P.H. 2004, In: North American Plant Collections Consortium (NAPCC) report 2004.
- Reichard, S.H. and White, P. 2001, Horticulture as a pathway of invasive plant introductions in the United States. *BioScience* 51: 103–113.
- Sheng, C.K. 1980, Plant introduction and botanic gardens in China. *Plant Science Bulletin* 26: 25–28.
- Tay, D. 2003. Herbaceous Ornamental Plant Genebank: its role in the floriculture industry. *Acta Hort.* 624:29-36.
- The St Louis Declaration on Invasive Plant Species. 2002, In: *Linking Ecology and Horticulture to Prevent Plant Invasions*. Proceedings of the Workshop at the Missouri Botanical Garden, St. Louis, Missouri, 1-4 December 2001. Appendix A. Missouri Botanical Garden, St Louis, Missouri.
- Wang, Da-Jun, & Zhang, Lian-Quan 1993, A brief history of ornamental plants in ancient China. p. 204–209. In: *Proceedings of the XI International Association of Botanic Gardens Conference*, Wuxi, China, 1993, China Agriculture Press, Beijing
- Woody Landscape Plant Germplasm Repository 2007. Genetic resources, evaluation and information management of woody landscape plants.
- http://www.ars.usda.gov/research/projects/projects.htm?ACCN_NO=408767&showpars=true&fy=2005