Plant Introductions: Historical Sketches[1]

Michael Kiehn[2]

Abstract: Plant species, their parts and derivatives have been transferred by humans since the beginning of history: unintentionally (e.g., with propagules adhering to clothes) or intentionally (e.g., when species or parts of them were used for food or as sources of tools). Numerous plant transfers resulted in species becoming permanently naturalized in new areas, in some cases with extremely negative effects for the region to which they were brought. However, transfers also often proved neutral or even beneficial. This article does not intend to give a comprehensive survey of the history and the consequences of plant transfers in space and time but presents and discusses illustrative examples of plant movements by people. Special emphasis is given to effects on islands and to historical, political, and economic aspects of long-distance plant trade in the Old World often little known by botanists.

Mechanisms of natural as well as of anthropogenic plant movements can only be understood if both spatial and historical dimensions are equally taken into account. These mechanisms are comparatively well studied for numerous plant species transferred by humans to new geographic areas (see, for example, Whistler 2009, Kueffer et al. 2010, Kiehn 2011). Therefore, such studies can contribute to a more general understanding of patterns and processes of plant migration and their establishment in new environments.

Such topics have always been of major interest for Professor Dieter Mueller-Dombois, whose ongoing and encouraging curiosity often resulted in a creative connection of different areas of research (see Vitousek and Drake 2012: this volume).

plant transfers to islands

Polynesian Introductions to Hawai'i

During their voyages in search of new inhabitable lands, the Polynesians carried ca. 60 species of plants with them (Whistler 2009). Most of them, such as taro, *Colocasia esculenta* (L.) Schott, and breadfruit, *Artocarpus altilis* (Parkinson) Fosb., were food sources, but some served other purposes: as sources of timber or medicine, including among others the kamani tree, *Calopyllum inophyllum* L., and the candlenut or kukui tree, *Aleurites moluccana* (L.) Willd. (fruits of the latter were also used instead of candles); for use in technical applications (such as hau, *Hibiscus tiliaceus* L., for fiber production); or for spiritual uses, such as the ti plant, *Cordyline fruticosa* (L.) Chev. In total, 27 plant taxa were introduced by the Polynesians on the Hawaiian Islands (Sohmer and Gustafson 1987). Some of them are still cultivated and used to this day. And several species introduced by the Polynesians today are "so well adapted to the Hawaiian landscape that it is difficult or impossible to distinguish them as nonnative" (Sohmer and Gustafson 1987:15). The number of plant species introduced to the Hawaiian Islands by the Polynesians was low compared with the at least 1,029 species native there (Wagner et al. 1999), and the ecological effects of most species can be considered neutral to even beneficial (with the notable exception of the

[1] Manuscript accepted 18 August 2011. This article is the written version of a lecture dedicated to Professor Dieter Mueller-Dombois on the occasion of his 85th birthday.

[2] Core Facility Botanical Garden, University of Vienna, Rennweg 14, 1030 Vienna, Austria (e-mail: michael.kiehn@univie.ac.at).

Pacific Science (2012), vol. 66, no. 2:119–125
doi:10.2984/66.2.2

candlenut tree, which is, by some authors, considered to be invasive [see PIER 2006]).

Invasive Aliens on Islands

Over the last five centuries a constantly increasing number of foreign plants was brought to islands, especially from the twentieth century onward. Today, in many island groups the number of established introduced species already exceeds the number of native ones (see Kueffer et al. 2010, Kiehn 2011: tab. 15.1). Thus the number of plant species currently cultivated in Hawai'i is estimated to be higher than 8,000, and more than 1,100 of them are naturalized (Staples and Herbst 2005). The rising number of nonnative species is also well documented for the Galápagos Islands, where only 77 naturalized plant species were known in 1971. In 1999, 471 species were reported. More than 600 nonnative species were recorded in 2001 (Baskin 2002, Tye et al. 2002), and 754 alien vascular plant taxa were counted in a comprehensive survey carried out between 2002 and 2007 (Guézou et al. 2010).

Some nonnative species turned out to have extremely negative effects on their new environments and/or to pose serious threats to the endemic fauna and flora. Three well-documented examples of such highly invasive alien plant species are as follows:

Cinnamomum verum J. Presl (Lauraceae). This species, originally native to Sri Lanka and India, was introduced to the Seychelles in 1772. By the end of the nineteenth century, it had already formed monotypic forests there. Today this species is the most widespread tree in the Seychelles, occurring from sea level to the mountaintops (Vielle 2003). In spite of this, the species has been brought to other tropical islands in the Pacific and the Caribbean and now is already rated as invasive in several other regions, such as American Samoa, Fiji, the Cook Islands, and the Hawaiian Islands (PIER 2011).

Cinchona pubescens Vahl (Rubiaceae). Since the 1930s, this neotropical species has been introduced as a medicinal plant to several tropical islands including the Galápagos archipelago, where, since the mid-1970s, it has started to cover large areas with monotypic stands. This effect can now be seen, among other places, on Santa Cruz Island, where treeless grassland and shrubland was still present on the hilltops in 1972 (Hamann, pers. comm.). By 2002, however, 11,000 ha had already been covered by *C. pubescens* (Soria et al. 2002, Kiehn 2011).

Miconia calvescens DC. (Melastomataceae). This species, originally native to South and Central America, was introduced to Tahiti (French Polynesia) as an ornamental in 1937. It took until the early 1970s before the first naturalized populations were reported on Tahiti. Since then, the species has spread all over the island and today forms dense stands on more than 80,000 ha (Meyer 2010). It also reached other islands of French Polynesia such as Moorea, where, at the end of the 1990s, it had already covered ca. 35% of the island surface (Meyer 2010). Between 40 and 50 Tahitian endemic plant species are directly affected by this invasion, and some species are threatened with extinction (Meyer and Florence 1996, Meyer 2004).

The three species just mentioned have been selected here not only because they clearly show the potential negative impacts of introduced species on island ecosystems and endemic species. They are also examples of species that, in spite of known negative effects on some archipelagos, are still brought to and cultivated on "new" islands, where, unfortunately, similar negative effects are to be expected. There is clear evidence for the fact that no plant species is invasive everywhere in the world and, as shown by Kueffer et al. (2010), not even in every tropical/subtropical island system, but risk assessments for new introductions to islands (as outlined by Daehler et al. 2004, for example) are urgently required at least for plant species intended for large-scale horticultural or commercial use to reduce chances of new plant invasions.

LONG-DISTANCE PLANT TRADE IN THE OLD WORLD

Plant transfers across continents for commercial purposes are not a modern phenomenon. They have a long history in human culture.

Trade in Ancient Times

Long-distance overland trade between Europe and Asia along the so-called Silk Road has been documented as far back as 2500 B.C. (Miller 1969, Heimberg 1981). This trade also included the transfer of plant species. Examples of species that made their way from Asia to the Mediterranean region via the Silk Road more than 2,000 years ago are the almond, *Prunus dulcis* (Mill.) D. A. Webb (Rosaceae), which has been reported in Egypt since ca. 2000 B.C. and for the western Mediterranean since around 400 B.C. (Socias i Company 1998, Zeinalabedini et al. 2010, and literature cited there); the pomegranate, *Punica granatum* L. (Punicaceae), which has been documented in the eastern Mediterranean region since ca. 1550 B.C. (Janick 2007); and the citron, *Citrus medica* L., which was known in southern Europe at least since ca. 330 B.C. (Schirarend and Heilmeyer 1996).

Regular ship trade via the Red Sea and the Gulf of Aden had begun to take place to and from Asia already several centuries B.C. (Miller 1969, De Romanis 1996). An interesting document exemplifying this trade is deposited at the Austrian National Library Papyrus Collection: a papyrus dated ca. A.D. 150 recording a customs declaration (P. Vindob. G 40822). The ship named *Hermapollon* and the goods declared on this papyrus originated from Muziris in India (Harrauer and Sijpesteijn 1985). The papyrus states the value of the whole freight as 6,926,852 drachmens; this is said to equal the average annual income of ca. 30,600 persons in Europe compared with modern standards (Luther 2004). On the back side of the papyrus the goods traded from India are specified: the three items still discernible are Gangitian nard (60 containers), ivory, and textiles probably made from silk (Harrauer and Sijpesteijn 1985, Casson 1990). Of interest in our context is the Gangitian nard, *Nardostachys grandiflora* DC. (=*N. jatamansi* DC.), a member of the Valerianaceae family originating from a limited area in the Himalayas. A valuable volatile oil can be extracted from its rootstock. Rootstock, leaves, inflorescences, and oil have been used since ancient times as medicine, in incenses, and for cosmetics. Already in antiquity the plant and its parts were highly esteemed and known for their high value. Consequently, the price of nard oil was regulated by the Diocletian price edict from the early fourth century A.D. (Naumann and Naumann 1973). The high price for nard products is also reflected by Pliny the Younger in his book *Naturalis Historia*, where he described the Indian nard in book XII:42ff. and gave prices for different parts of the plant, and by the Bible, where the high price of nard oil is mentioned by Mark (14:3–14:5). Thus the immense value of the 60 containers of *Nardostachys* parts or derivatives transported by a single ship according to papyrus P. Vindob. G 40822 is evident. The number of containers is also a clear indication of the enormous depletion of the natural populations of this species in ancient times. Nevertheless, the species survived until the present. Today the species is used in traditional Chinese medicine. In recent years, the exponentially growing demand for *Nardostachys* rootstock due to the increasing popularity of traditional Chinese medicine in the Western world again puts tremendous pressure on the natural populations of the species and made its listing in Appendix II of CITES (Convention on International Trade in Endangered Species) necessary to control its trade as a precautionary measure to prevent overexploitation (Mulliken and Crofton 2008).

The Nutmeg Trade

Beginning at the end of the fifteenth century, it became increasingly routine for ships engaged in the spice trade to circumnavigate the southern tip of Africa. The Dutch East India Company in particular successfully used that route because they controlled areas in the Malesian region and the port of Cape Town. The most interesting species connected with this trade was the nutmeg (*Myristica fragrans* Houtt.). This species is native to the Moluccas or Banda Islands, which are situated west of the western end of New Guinea. For more than two centuries, nutmeg was a source of immense income for the Dutch because the plant was said to be a cure for the plague and the Dutch had the trade monopoly. To secure

that monopoly, the Dutch even gave away the island of New Amsterdam in North America (today Manhattan) to the English, in exchange for the very small (3 by 1.5 km) Banda Island Run (Severin 1997). Only in the early eighteenth century, when fruits of the nutmeg were transferred from Banda to the West Indies islands, did the monopoly end (Groome 1970). As a side effect of this transfer of nutmeg to the New World, Grenada in the Lesser Antilles has remained the largest global exporter of nutmeg to this day.

Ambassadors as Plant Hunters

Another remarkable facet of the introduction of plants to new areas happened between Turkey and Europe in the sixteenth century. At that time there were strong political tensions between the Osmanian and the Austrian empires. To calm the situation, the Habsburg emperors of Austria sent diplomatic missions to Constantinople (today's Istanbul). The Viennese delegates to the court in Constantinople, especially the ambassadors and their physicians, were not only diplomatically active; they often were also interested in ornamental plants. Many species they saw in Constantinople were not known in Europe at that time. Thus the diplomats, especially Augier Ghislain de Busbecq (ca. 1520/1521–1591/1592) and David Ungnad (1530–1600), collected seeds and bulbs, prepared rooted cuttings and young plantlets of the unknown ornamentals and sent them back to the Habsburg Empire. That way, taxa such as tulips (*Tulipa* spp.), lilac (*Syringa vulgaris* L.), horse chestnut (*Aesculus hippocastanum* L.), and cherry laurel (*Prunus laurocerasus* L.) found their way into the gardens of Europe (Kerner von Marilaun 1893, Kraus 1894, Lack 2000, Müller 2011).

A New Era for Plant Transfers from Asia to Europe

Scientific and horticultural interest in Asiatic plants for European (and later also for American) gardens started in the eighteenth century, when large areas of the temperate climate zone of Asia became accessible to Westerners. Thus the first plants of *Ginkgo biloba* L. were grown in the Netherlands around 1730. Plant hunters such as Robert Fortune (1812–1880), Ernest Henry "Chinese" Wilson (1876–1930), and Joseph Francis Charles Rock (1884–1962), to name only a few, had been sent out by research institutions and horticultural enterprises since the middle of the nineteenth century. They returned with species that today belong to the "normal" set of plants in an average garden in the temperate regions (e.g., *Rhododendron* spp., *Wisteria sinensis* Sweet, and *Forsythia* × *intermedia* Zabel). French monks in China such as Jean Pierre Armand David (1826–1900), Pierre Jean Marie Delavay (1834–1895), and Paul Guillaume Farges (1844–1912) sent herbarium material and seeds to Paris. In that way species like *Davidia involucrata* Baill., *Incarvillea delavayi* Bureau & Franch., *Paeonia delavayi* Franch., and *Clematis fargesii* Franch., all commemorating their first collectors in their names, came to Europe.

Sometimes They Return Home

Some plant species were cultivated for several centuries abroad but then made their way back to their home countries. A quite spectacular case of this kind relates to two South African species of *Erica*, *E. verticillata* P. J. Bergius and *E. turgida* Salisb. Both species were collected in the Cape region of South Africa between 1785 and 1797 by two Austrian imperial gardeners, Franz Boos (1753–1832) and Georg Scholl (1751–1831). These two *Erica*s and numerous other species collected at that time in South Africa have been successfully propagated and cultivated at the Imperial Gardens in Vienna (today the Austrian Federal Gardens) for over 200 years, during which time they became extinct in the wild in the Cape region. In July 2001, plants of both species were officially handed over to the South African ambassador in Vienna by the Austrian Minister of Agriculture and the Environment, Dr. Wilhelm Molterer, to be repatriated to the Cape region. Since then, both species have been successfully reintroduced at two sites near Cape Town and have already set flowers and fruits there (Hitchcock 2005).

CONCLUSIONS

These examples show that species transferred from one part of the world to another can sometimes create problems. To minimize this danger for the future, risk assessments, especially for new ornamental plant trade introductions, are desirable, at least on a voluntary basis. But most introductions have proved to be harmless. In addition, some of these expatriates and their characteristic features are highly esteemed by many; they enrich our lives in different ways, and we would not like to be without them.

ACKNOWLEDGMENTS

I express my sincere thanks to Dieter Mueller-Dombois und his wife Annette for all the stimulating discussion about the Hawaiian and Pacific flora and vegetation throughout the years. I thank Peter Vitousek for having organized the symposium in Hilo, Hawai'i, to celebrate Dieter Mueller-Dombois' 85th birthday in 2010, and for inviting me to give a lecture there. My wife Monika contributed creative ideas to this article and helped me with literature search. I also thank her for a fruitful discussion and for the critical reading of the manuscript. Maria Petz-Grabenbauer (Vienna) provided biographical data on F. Boos and G. Scholl. Two anonymous reviewers are thanked for their useful comments and for linguistic improvements. Financial support for my stay in Hawai'i by the University of Vienna and the National Tropical Botanical Garden, Kalaheo, Kaua'i, Hawai'i, is gratefully acknowledged.

Literature Cited

Baskin, Y. 2002. A plague of rats and rubbervines: The growing threat of species invasions. Island Press, Washington, D.C.

Casson, L. 1990. New light on maritime loans: P. Vindob G 40822. Z. Papyrol. Epigraph. 84:195–206.

Daehler, C. C., J. S. Denslow, S. Ansari, and H. C. Kuo. 2004. A risk-assessment system for screening out invasive pest plants from Hawaii and other Pacific Islands. Conserv. Biol. 18:360–368.

De Romanis, F. 1996. Cassia, cinnamomo, ossidiana: Uomini e merci tra Oceano Indiano e Mediterraneo. "L'Erma" di Bretschneider, Rome.

Groome, J. R. 1970. A natural history of the island of Grenada, West Indies. Caribbean Printers, Arima, Trinidad.

Guézou, A., M. Trueman, C. E. Buddenhagen, S. Chamorro, A. M. Guerrero, P. Pozo, and R. Atkinson. 2010. An extensive alien plant inventory from the inhabited areas of Galapagos. PLoS One 5 (4): e10276. doi:10.1371/journal.pone.0010276.

Harrauer, H., and P. J. Sijpesteijn. 1985. Ein neues Dokument zu Roms Indienhandel P Vindob. G 40822. Anz. Oesterr. Akad. Wiss. Philos.-Hist. Kl. 122:124–155.

Heimberg, U. 1981. Gewürze, Weihrauch, Seide. Welthandel in der Antike. Kleine Schriften zur Kenntnis der römischen Besetzungsgeschichte Südwestdeutschlands 27.

Hitchcock, A. 2005. Restoration conservation at Kirstenbosch National Botanical Gardens. Accessed 29 March 2011. http://www.botanicgardens.ie/gspc/gppc/posters/kenilworth.htm.

Janick, J. 2007. Plant exploration: From Queen Hatshepsut to Sir Joseph Banks. Hortic. Sci. (Stuttg.) 42:191–196.

Kerner von Marilaun, A. 1893. Die Geschichte des Flieders. Vienna.

Kiehn, M. 2011. Invasive alien species and islands. Pages 365–384 *in* D. Bramwell and J. Caujapé-Castells, eds. The biology of island floras. Cambridge University Press, Cambridge.

Kraus, G. 1894. Geschichte der Pflanzeneinführungen in die europäischen botanischen Gärten. Engelmann, Leipzig.

Kueffer, C., C. C. Daehler, C. W. Torres-Santana, C. Lavergne, J.-Y. Meyer, R. Otto, and L. Silva. 2010. A global comparison of plant invasions on oceanic islands. Perspect. Plant Ecol. Evol. Syst. 12:145–161.

Lack, H. W. 2000. Lilac and horse-chestnut: Discovery and rediscovery. Curtis's Bot. Mag., ser. 6, 17:109–141.

Luther, A. 2004. Der Seekontakt zwischen Rom und Indien. Accessed 30 September 2010. http://www.fu-berlin.de/presse/publikationen/fundiert/2004_02/04_02_luther/ index.html.

Meyer, J.-Y. 2004. Threat of invasive alien plants to native flora and forest vegetation of eastern Polynesia. Pac. Sci. 58:357–375.

———. 2010. The *Miconia* saga: 20 years of study and control in French Polynesia (1988–2008). *In* L. L. Loope, J.-Y. Meyer, B. D. Hardesty, and C. W. Smith, eds. Proceedings of the International *Miconia* Conference, Keʻanae, Maui, Hawaiʻi, 4–7 May 2009. Maui Invasive Species Committee and Pacific Cooperative Studies Unit, University of Hawaiʻi at Mānoa. Accessed 30 April 2011. http://www.hear.org/conferences/miconia2009/proceedings/.

Meyer, J.-Y., and J. Florence. 1996. Tahiti's native flora endangered by the invasion of *Miconia calvescens* DC. (Melastomataceae). J. Biogeogr. 23:775–783.

Miller, J. I. 1969. The spice trade of the Roman Empire. Oxford University Press, Oxford.

Müller, R. C. 2011. Stil, Mode, Manie: von der Sehnsucht zur Sucht. Tulpen und die Pflanzenwelt des Orients im westeuropäischen Interesse. Pages 161–178 *in* I. Kästner and J. Kiefer, eds. Botanische Gärten und botanische Forschungsreisen. Shaker Verlag, Aachen.

Mulliken, T., and P. Crofton. 2008. Review of the status, harvest, trade and management of seven Asian CITES-listed medicinal and aromatic plant species. Bundesamt für Naturschutz (BfN), Bonn.

Naumann, R., and F. Naumann. 1973. Der Rundbau in Aezani mit dem Edikt des Diokletian und das Buleutorion in Stratonikeia. Wasmuth, Tübingen.

PIER 2006. *Aleurites moluccana*. Accessed 9 July 2011. http://www.hear.org/pier/wra/pacific/aleurites_moluccana_htmlwra.htm.

———. 2011. *Cinnamomum verum*. Accessed 12 July 2011. http://www.hear.org/pier/species/cinnamomum_verum.htm.

Schirarend, C., and M. Heilmeyer. 1996. Die Goldenen Äpfel. Wissenswertes rund um die Zitrusfrüchte. G + V Verlag, Berlin.

Severin, T. 1997. The Spice Islands voyage: The quest for Alfred Wallace, the man who shared Darwin's discovery of evolution. Carroll & Graf Publ., New York.

Socias i Company, R. 1998. Fruit tree genetics at a turning point: The almond example. Theor. Appl. Genet. 96:588–601.

Sohmer, S. H., and R. Gustafson. 1987. Plants and flowers of Hawaiʻi. University of Hawaiʻi Press, Honolulu.

Soria, M. C., M. R. Gardener, and A. Tye. 2002. Eradication of potentially invasive plants with limited distribution in the Galapagos Islands. Pages 287–292 *in* C. R. Veitch and M. N. Clout, eds. Turning the tide: The eradication of invasive species. Proceedings of the International Conference on Eradication of Island Invasives. Occasional Papers of the IUCN Species Survival Commission 27.

Staples, G. W., and D. R. Herbst. 2005. A tropical garden flora. Bishop Museum Press, Honolulu.

Tye, A., M. C. Soria, and M. R. Gardener. 2002. A strategy for Galapagos weeds. Pages 336–341 *in* C. R. Veitch and M. N. Clout, eds. Turning the tide: The eradication of invasive species. Proceedings of the International Conference on Eradication of Island Invasives. Occasional Papers of the IUCN Species Survival Commission 27.

Vielle, M. 2003. Management priorities for Seychelles: A basis for discussion. Pages 99–104 *in* J. Mauremootoo, ed. Proceedings of the Regional Workshop on Invasive Alien Species and Terrestrial Ecosystem Rehabilitation in Western Indian Ocean Island States: Sharing Experience, Identifying Priorities and Defining Joint Action, Seychelles, 13–17 October 2003. Indian Ocean Commission, Quatre Bornes, Mauritius.

Vitousek, P., and D. Drake. 2012. In appreciation of Professor Dieter Mueller-Dombois. Pac. Sci. 66:117–118.

Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1999. Manual of the flowering plants of Hawaiʻi. Rev. ed. University of Hawaiʻi Press, Honolulu. 2 vols. (Bishop Museum Special Publication 97.)

Whistler, W. A. 2009. Plants of the canoe people. National Tropical Botanical Garden, Lāwaʻi, Kauaʻi, Hawaiʻi.

Zeinalabedini, M., M. Khayam-Nekoui, V. Grigorian, T. M. Gradziel, and P. Martínez-Gómez. 2010. The origin and dissemination of the cultivated almond as determined by nuclear and chloroplast SSR marker analysis. Sci. Hortic. (Amst.) 125:593–601.