Medicinal and Aromatic Plants: Trade, Production, and Management of Botanical Resources

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Abstract

Medicinal and aromatic plants are offered in a wide variety of products on the market. At least every fourth flowering plant is used. The enormous demand in botanicals results in a huge trade from local to international level. In the 1990s, the reported annual world-wide importation of *pharmaceutical plants* amounted on average to 400,000 t valued at USD 1,224 million. The international trade is dominated by only few countries. About 80 % of the world-wide imports and exports are allotted to only 12 countries with the dominance of temperate Asian and European countries. Whereas Japan and the Republic of Korea are the main consumers of *pharmaceutical plants*, and China and India are the world's leading producing nations, Hong Kong, the USA and Germany stand out as important trade centres. Until now, the production of botanicals relies to a large degree on wild-collection. However, utilization and commerce of wild plant resources are not detrimental in themselves, but, for example, the increasing commercial collection, largely unmonitored trade, and habitat loss lead to an incomparably growing pressure on plant populations in the wild. World-wide an estimated 9,000 medicinal plant species are threatened. Conservation concepts and measures which have to meet future supply and the provisions of species conservation range from resource management, cultivation, shifting processing from consumer to source countries, species conservation to trade restrictions or even trade bans. Medicinal and aromatic plants are of high priority for conservation action, as wild-crafting will certainly continue to play a significant role in their future trade: the sustainable commercial use of their biological resources may provide a financial instrument for nature conservation.

INTRODUCTION

Phytopharmaceuticals, also some pharmaceuticals, herbal remedies, dietary supplements, homeopathics, medicinal and herbal teas, liqueurs, spirits, sweets, aromas and essences, perfumes, cosmetics, colouring agents, varnishes, fireworks, and detergents – plant-based products offered in a wide variety on the market. Whereas in some goods the herbal ingredients are evident, e.g. in teas or in herbal remedies where they are declared on the packaging, in other products the botanically source is more secret: the bitter taste of Campari is based on the Common Centaury (*Centaurium erythraea*), and the fenugreek (*Trigonella foenum-graecum*) contains steroid-saponins which are extracted for use in oral contraceptives. The use of botanical raw material is in many cases much cheaper than to use chemical alternative substances.

As a consequence, there is an enormous demand in botanicals resulting in a huge trade, on local, regional, national and international level - for domestic use and for commercial trade. Different aspects are associated with the trade in medicinal and aromatic plant material, the trade structure, trade volumes and values, the herbs used and their production, the ecological and socio-economic impacts of the trade, and the management of the botanical resources.

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MEDICINAL AND AROMATIC PLANTS IN USE

Species in Use

World-wide, it is estimated that up to 70,000 species are used in folk medicine (Farnsworth and Soejarto, 1991). The WHO reports over 21,000 plant taxa used for medicinal purposes (Groombridge, 1992). Unfortunately, there is no idea how many species are used in the other areas of use, like cosmetics, spirits or aromas which makes determining exactly the number of all medicinal and aromatic plant species used world-wide impossible. However, it can be stated, that at least every fourth plant is in use, a calculation based upon the estimated total number of 300-350,000 flowering plants.

The number of medicinal and aromatic plant species used in some regions are impressive: In India, which is said to have probably the oldest, richest and most diverse cultural traditions in the use of medicinal plants, about 7,500 species are used in ethnomedicines (Shankar and Majumdar, 1997) which is half of the country's 17,000 Indian native plant species. In China, the total number of medicinal plants used in different parts of the country add up to some 6,000 species according to Xiao (1991) and to over ten thousand according to He and Sheng (1997). Of these, approximately 1,000 plant species are commonly used in Chinese medicine, and about half of these are considered as the main medicinal plants (He and Sheng, 1997). In Africa, over 5,000 plant species are known to be used for medicinal purposes (Iwu, 1993).

In Europe with its long tradition in the use of botanicals, about 2,000 medicinal and aromatic plant species are used on a commercial basis (Lange, 1998). In Germany, Lange (1996) identified not less than 1,500 taxa as sources of medicinal and aromatic plant material. In Spain, it is estimated that 800 medicinal and aromatic plant species are used of which 450 species are associated with commercial use (Blanco and Breaux, 1997; Lange, 1998).

Geographical Origin of the Species in Use

Herbs used in a country can be either indigenous or native to other regions or even continents. The share of both plant groups depends on the country's cultural preferences, importance of traditional medicines, history, trade relations, and of course of the wealth or poverty of a country.

Traditional medicines are playing an important role in many parts of the world. In south and southeast Asia, the Ayurveda, Unani and Siddha medicines are widely distributed and based on not less than 400, 500 respective 1,800 native Indian plant species (Shankar and Majumdar, 1997). The TCM, the traditional medicine of eastern Asia, relies in most cases on indigenous plant species. Traditional healers in many African countries rely on local or at most regional plant material (Marshall, 1998). In Bulgaria, about 750 native plant species, or 20 % of the total flora, are used in folk medicine. Of these, 200-300 species are most commonly used (Hardalova, 1997). Further, in Albania, 205 native plant species are used as sources of botanicals (Vaso, 1997; Lange, 1998). In Hungary, some 270 native medicinal and aromatic plant taxa are used, 180-200 of which are officially recognised by the Hungarian Pharmacopoeia (Bernáth, 1996). Özhatay et al. (1997) list a total of 337 native taxa that have been commercially traded in Turkey since at least 1990 (Lange, 2001). From the French pharmacopoeia and lists of medicines Goi et al. (1997; Lange, 1998) noted some 900 taxa, of which almost half are native to Europe. This means, that many countries rely on a major part on their own plant diversity. Many of them cannot afford to import foreign botanicals, finished herbal products or even phytopharmaceuticals and the country's own "biodiversity" is mainly offered in a crude form or at most as little processed products on the market.

On the other side, there are the developed countries which use besides indigenous plant species a lot of non-native species and process them in their well developed pharmaceutical, cosmetic and extract-producing industry. Accordingly, the plant material is offered to the consumers as mainly packed and finished products, and the crude material plays a minor role in the retail trade. This features apply above all to the highly

industrialized countries of temperate Asia (e.g. Japan and the Republic of Korea), of the Americas and of Europe.

The geographical origin of the botanicals used in Germany (Lange, 1996) may illustrate the kind of use of non-native and native species (Fig. 1). In general, the medicinal and aromatic plants are coming from all geographical regions of the world, and many of these species show a wide geographical range. The high figure of 849 species occurring in temperate Asia of which 248 are restricted to this region is due to the TCM botanicals increasingly used in Germany. 454 species grow in North America, many of them are used in homeopathy. Species with their distribution area restricted to Africa, South America, Australia, New Zealand or the Pacific play a minor role in Germany's industry. A high number of not less than 605 species are native to Europe. The majority of them is distributed across several geographical units, e.g. Eurasia or even the Northern Hemisphere; only 16 species are limited to Europe. Many of the 605 species are growing in Mediterranean countries like Italy, France, Spain and Greece, and more than two third of them occur in east and southeast Europe, in Romania (451 species), Bulgaria (421 species), Hungary (415 species), Albania (391 species), and in Poland (386 species). In general, both regions are rich suppliers for botanicals within Europe (Lange, 2001).

Based on this analysis, an astonishing fact is revealed: In Germany not less than 5 % of the European plant diversity is used, but the share of the South American plants used is less than 0.2 % of the total plant inventory of that continent which shows with more than 100,000 plant species the world's most diverse flora. Farnsworth and Soejaerto (1991) came to a comparable result when analysing the geographical origin of the world's c. 121 clinically useful prescription drugs used in the USA: 80 % of them derived from plants other than the tropics, mainly the north temperate and subtropical regions, while only the remaining 20 % or 23 drugs had been processed from tropical plants. In general, the knowledge of the medicinal and aromatic plants of the temperate regions with a poorer flora, is better than that of the tropics. Two facts may play a role in this field: (1) Phytochemical studies and medical advances in the temperate areas have taken place for a much longer period than those in the tropical regions, and (2) the problems of accessibility, logistical and political problems, in the collection of plant samples from the tropical rain forests (Farnsworth and Soejaerto, 1991).

The use of native species is documented also for other industrialized countries: Two thirds of the 2,000 plant taxa used in Europe on a commercial basis are native to this region. In the United States, at least 180 native plant species are offered on the non-prescription medicinal market (Robbins, 1999); this figure does not include those species used at regional or local level.

To summarize it, in most countries native species are used, but the ratio native:non-native species differs from country to country and coupled with this, the plant material offered ranges from the majority offered as crude material to the offer of mainly packaged and finished products.

MEDICINAL AND AROMATIC PLANTS IN TRADE

Botanicals in International Trade Statistics

The analysis of international trade figures of botanicals gives an overview on the main features of the world-wide trade in this commodity, in particular on the significance of this market, the main acting countries and the main trade streams (see also Lange, 1997, 1998). For this purpose, the international trade figures of the commodity group *pharmaceutical plants*, SITC.3 292.4[1], compiled in the UNCTAD COMTRADE database by the United Nations Statistics Division, New York, have been evaluated. Principally, the presented global trade figures are based on the export and import statistics of 162 countries for the period 1991 to 2000, in which 110 countries reported an import and/or export of

[1] Standard International Trade Classification Revision 3

pharmaceutical plants. Commodity group 292.4 equates to HS[2] 1211 plants and parts of plants (including seeds and fruits), of a kind used primarily in perfumery, in pharmacy or for insecticidal, fungicidal or similar purposes, fresh or dried, whether or not cut, crushed or powdered.

Traded Forms of Botanicals

The plant raw material in trade consists of mainly dried plant parts, roots, leaves, bark, wood, flowers, or seeds, or sometimes, of several plant parts or even the whole plant if the demanded constituents are concentrated in several plant organs or even in the whole plant body. To a small extent, the plant material is traded fresh or preserved in alcohol (Lange, 1996). The bulk of traded plant material is not or only little processed, which is in general cheaper than that which has been further processed, i.e. cut, rubbed, powdered or even extracted.

Characteristics of the Trade

The global importance of the commodity *pharmaceutical plants* is enormous. In the 1990s, its reported annual overall importation amounted on average to 400,000 t valued at USD 1,224 million[3]. The international trade is dominated by only few countries: 8 2 % of the world-wide importation was channelled to just 12 countries (Fig. 2), and 12 countries were responsible for 80 % of the overall world‘s exportation. The role of temperate Asia and Europe in this trade is dominant, as the countries of temperate Asia are responsible for 42 % of the annual global importation and Europe for one third (Fig. 2). Regarding single countries, the import share of the USA is 13 % and of Germany 11 %. The list of the world’s top 12 countries of import (Table 1, left column) shows that Hong Kong[4] is by far the most important importer of pharmaceutical plants with an annual average of approximately 67,000 t. It is followed by Japan with an average import of about 51,350 t and the USA with 49,600 t a year. Germany follows on 4th place importing on average 45,350 t per year. No fewer than five European countries, all of them European Union Member States, are among the top 12 countries of import. On the export side (Table 1, right column), China heads the list of the world’s top 12 countries of export. It exported on average about 147,000 t of pharmaceutical plants in the period 1991-2000. This figure is more than double as high as the quantities exported from Hong Kong (including re-exports, see below), more than four times as high as the quantities exported from India, and ten times as high as those from Germany and the USA. Further important exporters are Mexico, Egypt, Chile, and Bulgaria. Three countries, namely the USA, Germany, and Hong Kong, are among the 12 leading countries of export and the 12 leading countries of import. All three countries stand out as important trade centres for botanicals, showing both high import and high export quantities, which are, in the case of Hong Kong, mostly re-exports. The net imports of all countries highlight the consumer and the source countries of botanicals (Fig. 3). Accordingly, Japan is by far the most important consumer country, followed by the USA, Germany and the Republic of Korea, and by four further European countries, France, Italy, the United Kingdom and Spain. In these countries, the raw material is mainly processed in each country’s enormous industry, and then sold as finished products either on the domestic market or exported as such. On the other side, Fig. 3 reveals China as most important supplier of the raw material to the world’s medicinal and aromatic plants market, followed by India on second place. Within Europe, Bulgaria and Albania are important source countries for pharmaceutical plants, within North America, Mexico, and in Africa, Egypt and Morocco.

Europe as a whole as well as many European countries are important actors in the world-wide botanical’s trade (Lange, 1998, 2001, 2002). All European countries together

[2] Harmonized Commodity Description and Coding System

[3] These figures do not include the quantities purchased and used within a country which are in some countries, like China or India, very high.

[4] Hong Kong = China HK SAR

imported annually on average 127,230 t of *pharmaceutical plants* in the period 1991-2000. About 85 % of them were destined to European Union countries. On the other hand, the annual European export average amounted to 75,900 t. During this period, the exports have been destined to more than 150 countries all over the world, but, only a small share of the overall European export, only 20 % was directed to non-European destinations, above all to North America. The exports were dominated by eastern and south-eastern European countries which account for at least 50 % of the overall exports regarding quantities (Fig. 4), but only to one third in the case of value. Most of these countries, like Bulgaria, Albania, Poland, and Hungary, mainly former Eastern Bloc countries, are important supply countries of botanicals within Europe (Lange, 1998, 2001, 2002). The dominance of Germany in the intra-European drug trade is evident: (1) One third of the overall quantities of *pharmaceutical plants* imported into Europe are destined to Germany (Fig. 5); (2) the share of the country's exports is approximately one fifth in terms of quantities; (3) moreover, Germany acts as a link between the markets of eastern and south-eastern Europe and those of west and central Europe: It imports two third of the plant material exported from south and southeast European countries (Fig. 6; Lange, 1998), and exports it above all to central and western European countries (Fig., 7; Lange, 1998).

Besides Germany, there are two further important trade centres for botanicals (see above). Similar to Germany, the USA imports the commodity *pharmaceutical plants* from all over the world, but the main destinations of the exports are Canada, the United Kingdom, Germany, Saudi Arabia, Hong Kong, and Kuweit. Hong Kong is the third important trade centre playing a pivotal role in the east and southeast Asian trade. In contrast to Germany and the USA, 95 % of the imports of Hong Kong are re-exported. Further, 80-90 % of the country's imports are from a single country, namely China, the remaining from Indonesia, the Republic of Korea, Australia, Thailand, and Macau (=China MC SAR). The exports have been destined to many countries all over the world with preference to east and southeast Asian countries. However, its importance declined during the 1990s, as the exports and imports of Hong Kong decreased from some 80,000 t in 1991 to 38,000 t in 2000.

Major Traded Botanicals

There are no or only few reliable trade data available for single botanicals (Lange, 1996, 1998). The commodity group *pharmaceutical plants* includes those used only in small quantities as well as bulk material with great industrial importance. In Germany, the most used medicinal plant is Gingko (*Gingko biloba*), followed by i.a. Horse-chestnut (*Aesculus hippocastanum*), Hawthorn (*Crataegus* spp.), St John's-wort (*Hypericum perforatum*), Nettle (*Urtica dioca*), Echinacea (*Echinacea* spp.), Saw Palmetto (*Serenoa repens*), and Milk Thistle (*Silybum marianum*) (Grünwald and Büttel, 1996). Some of these plants are also highly used in the USA, like Echinacea, St John's-wort, and Saw Palmetto, but the preferences are somewhat different: Siberian Ginseng (*Eleutherococcus senticosus*), Goldenseal (*Hydrastis canadensis*), Cat's Claw (*Uncaria* species), Astragalus membranaceus, Dong Quai (*Angelica sinensis*) and Cascara Sagrada (*Rhamnus purshianus*) are listed among the top-selling botanicals (Laird, 1999).

Wild or Cultivated Origin?

In general, cultivation of medicinal and aromatic plant species is known since some thousand years. For example, Opium Poppy (*Papaver somniferum*) has been known from cultivation since about 2700 B.C. (Heeger, 1989). In central Europe there is a long tradition of growing medicinal plants, dating back to the medieval gardens of Christendom (Hobhouse, 1992). Within in the European Union, medicinal and aromatic plants are cultivated today on an area of about 70,000 ha which a recent study on behalf of the European Commission has shown (Verlet and Leclercq, 1997). France (25,000 ha) and Spain (19,000 ha) are the countries with the largest areas under cultivation, followed by Germany (5,700 ha), Austria (4,300 ha) and Greece (4,000 ha). Outside the European

Union, Hungary and Poland are important suppliers of botanicals to the European drug market sourced from cultivation. In Poland, 30,000 ha are under cultivation (Lutomski and Gorecki, 1999) and in Hungary 34,000-40,000 ha (Kupke et al., 2000). These figures are comparably low to the 300,000 ha under cultivation in India and 460,000 ha in China (Xiao, 1991).

Important crop species are, for example, pumpkin (*Cucurbita pepo*), lavender (*Lavandula* spp.), mint (*Mentha* x *piperita*), Opium Poppy (*Papaver somniferum*), Caraway (*Carum carvi*), Fennel (*Foeniculum vulgare*), Chamomile (*Matricaria recutita*), and Parsely (*Petroselinum crispum*) (Verlet and Leclercq 1997; Lange, 1998; Pank 1998). In India, namely Psyllium (*Plantago ovata*), Senna (*Cassia angustifolia*), *Atropa belladonna* and *A. acuminata* as well as *Cinchona* species are cultivated (Atal and Kapur, 1982). In China important crops are *Panax ginseng*, *Angelica sinensis*, *Coptis chinensis*, and *Paeonia suffruticosa* (Xiao, 1991). In all, more than 100 species are cultivated on a commercial scale (Xiao, 1991; more than 250 species according to He and Sheng 1997), and in Europe, about 130-140 species (Pank, 1998). These figures include besides native also non-native plant species, a few plant species known only from cultivation, such as *Mentha* x *piperita*, as well as plant species which are obtained both from cultivation and from wild stock. For example, *Gingko biloba* native to southeast China and *Echinacea purpurea* and *E. pallida* indigenous to North America, are cultivated in Europe or the North American *Panax quinquefolius* and *Strychnos nux-vomica* native from south Asia to northern Australia are cultivated in China (Xiao, 1991). Examples for cultivated and wild-collected plant species are Mountain Tobacco (*Arnica montana*), Yellow Gentian (*Gentiana lutea*), and St. John's-wort (*Hypericum perforatum*). In addition to these some hundreds plant species cultivated on a ± large scale, there are a lot of medicinal plants used in homeopathy which are cultivated on a small or even a very small scale, either in small beds in the companies' own gardens or glasshouses to fulfill the annual demand of sometimes only some kilograms of often fresh plant material.

The figure of 130-140 cultivated plant species in Europe is very little compared to the 2,000 commercially used. Consequently, in terms of numbers, about 90 % of the 1,200-1,300 European native species are primarily harvested from the wild - a surprisingly high share (Lange, 1998). Also in China, the major part of plant material used in TCM is sourced from wild populations. Among the 1,000 commonly used medicinal plants, 80 % in terms of numbers originate from the wild (He and Sheng, 1997).

To calculate the share of wild-collected botanicals in terms of quantities, is much more difficult. Unfortunately, there are no exact figures available of the total production of herbs within a country including plant material collected for own purposes, purchased for the domestic market, or destined for export either as raw material or processed commodity. Moreover, there are no exact figures of the medicinal and aromatic plant material produced under cultivation. Thus, a global estimation of the share of wild-collected plant material is impossible. However, there is few information available: In China, 60 % of the quantities in trade are sourced from the wild (He and Sheng, 1997). Theoretically, on average over 80,000 t of the annual exports of *pharmaceutical plants* are wild-harvested. But, the botanicals exported are only a small part of the huge annual domestic production which approached 700,000 t in the early 1990s (Xiao, 1991). In Nepal, every year more than 15,000 t of herbs are taken from the wild (Bhattarai, 1997). Dozens and possible hundreds of medicinal and aromatic plants are collected in large amounts from wild lands in Canada, Mexico and the United States (Robbins, 1999) and Fuller (1991) published a list of 71 taxa in commercial demand which are primarily wild-harvested.

In Europe, the production of herbs relies also to a large degree on wild-collection but the ratio wild-collection:cultivation differs from country to country (Lange 1998). In particular, in eastern and south-eastern European countries, wild-crafting is still playing a pivotal role (Lange, 1998, 2001, 2002). For example, according to Vaso (1997; see also Lange 1998), in Albania most of the raw plant material in trade is sourced through wild-

collection. The same applies to Turkey (Özhatay et al. 1997; Atay, in litt. to D. Lange, 19.2.1998; Lange 1998). In Bulgaria, not less than 75-80 % of the quantity of medicinal and aromatic plant material in trade is obtained from wild stock (Hardalova,1997), and in Hungary the share amounts to 30-50 % (Bernáth, 1996), which means that each year some 10,000-15,000 t of dried biomass are produced from wild Hungarian medicinal and aromatic plant populations for industrial use. According to Lutomski and Gorecki (1999), in Poland, although being a country where medicinal and aromatic plants are cultivated on a huge area, some 5,000 t of plant material is sourced annually from the wild. In Slovakia, Kupke et al. (2000) estimate the wild-collected plant material to 60-70 %. Accordingly, the quantity of wild-collected botanicals in east and southeast Europe in the late 1990s is estimated to a minimum of 30,000-45,000 t of dry plant material (the fresh material weights two to three times more).

The choice of wild or cultivated plants is not dependent upon the market catered for, but upon species. For example, rose hips demanded in large quantities are harvested in the wild, in Chile and in Turkey (Lange, 1996, 1998). Also thyme, gums, algae needed in great amounts are sourced from the wild. Liquorice roots greatly demanded for the liquor and sweets industry are obtained from cultivation and from wild-collection.

THREATS AND CONSERVATION ASPECTS

Ecological Impacts of the Trade in Medicinal and Aromatic Plants: Threat Factors

The utilization of botanicals raises questions about the environmental implications of the practice on wild populations, species and the ecosystems from which they are sourced. However, utilization and commerce of wild plant resources are not detrimental in themselves. But, a growing pressure on plant populations in the wild can be observed.

Threats facing medicinal and aromatic plants and their wild populations are (1) the intensive and increasing commercial collection, often concentrated in few areas, (2) the largely unmonitored trade, (3) destructive harvesting techniques, (4) trade structure changes in countries of the former Eastern Bloc, and (4) global habitat loss and alteration.

During the 1990s the demand in raw material increased due to the increasing demand in plant-based remedies and products – a result of the increasingly global nature of the trade, the world-wide population growth and the increasing popularity of herbs and herbal products in industrial nations and their effective marketing. This has resulted in some countries, above all in the USA and Japan, in explosive demand and consumption of medicinal plants (Table 2; Laird, 1999); in particular, the demand in St. John's-wort increased by several hundred per cent in the USA in the middle of the 1990s. Additionally, more and more people in industrialized countries are increasingly interested in foreign traditional medicines like Ayurveda and TCM. In all, the imports of pharmaceutical plants increased from about 270,000 t in 1991 to almost 400,000 t in 2000 (Table 2). In general, on regional and country level, the imports increased until 1996-1998, sometimes considerably as in the case of the temperate Asian countries (Table 2). Between 1996 and 1998, the market in pharmaceutical plants broke down in particular in the USA and in temperate Asia, but has already started to recover (Table 2). In many of the major supply countries of botanicals, the exports have increased significantly in the 1990s (Table 3). In China, the exports of pharmaceutical plants doubled almost from 107,500 t in 1991 to 186,450 t in 2000, and the domestic demand for botanicals has grown at an annual rate of 9 % over the past decades (He and Sheng, 1997). Also, Europe has doubled its export during this period, and Mexico have shown very high export increases since the midth of the 1990s (Table 3). Although huge efforts have been done in the area of cultivation, the increasing demand has been and is still covered by a major part through wild-collection.

The drastic decline of a species is often due to the demand in international trade and not to the supply needed by the indigenous population. The roots of the Himalayan *Rauvolfia serpentina*, Serpent wood, have been used for 4,000 years in the Ayurvedic medicine, but the discovery of reserpine in the roots, has led to a thoughtless exploitation

of this species. Recent examples are Pygeum, *Prunus africana* (Cunningham et al., 1997), and *Taxus wallichiana*, the Himalayan Yew (Laird and ten Kate, 1999; see below). All these species have become listed on CITES Appendix II.

The trade in botanicals is largely unmonitored. Only in a few cases, resource management takes place. In general, medicinal or aromatic plants are collected in few countries rather within their whole area of distribution. Wild-collection takes place in countries with low income level, or in countries with great unprivileged social groups where collection is often an additional or even the only income. Examples are Nepal, Mexico, Turkey, Albania and Bulgaria. As a result, plant populations are often locally over-exploited (see also Laird, 1999). In general, these countries are a very cheap source for botanicals. The relatively low prices for wild-harvested plant material is one fact to prevent the increase of the share of cultivated plant material in trade which is, in general, much more expensive.

There is a very particular impact on wild medicinal and aromatic plant populations in the countries of the former Eastern Bloc (Bernáth, 1996; Bernáth and Németh, 1999). It is the change of the trade after the end of the communism and its subsequent deregulation. The formerly centrally organised herb trade and the country-wide networks enabled a high control of the collection, purchase and export of herbs. After the fall of communism, the former legal structures did not longer apply, and the governmental instruments to control ceased to exist. This and the recent privatisation of rural lands, the high number of new evolved companies in this trade and their fluctuation, the influx of unspecialised labour to the business of collecting or dealing in the commodity have been leading to unregulated exploitation of medicinal and aromatic plants and unmonitored export of botanicals. As a result, an enlarging number of plant species has become threatened. Many of them had to be placed under legal protection, which ranges from controlled gathering to strictly protection (Bernáth, 1996; Németh, 1997; Lange, 1998).

A further threat may be destructive harvesting techniques. To harvest the bark by felling the whole tree, or to collect the fruits by cutting whole twigs may damage the plant significantly or even destroy it. An example is Alder Buckthorn (*Frangula alnus*), a small tree of which the bark is used. Owing to felling the whole tree for to obtain the bark the species became rare in Romania, Bulgaria and in Turkey (Özhatay et al., 1997; Lange, 1998). Cunningham (1997) reported *Griffonia simplicifolia* vines and *Voacanga africana* and *V. thouarsii* trees to be chopped down in order to obtain the fruits. Harvesting the roots or rhizomes of a plant is destructive per se. Many plant species of which the underground parts are used are threatened, for example *Gylcyrrhiza* species (He and Sheng, 1997; Özhatay et al., 1997; Lange, 1998), the source of liquorice. Further, the roots or rhizomes of many of the medicinal plants explicitly listed on CITES Appendices I and II due to their over-exploitation for medicinal use and trade are collected (Lange, 1999; Lange and Schippmann, 1999). Appendix II examples are the ginsengs, *Panax quinquefolius* and *P. ginseng*, *Picrorhiza kurrooa*, Himalayan Mayapple (*Podophyllum hexandrum*), and the Indian Nard (*Nardostachys grandiflora*). The Costus root, *Saussurea costus*, is listed on Appendix I.

An essential factor that poses a significant threat to wild populations and species is the continuing global destruction of habitats. This is often discussed in the context of the vanishing tropical and subtropical rainforests. However, habitat loss and alteration also affects the populations of medicinal plants in Europe or North America. It is largely a result of changing agricultural practices during the past 100-200 years. In Europe, there was a steady degradation of the relatively rich, pre-industrial countryside to a monotonous, large-scale, fully mechanised agro-industrial landscape. Habitats that are especially endangered in Europe are bogs, marshlands, and wet meadows. Their decline affects the populations of the medicinal plants Round-leaved Sundew, *Drosera rotundi-folia*, or Bogbean, *Menyanthes trifoliata*.

Over-exploitation of medicinal plant resources may result in a decline in genetic diversity. In areas with a high diversity in medicinal and aromatic plants this may lead to problems of genetic erosion. This applies to regions such as Mexico, parts of South

America, west Asia and India. The loss of genetic diversity may cause enormous problems in the context of cultivation aspects.

Threatened Medicinal and Aromatic Plants

In many cases several threat factors intensify the overall threat to a species. There is an increasing number of publications reporting on the shortage in natural resources of many medicinal and aromatic plants all over the world (i.a. Jain and Sastry, 1980; Fuller, 1991; Cunningham, 1997; He and Sheng, 1997; Lange, 1998, 2001; Bajaj, 1999; Robbins, 1999; Bhattarai et al., 2002). Many of them have to be assessed as endangered or even critically endangered or have to be put under legal protection. The question arises, how many medicinal and aromatic plant species are threatened as a result of their demand in trade? To ascertain exactly the number is impossible. The reasons are lack of information on many species' biology, ecology, distribution, population status, regeneration after harvest, use, supply and demand, as well as their availability. Leaman (1998) of the Medicinal Plants Specialist Group of the IUCN Species Survival Commission estimates the number of medicinal plants which are threatened world-wide to at least 10,000 species.

The threat to medicinal plants from over-collection is not a new phenomenon. It can be observed since the Roman period. However only few examples are known from the past. The oldest written record of an extinct medicinal plant species concerns a plant named Silphium (Koerper and Kolls, 1999). Ancient texts provide an extensive list of purported medicinal benefits for it. Between 570 and 250 B.C. many coins of the ancient Cyrene, in north Libya, depict the plant, which maybe belonged to the genus *Ferula*, similar to the Giant Fennel (*Ferula communis)* growing in the Mediterranean region. In the first century, according to Plinius, there was only one plant still found in north Africa. Attempts to cultivate the plant failed. It is most probably, that the plant was harvested to extinction.

Within Europe, at least 150 species are reported to be threatened at least in one country (Lange, 1998), which is more than $1/10^{th}$ of the European native medicinal and aromatic plant species and 1.2 % of the total European flora. Examples are well-known medicinal plants like *Arnica montana*, *Arctostaphylos uva-ursi* and *Gentiana lutea* (Lange, 1998). Oregano is a spice appreciated for its value in flavouring cookery, in particular for pizza. Many of the 36 species which are widely distributed in Eurasia and the Mediterranean area are used and collected for local use (Lange, 1998). Although, oregano is cultivated on a large scale in Poland and Chile, in Turkey and the Balkan region thousands of tonnes are sourced from the wild each year (Lange, 1996, 1998; Özhatay et al., 1997). These huge amounts of wild-harvested plant material have massive impacts on the populations resulting in decreasing population sizes of the common and widely distributed species. Endemics which are collected together with the common species, may be especially impacted by harvest (Özhatay, 1997; Lange, 1998). The genus *Sideritis* with its approximately hundred species is distributed in southern Europe and Asia Minor with centres of diversity in Spain and in Turkey. In particular, in Spain, southeast Europe and Turkey, a lot of *Sideritis* species, including many endemics are favoured as herbal tea (Blanco and Breaux, 1997; Lange, 1998). Threats facing these species today are apart from local and national demand, the increasing demand in international trade: Recently, it has become fashionable in Germany where it is sold as Greek mountain tea. Decline of population sizes are reported (Blanco and Breaux, 1997; Vaso, 1997; Lange, 1998), resulting in Red book-listing in Bulgaria and Albania. The rhizomes of Butcher's Broom, *Ruscus aculeatus*, a species ranging from the Mediterranean area to the Black Sea, are used increasingly in remedies for venous insuffiency. The plant material is mainly sourced from wild stock in Turkey where 2,000 t of fresh roots are collected per year. Owing to over-collection, the species has become locally extinct in Turkey (Özhatay et al., 1997; Lange, 1998). The Bearberry, *Arctostaphylos uva-ursi*, is a subshrub of high commercial value. Its leaves are used to treat inflammatory disorders of the lower urinary tract. Whereas the species is common in

northern Europe, Asia and North America, distribution in the south is relictic and limited to mountainous areas and the impact of any exploitation in this area may be serious. Nevertheless, Bearberry is collected in Romania, Bulgaria and in Spain, and indeed it is reported to be threatened in many central and southeast European countries (Blanco and Breaux, 1997; Lange, 1998). To monitor the trade, the species has been listed on Annex D of the Council Regulation (EC) No. 338/97 which implements CITES in the European Union. However, this does not affect the trade with Spain.

TRAFFIC North America identified some 70 native North American medicinal and aromatic plants showing declining populations in the 1990s (Robbins, 1999). Examples include Virginia Snakeroot, *Aristolochia serpentaria*, Blue Cohosh, *Caulophyllum thalictroides*, May Apple, *Podophyllum peltatum*, and Yellow Wild-indigo, *Baptisia tinctoria*. The bark of the Pacific Yew tree (*Taxus brevifolia*), contains paclixatel (taxol), discovered and developed as a promising anti-breastcancer substance from the 1960s to the 1980s (Laird and ten Kate, 1999). 6,000 kg bark obtained from 1,000 trees were necessary for the production of 1 kg taxol. After over-exploitating the stands of the Pacific Yew and the subsequent ban, trade shifted to exploit the Himalayan Yew, *Taxus wallichiana*, which were over-exploited to such a degree that it became listed on CITES Appendix II in 1994. Nowadays, Baccatin 3, a prestage of taxol is processed from the needles of varies Yew species, and recently the company Bristol-Myers Sqibb informed that it is possible now to process Paclitaxel through cell tissue culture (Anon., 2002).

The Asian Ginseng, *Panax ginseng*, is obviously the world's most well-known medicinal plant, and which in general is not known, one of the rarest medicinal plant (Lange, in preparation). The roots of the Asian Ginseng are regarded as a tonic with antistress, antifague and antiaging properties, and heighten the resistance of the organism to various environmental influences (Wichtl 1994; But et al., 1995). Ginseng is offered in lots of varieties: from the root itself, fresh or dried, instant tea, to tablets and tonics (Wichtl, 1994; Lange, in preparation). Originally, *P. ginseng* was distributed in northeastern China, Korea, and in parts of east Russia, but owing to the long use of the Asian Ginseng, the species became extinct in many areas. Today, the main area of the species lies in the Russian Far East where it grows mainly in very shady stands of old and dense mixed Korean Pine-forests (Zhuravlev and Kolyada, 1996). Although *Panax ginseng* is widely cultivated today, and most of the commodities in trade are sourced from cultivation, wild harvesting takes still place. Wild Ginseng roots are highly valued as medicine. During time of communism, collection of wild roots of *P. ginseng* in Russia was regulated and controlled according to well-established traditions. Since the beginning of the 1990s ginseng collection has changed dramatically in Russia: Suddenly, there was a great Chinese demand for wild Asian Ginseng roots. About 1-10 USD were paid for 1 g fresh root on the black market. In Hong Kong very old roots may achieve even prices of USD 20,000. Such a high price is an important incentive in a country with a lot of unemployed people. The traditional way of collection was replaced by uncontrolled harvesting carried out by mostly unskilled people. The excessive and illegal exploitation of wild Asian Ginseng has led to an alarming decrease of its population sizes during the 1990s. Loss of genetic diversity is the result, an alarming fact as Ginseng is an important crop species. On the 11th COP, the Russian populations of *Panax ginseng* were listed on CITES Appendix II.

Conservation Concepts and Management of Botanical Resources

In the case of medicinal and aromatic plants, conservation concepts and management measures have to meet both (1) future supply, and (2) the provisions of species conservation. Measures on local, regional, national or international range from resource management, cultivation, adequate species conservation programmes, and shifting processing from consumer to source countries, to trade restrictions or even trade bans. In the following, some selected conservation aspects and resource management issues will be briefly discussed.

According to IUCN, WHO and WWF (1993) the cultivation of medicinal and

aromatic plants is the best and promising way to satisfy the market's expanding demand for these raw materials. But, up to now cultivation has not proved to be profitable for the majority of taxa in trade (Lange, 1998): (1) Many plants are difficult to cultivate, (2) to take a plant into cultivation, if possible, will often last many years, (3) many plants are only required in small quantities, (4) in some cases the quality of wild-harvested material is supposed to be superior, and (5) the costs for wild-crafted plant material is in general lower than for cultivated material (Lange, 1997). Further, there is a socio-economic aspect which supports future wild-collection, as wild-collection may be an additional income or even the only income of rural or poor people in some countries. However, in the case of highly demanded medicinal and aromatic plants and those critically endangered through over-exploitation or habitat loss cultivation is certainly the only method to stop the decline of their population sizes and to secure the species' long term survival.

Medicinal and aromatic plants are of high priority for conservation action, as their wild-crafting will certainly continue to play a significant role in future trade. Accordingly, it is necessary to ensure the sustainability of their wild-collection through developing and implementing adequate general and species-specific management programmes which should cover trade monitoring and guidelines for sustainable collection, maybe supported by an adequate certification (Walter, 2002). This requires co-ordinated conservation work at regional, national or even global level involving conservationists, scientists, governmental authorities, producers, traders and the processing industry.

The protection of species through restrictions on trade, or, in the case of critically endangered plant species, a complete ban may be measures for improving the population status of the medicinal and aromatic plants concerned. In Bulgaria, a major supply country for botanicals within Europe, wild-harvesting of, and trade in medicinal and aromatic plants are governed by several ordinances (Lange and Mladenova, 1997). Several threatened plant species are subject to restrictions and prohibitions and their collection and trade is subject to prior authorisation. For this purpose a scientific based quota-system has been set up each year since 1992, fixing the species, quantities, and parts of plants allowed to be collected from which districts. The quantities vary considerably from year to year according to species and region. The ordinances include annual bans on the exploitation of regional populations of some taxa and the share allowed for the internal versus external market. Botanicals governed by these ordinances are, for example, the flowers and roots of Cowslip (*Primula veris*), Bearberry leaves (*Arctostaphylos uva-ursi*), and the herb of Yellow Pheasant's-eye (*Adonis vernalis*) (Mladenova and Lange, 1997; Lange, 1998).

On international level, CITES regulates the international trade in endangered species. Species listed on CITES Appendix II are allowed to commercial trade provided that certain biological and legal requirements are satisfied before export; Appendix I-listing prohibits commercial trade in specimens harvested from wild populations. About 232 medicinal and aromatic plant species are listed on Appendix II and two on Appendix I (Lange and Schippmann, 1999) of which at least some are significantly traded, e.g. Pygeum, the bark or the bark extract of *Prunus africana*, Costus root (*Saussurea costus*), and American Ginseng (*Panax quinquefolius*) (Schippmann, 1999). However, there is a great implementation deficit, as there is insufficient trade data reported in the official CITES records (Lange and Schippmann, 1997; Lange, 1999; Schippmann, 2001). It is very difficult to detect CITES-listed commodities in trade, as the trade names often differ considerably from the accepted scientific names and the traded commodities, the dried roots, leaves, flowers, bark etc., are difficult to recognize (Lange and Schippmann, 1997; Lange, 1999). Efforts are done to train Customs and CITES authorities. This is increasingly necessary, because more and more medicinal and aromatic plant species have become listed on the CITES Appendices at the CITES Conferences of the Parties during the 1990s, e.g. Red Stinkwood (*Prunus africana*) in 1995, Goldenseal (*Hydrastis canadensis*) and Indian Nard (*Nardostachys grandiflora*) in 1997, and Yellow Pheasant's-eye (*Adonis vernalis*) and the Russian populations of the Asian Ginseng (*Panax ginseng*)

in 2000 (Lange and Schippmann, 1999). A big problem is the similarity of species between listed and non-listed species. For example, two Pockwood tree species (*Guaiacum sanctum*, *G. officinale*) are listed, but recently came up that at least one further species, the Mexican *G. coulteri* is also traded (Grow and Schwartzman, 2001). It is impossible to distinguish the trade commodity for medicinal and aromatic purposes, the heart wood or the extract made thereof, originating from these three species. Thus, the wood of *G. sanctum* or *G. officinale* may be traded as *G. coulteri* or the trade will shift to exploit or even over-exploit *G. coulteri* populations which already has happened.

In situ and ex situ protection are measures for threatened medicinal and aromatic plants in order to protect them in their natural habitats, and to maintain their genetic diversity. For example, India has established some 36 nature reserves for medicinal plants.

In many cases the raw plant material is exported and the benefit for it is relatively low. The processing mainly takes place in consumer countries. The prices on export support this. The average export price per tonne amounted to USD 2,800 in the period 1991-2000. The most important supply countries show lower prices: Turkey 2,400 USD/tonne, Bulgaria 1,540/tonne, Hungary 1,550/tonne, Morocco 1,640 USD/tonne, Albania 1,450/tonne, and Egypt 1,150 USD/tonne. The lowest price, only 850 USD/tonne, were paid for the commodities exported from Mexico. On the other hand, the plant material exported from the USA cost 7,900 USD/tonne, from Germany USD 4,580/tonne, and from France USD 4,950/tonne. The Swiss export price amounted even to USD 8,770/tonne, the Japanese to 27,500 USD/tonne and the Korean to 31,500 USD/tonne. A contribution to decrease the pressure on wild populations may be to increase the value of the plant material exported by establishing at least primary processing stages in the countries of origin.

The idea that the sustainable commercial use of biological resources, here the medicinal and aromatic plant material, may be an incentive for the conservation of some ecosystems came up in the frame of the Convention on Biological Diversity. This idea is often discussed within the context of tropical forests (i.a. Laird, 1999; Laird and ten Kate, 1999). Instead of deforestation, a revenue is achieved from non-wood forest products (i.a. Laird, 1993). A well-known and often and controversely discussed example for the commercialisation of medicinal and aromatic plant material as a financial instrument for nature conservation, are projects of the Instituto Nacional de Biodiversidad (INBio) in Costa Rica. As an important component in its work to promote the sustainable use of Costa Rican biodiversity, INBio co-operates in its programmes on bioprospecting with pharmaceutical companies like Merck (USA), Bristol-Myers Squibb (USA) and Indena (Italy) (Laird, 1993; Sidler, 1994; Laird and ten Kate, 1999; ten Kate 1999).

A widely unknown, but very interesting example, is the commercial use of Arnica flowers obtained from Mountain Tobacco (*Arnica montana*) growing on extensive pastures on top of the Vosges in France within the borders of a nature park (Parc Naturel Régional des Ballons des Vosges). These poor meadows on acid soils, developed through traditional grazing, are threatened here, as well as all over Europe, by alteration, soil improvement, application of fertilizers, woodland encroachment, afforestation, and over-grazing. *Arnica montana*, a typical element of these mountainous grasslands, became rare in many European countries, and was consequently protected (Lange, 1998). Besides habitat loss the species is threatened due to collection for medicinal use. In the Vosges, the collection of fresh Arnica plants and flowers by the Swiss pharmaceutical company Weleda, contribute to the favourable population status of the Arnica populations through financing adequate habitat management measures which include extensively grazing, no application of fertilizers, and habitat improvement measures such as mowing to force back shrub invasion with above all Bilberry (*Vaccinium myrtillus*) (Ellenberger and Leuenberger, 2000; Ellenberger, pers. commun., 2002). This is accompanied by scientific investigations in developments in Arnica populations due to environmental changes in this area (Alnot, 1998; Alnot and Ellenberger, pers. commun., 2002) Here, the sustainable commercial use of the biological resources contributes to the protection of a typical

landscape and to maintain its characteristic flora and vegetation, and the necessary habitat management measures provide a financial instrument for nature conservation.

The international trade in botanicals may have a favourable effect on the wild medicinal and aromatic plants' populations. Medicinal and aromatic plants are well suitable to implement the objectives of the Convention on Biological Diversity, and the conservation of biological diversity. There is a great chance for to protect both the species and their habitats. It is of great interest to secure the long-term survival of the populations for further generations' use.

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Tables

Table 1. The world's top 12 leading countries of import and export of pharmaceutical plants, according to average quantities and values for the period 1991-2000. Figures based on commodity group pharmaceutical plants (SITC.3: 292.4 = HS 1211). Export figures include re-export. The quantities are given in tonnes [t]. The main trade centres are underlayed grey. Source: UNCTAD COMTRADE database, United Nations Statistics Division, New York.

Country of import	**Quantity [t]**	**Value [USD]**	**Country of export**	**Quantity [t]**	**Value [USD]**
Hong Kong	67,000	291,200,000	China	147,000	281,800,000
Japan	51,350	136,000,000	Hong Kong	63,150	228,800,000
USA	49,600	135,500,000	India	33,900	56,650,000
Germany	45,350	110,200,000	Germany	15,100	70,050,000
Rep. Korea	32,250	52,300,000	USA	13,500	115,500,000
France	21,350	52,000,000	Mexico	13,000	11,250,000
China	13,650	41,600,000	Egypt	11,750	13,850,000
Italy	11,700	42,850,000	Chile	11,600	28,200,000
Pakistan	11,050	11,150,000	Bulgaria	10,050	14,500,000
Spain	9,100	27,650,000	Singapore	9,600	56,600,000
United Kingdom	7,650	27,000,000	Morocco	8,000	13,300,000
Singapore	6,300	50,600,000	Pakistan	7,800	4,950,000
Total	**326,300**	**978,150,000**	**Total**	**344,400**	**893,400,000**

Table 2. Import quantities of pharmaceutical plants of selected regions during the period 1991-2000. Figures based on commodity group pharmaceutical plants (SITC.3:292.4 = HS 1211). The quantities are given in tonnes [t]. Source: UNCTAD COMTRADE database, United Nations Statistics Division, New York.

Region or country of import	**1991 [t]**	**1992 [t]**	**1993 [t]**	**1994 [t]**	**1995 [t]**	**1996 [t]**	**1997 [t]**	**1998 [t]**	**1999 [t]**	**2000 [t]**
World	268,750	368,700	372,800	390,650	430,050	476,950	503,500	411,150	379,200	395,650
Europe	96,550	109,100	108,100	113,200	122,000	134,900	146,400	160,700	138,150	143,150
Asia temperate	142,400	166,350	162,350	180,150	196,250	233,750	221,850	129,050	120,050	137,000
USA	328 ?	50,750	44,900	50,850	55,000	56,400	71,900	62,300	53,100	50,350
Germany	37,850	42,350	39,450	44,000	49,650	51,450	48,650	53,350	42,2500	44,250

Table 3. Export (including re-export) quantities of pharmaceutical plants of selected regions during the period 1991-2000. Figures based on commodity group pharmaceutical plants (SITC.3: 292.4 = HS 1211). The quantities are given in tonnes [t]. Source: UNCTAD COMTRADE database, United Nations Statistics Division, New York.

Region or country of export	**1991 [t]**	**1992 [t]**	**1993 [t]**	**1994 [t]**	**1995 [t]**	**1996 [t]**	**1997 [t]**	**1998 [t]**	**1999 [t]**	**2000 [t]**
World	377,450	385,450	400,250	427,200	445,700	453,250	454,000	427,500	497,200	448,000
China	107,500	113,350	126,050	155,450	142,550	165,000	165,200	143,150	165,250	186,450
Europe	46,900	55,200	58,500	65,600	93,850	80,750	83,250	99,400	86,750	88,600
Mexico	8,9500	7,850	4,700	0 ?	6,250	15,150	17,600	13,850	13,000	42,550

Figures

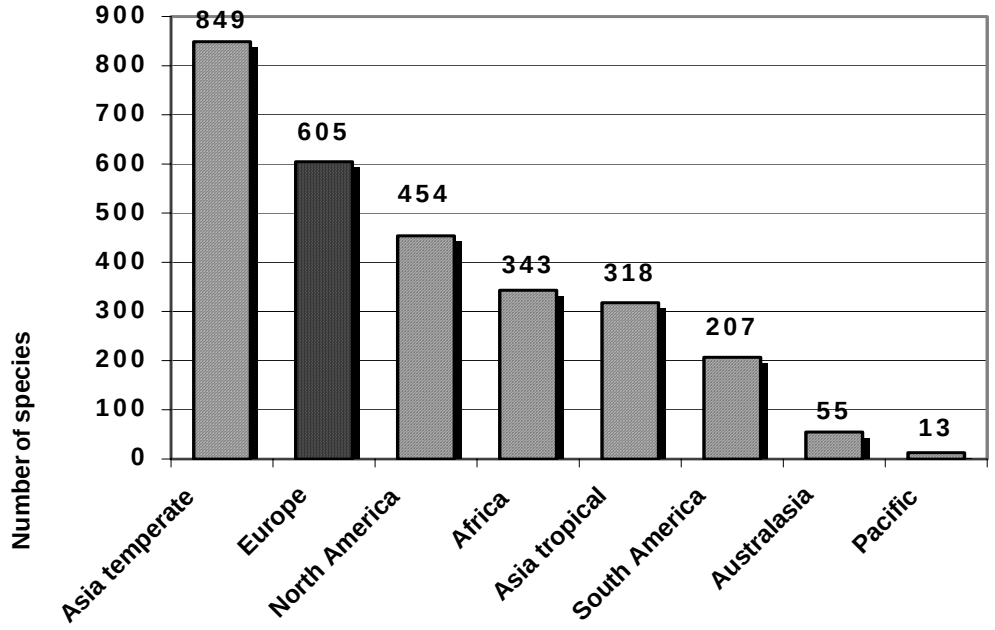

Fig. 1. Geographic range of the medicinal and aromatic plants used in Germany based on 1,464 analysed species (Lange, 1996).

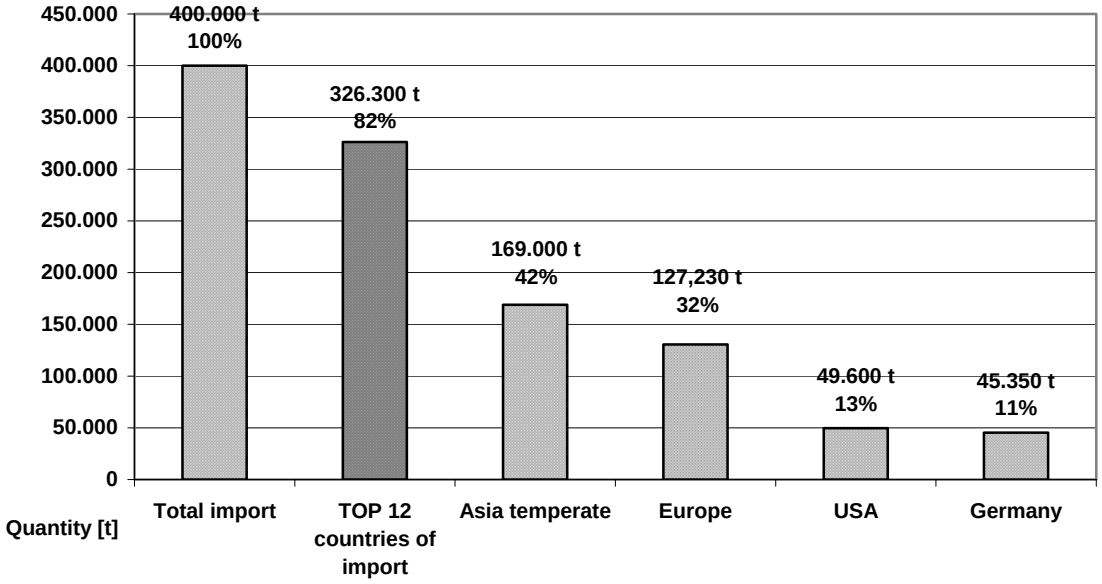

Fig. 2. The dominating actors in the international trade in pharmaceutical plants (SITC.3: commodity group 292.4) and their average import quantities (in t) for the period 1991-2000. – Source: UNCTAD COMTRADE database (United Nations Statistics Division, New York).

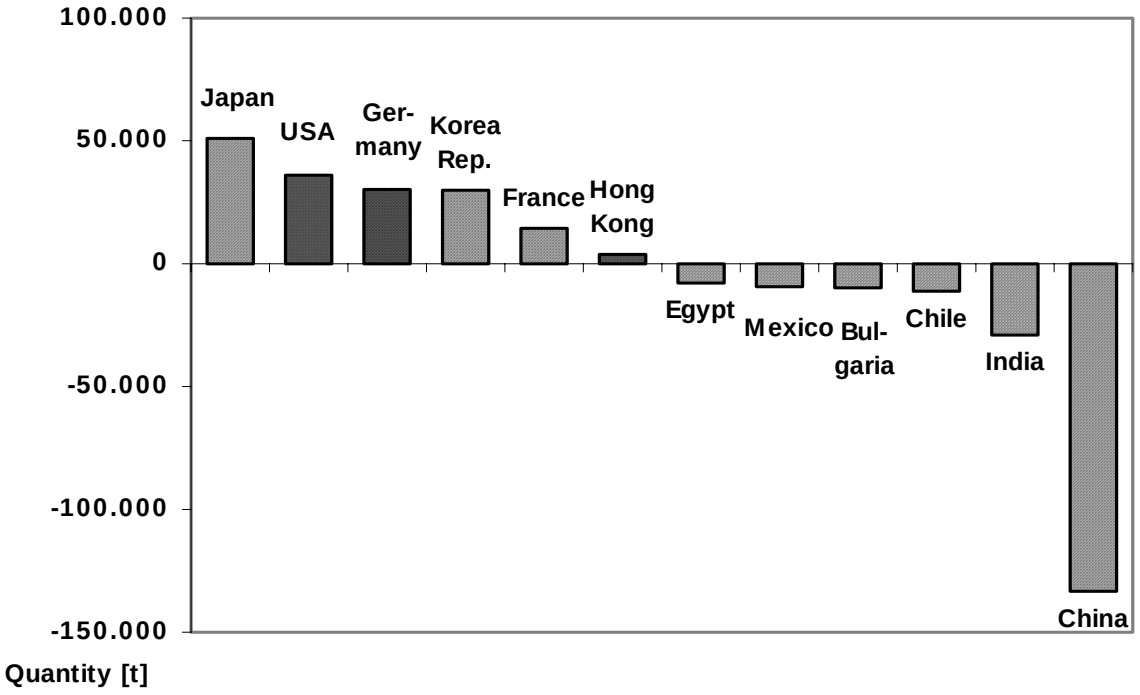

Fig. 3. Average net imports of pharmaceutical plants (SITC.3:292.4) of selected countries for the period 1991-2000. The world's top trade centres are shaded dark grey. The quantities are given in t. Source: UNCTAD COMTRADE database (United Nations Statistics Division, New York).

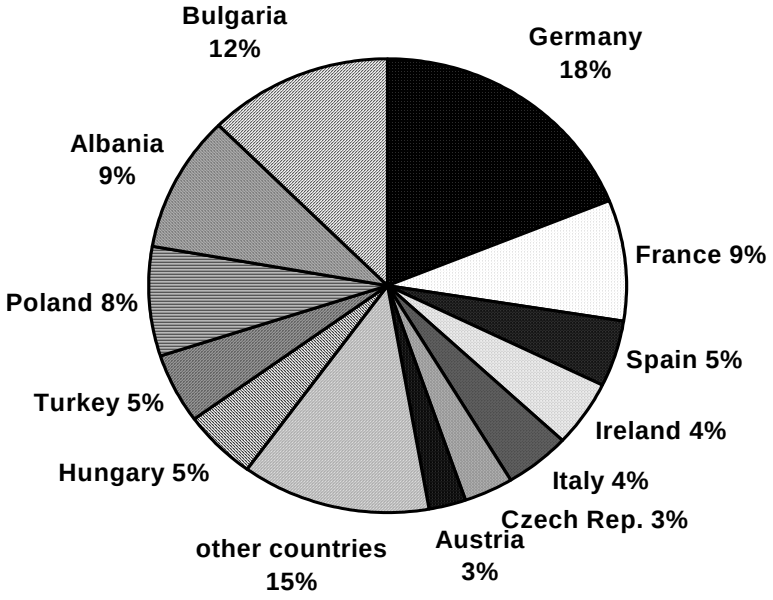

Fig. 4. Export of pharmaceutical plants (SITC.3:292.4) from European countries for the period 1991-2000. Total average export quantity 1991-2000: 75,900 t. Source: UNCTAD COMTRADE database (United Nations Statistics Division, New York).

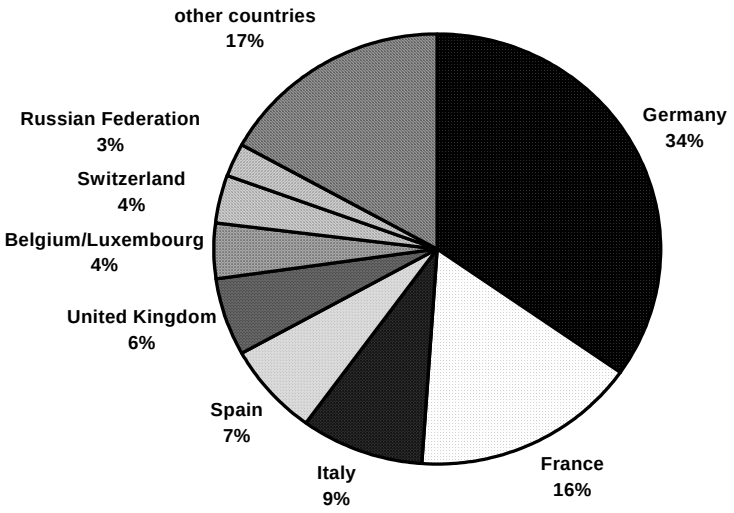

Fig. 5. Import of pharmaceutical plants (SITC.3:292.4) to European countries for the period 1991-2000. Total average import quantity 1991-2000:127,230 t. Source: UNCTAD COMTRADE database (United Nations Statistics Division, New York).

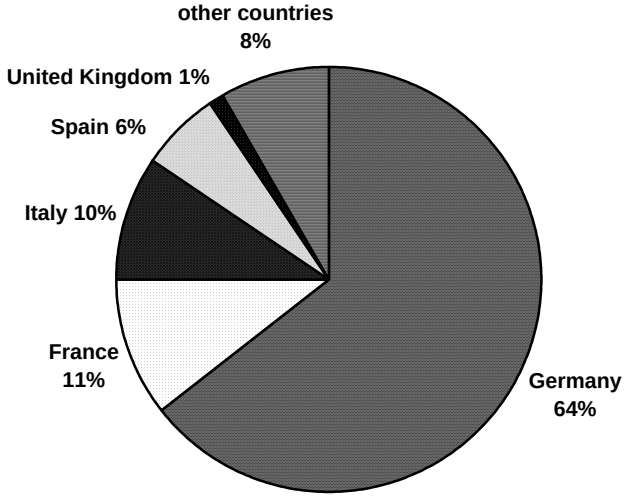

Fig. 6. Destination countries of the exports of pharmaceutical plants (SITC.3:292.4) from south and southeast European countries in 1996. Total export 32,000 t. Sources: Lange (1998); UNCTAD COMTRADE database (United Nations Statistics Division, New York).

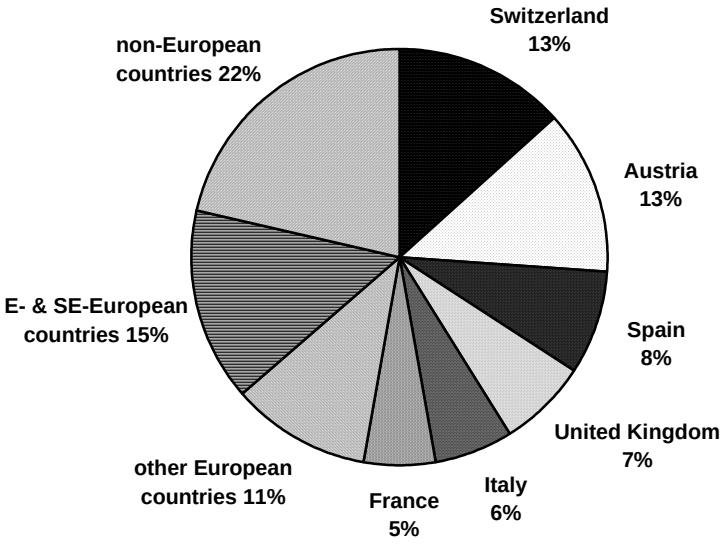

Fig. 7. Destination countries of the German exports of pharmaceutical plants (SITC.3:292.4) in 1996. Total export 15,300 t. Sources: Lange (1998); UNCTAD COMTRADE database (United Nations Statistics Division, New York).