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The role of New World biodiversity in the transformation of Mediterranean landscapes and culture

Abstract

Heywood, V.H.: The role of New World biodiversity in the transformation of Mediterranean landscapes and culture. — Bocconea 24: 69-93. 2012. — ISSN 1120-4060.

Over the past two millennia the Mediterranean region has been the recipient of many waves of plant introductions, some of which have produced major effects on the landscapes and lives of the peoples who inhabit its shores. The impacts of the introductions made by the Romans and the Moors are compared with those of the 'Columbian exchange' which led to a systematic and massive transfer and diffusion of plants, animals and diseases between the old and new worlds. The effects of the various introductions on both agricultural and urban landscapes are discussed as are the impacts on human diet and nutrition which had important demographic consequences and both deleterious effects on human health as well as providing plant-based medicines to cure some diseases such as malaria. Some of these effects are still being played out today. The social and economic consequences, although initially, scarcely perceptible, were quite profound in the subsequent centuries after the initial introductions. The landscapes and the economy of the region have also been affected in more recent times by changes in the way that the introduced crops are cultivated, such as intensification including irrigation and cultivation of fruit, salad crops and flowers in greenhouses or under plastic, crop substitutions such as sunflower (*Helianthus*) for olive, increased reforestation and plantation forests, often with exotic species such as *Eucalyptus*. Urban landscapes have been transformed as a consequence of the widespread introduction of ornamental subtropical species that are now almost their defining features. Finally, invasive alien species are an increasing threat to landscapes in several Mediterranean countries and likely to become more widespread in the face of climate change.

Introduction

The systematic and massive transfer and diffusion of plants, animals and diseases between the old and new world, often referred to as the 'Columbian exchange' (Crosby 1972, 2003), led in time to substantial changes of natural and agricultural landscapes and a major transformation of urban landscapes in the Old World although this varied considerably from country to country. In the Mediterranean region, especially Spain and Portugal which were the countries that received the initial introductions, there was no sudden and major transformation of the agricultural landscapes that had already been massively changed by plant introductions in earlier periods but rather a series of gradual alterations that took time to make any serious imprint. The Columbian exchange also had major impacts on human diet and nutrition, with important demographic consequences, and had

both deleterious effects on human health as well as providing plant-based medicines to cure some diseases such as malaria. Some of these effects are still being played out today. The social and economic consequences, although initially, scarcely perceptible, were quite profound in the subsequent centuries after the initial introductions.

The introduction process

The movement and exchange of germplasm of plants between countries and regions has been one of the defining characteristics of our species. Most civilizations have engaged in a two-way traffic of introduction and export of plant (and to a lesser extent animal) resources. As Harris (1998) observes, today's global market in plant products is the result of a long process of cross-cultural exchange whereby people with different cultural traditions living in different regions of the world have obtained useful plants from each other.

The process of plant introduction has a long history, dating back to at least the reign of Queen Hatshepsut of Egypt who sent an expedition, possibly from Kosseir on the Red Sea coast, in the summer of 1493 B.C. to the Land of Punt[1]. We know from the inscriptions on her funerary temple at Deir el-Bahri, near Luxor in the Valley of the Kings, that the expedition brought back many valuable woods, resin and frankincense and 'all kinds of herbs', and the bas reliefs clearly depict potted myrrh trees being transported (Fig. 1). Since the 15th century the acquisition and introduction of new crops was a key 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 of labour and plant genetic resources'.

Plant introduction and the subsequent, establishment and spread of plants and their exchange is complex and multidisciplinary and includes a large serendipitous element (Del Tredici 2000; Heywood 2007, 2010) as will become clear as we explore the earlier periods of introduction to the Mediterranean. Even today, for most countries it is often a poorly coordinated process and lacks any overall policy coherence.

The pre-Columbian introductions

For over 2000 years, the Mediterranean region and south Europe has been the recipient of new crops from other areas, notably the east, so the encounter with the New World beginning at the end of the 15th century[2] was by no means the first source of new introductions to these areas and probably not the most important in terms of subsequent landscape changes although a number of the American introductions such as maize (*Zea mays*), sunflower (*Helianthus annuus*) and potato (*Solanum tuberosum*) have left a major imprint on the zone while other American introductions such as tomatoes (*Lycopersicon esculentum*), peppers (*Capsicum* spp.) and haricot beans (*Phaseolus vulgaris*) have in more recent times left scars on the landscape through their cultivation in plastic tents or greenhouses ('plastification') as discussed below. On the other hand, as we shall see, the social and dietary consequences were immense.

The first main episode of domestication and diffusion of crops through the Mediterranean which started in the Neolithic and reached its peak in Classical times was of native species (Zohary 1998). It was an impressive array of cereals, pulses, oil and fibre, fruits and vegetables, including wheat, pea, lentil, chickpea, broad bean, olive, grape vine, fig, date palm, almond, melon, carrot, lettuce and artichoke. These founder crops were native to the region although they spread far beyond their centres of origin in south west Asia and the Middle East.

In terms of effects on the Mediterranean landscape, the most significant of these crops was the native olive (*Olea europaea* subsp. *europaea*). It was originally domesticated from eastern Mediterranean stocks (Zohary & Hopf 2000) and from Roman times olive cultivation subsequently (Loumou & Giourga 2003) spread across the Mediterranean, with a notable acceleration in the 18th and 19th centuries. During the course of domestication multiple wild genomes have contributed through hybridization to the enrichment of the domesticated genepool in the west Mediterranean (Baldoni & al. 2006; Besnard & 2007). Although Mediterreanean olive groves are an agro-ecosystem, they resemble the natural vegetation of the region and when abandoned often revert to typical Mediterranean natural scrub and forest. The wild olive (*Olea europaea* var. *sylvestris*) is a key component of Mediterranean vegetation along with the carob (*Ceratonia siliqua*) and the eponymous Oleo-ceratonion alliance is a characteristic sclerophyllous tree-shrub formation of the region. In fact, the distribution of the olive can be used to define the Mediterranean bioclimatic region in Eurasia and North Africa. Traditionally managed olive groves have been an economically important, highly sustainable and significant form of land use for millennia. The main olive oil producers are Spain (2.4 million ha), Italy (1.4 million ha), Greece (I million ha), Portugal (0.5 million ha) and withTunisia, Turkey and Syria the only other producers of significance, accounting for over 20 of world production (EFNCP/ARPA 2000). 98 % of the world production of olive oil takes place in the Mediterranean.

Another crop which made a considerable visual impact on the landscape was the cultivated grape vine (*Vitis vinifera* subsp. *sativa*) which originated some 8000 years ago in northern mountainous regions of the Middle East such as the northern Zagros, eastern Taurus and Caucasus Mountains and subsequently spread westwards through the Mediterranean to Crete, Italy, and the Iberian Peninsula although recent molecular studies suggest that the cultivated germplasm had at least two important origins, one in the Middle East where it shows higher genetic diversity in wild populations (Ergül & al. 2011) and the other in the western Mediterranean, the latter giving rise to some of today's western European cultivars (Arroyo-Garcia & al. 2006). Over 70% of the Iberian Peninsula cultivars display chlorotypes that are only compatible with their having been derived from western *V. sylvestris* populations.

Exotic crops introduced in pre-Columbian times, included both temperate species from central and east Asia such as millets (*Panicum miliaceum*, *Setaria italica*), hemp (*Cannibis sativa*), pistachio (*Pistacia vera*), apricot (*Prunus armeniaca*), and peach (*Prunus persica*) and warm weather crops from the Indian subcontinent and southeast Asia, including rice (*Oryza sativa*), cotton (mainly *Gossypium arboreum*), aubergine and various citrus species, and Sub-Saharan Africa such as cowpea (*Vigna unguiculata*) and aubergine (*Solanum melongena*)[3].

The introduction of citrus cultivation to the Mediterranean from various parts of Asia took place at various times over hundreds of years, depending on the species, the citron (*Citrus medica*) being the only one known in classical times in the east Mediterranean

(Scora 1975) and by the Romans while the lemon (*C. limon*), lime (*C. aurantifolia*), pomelo (*C. maxima*) and bitter orange (*C.* × *aurantium*) were also known by the Romans and later introduced by the Arabs through North Africa, the Iberian Peninsula and Sicily [4] (Ramon-Laca 2003). The sweet orange (*C.* × *sinensis*) appears to have been introduced to Europe at various times during the 15th and 16th centuries – via Spain by the Arabs, via Portugal by Vasca da Gama and other Portguese explorers after 1498 and via Italy by Genoese merchants around 1470 from the Levant (Webber & al. 2005). Although probably not the first to introduce the sweet orange, the Portuguese later made a major contribution to its diffusion and popularity through the introduction of improved varieties known as the Portugal orange. The subsequent extensive development and spread of citrus crops, including the much later introduction of the mandarine (*C. reticulata*), has left a clear footprint on the agricultural landscapes of the Mediterranean to the present day.

Another important episode of plant introduction was during the period of El-Andalus (8-13 C), when a great number of species were introduced to Spain, including rice (*Oryza sativa*), cannabis (*Cannabis sativus*), saffron (*Crocus sativus*) , safflower (*Carthamus tinctorius*), aubergine (*Solanum melongena*), spinach (*Spinacia oleracea*), liquorice (*Glycyrrhiza glabra*), chufa nut (*Cyperus esculentus*), banana (*Musa* spp.), artichoke (*Cynara cardunculus*), watermelon (*Citrullus lanatus*), mulberries (*Morus* spp.), bitter orange (*Citrus* × *aurantium*), lemon (*Citrus limon*), lime (*C. aurantifolia*), pomelo (*C. maxima*), citron (*Citrus medica*) as well as various herbs and spices and cotton (*Gossypium arboreum*, *G. herbaceum*), sorghum (*Sorghum* spp.) and sugar cane (*Saccharum officinarum*) (Hernández Bermejo & García Sánchez 1998, 2000). Some of these crops required irrigation which was a major reason for the great development and spread of new irrigation systems that complemented the earlier mainly urban water supply systems built by the Romans (Glick 1970; Trillo 2003, 2005) whose use of irrigation in agriculture was limited to particular circumstances such as market gardens which benefitted from any excess water from adjacent habitations (Watson 1983). These irrigation systems added further characteristic features to the landscapes. Otherwise, the plant introductions during El-Andalus did not have major impacts on the landscapes except at a local scale.

The Colombian plant introductions

The introduction of plants from the New World after 1492 was a long and complex process and went through various phases. They included not only food crops but medicinal plants, stimulants and industrial crops (Box 1.)

Box 1. The main post-Columbian plant introductions.
Food and fruit crops
Maize (*Zea mays*)
Potato (*Solanum tuberosum*)
Sweet potato (*Ipomaea batatas*)
Tomato (*Lycopersicon esculentum*)
Peanut (*Arachis hypogaea*)

Cassava (*Manihot esculenta*)
Peppers, chili pepper (*Capsicum annuum, C. frutescens*)
Beans (*Phaseolus vulgaris*, *P. lunatus*, *P. coccineus*)
Squashes (*Cucurbita* spp.)
Sunflower (*Helianthus annuus*)
Jerusalem artichoke (*Helianthus tuberosus*)
Cherimoya (*Annona cherimolia*)
Avocado/Aguacate (*Persaea americana* syn. *Persea gratissima*)
Pineapple (*Ananas comosus*)
Prickly pear *Opuntia* spp.

Stimulants
Tobacco (*Nicotiana tabacum*)
Chocolate (*Theobroma cacao*)
Cocaine (*Erythroxylon coca*)

Spices
Allspice (*Pimenta dioica*)
Peruvian pepper tree (*Schinus molle*)

Industrial crops
Cotton (*Gossypium hirsutum*)
Rubber (*Hevea brasilensis*)

Medicinal species
Quinine (*Cinchona officinalis*, *C.pubescens*)
Curare (*Chondodendron tomentosum, Strychnos toxifera*)
Cocaine (*Erythroxylon coca*)

Ornamentals
Century plant (*Agave americana* and other species)
Tree tobacco (*Nicotiana glauca*)
Jacaranda (*J. mimosifolia*)
Bougainvillea, *Brugmansia* spp.
Prickly Pear (*Opuntia ficus-indica* and other species)
Blue passion flower (*Passiflora caerulea*)
Pride of Barbados (*Caesalpinia pulcherrima*)
Coral Tree (*Erythrina crista-galli*)
Poinsettia (*Euphorbia pulcherrima*)
Indian Bean Tree (*Catalpa bignonioides*)
Trumpet creepers (*Pyrostegia venusta*, *Distichis buccinatoria*, *Campsis radicans*)
Swiss cheese plant (*Monstera deliciosa*)
Osage orange (*Maclura pomifera*)
Spanish bayonet (*Yucca aloifolia* and other spp.)
Palms (*Brahea armata, Roystonea regia*, *Washingtonia filifera*, *Jubaea chilensis*, etc.).

Spain played a crucial role not only as the prime recipient of the introductions but in their subsequent spread: many of the introductions were subsequently taken from Spain to other parts of Europe or the Mediterranean. Not only was Spain the major colonial power for the Americas but it was geographically the first stop for the returning vessels and within the Spanish ambit, the Canary Islands were often the first port of call for the returning ships and became especially significant in the 18th century when materials from the botanical expeditions to Peru, Chile, New Granada and the Philippines, undertaken during the Spanish Enlightenment (Ilustración), were brought back. Spain acted in effect as a diffusion centre of these new crops to the rest of the Mediterranean and Europe and beyond.

Other countries such as Portugal and France[5] were also involved in the introduction of crops to Europe although their role was much less important than that of Spain. Portugal, as neighbour, would logically have been expected to have shared some of material introduced from the Americas although there is no clear evidence of this.

While Sevilla was the primary port of entry of the new materials during the Columbian expeditions, ships are also known to have landed their cargoes, including new plant materials, in the northern ports of La Coruña, Vigo, Santander and Gibraltar, Malaga and San Lucar de Barrameda in the south. Galicia, for example, was the first region in Spain where potato was cultivated at the end of the 16th century by the families of Basque sailors who introduced it: they used it as a shipboard food and by the 1600s had introduced it to Ireland where it became a subsistence crop with all the historical consequences that are so well known.

Although we have extensive records of the American introductions from contemporary documents and the vast and largely unexplored archives of the Spanish colonies, notably the *Archivo General de Indias* in Sevilla, the details are not always clear and although the whole process was strictly controlled by the Crown, the infrastructure for handling the new potential crops was somewhat random and unsatisfactory. As Hernández Bermejo & Lora González (1992) comment, '… the process of incorporating local agricultural cultivation, transporting plant species to Spain and assimilating the ethnobotanical knowledge of the indigenous races took place in a climate of indifference, randomness and disorganization. Spain was to prove much more an instrument for extending Europe's influence in the New World than a channel for American plant germplasm to reach the Old Continent. Up to the mid-sixteenth century, plant species reached Europe generally as a result of private initiatives'.

It should be noted that at the time of the first introductions, no botanic gardens had yet been founded so the seeds, bulbs and other propagules were grown in a diversity of sites, usually by private individuals on their haciendas and by enterprising farmers and private individuals such as the families of sailors who crewed the ships bringing back the plant materials.

The initial spread of the first introductions

Little is known of the detail of the early spread of the various introduced species although there is some evidence of the early cultivation or use of some of them. But it is quite clear that large-scale cultivation (and any consequential landscape effects) of the New World crops did not happen until the end of the 17th century by which time maize, for example, was grown on a large scale in the south of France, the Danube region and south

Europe in general. This is not surprising taking into consideration the well known conservatism of farmers and their reluctance to try out new crops. As McNeill (1991) comments '… why should farmers give up familiar routines and crop rotations to make way for strange plants that looked very different from what they already knew and required rather strenuous cultivation during the growing season to keep down weeds?' In continuation, a summary is given of five of the most important introductions, potato, maize, chili pepper, tomato and beans.

Potato (*Solanum tuberosum*). The potato is the crop that probably had the greatest impact in the Old World in terms of nutrition although less so in the Mediterranean. It was discovered in the Andes in 1537 by the Spanish but the date of its introduction to the Europe and the Mediterranean is still not certain. There is a record that potato was being purchased as a provision for the wards in the Hospital de la Sangre in Sevilla in 1573 (Hawkes & Francisco-Ortega 1992), although there is a slight possibility that this referred to sweet potato (*Ipomaea*) with which there was a nomenclatural confusion at the time (Hawkes 1998). If this record is correct, this would imply that it must have been introduced some years earlier and then cultivated for several years to allow sufficient stocks to be built up and enough crop produced to market. The first introduction of the potato to mainland Spain was then probably c.1570 (see discussion in Hawkes 1998). The potato was first recorded from the Canary Islands in 1567 (Ríos & al. 2007) although Lobo Cabrera (1988) notes that in the Archivo Histórico Provincial de la Palmas there are records of the despatch of potatoes from Puerto de Las Isletas (Gran Canaria) to Antwerp in 1567 and from Tenerife to Rouen (France) in 1574, leading him to believe that the potato had been cultivated in Gran Canaria some decades earlier.

The potato was commonly grown in Spain and Italy by the end of the 16th century and reached Austria, Belgium, Britain, France, Germany, The Netherlands, Portugal and Switzerland around 1600 but was mainly grown initially by hobbyists and botanists, being viewed with some suspicion by the working classes, and did not became widely accepted until the following century leading to its more extensive cultivation and its use as a staple crop.

Today, the greatest diversity of potato cultivars is found in the Canary Islands, not on the mainland (cf. Marrero 2007) and the per capita consumption of c. 70 kg per annum is much higher than the national average although the area under cultivation in the Canary Islands has decreased substantially in the last 20 years (Redondo Zaera 2007).

Maize (*Zea mays*). Maize was introduced to Spain shortly after 1492 following the return of Columbus from his first voyage to the New World (1492–9) and fields of maize were reported to be grown in Sevilla in 1494, with cultivation subsequently increasing and expanding in Spain. Spain was the main entry point of maize to Europe (Revilla & al. 2003), from where it spread not only across the continent and the Mediterranean in the 16th century but through Asia, reaching China and Africa within 60 years (Johnson 1997). Its success was in large measure due to its not having to compete directly with existing grain crops such as wheat, barley, oats, millet and rice and its ability to grow in a range of environments and topographies that were unsuitable for these other crops. An alternative view is put forward by Andrews (1993) who suggests that maize, as part of a Mesoamerican complex comprising also beans, squash and peppers, was acquired by the Portuguese around 1500 and then spread by way of the Portuguese Atlantic islands, Angola, Mozambique, India and the Ottoman empire to the Balkans where the crops of the com-

plex developed its greatest diversity. It is known that Balkans farmers adopted maize in the 18th century to keep them away from the malaria-ridden lowlands.

In addition to its agroecological amplitude, maize had the advantage of being much more productive than the other cereal crops (except rice). By 1530 it had spread to Portugal, France and Italy (the Veneto) where, according to Brandolini & Brandolini (2001) '… due to the poor adaptation of Caribbean maize cultivars to the 38–45° latitude photoperiod, the crop did not spread until mid-1500, when better adapted varieties of the *Everta* (popcorns) and *Indurata* (flint) groups were imported from subtropical and temperate regions of Central and South America'. They also suggest that the subsequent rapid diffusion of maize in Italy and from Italy into southern Europe into new environments, with new uses being developed together with the crossing of cultivars of different provenances resulted in numerous new populations particularly suited to the range of agroecosystems. New classes of maize cultivars were subsequently introduced in the 17th and 18th centuries, and these in turn were replaced by higher yielding USA Corn Belt dent cultivars in the 19th century.

Chili pepper (*Capsicum annuum*)

The main species of *Capsicum* to be brought to Europe and cultivated was *Capsicum annuum*, a species widespread in Central and South America (Hawkes 1998). Its first introduction to Spain is attributed to Diego Álvarez Chanca, a physician on Columbus' second voyage to the West Indies in 1493, who wrote about its medicinal effects in 1494. Although details of its initial cultivation are sparse, *C. annuum* reached Italy by 1526 and spread to other countries in south, central and eastern Europe during the 16th century.

Tomato (*Lycopersicon esculentum*)

Tomato was first domesticated in Mexico, long before it was discovered by western explorers. It is not known when it was first cultivated in Spain or elsewhere in Europe. The earliest record is by the Italian botanist Matthioli in 1544. It has been suggested by Jenkins (1948) that Cortés may have sent seed directly to the Emperor of Austria in 1526 with the plant subsequently spreading to other parts of Europe by c. 1590. Initially the tomato was grown in Europe for the attractiveness of its fruits but was not often eaten, except in Italy and Spain. The fruit was thought to be unwholesome or even poisonous like its Solanaceous relatives, deadly nightshade (*Atropa belladonna*) and henbane (*Hyoscyamus niger*). It was not generally accepted and grown as a nutritious crop until the 18th century in southern Europe and did not become popular in northern Europe until the following century. Tomato (*Lycopersicon esculentum*) is an important source of vitamins, although not high in calorific value, and today it is the second most important vegetable crop next to potato. As Nunn and Qian (2010) comment, it has truly become a global food. Present world production is about 130 million metric tonnes of fresh fruit produced on 3.7 plus million hectares, with Turkey, Egypt, Italy and Spain being 4th, 5th, 6th and 8th ranking producers.

Beans (*Phaseolus vulgaris*)

In the pre-Colombian period, 'beans' known as *habichuelas* were grown in the Iberian peninsula long before American beans (mainly *Phaseolus* spp., especially *P. vulgaris*) were introduced. They were mainly *Vigna sinensis* or possibly even *Dolichos lablab*, Old World species long known in the west Mediterranean but especially cultivated during the hispanoarabic period (Hernández Bermejo & Lora González 1992). Columbus brought back samples of *Phaseolus vulgaris* in 1493 and the first introduction into cultivation of the

common bean (*Phaseolus vulgaris*) from Central/South America took place around 1500 in western Europe (Zeven 1997), and then largely replaced these earlier species in Spain and Portugal. They apparently reached Italy by 1528 where they became so popular in some parts of the country such as Tuscany where they were introduced in 1528 that they came to be known as 'the poor man's meat' ('la carne del povero') (Artusi 1891) and the Tuscans became known as *mangiafagioli* (bean eaters).

Other *Phaseolus* species were also introduced from the Americas, notably *P. coccineus* (Scarlet runner bean, alubia de España, judión), and *P. lunatus* (Lima bean), although not as extensively grown.

Beans are both highly nutritious and easy to grow and store and the seeds were attractive and easily transported. They are high in protein, complex carbohydrates and a source of iron, potassium, selenium, vitamin B6, folic acid and soluble fibre and their proteins are high in lysine and provide amino acid complementary to those of cereal grains. Because of their nutritional value and ease of storage, *Phaseolus vulgaris* beans became a primary food for sailors, hence the name Navy bean. The pods are also eaten (green beans) and the two main areas of production today are around the Mediterranean basin and the USA.

Acclimatization, acclimatization gardens and societies

The process of introduction of exotic germplasm was often carried out through the use of acclimatization gardens or stations where the aim was to allow the new plants to adapt to the new environmental conditions. The concept of acclimatization in the sense of gradual adjustment of plants or animals to new climatic or other ecological conditions other than those to which they are accustomed is highly debatable[6]. It is in effect really a selection process rather than any physiological adaptation of individual plants or animals. But it was widely practised and as Weigel (2003) comments, acclimatization as such was an important aspect of colonialism in that the survival of settlers depended on the successful survival of the plants and animals they brought with them and Hardy (1860) went so far as to say that 'The whole of colonization is a vast act of acclimatization' (transl. by Weigel 2003). Acclimatization societies were established in most of the British colonies. On the other hand, the comment of Francis (1862) 'So new to the world is the subject of acclimatization, as now understood, that it has little literature, and the advocates of it little experience' could almost have been written today as although the subject matter is no longer new, our comprehension of it remains poor. Much of what is termed acclimatization is no more than successful introduction of exotic organisms. Some biologists are highly critical of the whole concept of acclimatization. Low (2002), for example, calls it 'one of the most foolish and dangerous ideas ever to infect the thinking of nineteenth-century men'.

Acclimatization was a somewhat haphazard affair in the period of the first introductions from America and only in the following centuries were various acclimatization gardens created in Spain for the plants brought from overseas – in Cartagena, Cordoba (although short-lived), Barcelona, Aranjuez, Madrid, Burgos, Sevilla, Carmona, Cádiz, La Orotava (Tenerife), Valencia (see detailed discussion by Puerto Sarmiento 2002). Although Cadiz was the main reception centre for seeds and plants during the 18th century, arguably the

most important acclimatization garden was that of La Orotava on the island of Tenerife, Canary Islands founded in 1788 by the Marques de Villanueva in accordance with a Royal Order by Charles III, and still surviving today as a botanic garden. The plants were then transferred to the now defunct botanic garden at the Puerto de Santa Maria before being sent to Madrid. Of course, many of the species successfully cultivated in La Orotava did not survive their subsequent shipment to the mainland or withstand the harsh climate of the Castilian meseta and most of them succumbed. Others could only be grown under protection in orangeries or similar structures which were developed in response to the custom that started towards the end of the 15th century of growing oranges, lemons and other tender trees in Europe. According to Spiegel-Roy & Goldschmidt (1996) by the fourteenth century, specially heated buildings known as *stanzone per i cidri*, were used in Italy to protect these plants in winter. In France, the gardens in which oranges were grown in great tubs or pots were known as 'orangeries' and the plants were put in sheds under cover. Subsequently partly glazed buildings were developed – and these by transfer became known as *orangeries*, the first of which was at the Chateau d'Amboise of Charles VIII. In Italy, these buildings were known as *limonaia*.

At the Royal Gardens of Aranjuez, Philip II attempted the acclimatization of species from all around the world. Species which fared well included *Magnolia grandiflora. Liriodendron tulipifera, Acer saccharum, Acer negundo and Robinia pseudoacacia*. In Madrid the Royal Botanic Garden also played a prominent role in both the dissemination of material of the introduced species to other parts of Spain as well as undertaking acclimatization experiments.

Human nutrition and diet

Despite their introduction in the Columbian period, it was usually some time before any of the introduced American crops played a major role in nutrition in Mediterranean countries but by the 18th century, maize and potato as well as peppers, beans and tomato were basic components of the Spanish diet (Diaz-Yubero 1998).

Initially there was, as we have seen, considerable reluctance to consume the new crops which were often viewed with suspicion. Potato, for example, was considered only suitable for the poor and needy. Likewise, maize, despite its much higher productivity than wheat, its shorter growing season, and its ability to grow in a range of environments, including marginal zones, was viewed with some suspicion and even believed to be less nutritious than other native cereals, although the contrary was true: indeed, one of the key benefits of the new crops was their much greater calorific value per hectare than the conventional cereal crops. Maize was initially regarded as suitable only for animals or food for the poor peasants who ground it up with water and ate it as polenta, replacing the millet, barley, or Saracen corn that had been used for several centuries previously to make it. Because of its high productivity it was grown by landowners' estates to feed their workers and eventually it became a unique staple crop. Later, as noted below, the excessive consumption of maize as polenta or bread by the poor in northern Italy at the end of the 19th century lead to dietary deficiency disease.

There is no doubt that some of the American crops were later to have very considerable effects on the nutrition, eating habits and cuisine of the Europe and the Mediterranean (and other parts of the world) and by retroexport back to the New World.

Much has been written about the 'Mediterranean Diet' some of whose characteristic components derive from New World species such as *Phaseolus* beans, tomatoes and peppers as well as other exotic species such as aubergine (*Solanum melongena*) and citrus and other fruits that came to the Mediterranean from the east. In fact while these species do contribute, they are not necessarily the most important components of this diet which is characterized by (Romano 2005):

- High consumption of olive oil
- High consumption of legumes
- High consumption of cereals
- High consumption of fruits
- High consumption of vegetables
- Moderate consumption of dairy products
- Moderate to high consumption of fish and poultry
- Low consumption of meat and meat products
- Moderate consumption of wine and other alcoholic drinks

The so-called Mediterranean diet (Keys & Keys 1959[7]) or more properly diets that are rich in fruit, vegetables, legumes and olive oil, as well as fish and poultry, but low in meat and animals fats (Heinrich & al. 2006) often includes a range of local wild-gathered plants such as 'wild greens' (Heywood 2009). Salas-Salvadó & al. (2006) suggest that the origins of such a diet may be found in part in that of el-Andalus: 'The diet in al-Andalus was varied and very probably made a substantial contribution to the origin of the present-day Mediterranean diet, rich in olive oil, wholemeal cereals, fruit and vegetables, fish, lamb, poultry, nuts and spices'.

One might well wonder how far today's typical Spanish and Italian diets which include a high consumption of pork and pork based products (jamon serrano, prosciutto, salume, salchichon, chorizo, morcilla, mortadela etc.) as well as other meats, and a diversity of cheeses, alongside a diversity of vegetables and fruits complies with this definition (cf. Diaz Yubero 2002). Certainly the Cretan diet is much more restrictive and at least until recently did not include much meat but did include regular use of wild greens as well as many other vegetables.

Apart from dietary and health considerations, the introduced American species have had major cultural effects on eating habits and the development of the various Mediterranean cuisines. It would be difficult to imagine the French, Spanish and Italian cuisines without tomatoes or peppers – one or the other or both components of such classic dishes as caponata, ratatouille, escalivada, gazpacho – and they are also (especially tomato) now entrenched in the Turkish, Moroccan and Lebanese cuisines. Courgettes or zucchini (young fruits and flowers of *Cucurbita pepo* from Mexico and North America) are also now a characteristic component of most Mediterranean cuisines. It is noteworthy that the key components of the pre-Colombian diet complex of maize, beans and squash was exported to the Old World. The combination of maize and beans ensured amino acid complementarity.

Likewise dried beans (*Phaseolus vulgaris*, *P. lunatus and P. coccineus*) have become a classic part of the food culture of the Mediterranean. Thousands of varieties, especially of *P. vulgaris*, have been selected. In Spain the number of cultivars grown has greatly diminished in the past 40-50 years (cf. Puerta Romero 1961) and many are at risk of total disappearance. Selected varieties are still prized in several Mediterranean countries. In Spain, examples are the judiones de La Granja, known since the 18th C, and judías de El Barco de Avila, used in various bean stews, and the *faba asturiana*, now a protected denomination by decree of the Government of the Principality of Asturias, used to prepare the classic bean stew *fabada.* The green pods of both *P. vulgaris* (haricots verts, judias verdes, French beans, green beans, etc.) *P. coccineus* (scarlet runner bean) are also used as a vegetable in western Europe.

Large beans are widely consumed in other Mediterranean countries such as Turkey, and Greece and in East Europe. In Greece, where beans are the most important pulse crop, the elephant and giant white kidney beans (*fasolia gigantes*) come from Prespes in the Florina prefecture (Macedonia).

In Italy, canellini and borlotti beans are celebrated and in France, the small pale green flageolet beans are grown in the Arpajon region in Brittany, the cocos are large white beans and used in making cassoulet, while another large white bean, the *lingot de Lauragais* is the preferred cassoulet bean.

These beans complemented and partially substituted for the traditional staple dishes such as cocido in Spain and Portugal based on chickpea (*Cicer arietinum*) introduced to the Mediterranean about 4000 BC.

Effects of introduced American plants on health

Pellagra. A great deal has been written about the disastrous consequences of the introduction of fatal diseases to the New World by the Conquistadores (e.g Crosby 1972, 2003; Nunn & Qian 2010) but some of the American crops introduced to the Old World also had implications for human health there. Perhaps the most notable was the link between the popularization of maize and the appearance of the skin infection *pellagra*, now known to caused by a dietary deficiency of niacin and its skey metabolic precursor tryptophan. The disease causes weakness, apathy, loss of appetite and neurasthenia and in its later stages is characterized by the three Ds – dermatitis, diarrhoea and dementia – and if untreated, pellagra typically leads to death in four or five years.

The connection between maize and pellagra was first described by Gaspar Casal, an physician from Oviedo, Asturias in north Spain in 1735, who named it *mal de rosa.* When it became an endemic disease in northern Italy, Francesco Frapoli of Milan named it ‘pelle agra’ (pelle, skin; agra, rough).

As Livi-Baci (1986) has noted, the history of pellagra is closely related to the history of maize in Spain, France, Italy and several areas of eastern Europe, notably Romania. Maize was already grown in the Veneto in the 16th century and it spread to Lombardy in the 17th century and it became popular in Romagna (Emilia region) in the second half of the 18th century and by the end of that century its cultivation and consumption had increased in the north and centre of Italy. By then the living conditions of the rural population had deteri-

orated, partly as a consequence of the Napoleonic wars and the high productivity and its relatively low price compared with wheat, acted as an incentive for its cultivation and as mentioned above polenta based on maize flour became the core component of the frugal diet of the peasantry in northern and central Italy in the form of bread or polenta (Mariani-Costantini & Mariani-Costantini 2007). Such a monophagous diet based on maize is poor in niacin and so pellagra increased.

In Spain, pellagra and maize spread in Galicia, Asturias, Navarra, Aragon and Castilla la Nueva but without reaching the intensity that it did in Italy. By the end of the 16th century, maize which came to be known as 'Blé de Turquie' (Turkish wheat), was grown on a limited scale in France. Cultivation of maize became fairly widespread in southern and western France by the early 19th century, coincident with numerous reports of pellagra among peasants in the provinces of the Gironde, the Landes, the Haute-Garonne, and areas adjacent to the Pyrenees.

Curiously enough, despite their staple diet of maize, populations of Mexico and Central America have remained essentially pellagra-free. This is probably due to the traditional method of preparation of maize by presoaking it in lime before cooking (nixtamalization) which improves the bioavailability of calcium and liberates part of the bound niacin, enhancing the dietary content of niacin and ensuring protection against pellagra if eaten regularly in the absence of legumes or animal protein (Rajakumar 2000).

The causes and cure of pellagra were discovered, not in the Mediterranean, but by Dr. Joseph Goldberger, surgeon in the United States Hygienic Laboratory (precursor of the National Institutes of Health), who was asked to investigate the disease which was first described in North America in 1864, although undoubtedly it had been widespread long before and had become a serious and baffling problem in southern United States in the first decades of the 20th century (Evans & Feinstein 1994). Goldberger's observations and those of Italian researchers, convinced him that pellagra was a dietary disorder, not an infectious disease. He died, however, before discovering exactly what was missing in the diet of pellagra victims and it was not till the 1930s that it was discovered that the administration of nicotinic acid or vitamin B niacin could be used to cure the disease (Kraut 2003; Mariani-Costantini & Mariani-Costantini 2007).

Medicinal drugs

Plants that were beneficial to human health introduced from the Americas include quinine, curare and cocaine, the latter (from Coca, *Erythroxylum coca*) also being used to produce a notorious addictive intense euphoric drug which has caused serious social and health problems. There is also considerable research into the metabolic effects of other introductions such as tomato (Preedy & Watson 2008), *Opuntia* and *Aloe*, the latter also having an important role in many cosmetic preparations.

Quinine (*Cinchona officinalis*) – Chinchón, Cinchona, Cinchon, Quina, Quina-quina, Quinine. The probably apocryphal story of the apparent cure from malaria in 1638 of the Countess of Chinchón, wife of the then Viceroy of Peru, by an extract of the bark of a tropical South American tree, later named (but misspelt) by Linnaeus as *Cinchona* after the

Countess, has often been related (e.g. Hobhouse 1985). It was exported to Europe in the 1630s or 1640s and quinine, one of the alkaloids that the *Cinchona* bark contains, was isolated from it in 1817. Quinine has helped to eliminate malaria, 'one of the great banes of existence' (Hobhouse 1985) in Europe and other parts of the world and allowed the opening up of large parts of the tropics to the European explorers and colonizers.

Quinine is reported as being involved in the origin of homeopathy in the 18th century by a German physician Samuel Hahnemann (Bradford 1895), although the principles of homeopathy were already known to Hippocrates. Other uses are to relieve cramp and as a flavouring in tonic water, bitter lemon, Irn-Bru and in some aperitifs such as Byrrh, Dubonnet, Lillet, Maurin Quina[7] and St. Raphaël and quinine liquor wines such as Licor de Palo, commonly used in the 16th and 17th centuries in Mallorca to combat malaria which was then prevalent in the marshy areas , and Jerez Quina and Málaga Quina.

Curare. The name curare refers to any of a variety of substances originally used as arrow poisons by native South Americans in hunting and in warfare. The main active substance of curare, d-tubocurarine, is an alkaloid extracted from *Chondodendron tomentosum, Strychnos toxifera,* and other plant species, from tropical America, used in modern medicine primarily as an auxiliary in general anaesthesia, frequently with cyclopropane, especially in abdominal surgery. When injected, curare acts as a neuromuscular blocking agent.

The introduction of curare into anaesthetic practice, by Griffith and Johnson, in 1942, caused profound changes in the efficacy and safety of anaesthesiology. It made possible the development of true balanced anaesthesia, and the elimination of the explosive inhalation anaesthetics and the profound metabolic disturbances associated with their use (Foldes 1993).

Stimulants

Europe was unusual among the continents in not having a major native alkaloidal stimulant. The introduction of tobacco and chocolate were both to have far reaching consequences.

Tobacco (*Nicotiana tabacum*). Tobacco leaves were brought back to Spain by Fernando Cortez in 1518 and by Gonzalo Fernández Oviedo in 1519. Its cultivation in Europe began in 1556 after Andre Thevet brought seeds back from Brazil to France and two years later it was first grown in Lisbon and the following year in Spain. By the end of the 16th century, tobacco was being grown in Belgium, England, Italy and Spain. Although originally regarded as a medicinal plant, by the middle of the 17th century it was considered as a recreational herb.

The introduction of tobacco was to have incalculable political, social and economic consequences. It is generally agreed to be the most widely grown non-food crop and the tobacco industry affords employment to around 100 million full- and part-time workers. National governments obtain significant revenues from the sale of tobacco and tobacco products and exploit the culture of dependency.

Tobacco reached Fez in 1599 and according to Lunde (1992) its progress through the Middle and Far East can be almost exactly dated by the publication of prohibitions against its consumption. Japan forbade the use of tobacco in 1607, the Ottoman Empire in 1611. The Moguls forbade it in 1617.

Tobacco's 'pervasive global entrenchment' (Goodman 1993) is a still poorly understood sociological phenomenon. Its stimulatory and social benefits turned out to be vastly out-

weighed by its impacts on human health but these did not become apparent or understood until 500 years after its introduction; and only today are we seeing widespread restrictions on its public consumption being introduced on health grounds.

In Europe, the EU has financed the cultivation of tobacco through a Common Market Organization (CMO) since 1970 with annual subsidies of 1 billion Euro, most of which is disbursed to farmers in Italy, Greece and Spain which together account for 87 % of total production. With an annual output of 334 000 tonnes, the EU is the world's fifth largest producer of raw tobacco. European tobacco cultivation is clustered in a small number of countries and concentrated especially in certain regions of Italy (Campania, Umbria and Veneto), Greece (central Macedonia, East Macedonia, Thrace and Continental Greece) and Spain (Extremadura). These three countries account for almost 87.8% of EU output, with the other EU producer states (France, Germany, Portugal, Belgium and Austria) providing just 12.2%. Greece is the only European country where tobacco is an important contributor to agricultural income. Latakia and Oriental blends of tobacco are grown in Syria, western Turkey, Greece and Cyprus. Most 'Turkish' type tobacco is grown in Greece.

Chocolate (*Theobroma cacao*). Chocolate was first introduced into Spain after 1502 but was not initially acceptable until about 20 years later when vanilla and sugar were added to the ground up fermented and roasted seeds to prepare the beverage. Although it could not be cultivated commercially in the Mediterranean, cocoa beans were imported on a large scale at the beginning of the 17th century to Italy, Germany, Austria, France and Britain to produce chocolate.

Although initially used to make a beverage, chocolate has become a major item of confectionery and cooking in many parts of the world, leading to the development of a large industry. The widespread consumption of chocolate in the form of bars and as individual confections such as pralines, truffles, giandujas and fondants, often sold in highly decorated or elegant boxes of chocolates, is also a significant social phenomenon. The popularity of chocolate confectionery is doubtless due in large measure to the presence of alkaloids such as theobromine and phenethylamine which produce various physiological or psychoactive effects.

The Phylloxera epidemic

A curious example where North American biodiversity both helped destroy and save a crop was the case of Phylloxera (*Daktulosphaira vitifoliae*) a sap-sucking aphid native to eastern North America that feeds on the roots of grapevines. It was inadvertently introduced to Europe, possibly on imported North American vinestocks or plants, and caused an epidemic which by the end of the nineteenth century destroyed most of the wine grapes in Europe which were all self-rooted *Vitis vinifera*. Subsequently, phylloxera has affected most of the world's vine-growing areas in Europe, Australia, New Zealand, South Africa and elsewhere. The native grape species of North America are to some degree resistant to Phylloxera and after unsuccessful trials with hybrids between *Vitis vinifera* and North American species such as *V. labrusca*, scions of *V. vinifera* were grafted on to the rootstocks of resistant strains of *V. labrusca* and this is now the preferred method used today (Christy 200).

Transformation of natural and agricultural landscapes

The main visible effects of New World biodiversity on the landscapes of the Mediterranean have been as a consequence of:
- Deliberate introduction of species for agriculture and other commercial purposes
- The spread of deliberately of accidentally introduced invasive species

The landscapes of the Mediterranean in the late 15th century were characterized by forests of oak and pine, various kinds of scrub, pasture and grazing land and fields of cereal, chick pea and other pulses. Energy requirements were met by the three main plant resources that were exploited in every agrarian economy: food for humans, fodder for working animals and fuelwood (Malanima 2006). In the 15th century and in the early modern world, Europe was exceptional in that agriculture did not generally rely on rivers for irrigation, and the prevalent arable crop, wheat, had the lowest yield of any of the world's main three cereals. Thus, European cereal yields in the 16th and 17th centuries averaged 400-500kg per ha while those of rice and maize yielded between 1000 to 2500 kg per ha.

In the most productive irrigated agriculture regions of Asia, a family could support itself on 1 ha of land or less and had no fallow land and only limited pasture land. Europeans in contrast needed about 10 ha of land, including uncultivated land and extensive pastures, to support a household. Growth in population was normally met by extending arable land at the expense of forest and pasture. As a consequence, European agricultural systems had a low population density compared with those of Asia. This situation persisted until nineteenth century when the period of modern growth in European was driven by the use of underground forests – fossil fuel.

The Mediterranean climate with its hot dry summers was not really suitable for most of the New World crops such as potato and maize which needed water. They were more suited to areas such as the Po valley with summer rainfall and the Danube basin.

The early arrivals from the Americas had little visible impact on the natural or even agricultural landscapes during the subsequent one to two centuries until the cultivation of maize, potatoes and other introduced crops in the 18th century extended in many Mediterranean countries and changed the appearance of the agricultural spaces and this persisted with some variations until modern times.

The agricultural landscapes of Spain, as already noted, had already been transformed during the Classical period, then by the influx of new crops under the period of El-Andalus and by their sophisticated agricultural techniques including irrigation systems. The diversity of crops and fruit trees cultivated was remarkable but with the Reconquest, the Castilian system was reimposed and many of the innovations of Al-Andalus were discontinued.

Apart from various periods of deforestation and later reafforestation, and changes in the forest/scrubland mosaic, the natural and seminatural landscapes then remained largely unchanged until modern times.

Recent landscape changes

Agricultural landscapes in Europe and the Mediterranean have shown considerable changes in recent decades. Changes in the extent of cultivation of New World crops have been only one factor of many. The main factors have been changes in land use patterns such as:

- Increased reforestation
- Movement away from the land
- Abandonment of terraces
- Increase in the proportion of arable land at the expense of meadows and pastures
- Increase in area under irrigation. The irrigated area in the Mediterranean has doubled in the past, 40 years according to a recent report (WWF 2006), accounting for 20.5 million ha in 2000 compared to 11 million ha in 1961. The biggest increases in absolute terms have occurred in Turkey (3.2 million ha) and Spain (1.7 million ha). Most of the countries' water supply projects, mainly constructions of dams or ground water exploitation, are for irrigation purposes. Some countries however, show a different development. Italy for example has reduced its irrigated area over the last twenty years. See also below under water shortage.
- Reduction of the agricultural sector and loss of land to the urban sector. In Greece, for example, since the early 1970s, the agricultural sector has dramatically shrunk. Its contribution to total employment and GDP has significantly decreased: from 40.6% and18.9% in 1972, to 21.6% and 13.9% in 1992, respectively. In Italy, for example, the area covered by agriculture progressively decreased from about 20.7 million hectares at the beginning of the century to 15 million hectares in the last decade.
- Changes in crop patterns, partly in response to EU measures that affect crop profitability.
- Crop substitutions (Hernández Bermejo & Léon 1992). Examples are the spread of sunflower cultivation *Helianthus* at the expense of olive; the replacement of millets (*Panicum*, *Setaria* and *Pennisetum*) by maize; the replacement of vines by other fruit crops.
- Agricultural intensification, including, in the last few decades, intensive cultivation of horticultural crops under glass or plastic (protected cultivation). There has been a rapid increase in protected cultivation in the Mediterranean in recent decades and it now occupies 143,000 ha of greenhouses. The main crops are vegetables (tomato, sweet pepper, cucumber, melon, watermelon, strawberry, squash, green bean, eggplant) plus limited amounts of cut flowers (carnation and rose) and ornamentals (Castilla 2002). In Spain, which occupies primary position, the evolution of the protected area (23,850 ha in 1989; 47,700 ha in 1999) shows stabilization at the end of the 20th century. Recent estimates of the Spanish greenhouse area, including walk-in tunnels, reached slightly over 53,800 ha (Castilla & Hernández 2005). In the province of Almería (Spain), in the 'sea of plastic' (Mar del Plástico), more than 20 000 ha of traditional agriculture have been converted into protected or greenhouse cultivation in just 6 years. Intensive protected cultivation is now established across the Mediterranean as far as Turkey where greenhouse cultivation reached nearly 25 000 ha by 2002 (Yilmaz & al. 2005), largely in the Antalya region.
- Tourism. The Mediterranean is the leading tourist destination in the world with the twenty countries bordering the Mediterranean Sea attracting over 30% of world tourism. The 46,000 km long coastal zone is visited by about 183 million tourists during the 3-month

summer season. 25,000 km of this total are already urbanized and have already exceeded a critical limit. An additional 100 million domestic tourists bring the total up to about 280 million visitors a year. Over 12 million tourists visit the Mediterranean islands each year. The increase of tourism has led to massive urban and tourist development with accompanying infrastructural effects. This is especially accentuated in coastal areas such as in parts of the Mediterranean and on islands, leading to the phenomenon known as 'coastalization'.

- Coastalization[8] – the concentration of population and economic activities on coastal spaces which has inevitably led to an impoverishment of biodiversity, loss or fragmentation of habitats
- Fire
- Land degradation
- Water shortage
- Land degradation and water shortage have become major threats to the sustainability of the seminatural and cultivated ecosystems in the Mediterranean and pastures and grazing lands are particularly susceptible. The WWF report already mentioned above (WWF 2006) on drought in the Mediterranean, which is estimated to become worse and more frequent in the coming years as a consequence of climate change, warns of the need to avoid unsustainable management of water such as increased irrigation in responses to EU subsidies and wasteful low efficiency irrigation in non-EU countries.

Transformation of urban landscapes

In addition to the effects of plant introductions on the countryside, over time urban landscapes changed as a consequence of the widespread introduction of ornamental species such as Jacaranda (*Jacaranda mimosifolia*), magnolia (*Magnolia grandiflora*), *Cassia* spp., Honey Locust (*Gleditsia triacanthos*), Lantana (*Lantana camara*) etc. to parks and gardens and as street trees, with the exotic tropical and subtropical plantings giving a misleading impression to the casual visitors as to the true nature of the Mediterranean region. In the *Agricultura de Jardines* (1604) of Gregorio de los Rios, written between 1590 and 1591 and published in 1604, one of the very earliest accounts of gardening in Europe (1592), 16 of the c.200 species listed as being grown in gardens in Castile were from the Americas. An account of the main ornamental species used in Al-Andalus is given by García-Sánchez & Hernández-Bermejo (2007).

The introduction of ornamental species continued in the post-Colombian period and accelerated in the 18th century with the series of expeditions organized to the New World, notably the 'Real Expedición Botánica de Nueva España'.

Sánchez de Lorenzo (2007) lists some 50 species brought from Cuba alone between 1785 and 1804 as seeds or living plants and their date of introduction and destination (Aranjuez or the Royal Botanic Garden Madrid) although as he comments most of them were in time lost due to climatic or physiological factors. On the other hand most of the Cuban species that are cultivated in Spain are to be found in the Canary Islands where they were introduced via the Jardín de Aclimatación de la Orotava, Tenerife, and grow well in the mild Mediterranean-subtropical climate of the islands.

Many of the ornamental species complement the indigenous flora, thus palms (the natives palms of the Mediterranean are the dwarf palm *Chamaerops humilis* widespread in the west and central coastal areas, the curious *Phoenix theophrasti* restricted to a waterway in Crete) which are so characteristic of the urban landscape occupy a niche that the native flora does not fill. Likewise, introduced American *Opuntia* spp. and *Agave*, make up for the lack of native large succulent life forms.

Notable species include: Jacaranda (*J. mimosifolia*), Bougainvillea, *Brugmansia* spp. Prickly Pear (*Opuntia ficus-indica* and other species), Blue passion flower (*Passiflora caerulea*), Pride of Barbados (*Caesalpinia pulcherrima*), Coral Tree (*Erythrina cristagalli*), Poinsettia (*Euphorbia pulcherrima*), Indian Bean Tree (*Catalpa bignonioides*), Trumpet creepers (*Pyrostegia venusta*, *Distichis buccinatoria*, *Campsis radicans*), Swiss cheese plant (*Monstera deliciosa*), Osage orange (*Maclura pomifera*), Spanish bayonet (*Yucca aloifolia* and other spp.), palms (*Brahea armata, Roystonea regia*, *Washingtonia filifera*, *Jubaea chilenensis*, etc.).

Naturalized alien and invasive species

While they have so far not had such an impact as in other Mediterranean-climate zones such as South Africa and Australia, alien invasive species are an increasing threat to landscapes in several Mediterranean countries and likely to become more widespread in the face of climate change. Blondel and Aronson (1999) take the, probably overoptimistic view, that 'Surprisingly, invading plant species are not a real threat in Mediterranean ecosystems. Of the 25,000 or so species existing today in the region, no more than 250, that is around 1%, are considered non-native and very few may be considered as harmful for natural communities'. These numbers may be questioned. The most detailed information on alien and invasive species at country level is available for Spain where Sanz-Elorza & al. (2005) record 123 of the most invasive species and the largest number of these are of American origin (see their Fig. 7). Another valuable information source is the Proceedings of the workshop on Invasive plants in Mediterranean type regions of the world (Brunel 2006)[10].

Notable examples of post-Columbian introductions from the Americas that have become invasive in the Mediterranean and with an appreciable effect on the landscape include *Opuntia* spp., *Agave* spp., *Nicotiana glauca*, *Solanum elaeagnifolium*, *Vitis* spp. and *Cortaderia selloana.*

Opuntia ficus-indica was introduced into Spain around 1500 and later spread through the Mediterranean basin by sailors who used it as an antiscorbutic. It was also cultivated for its fruits and as a host plant for the cochineal insect. Later is was grown as an ornamental and used as a living hedge. It soon escaped and became invasive in most south European and Mediterranean countries. Other species of *Opuntia* such as *O.dillenii*, *O. monacantha* and *O. stricta* have also become naturalized in parts of the Mediterranean and show invasive characteristics, although more localized than *O. ficus-indica*. There is considerable uncertainty as to the taxonomy and nomenclature of some of these species.

Agave spp. *A. americana* is a Mexican species that was introduced to Spain in the 16th century as an ornamental plant and then grown as a textile plant for its fibres. In some parts of Spain it was used traditionally as a living fence to mark off properties. It is now wide-

ly naturalized throughout the Mediterranean basin and is invasive in parts of its range and can form large stands which are prominent features on the landscape.

Nicotiana glauca (tree tobacco) is a South American (Argentina, Bolivia, Paraguay) shrub or small tree which was originally introduced as an ornamental and is now naturalized in most of the Mediterranean and highly invasive in western parts.

Solanum elaeagnifolium which is native to SW United States, N. Mexico and possibly Argentina, is invasive in parts of the Mediterranean region, especially in North Africa (Algeria, Morocco, Tunisia) and is also locally invasive in parts of Croatia, Cyprus, France, Greece, Italy, Montenegro, Serbia, Spain and where it invades various agroecosystems (maize, sorghum, vegetable crops), anthropised habitats and some semi-natural habitats (pastures). It was the subject of a recent EPPO/FAO Workshop (EPPO 2006).

Vitis spp. The role of rootstocks of North American species of vine (*Vitis* spp.) introduced in the 19th century to combat the effects of *Phylloxera* has already been mentioned. Recent studies by Laguna (200M) indicate that the greater part of the wild specimens of grapevines, usually attributed to *Vitis vinifera* subsp. v*inifera* throughout Europe, really belong to a complex group of alien invasive taxa – both mainly North American species such as *V. riparia, V. rupestris, V. berlandieri, V. labrusca* and hybrids with them which have become naturalized. Some of these are genetically very complex such as 'wild' specimens of the multihybrid *Vitis aestivalis* × *berlandieri* × *cinerea* × *labrusca* × *riparia* × *rupestris* × *vinifera* have been recently found in Spain.The abandoned cuttings and plants are becoming very aggressive invaders of roadsides, field edges and riverine vegetation (Laguna 2004).

Cortaderia selloana (Pampas grass) is a vigorous grass from South America (Argentina, Brazil, Chile and Uruguay) which was originally introduced as an ornamental. It now invades road margins, railway lines and some natural and seminatural habitats such as sand dunes and river banks and is a serious threat, for example, in the Canary Islands. Because of its size, plumose inflorescences and density, it is conspicuous in the landscape.

In reverse direction, several Old World species have become seriously invasive in the New World. In particular, the impacts of the deliberate introduction of perennial C4 grasses from Africa, following the clearing of native forests and grasslands to pasture for livestock grazing, has had a major and extensive effect on the appearance of the landscapes in the New World tropics, subtropics and temperate regions of the Americas (Williams and Baruch 2000). In particular, the Mediterranean basin has been a major source of invasive species in the New World (Heywood 1989).

Conclusions

The effects of the various waves of post-Columbian plant introductions on the landscapes and culture of the Mediterranean region must be viewed in a broad historical context. Moreover, the impacts have interacted with other ecological and sociological changes and are still unfolding today.

The effects of post-Columbian biodiversity exchange on landscapes have been more dramatic and extensive in the New World, especially in Mexico, the Caribbean and to some extent North America, than in the Old World. The more immediate impacts of American

introductions, such as maize, potato and sunflower, on landscapes of the Old World were not very marked except locally in areas such as the Veneto (Italy) where maize was cultivated extensively. Even centuries later, the main visual impacts on the landscapes have been minor compared with the effects of earlier plant introductions, notably those of the Classical period and those during the period of el-Andalus. Both of these made their mark on the landscape such as the extensive spread of olive cultivation, vineyards and citrus fruits, the introduction of irrigation systems and, in recent times, intensive horticultural cropping often under protection such as glass or plastic.

The main impact of New World introductions in Europe and the Mediterranean was on the nutritional balance of the agricultural economy, with maize, potatoes and beans (*Phaseolus*) producing many more calories per hectare than the traditional arable crops of pre-columbian agriculture such as wheat and barley. The introduction of crops with higher calorific value had a marked impact on demography, with the increased agricultural productivity allowing substantial population growth and consequent development.

Post-Columbian introductions of American ornamental species, especially trees and shrubs, together with introduced species from Africa, Asia and to a lesser extent Australia, have transformed the urban landscapes in the Old World, especially in southern Europe and the Mediterranean region, to such an extent that they are now assumed by the casual visitor to be part of the native landscape.

Cultural or traditional landscapes today dominate the Mediterranean region. The question then arises as to how many of these can we or should we maintain or preserve in a sustainable manner in the face of global change.

A significant number of species introduced in post-Columbian times have become invasive. The traffic has been two way. Some New World species such as *Opuntia* spp., *Agave* spp. and *Nicotiana glauca* and *Solanum elaeagnifolium*, have become serious pests in parts of the Mediterranean. On the other hand, the Mediterranean region has been a major source of invasive species in the New World. The Old World tropics have also provided some of the most serious invaders in the New World.

References

Andrews, J. 1993: Diffusion of Mesoamerican food complex to southeastern Europe. – Geographical Rev. **83:** 1094-204.

Arroyo-Garcia, R., Ruiz-Garcia, L., Bolling, L., Octete, R., Lopez, M., Arnold, C., Ergul, A., Soylemezoglu, G., Uzun, H., Cabello, F., Ibanez, J., Aradhya, M.K., Antanassov, A., Balint, S., Cenis, J., Constantini, L., Gorislavets, S., Grando, M.S., Klein, B.Y., Mcgovern, P.E., Merdinoglu, D., Pejic, I., Pelsy, F., Primikirios, N., Risovannaya, V., Roubelakis-Angelakia, K.A., Snoussi, H., Sotiri, P., Tamhankar, S., This, P., Troshin, L., Malpica, J.M., Lefort, F. & Martinez-Zapater, J.M. 2006: Multiple origins of cultivated grapevine (*Vitis vinifera* L. ssp. *sativa*) based on chloroplast DNA polymorphisms. – Molecular Ecol. **15:** 3707-3714. doi: 10.1111/j.1365-294X.2006.03049.x

Artusi, P. 1891: La scienza in cucina e l'arte di mangiar bene. – Firenze.

Baldoni, L. 2006: Genetic Structure of Wild and Cultivated Olives in the Central Mediterranean Basin. – Ann. Bot. **98:** 935-942.

Bayer, R. J., Mabberley, D. J., Morton, C., Miller, C .H., Sharma, I. K., Pfeil, B. E., Rich, S., Hitchcock, R. & Sykes, S. 2009: A molecular phylogeny of the Orange Subfamily (*Rutaceae*: *Aurantioideae*) using nine Cpdna sequences. – Amer. J. Bot. **96:** 668–685.

Beattie, G. A. C., Holford, P., Mabberley D. J., Haigh, A. M. & Broadbent, P. 2008: On the Origins of Citrus, Huanglongbing, Diaphorina citri and Trioza erytreae. – in: R. Gottwald, T. & Graham, J. H. (Eds.), International Research Conference on Huanglongbing. Proceedings of the Meeting. Orlando, Florida. www.plantmanagementnetwork.org

Besnard, G., Rubio de Casas, R. & Vargas, P. 2007: Plastid and nuclear DNA polymorphism reveals historical processes of isolation and reticulation in the olive tree complex (*Olea europaea*). – J. Biogeogr. **34:** 736–752.

Blondel, J. & Aronson, J. 1999: Biology and Wildlife of the Mediterranean Region. – Oxford.

Bradford, T. L. 1895: Life and Letters of Dr Samuel Hahnemann. – Philadelphia.

Brandolini, A. & Brandolini A. 2001: Classification of Italian maize (Zea mays L.) germplasm. – Pl. Gen. Res. News. **126:** 1-11.

Brunel, S. (ed.) 2006: Invasive Plants in Mediterranean type regions of the world. –Environmental Encounters Series No. 59. – Strasbourg.

Castilla, N. 2002: Current situation and future prospects of protected crops in the Mediterranean region. – Acta Hort. (ISHS) **582:** 135-147.

— & Hernández, J. 2005: The plastic greenhouse industry of Spain. – Chron. Hort. **45:** 15-20.

Christy, C. 2005: The Botanist and the Vintner: How Wine Was Saved for the World. – Chapel Hill, NC.

Crosby, A. W. 1972, 2003: The Columbian Exchange. Biological and cultural consequences of 1492. 30th anniversary edition. – Westport CT.

Daunay, M.-C., Lester, R. N. and Ano, G. 2001: Eggplant. Pp.:199-222. In: Charrier, A. Jacquot, M., Hamon, S. & Nicolas, D. (Eds.), Tropical Plant Breeding. – Paris, Enfield, Plymouth.

—, Lester, R.N., Gebhardt, C. G., Hennart, J. W., Jahn, M., Frary, A. Doganlar, S. 2001: Genetic resources of eggplant (*Solanum melongena* L.) and allied species: a new challenge for molecular geneticists and eggplant breeders. Pp.251-274 in: van den Berg, R.G., Barendse, G.W.M., van der Weerden G.M. & Mariani C. (Eds.), *Solanaceae* V: Advances in Taxonomy and Utilization. –Nijmegen.

Del Tredici, P. 2000. Plant exploration: a historic overview. Pp. 1–5 in: Ault, J.R. (ed.), Plant exploration: protocols for the present, concerns for the future, Symposium proceedings. – Chicago.

Díaz Yubero, I. 1998: Sabores de España. Pirámide. –Madrid.

— 2002. Nuestra dieta: Composición y futuro. Distribución y consumo Año nº 12, **61:** 75-113.

Dugo, G. & Di Giacomo, A. (eds). 2002: *Citrus*. The Genus *Citrus*. – London.

Dunlap, T. R. 1943: Remaking the Land: The Acclimatization Movement and Anglo Ideas of Nature. – J. World Hist. **8:** 303-319.

EFNCP/ARPA 2000: The environmental impact of olive oil production in the EU: practical options for improving the environmental impact. Commissioned report to DG Environment. – European Forum on Nature Conservation and Pastoralism, Peterborough, UK and the Asociación para el Análisis y Reforma de la Política Agro-rural Madrid, Spain.http://ec.europa.eu/environment/agriculture/pdf/oliveoil.pdf

EPPO 2006: European and Mediterranean Plant Protection Organization. EPPO/FAO Workshop - How to manage Invasive Alien Plants? A case study of Solanum elaeagnifolium – Sousse, Tunisia, 2006-05-29/31. http://archives.eppo.org/MEETINGS/2006_meetings/solanum _presentations/workshop_solanum_TN.htm

Ergül, A., Perez-Rivera, G., Söylemezoğlua, G., Kazan, K. & Arroyo-Garcia, R. 2011: Genetic diversity in Anatolian wild grapes (Vitis vinifera subsp. sylvestris) estimated by SSR markers. Pl. Genetic. Res. **9:** 375-383.

Evans, B. K & Feinstein, A. R. 1994: Joseph Goldberger: an unsung hero of American clinical epidemiology. – Ann Intern Med. **121(5):** 372-375.

Foldes, F. F. 1993: Anaesthesia before and after the introduction of curare. – Anaesthesiol Reanim. **18(5):** 128-31.

Folk, G. E. Jr. 1966: Introduction to environmental physiology.– Philadelphia.

García-Sánchez, E.& Hernández-Bermejo, J. E. 2007: Ornamental plants in agricultural and botanical treatises from Al-Andalus. Pp. 75-94 in Conan, M. (ed.): Middle East Garden Traditions : Unity and Diversity. Dumbarton Oaks Colloquium Series in the History of Landscape Architecture 31. – Harvard.

Glick, T. F. 1970: Irrigation and society in medieval Valencia. Harvard University Press, Cambridge, Mass. http://libro.uca.edu/irrigation/irrigation.htm

Goodman, J. 1993: Tobacco in History: The cultures of dependence.– London.

Hardy, A. 1860: L' Algérie agricole commerciale, industrielle. – Paris.

Harris, D.R. 1998: Introduction: the multi-disciplinary study of cross-cultural plant exchange. Pp. 85–91 in: Prendergast, H. D. V., Etkin, N. I., Harris, D. R. & Houghton , P. J. (Eds.), Plants for Food and Medicine. – Kew.

Hawkes, J. G. 1998: The evolution of cultivated potatoes and their tuber-bearing wild relatives. – Euphytica **36:** 189-208.

— & Francisco-Ortega, J. 1992. The potato during the late 16th century. – Econ. Bot. **46:** 86-97.

Heinrich, M., Müller, W.E. & Galli, C. (Eds.): 2006: Local Mediterranean Food Plants and Nutraceuticals. – Forum of Nutrition, **59.** – Basel.

Hernández Bermejo, J. E. & León, J. (Eds), Cultivos Marginados. Otra perspectiva de 1492. –Rome.

— & Lora González, A. 1992: Procesos y causas de la marginación; repercusiones de la introducción de la flora americana en España. – Pp. 261-272 in: Hernández Bermejo, J.E. & León, J. (Eds), Cultivos Marginados. Otra perspectiva de 1492. –Rome.

— & García-Sánchez, E. 1998: Economic botany and ethnobotany in al-Andalus. – Econ. Bot. **52:** 15-26.

— & — 2000: Botánica económica y etnobotánica en al-Andalus (Península Ibérica: siglos X-XV): un patrimonio desconocido de la humanidad. – Arbor **166:** 311-331.

Heywood, V.H. 1989: Patterns, extents and modes of invasions by terrestrial plants. – Pp. 31-60 in: Drake, J.A., et al (Eds.). Biological Invasions: a Global Perspective. – Chichester.

— 2007: Botanic gardens as introduction centres for plants of economic importance– a reappraisal. Proceedings 3rd Global Botanic Gardens Congress 1-6. Botanic Gardens Conservation International. 2007. http://www.bgci.org/files/Wuhan/PlenaryAddresses/Heywood.pdf

— 2009: Introduction: perspectives for economically important wild species and neglected crops in the Mediterranean. – Bocconea **23:** 107-114.

— 2010: The role of botanic gardens as resource and introduction centres in the face of global change. – Biodiversity and Conservation DOI 10.1007/s10531-010-9781-5

Hobhouse, H. 1985: Seeds of Change. Five plants that transformed mankind. – Sidgwick & Jackson, London. Revised edition 1986, New York. Paperback edition 1992, London.

Jenkins, J.A. 1948: The rigin of cultivated tomato. – Econ. Bot. **2:** 379-392.

Johnson, S.A. 1997: Tomatoes, Potatoes, Corn, and Beans: How the Foods of the Americas Changed Eating around the World. – New York.

Juma, C. (ed) 1989: The Gene Hunters: Biotechnology and the Scramble for Seeds. – Princeton.

Keys, A. & Keys, M. 1959: How to eat well and stay well: the Mediterranean way. – New York.

Livi-Bacci, M. 1986: Fertility, nutrition and pellagra: Italy during the vital revolution. – J. Interdiscipl. Hist. **16:** 431-454.

Folk, G. E. 1966: Introduction to Environmental Physiology. – Philadelphia.

Francis, G. W. 1862: The Acclimatisation of Harmless, Useful, Interesting, and Ornamental, Animals and Plants. – Adelaide.

Jenkins, J.A. 1948: The origin of the cultivated tomato. – Econ. Bot. **2:** 379-392.

Kraut, A. M. 2003: Goldberger's War: The Life and Work of a Public Health Crusader. – New York.

Laguna, E. 2004: American and Hybrid Grapevines (*Vitis* Spp.): A new concept of invasive plants to Europe. – Planta Europa IV Proceedings. http://www.nerium.net/plantaeuropa /Download/Procedings/Laguna.pdf

Loumou, A. & Giourga, C. 2003. Olive groves: the life and identity of the Mediterranean. – Agric. Human Values **20:** 87-95.

Lobo Cabrera, M. 1988: El comercio canario europeo bajo Felipe II. – Madeira.

Low. T. 2002: Feral Future. The untold story of Australia's exotic invaders. – Chicago & London.

Lunde, P. 1992: Questionable Origins. – Saudi Aramco World May/June issue, 47–55.

McCann, J. C. 2005: Maize and Grace: Africa's Encounter with a New World Crop 1500-2000. – Harvard.

McNeill, W. H. 1991: American food crops in the Old World. Pp. 42-89 in: Viola, H.J. & Margolis, C. (Eds.), Seeds of Change. A quinicentennial commemoration. –Washington & London.

Malanima, P. 2006. Energy crisis and growth 1650–1850: the European deviation in a comparative perspective – J. Global Hist. **1:** 101–121.

Mariani-Costantini, R. & Mariani-Costantini, A. 2007. An outline of the history of pellagra in Italy. – J. Anthropol. Sci. **85:** 163–171.

Market Brief. 2002: The Pulse Products Market in Greece. October 2002. – Report prepared by the Market Research Centre, Market Support Division (TCM), Department of Foreign Affairs and International Trade, Ottawa K1A 0G2.

Marrero, Á. 2007: Cultivos tradicionales de papas en Canarias: la otra biodiversidad. Rincones del Atlántico, **4:** 262-273.

Noah, A. & Truswell, A. S. 2001: There are many Mediterranean diets – Asia Pacific J. Clin. Nutr. **10(1):** 2-9.

Nunn, N. & Qian, N. 2010: The Columbian Exchange: a history of disease, food, and ideas. – J. Econ. Perspect. **24:** 163-188.

Preedy, V. R. & Watson, R. R. (Eds.) 2008: Tomatoes and Tomato Products Nutritional, Medicinal and Therapeutic Properties. – U. S.

Puerta Romero, J. 1961: Variedades de judía cultivadas en España. – Madrid.

Puerto Sarmiento, F.J. 2002: Jardines de aclimatación en la España de la Ilustración. – Ciencias 68 Octubre-Diciembre. www.ejournal.unam.mx/ciencias/no68/CNS06804.pdf

Rajakumar, K. 2000: Pellagra in the United States: a historical perspective. – South Med. J. **93:** 272-277.

Ramon-Laca, L. 2003: The introduction of cultivated citrus to Europe via Northern Africa and the Iberian Peninsula. – Econ. Bot. **57:** 502-514.

Redondo Zaera, M. 2007: La papa. El cultivo social por excelencia, en horas bajas. Rincones del Atlántico **4:** 274-279.

Revilla, P., Soengas, P., Cartea, M. E., Malvar, R. A. & Ordas, A. 2003: Isozyme variability among european maize populations and the introduction of maize in europe. – Maydica **48:** 141-152.

Romano, F. 2005. Scientific opening. International Conference on Health Benefits of Mediterranean Diet (EGEA). From scientific evidence to health prevention actions. Pp.: 7-8. http://www.aprifel.com/_pdf/MinutesEGEA_2005_1.pdf

Rios, D., Ghislain, M., Rodriguez, F., Spooner, D.M. 2007. What is the origin of the European potato? Evidence from Canary Island landraces. – Crop Sci. **47:** 1271-1280.

Salas-Salvadó, J., Huetos-Solano, M. D., García-Lorda, P. & Bulló, M. 2006: Diet and dietetics in al-Andalus. – Brit. J. Nutr. **96:** 100-104.

Sánchez de Lorenzo Cáceres, J. M. 2007: Plantas de la flora cubana cultivadas en España. – http://www.arrakis.es/~jmanuel/Plantascubanas.pdf

Sanz-Elorza, M., Dana Sánchez, E. D. and Sobrino Vesperinas, E. (eds), 2005 [2004 on title page]: Atlas de las Plantas Alóctonas Invasoras en España. Pp. 378. – Madrid.

Scora, R.W. 1975: On the history and origin of citrus. Bulletin of the Torrey Botanical Club **102:** 369-375.

Shaw, I. 2003: Oxford History of Ancient Egypt. – Oxford.

Spiegel-Roy, P. and Goldschmidt, E. E. 1996: Biology of Citrus. – Cambridge.

Tripp, R. 2005: Politics and history through the mill. – Nature **434:** 825 doi:10.1038/434825a.

Trillo San José, C. 2003. Agua y Paisaje en Granada. Una herencia de al-Andalus. –Granada.

— 2005: A social analysis of irrigation in Al-Andalus: Nazari Granada (13th-15th centuries). – J. Medieval Hist. **31:** 163-183

Watson, A.M. 1983: Agricultural innovation in the early Islamic world. The diffusion of crops and farming techniques: 700-1100. – Cambridge.

Webber, H.J., Reuther, W. and Lawton, H.W. 2005: Chapter 1 .History and Development of the Citrus Industry. In: The Citrus Industry, 1: History, World Distribution, Botany, and Varieties. – Riverside.

Weese, T. L. & Bohs, L. 2010: Eggplant origins: out of Africa into the Orient. – Taxon **59:** 49-56.

Weigl, E. 2003. Acclimatization: The Schomburgk brothers in South Australia. Humboldt im Netz. – Int. Rev. Humboldtian Stud. **4(7):** 1-13. http://www.uni-potsdam.de /u/romanistik/humboldt/hin/hin7/inh_weigl_1.htm (2003).

Williams, D. G. & Baruch, Z. 2000: African grass invasion in the Americas: ecosystem consequences and the role of ecophysiology. – Biol. Invas. **2:** 123–140.

WWF. 2006: Drought in the Mediterranean:WWF Policy Proposals. Nicola Isendahl (main text), Guido Schmidt (policy recommendations). – WWF/Adena, WWF Mediterranean Programme, WWF Germany.

Yilmaz, I. , Sayin, C. & Ozkan, B. 2005: Turkish greenhouse industry: Past, present, and future. – New Zealand J. Crop Hort. Sci. **33:** 233-240

Zeven, A.C. 1997: The introduction of the common bean (*Phaseolus vulgaris* L.) into Western Europe and the phenotypic variation of dry beans collected in The Netherlands in 1946. – Euphytica **94:** 319-328.

Zohary, D. 1998: The diffusion of south and east Asian and of African crops into the belt of Mediterranean agriculture. Pp. 123–134 in: Prendergast, H. D. V., Etkin, N. I., Harris, D. R., Houghton, P. J. (Eds.), Plants for Food and Medicine – Richmond.

— & Hopf, M. 2000: Domestication of plants in the Old World, 3rd edn. – Oxford.

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Notes

[1] Often identified as being near present-day Somalia although a strong argument has now been made for its location much nearer Egypt, in either southern Sudan or the Eritrean region of Ethiopia, where the indigenous plants and animals agree most closely with those depicted in the Egyptian reliefs and paintings (Shaw 2003).

[2] Earlier contacts with the New World, by the Chinese and other groups, are not considered here.

[3] The origin and domestication of the aubergine or egg plants is still not clear. According to Weese and Bohe (2010), they are probably of African origin (*Solanum incanum* group) and subsequently spread through the Middle East to Asia giving rise to weedy forms of *Solanum melongena* which were then domesticated and spread to India as crop plants from where they were introduced into North Africa and into the Iberian peninsula by the Moors in the 9th century (Lester & Hasan 1991; Daunay & al. 2001a,b).

[4] Although it is widely believed that *Citrus* originated in Southeast Asia between India and China and southwards through Malesia (Dugo & Di Giacomo 2002), recent work suggests that the genus comprises two clades, a southern one from New Guinea, Australia, New Caledonia, New Ireland, made up of wild species and two species traditionally considered of Indian origin, and a northern clade largely from mainland Asia that contains most of the economically important citrus species and cultivars. *C. medica*, the first described species of *Citrus* is the only widely cultivated species of the northern clade. Although long considered to be native to India, according to Beattie & al. (2008) it probably originated in Australasia, possibly in New Guinea.

[5] The French involvement in tropical germplasm introduction developed later and followed a different pattern, the key central institution being the Muséum National d'Histoire Naturelle and the Jardin des Plantes where the holder of the *Chaire des Cultures*, André Thouin (1747–1824), was responsible *inter alia* for successfully cultivating vanilla (*Vanilla planifolia*) from Mexico where it was grown by the pre-Hispanic cultures, to the Jardin de la Compagnie (the French East Indies Company) on the Island of Réunion from where it spread to other Indian Ocean islands.

[6] Folk (1966) gives a detailed discussion of the various often conflicting uses of the term acclimatization. As noted by Mazess (1975) there has been a tendency to use it in a sense of adjustments made by a species over the course of several generations. This is effectively synonymous with 'genetic adaptation' as a result of natural selection and contrasts with the earlier idea of acclimatization being the adjustment of an individual organism to its environment. It is this latter usage that Mazess recommends although the nature and extent of such adjustment remains a subject that needs further consideration.

[7] The Mediterranean diet was inscribed in 2010 on the UNESCO Representative List of Intagible Cultural Heritage of Humanity.

[8] The Green Devil advertising Maurin Quina, an aperitif produced by Auguste Maurinat in his distillery in Esplay in the Haute-Loire district of France, was the designer Leonetto Cappiello's most famous poster.

[9] Described as 'Linear and nuclear concentrations along the coast […] phenomena that are directly linked with intensive housing development, indiscriminate land occupation, and the possession of large reserves of land which it is possible to build on' in the conclusions of the International Congress, 'Sustainable Tourism in the Mediterranean: The Participation of Civil Society', 1998. MED Project ULIXES 21. For Sustainable Tourism in the Mediterranean.

[10] A second International Workshop on Invasive plants in the Mediterranean Type Regions of the World was held in Trabzon, Turkey, in August 2010: http://archives.eppo.org/ MEETINGS/2010_conferences/mediterranean_ias.htm