María de Cortes Sánchez-Mata ·
Javier Tardío *Editors*

Mediterranean Wild Edible Plants

Ethnobotany and Food Composition Tables

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"Schleiden, in his principles of botany states: 'Botany is an indispensable branch of knowledge for the chemist and physiologist'. I think he might have said, with equal truth, chemistry and physiology are indispensable branches of knowledge to the botanist".
Helen C. De Silver Abbott
(Beginning of a lecture delivered before the Franklin Institute of the State of Pennsylvania, USA, 1887).

Preface

This book was born from the close cooperation between two groups led by us: a group of ethnobotanists, working at three different centres (*IMIDRA*, *Universidad Autónoma de Madrid* and *Real Jardín Botánico de Madrid*) and a group of food chemists working at *Universidad Complutense de Madrid,* with the purpose of improving the knowledge of the wild edible plants traditionally used in the Mediterranean area, especially about their nutritional aspects. This collaboration started at the end of 2006, with a research project granted by the Spanish Ministry of Education and Science (CGL2006-0946/BOS), studying 24 of the most important wild plants (20 vegetables and 4 fruits) habitually consumed in central Spain, at least in the last 50 years.

Hence, the idea of writing a book about this topic with the central aim of compiling and resuming the most relevant published nutritional data about the main wild edible plants traditionally consumed in the Mediterranean region. This information, not usually included in nutrient databases of foods, provides an interesting tool to be used with the purpose of the revalorization of wild food species, preservation of their traditional uses and also as alternatives to improve the diversity of modern Mediterranean diets, as they may represent valuable sources of nutrients often lacking in modern societies, such as fibre or vitamin B_9.

With this purpose, the work has expanded from the two initial groups to involve different contributors, including experts from different countries, most of them bordering the Mediterranean Sea. As a result, a multidisciplinary approach has been achieved.

The book is organized into four parts that deal with different aspects of wild edible plants, the last one and largest offering a detailed compilation of ethnobotanical and nutritional information about some of the most important Mediterranean wild edible plants.

The first part, with five chapters, treats about different aspects of the ethnobotany of wild edible plants. Chapter 1 presents an historical perspective of the use of wild food plants in the Mediterranean region. Chapter 2 explains the characteristic of the Mediterranean climate and its influence on the landscape and the abundance of wild edible plants. Chapter 3 analyzes the trends of the wild food plant consumption in Europe, highlighting the herbophilia of the Mediterranean countries.

Chapter 4 presents an ethnobotanical analysis of the wild fruits and vegetables traditionally consumed in Spain, an example that can be extensible to other countries of the Mediterranean region. Lastly, Chapter 5 discusses the availability of these wild resources as well as the possibilities of some of these species for cultivation.

The second part, with four chapters, is devoted to the importance of nutrients and bioactive compounds of the Mediterranean wild edible plants. Chapters 6 and 7 deal with their contribution to dietary intakes of micronutrients (vitamins and minerals, respectively), taking into account the current recommendations. Chapter 8 presents the fatty acid profiles of these plants, whereas Chapter 9 covers their role as sources of carotenoids, fibre, phenolics and other non-nutrient bioactive compounds.

The third part, with three chapters is about the biological activities of wild edible plants, as sources of antioxidants (Chapter 10) and components with antimicrobial actions (Chapter 11), as well as their potential biological–pharmacological activities (Chapter 12).

The fourth part is Chapter 13, a large descriptive dossier of 38 monographs about 41 selected wild edible plants traditionally and widely consumed in different countries of the Mediterranean basin. These monographs have two sections. The first one consists of a botanical and graphical description of the species and a resume of the ethnobotanical data registered in the Mediterranean countries for this edible plant. The second section supplies composition data of their edible parts, in the format of conventional food composition tables, covering the main constituents of proximal composition, minerals, vitamins and other bioactive compounds as well as fatty acid profiles. These analytical data, based on the scientific literature, try to remark the nutritional relevancy of each one of the selected species, and may be a valuable tool to preserve or revalorize their food use.

Finally, we thank all the authors and collaborators who have contributed to the different phases of the elaboration of the present work, making possible the integration of many different branches of science in this book, which we hope could be useful for the valorization of wild edible plants and could help expand the knowledge of this ancient human resource.

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Part I
Ethnobotany of Wild Edible Plants

Chapter 1
A Historical Perspective of Wild Plant Foods in the Mediterranean Area

María Esperanza Torija-Isasa and María Cruz Matallana-González

1.1 Introduction

The human feeding process has experienced constant evolution through history. The first human beings were able to intuitively select from the environment products that could be used for food, preferring those which provided energy and nutrients and rejecting what they thought could be harmful. With the aim of satisfying the most basic need (hunger), they tried to use different natural products for food; later, in times of abundance, they could make a selection, and finally they learnt how to cook, preserve and produce food products (Toussaint-Samat 2009).

The human being is a selective omnivore, which means that his nutrition is not linked to one or several foods. His food habits allow him to choose between food from different origins and even between different varieties of a given food. The primitive food behaviour was influenced exclusively by natural appetite. Whether a certain kind of food is accepted or not depends first on whether a society considers it edible. Then, its acceptance depends on the sensorial exigencies, such as external aspect, odour, taste, flavour, texture and even the noise produced when it is consumed. The consequences derived from that selection are mostly biological since foods provide energy, nutrients and other compounds for human organism. A right selection may have good consequences on health status, while a wrong choice may give rise to diseases; this has been sometimes empirically taken into account during the evolution of human beings to influence the acquisition of food habits. However, sociocultural factors have also produced changes in food behaviour since feeding is influenced by different individual or collective facts such as culture, economy, geography and environment, as well as physiology and personal psychology (Harris 1991).

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From ancient times, humans took from the surrounding environment those products that could be used as food. Plant products known by primitive people were used with different objectives: food, medicine, production of materials (for example clothes) or magic rituals. Wild plant gathering has been a habitual practice since ancient times all over the world, especially in times of famine. Many species now considered as weeds were food for numerous cultures. Today, lots of them have been forgotten in our society even though they have an important nutritive value; in other countries, however, many plant species are still in use.

Phytogenetic resources are essential to improve food security, including seeds and propagation materials from traditional and modern varieties, and also wild species, which are often used as food. The loss of these resources and the absence of suitable links between preservation and utilization are an important danger for food security in the future world. Despite their importance for human survival, plant biodiversity is being lost at an alarming rate. Hundreds of thousands of traditional heterogeneous varieties existing through generations in the fields until the beginning of the twentieth century have been replaced by a small number of commercial modern varieties (Esquinas-Alcázar 2013).

For this reason, the Food and Agriculture Organization of the United Nations and the World Health Organization (FAO/WHO) are devoted to improve the knowledge and preservation of phytogenetic resources, with the aim to assure sustainable food provision in the future and contribute to the optimal utilization of the available genetic resources, including wild plants which may be relatives of crop products, but may contain different genetic material allowing them to live in stress conditions or providing a higher nutritive value. In the past years, the importance of biodiversity has stood out in many campaigns, such as the FAO/WHO World Food Day, with the topic "Harvesting Nature's Diversity" in 1993 or "Biodiversity for Food Security" in 2004 (FAO 2011a, b).

The wild flora has played an essential role in human feeding, and even nowadays, there are groups depending at a high rate on wild edible plants. In our environment, wild plants have been and are a seasonal complement for our diet, although in times of famine, they have been employed as emergency foods. The most valued species are even subjects of seasonal commerce, usually as consumer products and often in ambulant markets and are also present in some compilations of traditional food recipes.

1.2 Prehistory

The interpretation of the archaeological remains is not an easy task; however, the role of wild plants in the diet of communities during prehistory is supposed to be highly important. Wild plants are abundant resources, easily gathered and collected, which was the reason that, for example, young parts of *Malva parviflora* L., *Rumex* sp., *Silene* sp., *Sisymbrium* sp., *Plantago* sp. or *Calendula* sp. could be used as habitual foods by primitive civilizations (Peña Chocarro 2000). The hunter-gatherer societies had enough resources to survive, although in many cases they were sea-

sonal resources. However, the study of wild vegetables used in the prehistoric period is difficult since most palaeobotanical remains include seeds and even fruits, but not frequently leaves. For example, Olària i Puyoles (2004–2005) mentioned the proofs for the collection of some wild fruits or seeds, such as *Arbutus unedo, Quercus* sp., *Vitis sylvestris, Lathyrus* sp., *Pisum* sp. and *Olea* sp. in Grotta dell'Uzzo (Italy) and also seeds of *Papaver somniferum* L., *Myrtus communis, Rubus idaeus* and acorns of *Quercus* sp. in Cueva del Toro (Antequera, Spain). Lopez et al. (2013) also mentioned the presence of wild *Lathyrus cicera* among others in "Cova des Riuets" (Balearic Islands, Spain). Verde et al. (2004) supposed that many wild vegetables were widely used in the Palaeolithic in spring, especially plants living in wetlands (watercress) or sprouts from different species (asparagus). In the Neolithic, many weeds were still gathered, such as bugloss or bladder campion. Many of these species were weeds growing in cultivated fields, especially grain crops, or in ditches (Alarcón 2013). With the development of agriculture, human beings started to grow a great number of species, beginning with those preferred for food or those more easily adaptable to cultivation, such as cereals and legumes, and also vegetables. However, many vegetables were never domesticated, including leaves, stems, flowers as well as subterranean parts. An increase in the consumption of vegetables, and particularly greens, in this period of the history, might have had a role in the reduction of vitamin deficiencies (Latham 2002).

The adventitious species linked to fields, as well as ruderal species developed in some spaces modified by human beings, were used in the Neolithic period, such as *Plantago* sp., *Chenopodium* sp., *Amaranthus* sp., *Polygonum* sp. as well as some grains of wild species. Precioso-Arévalo (2003) mentioned plants which have been found in palaeobotanical remains belonging to the genus *Silene, Chenopodium* or *Brassica,* as well as *Calendula arvensis* M. Bieb. and *Chenopodium album* in several archaeological sites in the East of Spain.

1.3 Ancient Civilizations

There are not only many evidences about cereal and legume crops in ancient Near Orient cultures but also of the gathering of nuts such as acorns, pistachios and almonds (Redman 1990). García Lenberg (1998) reported some difficulties to identify plants from palaeobotanical remains and cuneiform texts from ancient Mesopotamia. According to this author, references to *Allium* genus, mainly garlic and onion, have been found, as well as different legume seeds, such as vetches. Cucumber seeds may also have been consumed in Nimrud in the seventh century BC, although it is not clear if they correspond to the same product that we know nowadays (Toussaint-Samat 2009).

In Egypt, many vegetables were highly valuable, such as garlic, onion, mint, caraway, fennel or coriander, firstly as wild herbs, but later as cultivated plants. Other vegetables with a double ornamental and food use were lotus and water lily, which became important for Egyptian food habits (Martínez Llopis 1989; Aboelsoud 2010).

Many of the most used plants are mentioned in Ebers Papyrus (sixteenth century BC), one of the most ancient maintained medical documents, compiling about 700 remedies, not only explaining their medicinal applications but also some of their food uses. In this document, reference to lotus appears together with other vegetables such as onions, dates, pomegranates, poppy, elderberry or mint. Lotus, an aquatic plant of the Nymphaeaceae family known as "Egyptian white nenuphar" or "Egyptian white lotus", was a symbol of water and origin of life, as its seeds and tubers were consumed as food in this culture (Aboelsoud 2010; Clifton 1986).

Vegetables were basic components of the Greek diet from ancient times, as shown in different references from ancient Greek literature. For example, Hesiod (eighth century BC) in his manuscript "Works and Days" referred again to lotus, adding also "what a rich treasure is given by asphodel and mallow…" (Vianello de Córdova 1979). Also, some relevant references to lotophagi (lotus eaters) can be found in Homer's manuscripts (eighth century BC), such as *Odyssey* (XI, 76–104; V, 594–608) and *Iliad* (XIV, 346–351). Herodotus (484–425 BC) also mentioned two varieties of lotus: one growing close to the Nile river, and the other one in the so-called lotophagus country. This place is located on the coast of Libya (García González 2008).

Antiphanes (408–334 BC) wrote about people eating leaves (*phyllotrôges*), either wild or cultivated; some comments illustrate how they used to be the main dish of the meal, being consumed either raw or cooked, and also accompanying other foods such as meat or fish, according to García Soler 2001. This author also indicated that the roots and stems of mallows (*maláche*) were eaten either cooked alone or as an ingredient of other dishes.

The Greek historian Polybius (200–118 BC) made the first description of Lusitania, indicating that wild fruits were better preserved there due to the characteristics of the air. He also said that there the asparagus did not stop blooming for more than 3 months (Cubero Corpas 1994; García Quintela 2001).

Many wild plants gathered in ancient Greece also became cultivated, such as cabbage, called *krámbe,* being the flat variety the most widespread. Nicandrus (second century BC) indicated that it sometimes grew wild and presented different colours: brown, purple or "frog colour". There were also different types of lettuces (*thrídax*). Another important wild edible species in classical culture was *skólymos,* which according to Dioscorides' (first century AD) description may be identified as thistle or artichoke (Font Quer 1962). Other Asteraceae belonging to the genus *Sonchus* (*sónkos*) were less appreciated. The "patience herb" (*lápathon*), identified as *Rumex* spp., was usually eaten cooked, being highly appreciated for its pleasant taste and penetrant smell (García Soler 2001; Martínez–Llopis 1989).

Nettle was an appreciated plant in ancient Greece. Aristophanes (444–385 BC) wrote about nettle gathering before the swallows' arrival. Later, Athenaeus of Naucratis (249–150 AD) devoted a short part of the second book of *Deipnosophistae* (meaning "Dinner-table philosophers") to nettle use (*akaléphe*). Teophrastus (372–288 BC) also wrote about cooking of nettles, particularly young stems, and how they became cultivated vegetables. He also indicated that thistle leaves were also

eaten in Sicilia (being bitter and suitable for preservation in brine); thistle stems and inflorescences were also used.

Like the Greeks, it is known that Romans were very interested in eating wild nettles or mallow leaves. Many Roman authors have written about these uses: For example, Plautus (251–184 BC) wrote how Roman cooks prepared dishes using a lot of leafy vegetables and herbs dressed with other herbs. Martínez–Llopis (1989) commented about the high appreciation given by Romans to nettle, as well as mallows, vine leaves or polypodium.

Marcus Terentius Varro (116–27 BC) also wrote about chard roots and leaves (white or black chards), cooked together with lentils; this author also mentioned the use of vine or mustard leaves, as well as parsley (called *holisera*). In Rome, thistle stems were also preserved in vinegar, honey or cumin, as indicated by Pliny the Elder (first century AD) in his *Natural History;* also in the widely known ancient roman cooking book *De re coquinaria* written by Apicius (first century AD), several recipes are compiled using thistle midribs cooked, fried or dressed with sauces (Ibáñez Ártica 1995; Martínez–Llopis 1989).

Mention should be made about *De Materia medica,* written by Dioscorides. As the doctor of the army of the Roman emperor Nero, he had the opportunity to travel all around the Mediterranean, compiling the knowledge about the use of natural remedies, including about 600 plant species (López Eire, 2006). But he also described other plant uses, such as food. For example, Dioscorides mentioned the consumption of mallows roots and stems raw in salads, cooked and also as ingredients of several dishes (Font Quer 1962). The same author commented about eating the new growth of an indeterminate thistle, probably *Cynara cardunculus* L., cooked as asparagus.

Other vegetables eaten by Romans: wild *Apium graveolens* L. was appreciated for its leaves, seeds and stems, which were candied the same way as those of *Angelica sylvestris* L. or *A. archangelica* L.; *Umbilicus rupestris* (Salisb.) Dandy (Venus navel) leaves were eaten raw in salads and highly lauded by Hippocrates; and *Inula helenium* L. roots, with a bitter taste, were used either as medicine or food, cooked or preserved in oxicrate (a mixture of water, honey and vinegar), considered useful for gastric diseases (Martínez–Llopis 1989; Grande de Ulierte 2014).

At this moment, the Mediterranean was characterized by its important commercial activity, promoting the exchange of knowledge between different cultures surrounding this area: Phoenician, Greek, Carthaginian and Romans. The Roman Empire expanded to Asia Minor and Africa. Israel was also characterized by the use of herbs for food or seasoning, such as mint, dill or cumin mentioned in the New Testament (Mt 23, 23). After the fall of the Roman Empire, the Byzantine Empire influenced Mediterranean culture. Stephanus of Byzantium (sixth century AD) wrote about the islands Melussa and Kromyusa (thought to be Majorca and Minorca), whose names are derived from the translation of apple and onions, respectively; they may give an idea that those were important plants growing and used in those regions (Cubero Corpas 1994). During all these centuries, the transfer of crops, medicinal and aromatic plants from East to West became very important (Hernández Bermejo and García Sánchez 1998).

1.4 Middle and Modern Age

During the Middle Ages, agriculture was already widely expanded and many wild plants previously eaten had become cultivated vegetables, although many others such as wild nettle leaves, purslane, arugula or borage leaves were still used as foods. The writings of some Hispano-Arabic writers from the Andalusi Agronomic School (tenth to fifteenth centuries AD), such as Arib ben Said, Ibn Wafid, Ibn Hayyay, Abu l-Jayr or Ibn Bassal, reflect the introduction of some Oriental species in the Iberian Peninsula (Hernández Bermejo and García Sánchez 1998).

In medieval literature, such as *The Miracles of Our Lady* (written by Gonzalo of Berceo) or *Codex Aemilianensis* (the first glossary made in the Iberian Peninsula, presumably finished in 964 at the monastery of *San Millán de la Cogolla*), different wild plants growing around the paths and others in gardens are mentioned. The interpretation made by Dutton (1980) of these works indicates the food use of some of the species mentioned, eaten mostly by poor people, who usually had better access to these products; many of them were also included in medieval pharmacopoeias. Some examples of the wild species used according to this author are gooseberries, said to be sweeter than sugar; cooked young nettle leaves; watercress, abundant in boggy places and slow streams and served as fresh salads throughout the year; or wild fennel widely used in the preparation of food and medicines, with a taste similar to anise (Dutton 1980; García-Turza 2004).

The arrival of Europeans to the New World played a crucial role for the introduction and exchange of plant species between Europe and America. Many chronicles reflect plants transported by colonists, farmers, physicians and naturalists on their arrival in America, but also the transport of American plants to Europe, many of which became adapted to cultivation (Hernández-Bermejo and García-Sánchez 1998). Some species, such as wild purslane, are nowadays traditionally consumed in both Europe and America.

During the Renaissance, there was a renewed interest in Europe for classical culture, which was evident in art, literature and also in sciences. In this context, different authors afforded the translation of *De Materia Medica* written by Dioscorides to popular languages: The first one was edited in Venice by Giovanni de Farri in 1542, followed by Pier Andrea Mattioli in 1543, both of them in Italian language. Also important was that of Andrés Laguna into Spanish, commented and published in 1555 (Font Quer 1962).

The habit of gathering plants from the wild has continued during centuries, linked especially to rural societies. They provided a source of food for many people in times of wars and famines, situations that become frequent during the sixteenth to nineteenth centuries. They often represented an important dietary contribution when men were fighting and women were in charge of bringing food to the family. Sometimes, these plants were weeds growing in the crops, and their collection represented both a necessary agricultural practice and, at the same time, a source of food.

But still the habit of gathering plants were often due to the fact that some species were considered as delicacies, as described by Nicolás Monardes, a Spanish physician and botanist from the sixteenth century who described how scorzonera roots preserved in sugar were almost as delicate to taste as those of coriander, which was used to make sweets. Also, the English gardener John Evelyn wrote in seventeenth century about eating some young shoots of scorzonera the same way as asparagus or cooked in pots, indicating the existence of a white and a red variety widely employed in Spain and Italy. In France, Jean-Baptiste de La Quintinie, the gardener of Louis XIV, mentioned the use of purslane for the king's salads, preserved in salt and vinegar (Genders 1998).

Some species, such as *Smyrnium olusatrum* L., consumed as a vegetable and condiment in the times of Dioscorides or Columella (first century AD), became underutilized from the seventeenth century, and no reference to it is found in the works of Spanish agronomists from the nineteenth century, presumably being displaced by other vegetables such as *Apium graveolens*. Some of these species are now plants growing in nitrified environments altered by human activities or are weeds in crops (Morales et al. 2011).

1.5 Contemporary Age

Nowadays, agriculture crops have displaced many of the previously known and appreciated wild species. Some agricultural techniques, such as the use of chemical pesticides, often displace wild greens to places far from cultivated fields (Tardío et al. 2005). However, Mediterranean traditions have made possible that a considerable number of them continue being present in the diet of many people for different reasons: the pleasure of gathering wild plants from the fields, the knowledge about their good properties from either a nutritional or functional point of view, the interest of keeping traditional food habits, or contrarily but not incompatible, the search for "new" (or forgotten) ingredients with unusual flavours, taste or textures in the so-called nouvelle cuisine.

Many ethnobotanical works have been recently published, registering the traditional knowledge about the plants used during the past decades, as can be seen in some of the following chapters, especially in Chap. 13. In Spain, for example, many studies have been carried out in various regions (e.g. Fajardo et al. 2000; Menéndez-Baceta et al. 2012; Pardo-de-Santayana et al. 2005; Tardío et al. 2005; Verde et al. 1998). A compilation of the wild edible plants traditionally consumed in Spain was published by Tardío et al. (2006). This study reflects the consumption of more than 400 species for different food uses, including vegetables (e.g. *Rorippa nasturtium-aquaticum* (L.) Hayek, *Silene vulgaris* (Moench.) Garke, *Asparagus acutifolius* L., *Scolymus hispanicus* (L.) and fruits (*Fragaria vesca* L., *Rubus ulmifolius* Schott, *Castanea sativa* Mill., *Fagus sylvatica* L., *Pinus radiata* D. Don). Also in Italy, during the past 25 years, the consumption of non-cultivated plants has been the focus of a growing number of studies devoted to document traditional knowledge about anthropology in an ethnoecologic/ethnobotanic context. Just to cite a few examples:

Pieroni et al. (2005) informed about the use of unusual species in Central Lucania; Ghirardini et al. (2007) studied 21 communities in Italy where the gathering, processing and consumption of wild edible plants are still important activities despite the socio-economic changes, with species such as *Asparagus acutifolius, Reichardia picroides* (L.) Roth, *Cichorium intybus, Foeniculum vulgare, Sambucus nigra* L., *Silene vulgaris, Taraxacum officinale* (L.) Weber ex F. H. Wigg. and *Urtica dioica* L. as those common in many Italian regions and especially *Borago officinalis* L. as one of the most valued species; Scherrer et al. (2005) and Cornara et al. (2009) studied the use of different species in Campania and Liguria, respectively, to elaborate different typical dishes as *minestra* of *prebuggin.* Other recent studies show a trend of revalorization of wild edible plants in Turkey (Dogan et al. 2004), Jordan (Tukan et al. 1998) and Bulgary (Nedelcheva 2013).

Although some previous studies about wild food plant composition exist (Cowan et al. 1963), from the eighties to the present day, wild edible species in the Mediterranean countries have been more intensively studied, including their biological activity (Heinrich et al. 2006). There have been many surveys about their role in human nutrition, such as those conducted in Spain (Guil-Guerrero and Torija-Isasa 2002; Romojaro et al. 2013; Sánchez-Mata et al. 2012), Portugal (Barros et al. 2010; Martins et al. 2011; Pereira et al. 2011), Greece (Vardavas et al. 2006; Trichopoulou et al. 2000; Zeghichi et al. 2003), Italy (Aliotta and Pollio 1981; Bianco 1998; Gatto et al. 2011) and Turkey (Özcan et al. 2008; Yildrim et al. 2001).

This fact is connected not only with the inscription of the Mediterranean diet in the Representative List of the Intangible Cultural Heritage of UNESCO (UNESCO 2015) but also with all the nutritional studies showing the health benefits induced by Mediterranean diet (Mosconi et al. 2014; Sofi et al. 2010). This Mediterranean diet should be understood not only as food choice recommendations where fruits and vegetables (either wild or cultivated) have a predominant role but also as a lifestyle in which the selection of local traditional products, the traditional culinary activities, the transmission of expertise, the sustainable development of rural communities and the preservation of the biodiversity is an essential part of the human–environment interaction. The Mediterranean diet is characterized by a nutritional model that has remained more or less constant over time and space, from ancient times till nowadays, and its preservation is a challenge of the Mediterranean societies. In this context, all the studies which advance knowledge about traditional foods eaten in this area are quite valuable from both a cultural and a nutritional point of view.

References

Aboelsoud NH (2010) Herbal medicine in ancient Egypt. J Med Plant Res 4(2):82–86

Alarcón Víllora MR (2013) Entre “malas hierbas”, criptocultivos y plantas cultivadas: la colleja (*Silene vulgaris*). Ambienta 102:180–188

Aliotta G, Pollio A (1981) Vitamin A and C content in some edible wild plants in Italy. Riv Ital EPPOS 63:47–48

Barros L, Carvalho AM, Morais JS, Ferreira ICFR (2010) Strawberry-tree, blackthorn and rose fruits: detailed characterisation in nutrients and phytochemicals with antioxidant properties. Food Chem 120(1):247–254
Bianco VV, Santamaria P, Elia A (1998) Nutritional value and nitrate content in edible wild species used in Southern Italy. Acta Hort (ISHS) 467:71–87
Clifton C (1986) The sacred Lotus-food and symbol. In: Jaine T (ed) The cooking medium Oxford symposium of food and cookery. Oxford University Press, London
Cornara L, La Rocca A, Marsili S, Mariotti MG (2009) Traditional uses of plants in the Eastern Riviera (Liguria, Italy). J Ethnopharmacol 125(1):16–30
Cowan JW, Sabry ZI, Shadarev SB, Sakr AH (1963) Composition of edible wild plants of Lebanon. J Sci Food Agric 14(7):484–488
Cubero Corpas C (1994) Los recursos vegetales y su aprovechamiento en Hispania según los textos clásicos. Pyrenae 25:117–121
Dogan Y, Baslar S, Ay G, Mert HH (2004) The use of wild edible plants in Western and Central Anatolia (Turkey). Econ Bot 58(4):684–690
Dutton B (1980) Berceo y la Rioja Medieval: Apuntes Botánicos. Berceo 98:3–30
Esquinas Alcázar J (2013) Biodiversidad y Seguridad. Cuadernos de estrategia 161:109–156
Fajardo J, Verde A, Rivera D, Obón C (2000) Las plantas en la cultura popular de la provincia de Albacete. Instituto de Estudios Albacetenses, Albacete
FAO (2011a) El Segundo Informe sobre el Estado de los Recursos Fitogenéticos para la Alimentación y la Agricultura en el Mundo. Comisión de Recursos Genéticos para la Alimentación y la Agricultura, Roma
FAO (2011b) Consulta de expertos sobre indicadores de nutrición para la biodiversidad. 2. Consumo de alimentos. Organización de las Naciones Unidas para la Alimentación y la Agricultura, Roma
Font Quer P (1962) Plantas Medicinales. El Dioscórides renovado. Labor, Barcelona
García González JA (2008) Los lotófagos y el loto homérico. Baetica 30:171–188
García Lenberg J (1998) Vegetales comestibles en Asiria y Babilonia: la evidencia de la documentación escrita y paleobotánica. Rev sobre Oriente Próx y Egypto en la antig 1:193–202
García Quíntela MV (2001) Mitos hispánicos. La Edad Antigua. Akal, Madrid
García Soler MJ (2001) El arte de comer en la Antigua Grecia. Biblioteca Nueva, Madrid
García-Turza C (2004). El Códice Emilianense 31 de la Real Academia de la Historia. Presentación de algunas de las voces de interés para el estudio lingüístico del latín medieval y del iberorromance primitivo. Aemilianense 1:95–170.
Gatto MA, Ippolito A, Linsalata V, Cascarano NA, Nigro F, Vanadia S, Di Venere D (2011) Activity of extracts from wild edible herbs against postharvest fungal diseases of fruit and vegetables. Postharvest Biol Technol 61(1):72–82
Genders R (1998) Plantas Silvestres Comestibles: frutos, bayas, raices, brotes. Blume, Barcelona
Ghirardini M, Carli M, del Vecchio N, Rovati A, Cova O, Valigi F, Agnetti G, Macconi M, Adamo D, Traina M, Laudini F, Marcheselli I, Caruso N, Gedda T, Donati F, Marzadro A, Russi P, Spaggiari C, Bianco M, Binda R, Barattieri E, Tognacci A, Girardo M, Vaschetti L, Caprino P, Sesti E, Andreozzi G, Coletto E, Belzer G, Pieroni A (2007) The importance of a taste. A comparative study on wild food plant consumption in twenty-one local communities in Italy. J Ethnobiol Ethnomed 3(1):22
Grande de Ulierte E (2014) Los alimentos vegetales en la Hispania romana. PhD Thesis. Universidad Complutense de Madrid.
Guarrera PM, Forti G, Marignoli S (2005) Ethnobotanical and ethnomedicinal uses of plants in the district of Acquapendente (Latium, Central Italy). J Ethnopharmacol 96(3):429–444
Guil-Guerrero JL, Torija-Isasa ME (2002) Edible wild plants. In: Majundar DK, Govil JN, Singh VK (eds) Recent progress in medicinal plants, vol VIII. SciTech Publishing LLC, Texas, pp 431–466
Harris M (1991) Introducción a la antropología cultural. Alianza Universidad, Madrid
Heinrich M, Müller WE, Galli C (2006) Local Mediterranean food plants and Nutraceuticals. Karger, Basel

Hernández-Bermejo JE, García-Sánchez E (1998) Economic botany and ethnobotany in al-Andalus (Iberian Peninsula: Tenth-fifteenth centuries), an unknown heritage of mankind. Econ Bot 52(1):15–26

Ibáñez Ártica M (1995) Apicius. De re coquinaria. Gastronomía en la antigua Roma imperial. R & B, Bilbao

Latham MC (2002) Nutrición humana en el mundo en desarrollo. Organización de las Naciones Unidas para la Agricultura y la Alimentación. Colección FAO: Alimentación y nutrición N° 29. FAO, Roma

López Eire A (2006) Dioscorides. De Materia Medica. Manuscrito de Salamanca. Ediciones Universidad de Salamanca, Salamanca

López Gari JM, Pérez Jordá G, Marlascaa Martín R, Farrera Fernández VM Enrich Hoja J (2013) La primera agricultura Pitiusa y Balear: las evidencias de la Cova des Riuets. SAGVNTVM. 45:65–77

Martínez Ezquerro A (1995) Denominaciones populares de plantas silvestres. Revista de Folklore 178:132–142

Martínez–Llopis MM (1989) Historia de la Gastronomía Española. Alianza Editorial, Madrid

Martins D, Barros L, Carvalho AM, Ferreira ICFR (2011) Nutritional and in vitro antioxidant properties of edible wild greens in Iberian Peninsula traditional diet. Food Chem 125(2):488–494

Menendez–Baceta G, Aceituno–Mata L, Tardío J, Reyes–García V, Pardo-de-Santayana M (2012) Wild edible plants traditionally gathered in Gorbeialdea (Biscay, Basque Contry). Genet Resor Crop Evol 59:1329–1347

Morales R, Tardío J, Aceituno L, Molina M, Pardo-de-Santayana M (2011) Biodiversidad y Etnobotánica en España. In: Viejo-Montesinos JL (ed) Biodiversidad. Aproximación a la diversidad botánica y zoológica de España. Real Sociedad Española de Historia Natural, Madrid, pp 157–207

Mosconi L, Murray J, Tsui WH, Li Y, Davies M, Williams S, Pirraglia E, Spector N, Osorio RS, Glodzik L, McHugh P, de Leon MJ (2014) Mediterranean diet and magnetic resonance imaging-assessed brain atrophy in cognitively normal individuals at risk for Alzheimer's disease. J Prev Alzheimers Dis 1(1):23–32

Nedelcheva A (2013) An Ethnobotanical study of wild edible plants in Bulgaria. Eur Asian J Biosci 7:77–94

Olària i Puyoles C (2004–2005) El tránsito hacia las economías de producción de las últimas tribus cazadoras-recolectoras del Mediterráneo peninsular. Una reflexión acerca de la validez de ls tesis difusionistas frente a las evolucionistas. Quad Preh Arq Cast 24:43–60

Özcan MM, Unver A, Ucar T, Arslan D (2008) Mineral content of some herbs and herbal teas by infusion and decoction. Food Chem 106(3):1120–1127

Pardo-de-Santayana M, Tardío J, Morales R (2005) The gathering and consumption of wild edible plants in the Campoo (Cantabria, Spain). Int J Food Sci Nutr 56(7):529–542

Peña-Chocarro L (2000) Agricultura y alimentación vegetal en el poblado de la Edad del Bronce de Peñalosa (Baños de la Encina, Jaén). Complutum 11:209–219

Pereira C, Barros L, Carvalho AM, Ferreira IC (2011) Nutritional composition and bioactive properties of commonly consumed wild greens: potential sources for new trends in modern diets. Food Res Int 44(9):2634–2640

Pieroni A, Nebel S, Santoro RF, Heinrich M (2005) Food for two seasons: culinary uses of non-cultivated local vegetables and mushrooms in a south Italian village. Int J Food Sci Nutr 56(4):245–272

Precioso-Arévalo ML (2003) Estudio de los restos paleobotánicos en Murcia. 2. Las plantas recolectadas y sinantrópicas. Revista ArqueoMurcia. No 2. http://www.arqueomurcia.com/revista/n1/htm/semillas.htm. Accesed Feb 2015

Rampelbergh J (2006) Influencia Árabe en algunos aspectos de la vida Occidental. www.caei.com.ar/es/programas/medioriente/01. Accessed Feb 2015

Redman CL (1990) Los orígenes de la civilización. Desde los primeros agricultores hasta la sociedad urbana en el Próximo Oriente. Ed. Crítica, Barcelona

Rivera D, Obón C, Heinrich M, Inocencio C, Verde A, Fajardo, J (2006) Gathered mediterranean food plants—Etnobotanical investigations and historical development. Forum Nutr 59:18–74

Romojaro A, Botella MA, Obon C, Pretel MT (2013) Nutritional and antioxidant properties of wild edible plants and their use as potential ingredients in the modern diet. Int J Food Sci Nutr 64(8):944–952

Sánchez-Mata MC, Cabrera-Loera RD, Morales P, Fernández-Ruiz V, Cámara M, Díez-Marqués C, Pardo-de-Santayana M, Tardío J (2012) Wild vegetables of the Mediterranean area as valuable sources of bioactive compounds. Genet Resour Crop Evol 59(3):431–443

Scherrer A, Motti R, Weckerle CS (2005) Traditional plant use in the areas of Monte Vesole and Ascea, Cilento National Park (Campania, Southern Italy). J Ethnopharmacol 97:129–143

Sofi F, Abbate R, Franco G, Casini A (2010) Accruing evidence on benefits of adherence to the Mediterranean diet on health: an updated systematic review and meta-analysis. Clin Nutr 92(5):1189–1196

Tardío J, Pascual H, Morales R (2005) Wild food plants traditionally used in the province of Madrid. Econ Bot 59(2):122–136

Tardío J, Pardo-de-Santayana M, Morales R (2006) Ethnobotanical review of wild edible plants in Spain. Bot J Linn Soc 152(1):27–72

Toussaint-Samat M (2009) A history of food. Wiley, West Sussex

Trichopoulou A, Vasilopoulou E, Hollman P, Chamalides Ch, Foufa E, Kaloudis Tr, Kromhout D, Miskaki Ph, Petrochilou I, Poulima E, Stafilakis K, Theophilou D (2000) Nutritional composition and flavonoid content of edible wild greens and green pies: a potential rich source of antioxidant nutrients in the Mediterranean diet. Food Chem 70:319–323

Tukan SK, Takruri HR, Al-Eisawi DM (1998) The use of wild edible plants in the Jordanian diet. Int J Food Sci Nutr 49(3):225–35

UNESCO (2015) http://www.unesco.org/culture/ich/index.php?lg=en&pg=00011. Accessed Feb 2015

Vardavas CI, Majchrzak D, Wagner KH, Elmadfa I, Katafos A (2006) The antioxidant and phylloquinone content of wildly grown greens in Crete. Food Chem 99(4):813–821

Verde A, Rivera D, Obón C (1998) Estudio etnobotánico de las Sierras de Segura y Alcázar: Las plantas y el hombre. I.E.A. Albacete

Verde A, Fajardo J, Rivera D, Obón C, Inocencio C, Heinrich M (2004). La alimentación en Castilla-La Mancha: de la escasez al desperdicio (El valor de los alimentos locales y su utilización sostenible). Azarbe, Murcia

Vianello de Córdova P (1979). Hesiodo. Los trabajos y los dias. UNAM, Mexico

Yildrim E, Dursuna A, Turan M (2001) Determination of the nutrition contents of the wild plants used as vegetables in Upper Çoruh Valley. Turk J Bot 25:367–371

Zeghichi S, Kallithraka S, Simopoulos AP, Kipriotakis Z (2003) Nutritional composition of selected wild plants in the diet of Crete. In: Simopoulos AP, Gopalan C (eds) Plants in human health and nutrition policy. World Review of Nutrition and Dietetics, vol 91. Karger, Basel. pp 22–40

Chapter 2
The Mediterranean Landscape and Wild Edible Plants

Daniel Sánchez-Mata and Ramón Morales

2.1 Introduction

What do we think of when we evoke a Mediterranean environment? How can we define the Mediterranean landscape? From its Latin origin, the word *Mediterranean* means *in the middle of the Earth*, and this geographical name comes from the evidence of an inland sea surrounded by different lands: the Mediterranean Sea.

The main impression of the climate in these lands is their mild and rainy winters contrasting with hot and dry summers. This predominant set of features is a distinctive pattern for the Mediterranean macrobioclimate, typical in the Mediterranean basin between South Europe, North Africa and West Asia, which is also found throughout southern and south-western territories on all the continents on Earth. These areas are often home to some common *Mediterranean plants* and *Mediterranean crops* exported by European settlers, including wheat, asparagus, grapes, olives, citrus fruits, figs, carob, etc.

The lands in these regions around the world are covered by characteristic vegetation types involving dense forests, woodlands and thickets of woody shrubby plants of varying density, generally with evergreen sclerophyllous leaves. There are different vernacular names for these plant formations depending on the territories, languages, physiognomic structures and main species composition of the forests (such as *encinar* and *quejigar* in Spain) to shrublands (*coscojar, matorral, arbusteda, maquia*, etc., in Spain; *maquis* in France and Israel; *macchia* in Italy; *fynbos* or *renosterveld* in South Africa; *chaparral* in California; *matorral* in Chile; and *kwongan* or *mallee* in Australia).

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The Mediterranean macrobioclimate and its associated Mediterranean vegetation have a restricted distribution ranging across a wide band of bioclimates, with its geological origins in the Pleistocene era (Axelrod 1973) and a dependence on cold ocean currents (Raven 1973). Thanks to these features, Mediterranean ecosystems show a remarkably high diversity in the heterogeneity of their plant and animal communities, landforms, lithologies and soil types (Di Castri 1981).

A closer look at the Mediterranean Basin regions (all the territories surrounding the Mediterranean Sea) shows that the Iberian Peninsula is the largest geographic area where a true Mediterranean macrobioclimate can be recognised; around 80% of its area displays this macrobioclimate. Within other geographical territories and areas, such as the Italian, Balkan and Anatolian peninsulas, the Mediterranean macrobioclimate is present to a lesser degree (Fig. 2.1).

A key historical point to remember is that a great part of the European culture was developed in this region of the world. Human activity and management of almost all its ecosystems is therefore an ancient practice in the Mediterranean Basin. Mankind's evolution in this area from hunter-gatherers to farmers occurred around 8000 years ago, and since then the changes in our environment have become ever more pronounced. All the successive cultures who settled in the Mediterranean territories used the natural resources as an important natural legacy. Wild plants were a major source of food and a key nutritional complement to the animal proteins obtained from hunting and fishing. Knowledge of wild edible plants has survived in more advanced farming and livestock societies, and in times of hardship, such as war and famine, it has once again served as a vital source of food and medicinal resources.

2.2 Mediterranean Macrobioclimate and Vegetation Around the World

Bioclimatology is an ecological discipline used widely in phytogeography to determine the relationships between the climate and climatic variables (mainly temperature and rainfall) and the geographic distribution of living organisms and their communities on Earth, focusing mainly on plant taxa and plant communities (Tuhkanen 1980; Rivas-Martínez et al. 2011). Various bioclimatic indexes have been successfully applied to describe, classify and map different vegetation types (Prentice 1990; Blasi et al. 1999; Gavilán 2005; Gavilán et al. 2007; Nakamura et al. 2007).

Bioclimatic models have shown significant reciprocity between climate and vegetation around the world and are compiled and explained in the recently published bioclimatic approach by Rivas-Martínez et al. (2011). This *Worldwide Bioclimatic Classification System* is the most useful tool for understanding the highly diverse climatic reality of our world in relation to the distribution and diversity of natural ecosystems. This classification system also enables the large-scale mapping of a series of bioclimatic indexes and major vegetation types, as adopted and recently

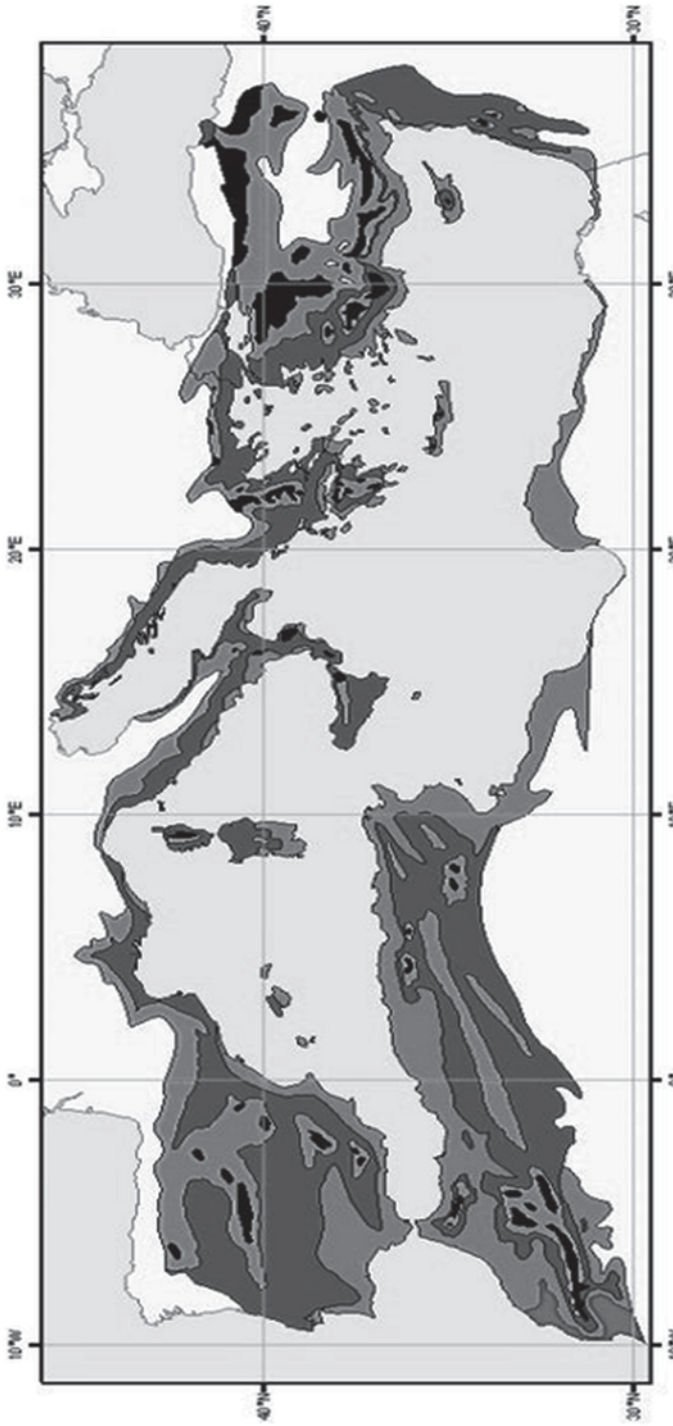

Fig. 2.1 Distribution of the Mediterranean macrobioclimate in the Mediterranean Basin. (Elaborated by Javier Tardío, based on Quézel and Médail 2003)

published by the United States Geological Survey for all the US conterminous territory (Sayre et al. 2009) and by the Association of American Geographers for the African continent (Sayre et al. 2013).

Macrobioclimates are the supreme typological units of the above-mentioned bioclimatic classification system. They are biophysical models defined by specific climate and vegetation values covering a broad territory, and are connected with the major accepted climate types, bioregions and biogeographical regions on the Earth. Following the European tradition, there are five recognised macrobioclimates: Tropical, Mediterranean, Temperate, Boreal and Polar. Their respective subordinate units or bioclimates are represented by a series of plant formations, biocoenoses and typical plant communities.

Emberger (1954) defined the *Mediterranean climate* as 'an extratropical climate with seasonal and daily photoperiodicity, with rainfall concentrated in the cold or relatively cold seasons of the year, summer, the hottest season, being dry'.

This sound definition dating from the 1950s was studied and debated for years. In the 1980s, the Mediterranean macrobioclimate was defined as transitional between the Temperate and Tropical macrobioclimates. It is characterised by its concentration of rainfall in winter, a variable summer drought, high variability of year-on-year precipitation, mild to warm or hot summers, cool to cold winters and intensive solar radiation, especially in summer (Di Castri 1981). Along the south-western coasts of the continents where the Mediterranean macrobioclimate typically occurs, marine fog and high air humidity are frequent climate processes.

A modern view of the Mediterranean macrobioclimate, its typical features, its characteristic bioclimatic indexes and its distribution throughout the emerged lands in the world using an objective bioclimatic discrimination can be found in the above-mentioned compilation by Rivas-Martínez et al. (2011). The most notable aspect of the Mediterranean macrobioclimate affecting its main vegetation types is the restricted summer rainfall when temperatures reach their maximum, creating the real but variable period of drought which is characteristic of this macrobioclimate. This summer drought is the most important ecological factor for natural Mediterranean vegetation and for crops, all of which are also exposed to irregular rainfall (monthly and yearly) that increases the severity of the Mediterranean macrobioclimate.

Plants that have developed and diversified in areas with a Mediterranean macroclimate have acquired special characteristics adapting their morphology and metabolism to survive during the drought period and to resprout after wildfires, a frequent phenomenon affecting natural vegetation in Mediterranean areas.

The main Mediterranean vegetation types (natural potential vegetation) throughout the Mediterranean Basin are sclerophyllous or marcescent oak forests and woodlands at lower elevations, marcescent oak forests in middle elevations and conifer forests or woodlands at higher elevations. Conifer forest communities are always the structure of the natural potential vegetation at the timber line, and they are present as the tree line in Mediterranean high mountain territories. A wide variety of shrubby plant communities structure different formations as xeric vegetation as well as perennial herbaceous vegetation. Annual vegetation (structured by therophytes) develops as pioneer vegetation elsewhere or as nitrophilous formations close to human or animal sites covering a diverse group of habitat types.

Thus, typical Mediterranean shrublands are mainly xeric formations from forest vegetation series, or potential vegetation developed in more xerothermic territories. In the Iberian Peninsula, these potential shrublands cover broad areas of the Ebro River basin and vast areas throughout the south-eastern Iberian territory. In general, we can define Mediterranean shrublands as scrub formations, developed primarily within the more xerothermic range of Mediterranean bioclimates. They are characterised and structured by woody shrubby plants usually with small, stiff, thick, broad evergreen leaves (sclerophyllous leaves), sometimes with an overstory of small scattered trees, with or without an understory of annuals and herbaceous perennials. These usually dense formations may be the natural potential vegetation in extreme xerothermic Mediterranean territories (primary vegetation) or permanent vegetation in sloping or rocky sites, cliffs, etc. They can also represent different successional stages according to the bioclimate and/or human impact (secondary vegetation). These shrublands are always fire prone in territories with a Mediterranean bioclimate.

In the diverse territories with a Mediterranean macrobioclimate around the world, the vegetation shows a similar structure, but with different plant taxa, dynamics and origin. Figure 2.2 shows several selected climatic diagrams from four different places of California, Chile, South Africa and Australia; summer drought is a common feature of these graphs, clearly displaying the Mediterranean character of their bioclimate.

In western North America, from the Pacific Ocean to the Sierra Nevada Mountains, Californian Mediterranean vegetation is very diverse (Barbour et al. 2007). We can distinguish the Temperate macrobioclimate moving north to the Oregon border and the Tropical moving south to the Mexican border or southeast into territories in Nevada and Arizona. West to east, from the Pacific coast to the Sierra Nevada foothills, continentality can be assumed to be the cause of the extreme contrast between the redwood (*Sequoia sempervirens* (D. Don) Endl., Cupressaceae) and coast live oak (*Quercus agrifolia* Née, Fagaceae) forests along the Pacific areas. Continentality increases eastwards towards the Great Central Valley, and these forests are replaced mainly by woodlands of grey pine (*Pinus sabiniana* D. Don, Pinaceae) and blue oak (*Quercus douglasii* Hook. & Arn.) in the foothills and of valley oak *Quercus lobata* Née in the valley bottoms. Ascending through Sierra Nevada, conifer forests appear from the middle elevations to the higher areas, mainly formations structured by *Pinus* sp. pl. (Pinaceae), *Calocedrus decurrens* (Torr.) Florin (Cupressaceae), *Abies lowiana* (Gordon) A. Murray bis (Pinaceae), *Abies magnifica* A. Murray bis and *Tsuga mertensiana* (Bong) Carrière (Pinaceae) in an altitudinal succession. The characteristic *California chaparrals* are typical Mediterranean shrubby vegetation. As in the Mediterranean Basin, these formations may be xeric vegetation from forest communities at disturbed sites, potential vegetation in the more xerothermic areas or permanent plant communities if they grow in special habitats or soils.

The structure of the Mediterranean vegetation in central Chile is comparable to California from the Pacific Ocean to the foothills of the Andean ranges (Dallman 1998). The Mediterranean territory extends north south from La Serena to north of Concepción, including the capital city of Santiago de Chile. *Matorrals* in the

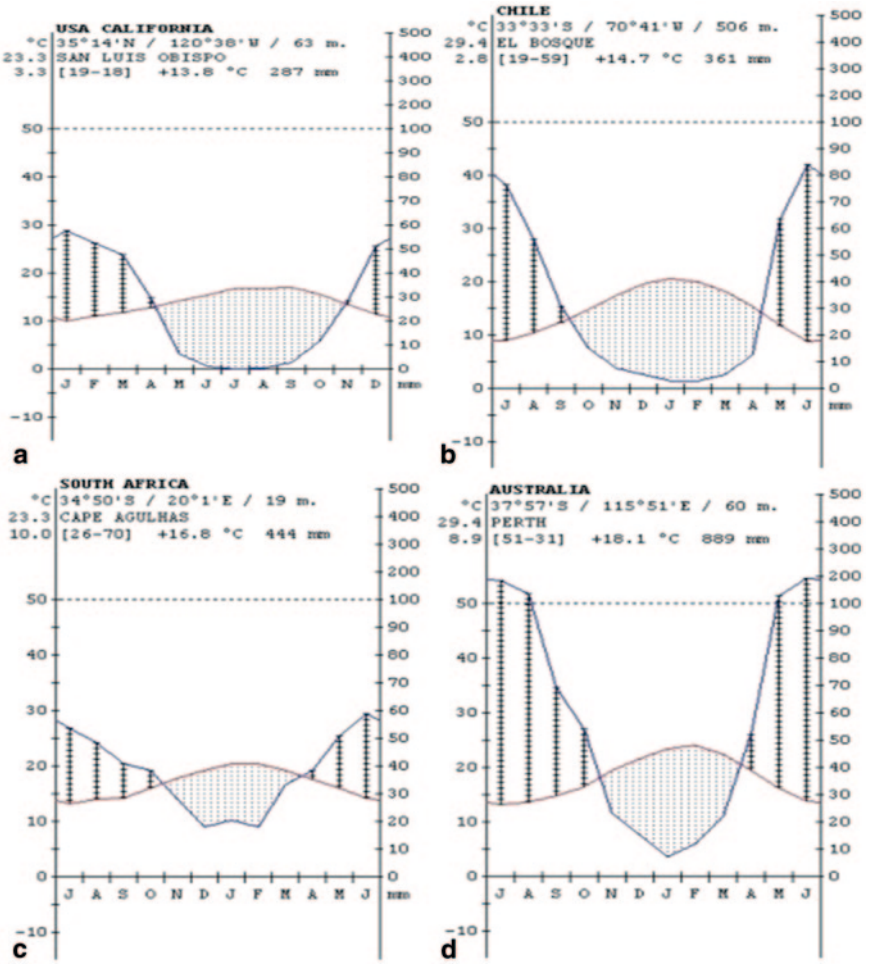

Fig. 2.2 Climatic diagrams of four stations with Mediterranean macrobioclimate around the world, showing their characteristic summer drought period. **a** San Luis Obispo, CA (USA). **b** El Bosque (Chile). **c** Cape Agulhas (South Africa). **d** Perth (Australia)

more xerothermic regions with cacti and bromeliads or along the coastal areas or Andean foothills—*Lithraea caustica* Hook. & Arn. (Anacardiaceae), *Quillaja saponaria* Molina (Rosaceae), *Acacia caven* (Molina) Molina (Fabaceae), *Echinopsis chiloensis* (Colla) H. Friedrich & G.D. Rowley (Cactaceae), etc.—and sclerophyllous woodlands—*Cryptocaria alba* (Molina) Looser (Lauraceae), *Peumus boldus* Molina (Monimiaceae), *Maytenus boaria* Molina (Celastraceae), *Jubaea chilensis* Baill. (Arecaceae), etc.—are the most frequent Mediterranean formations.

Fynbos *(fine bush)* is the most widespread and diverse native formation throughout the Mediterranean macrobioclimate territory in South Africa, located between the Western Cape and Port Elizabeth to the east. Fynbos is dominated mainly by

Fig. 2.3 Several Mediterranean landscapes around the world showing their typical features. **a** A climactic *serpentine chaparral* (xero-edaphic potential vegetation) in California (Napa County). **b** A vegetation mosaic with several shrub formations in an open holm oak woodland (*Quercus ilex* subsp. *ballota* (Desf.) Samp.) in eastern Spain. **c** A *dehesa* formation, with the same species in central Spain. **d** A mosaic of managed Mediterranean vegetation in Crete (Amari Valley)

evergreen shrubs with a high index of biodiversity and endemicity. Proteaceae, Ericaceae and Restionaceae growing alongside succulent plants (*Euphorbia, Aloe*, etc.) structure the woody community characteristic of the Western Cape region of South Africa with a Mediterranean macrobioclimate (Dallman 1998).

The *kwongan* formations in Western and South Australia show a similar structure to the South African fynbos. This is a typical form of sclerophyllous scrub vegetation found mainly between Perth and Adelaide. The *mallee* formations are structured by several species of *Eucalyptus* (Myrtaceae), adopting a multitrunk architecture originating from resprouts after wildfires. These formations can be seen in the drier northern half of the Mediterranean macrobioclimate region of South Australia north of Adelaide. Woodland and forests structured by *Eucalyptus* sp. pl. still remain in the wetter areas of Western and South Australia. There are several plant formations with a well-defined structure characteristic of typical Mediterranean vegetation throughout the Australian landscape (Dallman 1998).

Figure 2.3 shows four different Mediterranean plant formations and communities around the world.