Chapter 5
Natural Production and Cultivation of Mediterranean Wild Edibles

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5.1 Introduction

As discussed in previous chapters, foraging wild plants for food is still a popular activity in rural contexts of the Mediterranean region (Hadjichambis et al. 2008). Although it is no longer a subsistence practice, recreational harvesting for domestic consumption currently attains traditional and new collectors such as retired people and Sunday excursionists from urban areas, and a renewed interest for commercial harvesting is arising (Molina et al. 2012). Green wild vegetables are frequently sold in Italy, Greece, and Croatia (D'Antuono and Lovato 2003; Łuczaj et al. 2012). For instance, the vegetable mix called *mišanca/pazija* in Croatia, containing several wild species (Fig. 5.1), is currently sold in every market of the Dalmatian coast (di Tizio et al. 2012; Łuczaj et al. 2013). In Spain, gourmet liqueurs and marmalades made from wild fruits are sold in some street markets and shops (Pardo-de-Santayana et al. 2010), and wild vegetables can be occasionally found in local markets and restaurants (Parada et al. 2011; Tardío 2010). Even avant-garde restaurants, such as the Danish restaurant "Noma" in Copenhagen, considered one of the best restaurants in the world nowadays, offers a very wide selection of wild food plants (See Chap. 3). As in the case of mushrooms (de Frutos et al. 2009; Martínez de Aragón et al. 2007), the demand for some wild plants seems to be increasing, becoming an economically profitable activity (Łuczaj et al. 2012).

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Fig. 5.1 *Left and right,* vegetable mixes called *mišanca/pazija*, with several species collected from the wild, are currently sold in some markets of Dalmatia, Croatia. (Photographs by Łukasz Łuczaj; with permission)

The present tendency towards the recovery of food traditions and the need for product diversification may also offer opportunities for new crop domestication (D'Antuono and Lovato 2003; Egea-Gilabert et al. 2013). Native species of wild fruits and vegetables often represent unexploited resources that can promote a healthier and more diverse diet (Sánchez-Mata et al. 2012). In this way, there is a large set of wild-growing species used in Mediterranean traditional cuisines that deserves more attention. The cultivation of plants already known and traditionally used for food may represent alternative crops for niche markets (Benincasa et al. 2007; D'Antuono et al. 2009).

Some wild edibles are either obtained from the wild or from cultivation. For instance, the golden thistle (*Scolymus hispanicus* L.; Fig. 5.2) has been subject to cultivation in the past (Hernández Bermejo and León 1994) but is currently a minor crop only cultivated in a few areas of southern Spain (Soriano 2010) and southern Italy (Laghetti 2009). It is also a culturally important species gathered from the wild in several Mediterranean countries such as Greece, Italy, Morocco, and Spain (Hadjichambis et al. 2008; Leonti et al. 2006; Nassif and Tanji 2013). Similarly, bladder campion (*Silene vulgaris* (Moench) Garcke) growing in agricultural areas is tolerated and gathered for domestic consumption, and it is cultivated in some home gardens in Spain (Alarcón 2013) and Italy (Laghetti et al. 1994).

We can also find examples of recent domestication processes in other traditional wild vegetables such as the rocket salads (*Eruca vesicaria* (L.) Cav., and *Diplotaxis tenuifolia* (L.) DC.) and watercress (*Rorippa nasturtium-aquaticum* Hayek). In these "new" vegetables, the favorable combination of positive experience (sensory component of acceptance) and information (local gastronomy, health promotion) has contributed to successfully spreading their use (D'Antuono et al. 2009).

Despite the economic and nutritional interest of wild edible plants, there is still a poor knowledge of their natural production and its agronomic potential (Molina et al. 2014). In this chapter, we firstly present a review of worldwide studies on availability and production of wild edible plants, both on their natural environments and also some cultivation assays with Mediterranean plants. Afterwards, we resume our investigations on wild food plants production in their natural habitats and under cultivation in central Spain, taking into account the edible parts that are traditionally collected and consumed.

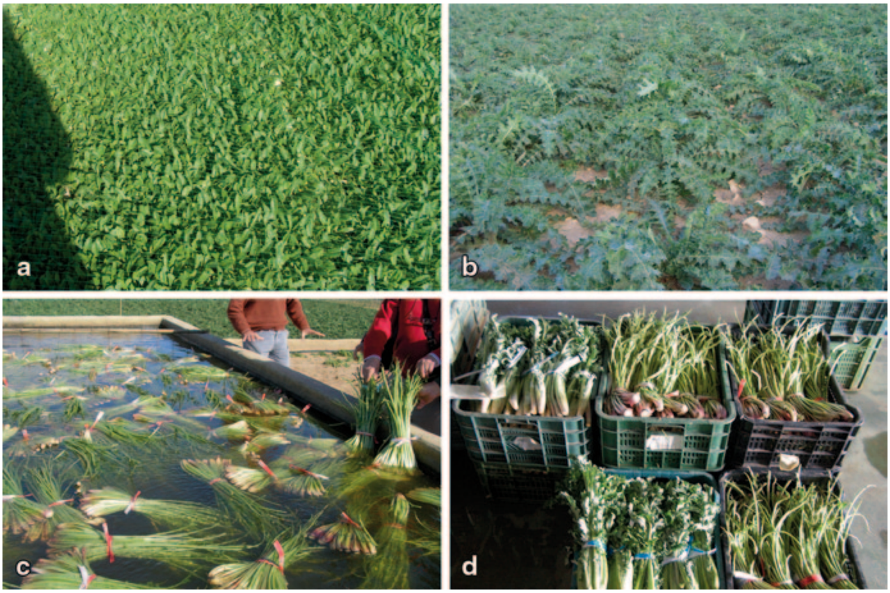

Fig. 5.2 Commercial cultivation of golden thistle in southern Spain by a local agricultural cooperative. Seedbed (**a**), crop plants before harvesting (**b**), harvested and peeled midribs, being cleaned in water tanks, where they remain turgid (**c**), edible plant material ready for commercialization (**d**). (Photographs courtesy of Centro de Conservación de Recursos Fitogenéticos del Instituto Nacional de Investigaciones Agrarias (CRF-INIA); with permission)

5.2 Studies on Availability and Production of Wild Edible Plants

5.2.1 Overview of Natural Production Studies

According to the great heterogeneity of wild edibles regarding life and growth forms, natural habitats, and edible parts, a broad range of plant yield rates and natural supplies of these species should be expected. Wild edible plants include fruit-tree species, tubers, edible young shoots, and leafy greens, among others. They can be found in a wide diversity of habitats, ranging from forests to human-disturbed areas, such as those from the agricultural landscape. Local supply and harvesting impact may also differ depending on life and growth forms, distribution areas, or parts used.

There are some studies that aim to evaluate quantitatively the natural availability of wild edible plants. The results of some of them are shown in Table 5.1. We can find examples from Mexico (Farfán et al. 2007; González-Amaro et al. 2009; González-Insuasti et al. 2008; Pérez-Negrón and Casas 2007), Argentina (Díaz-Betancourt et al. 1999; Ladio and Rapoport 2005; Rapoport 1995), North America (Kerns et al. 2004; Lepofsky et al. 1985; Murray et al. 2005), Finland (Ihalainen et al. 2003; Miina et al. 2009; Turtiainen et al. 2011), or South Africa (Youngblood 2004).

Table 5.1 Natural production of some wild vegetables and fruits in non-Mediterranean territories

Species	Production (kg ha^{-1})[a]	Site	Source
Wild vegetables			
Amaranthus hybridus L.	45	Santiago Quiotepec, Mexico	Pérez-Negrón and Casas 2007
Amaranthus hybridus L.	3000	Tlaxcala, Mexico	González-Amaro et al. 2009
Brassica rapa L.	600	Tlaxcala, Mexico	González-Amaro et al. 2009
Calandrinia micrantha Schltdl.	400	Tlaxcala, Mexico	González-Amaro et al. 2009
Chenopodium berlandieri Moq.	700	Tlaxcala, Mexico	González-Amaro et al. 2009
Claytonia perfoliata Donn ex Willd.[b]	11000	Bariloche, Argentina	Díaz-Betancourt et al. 1999
Malva parviflora L.	400	Tlaxcala, Mexico	González-Amaro et al. 2009
Portulaca oleracea L.	4.6	Santiago Quiotepec, Mexico	Pérez-Negrón and Casas 2007
Wild fruits			
Berberis buxifolia Lam.	280	Bariloche, Argentina	Ladio and Rapoport 2005
Empetrum nigrum L.	6.5–12.4	Mackenzie River Delta Region, Canada	Murray et al. 2005
Prunus serotina Ehrh.	1436	Monarch Butterfly Biosphere Reserve, Mexico	Farfán et al. 2007
Rosa rubiginosa L.	2000	Bariloche, Argentina	Ladio and Rapoport 2005
Rubus chamaemorus L.	0.9	Central Finland	Raatikainen et al. 1984
Rubus chamaemorus L.	0-12.3	Mackenzie River Delta Region, Canada	Murray et al. 2005
Rubus idaeus L.	0.2	Central Finland	Raatikainen et al. 1984
Vaccinium microcarpon L.	1.3	Central Finland	Raatikainen et al. 1984
Vaccinium myrtillus L.	22.3	Finland	Turtiainen et al. 2011
Vaccinium oxycoccos L.	2	Central Finland	Raatikainen et al. 1984
Vaccinium uliginosum L.	0.7	Central Finland	Raatikainen et al. 1984
Vaccinium uliginosum L.	0.8–7.5	Mackenzie River Delta Region, Canada	Murray et al. 2005
Vaccinium vitis-idaea L.	22.7	Finland	Turtiainen et al. 2011

[a] Some original data were expressed as t ha^{-1} or as g m^{-2}

[b] Syn. *Montia perfoliata*. Estimations were obtained from three consecutive cuts in 0.25-m^2 plots

Some of these studies assess the local supply and current demand of wild food resources. For instance, Farfán et al. (2007) documented an extraction of 7.47, 4.40, and 1.82 t of fruits per year of *Prunus serotina* Ehrh., *Rubus liebmanii* Focke, and *Crataegus mexicana* Moc. & Sessé ex DC. by the Mazahua indigenous community of Mexico. Bearing in mind the local availability of these species (Farfán 2001), the extraction rates were of 2.4 %, 73.3 %, and 5.4 %, respectively. Among wild leafy greens, these authors documented some less variable extraction rates of 18.2 %, 19.6 %, and 13.2 % in *Brassica campestris* L., *Amaranthus hybridus* L., and *Rorippa nasturtium-aquaticum* (L.) Hayek, respectively. Other studies conducted in the Tehuacán–Cuicatlán Valley in central Mexico also report important amounts of wild greens and cactus fruits (Pérez-Negrón and Casas 2007). According to these authors, the local supply of wild food plants widely meets their current demand and apparently does not endanger their natural populations.

The importance of the spontaneous weed vegetation in traditional agroecosystems is also an interesting example of the economic potential of weedy vegetables. Some studies demonstrate that the potential benefits from the weed vegetation are sometimes higher than those derived from the main crop (González-Amaro et al. 2009). For instance, useful spontaneous plants growing in a maize field and its margins at Tlaxcala, Mexico, produce 14.8 t ha^{-1} (fresh weight), being the forage species the major contributors (9.7 t ha^{-1}) together with wild edible herbs such as *A. hybridus, Chenopodium berlandieri* Moq., *Brassica rapa* L., *Malva parviflora* L., and *Calandrinia micrantha* Schltdl. The first two species are widely available in the supermarkets of Mexico city as well as in traditional weekly markets (Vieyra-Odilon and Vibrans 2001). However, maize grain (1.5 t ha^{-1}), although supposedly the main purpose of maize cultivation, is a minor contributor to total productivity and potential net return. Maize straw is generally overlooked but is worth considerably more (3.7 t ha^{-1} of dry weight) and gives a modest profit. This research suggests that the non-crop production can be economically highly important in traditional cropping systems as well as a risk mitigator to compensate crop failures.

Comparative studies were also performed between tropical and temperate areas of America in order to assess the potential amount of wild food provided by common weeds in urban and agricultural environments. Edible fresh biomass varies between 1277–3582 kg ha^{-1} in Coatepec, Mexico, and 287–2939 kg ha^{-1} in Bariloche, Argentina, with average values of 2.1 and 1.3 t ha^{-1}, respectively (Díaz-Betancourt et al. 1999). It suggests that tropical weeds are more productive than temperate weeds. Among the most profitable wild edible plants growing in Bariloche, the authors indicate that *Claytonia perfoliata* Donn ex Willd. (syn. *Montia perfoliata* (Donn ex Willd.) Howell), a North American invader of Patagonian urban forests, shows clear capabilities to recover after harvesting the aerial parts (Díaz-Betancourt et al. 1999; Rapoport et al. 1998). Overall, exotic plants were the major contributors to wild edible biomass in disturbed areas, both in terms of species richness and coverage. Among fruits, yields of 0.28 t ha^{-1} of the native species *Berberis buxifolia* Lam. and 2 t ha^{-1} of the exotic species *Rosa rubiginosa* L. were reported in the surroundings of Bariloche, covering 33 and 1.2 % of the study area, respectively. They are currently consumed by 10 and 20 %, respectively, of the population at this site (Ladio and Rapoport 2005).

Regarding commercial wild berries, such as bilberry (*Vaccinium myrtillus* L.) and cowberry (*V. vitis-idaea* L.), many studies on fruit production have been carried out for decades (e.g., Raatikainen et al. 1984; Rossi et al. 1984). Mathematical models were also developed for predicting berry yields on national scales by means of forest stands data (Ihalainen et al. 2003; Miina et al. 2009). Bilberry is one of the economically most important wild fruit species in Finland, Sweden, and Norway (Turtiainen et al. 2011). Picking wild berries in the Nordic countries has been a popular traditional household and recreational activity, providing important additional income in some areas. Nowadays, approximately 60 % of the Finnish population participates in berry picking every year (Turtiainen et al. 2011). According to recent studies, Finnish annual berry production varies from 92 to 312 million kg (22.3 kg ha^{-1} on average) of bilberry and from 129 to 386 million kg (22.7 kg ha^{-1}) of cowberry (Turtiainen et al. 2011). Estimates from 1997 to 1999 indicate that approximately 5–6 % and 8–10 % of the total production of bilberries and cowberries, respectively, were collected in Finland, although it can be presumed that commercial wild berry picking after the phenomenon of foreign pickers has so far affected current utilisation rates of wild berries (Turtiainen et al. 2011).

Other studies also estimate annual yields of wild fruits, such as those carried out in North America (Murray et al. 2005) on blueberry (*Vaccinium uliginosum* L.), cloudberry (*Rubus chamaemorus* L.), and crowberry (*Empetrum nigrum* L.) and the works conducted in central Finland (Raatikainen et al. 1984) on black cowberry (*Empetrum* spp.), blueberry (*V. uliginosum*), raspberry (*Rubus idaeus* L.), cranberry (*V. oxycoccos* L. and *V. microcarpon* L.), and cloudberry (*R. chamaemorus*), among others.

Research on yield rates of edible wild bulbs and tubers of *Cyperus usitatus* Burch. ex Roem. & Schult., *Albuca canadensis* (L.) F.M.Leight., *Pelargonium sidoides* DC., and *Talinum caffrum* (Thunb.) Eckl. & Zeyh. were performed in South Africa (Youngblood 2004).

In the Mediterranean region, some studies on the availability and yield of wild food species have recently been conducted by our research group in central Spain (Dávila 2010; Molina et al. 2011, 2012, 2014; Polo et al. 2009; Tardío et al. 2011). However, as far as we know, research on this topic has been poorly addressed regarding Mediterranean wild edibles, despite its interest to design sustainable strategies of resource management and to promote environmentally friendly extraction practices for the use and commercialization of wild vegetables and fruits.

5.2.2 Some Cultivation Assays on Mediterranean Wild Plants

Cultivation assays of traditional wild edible plants are generally scarce, and some local experiences are only available on national publications, not accessible to the international scientific community. However, some morphological, agronomical, and/or biochemical analysis of several Mediterranean wild food plants have been recently conducted in Italy, Spain, Turkey, and Tunisia, including wild vegetables such as bladder campion, purslane, wild asparagus, and fleshy fruited species such as strawberry tree. These studies aim to assess the agronomic potential of traditional wild edible plants, identifying germplasm accessions with the most interesting phenotypic and nutritional qualities suited for breeding programs to develop commercial cultivars for the agricultural market (Egea-Gilabert et al. 2013). According to these studies, some wild species are considered promising new foods with possibilities for marketing as high-quality, minimally processed products.

Bladder campion

Bladder campion (*Silene vulgaris*) is one of the most appreciated leafy vegetables in the traditional gastronomy of many Mediterranean countries. This species also exhibits a good nutritional potential according to nutritional analysis performed on plant material growing wild (Morales et al. 2012a, b; Sánchez-Mata et al. 2012) and cultivated (Alarcón et al. 2006; Egea-Gilabert et al. 2013). For these reasons, it is considered an attractive candidate for cultivation and commercialization as a ready-to-eat product.

Cultivation experiments of this species were conducted in Spain, including outdoor field trials (Fernández and López 2005; García and Alarcón 2007) and indoor greenhouse cultivation, both in soil-based culture (Alarcón et al. 2006; Arreola et al. 2006; Franco et al. 2008) and in a hydroponic floating system (Egea-Gilabert et al. 2013). Agronomical, morphological, and/or nutritional parameters were evaluated, in some cases under organic production systems (Alarcón et al. 2006). Average crop yields of 3400 g m^{-2} were obtained at low labor requirements, including hand weeding and irrigation (Fernández and López 2005). It is considered a seasonal crop in which several harvests can be performed throughout the year, with a pick of production in spring. Harvest takes place before flowering, when the plants have four to six leaves. The tender aerial parts are cut, leaving the roots intact and allowing plant regeneration (Fernández and López 2005).

Since bladder campion shows high inter- and intra-population genetic variation, accessions with desirable agronomical traits for marketing, such as a large leaf blade width/leaf length ratio, short internode length, late flowering, intense green color of the leaves, and of course, high yield, could be selected to meet commercial size and quality standards (Egea-Gilabert et al. 2013; García and Alarcón 2007). In addition, accessions with a high level of nutritional compounds (glutathione, total phenols, and antioxidant capacity) and low concentrations of antinutritional compounds are desired (Alarcón et al. 2006; Conesa et al. 2009; Egea-Gilabert et al. 2013). The use of vegetative reproduction can be the starting point to the cultivation of the most interesting genotypes (Alarcón 2013). Other issues of interest for its cultivation were studied, such as the influence of fertilization strategies on yield (Arreola et al. 2004) and the influence of nursery irrigation regimes on vegetative growth and root development, assessing its potential as a crop for semiarid conditions (Arreola et al. 2006; Franco et al. 2008).

Purslane

Purslane (*Portulaca oleracea*) also has a long history of use for human food. Some varieties such as Golden Gerber, Garden (The Netherlands), and Golden (England) are commercially grown. It is considered a minor crop in the USA, and it is also cultivated on a small scale in France and Holland, whereas in other parts of the world, it is regarded as a weed (Cros et al. 2007). The interest in cultivating this annual species has grown in the last decades since it is considered an exceptionally rich source of bioprotective nutrients, particularly of ω-3 fatty acids and antioxidants (Dkhil et al. 2011; Mortley et al. 2012; Simopoulos et al. 1995).

In the Mediterranean region, some cultivation experiments have been conducted in Spain (Cros et al. 2007; Franco et al. 2011) and Italy (Gonnella et al. 2005) to grow common purslane for its interest as a baby-leaf vegetable or as a component of mixed ready-to-use vegetables. Plants grown in a hydroponic floating system and harvested at the five-leaf-pair stage produced yields of 1800–2200 g m^{-2} of fresh weight (Cros et al. 2007). Different substrates were tested, and peat was found to be the best one for floating system culture according to yield and fatty acid content parameters (Cros et al. 2007). Considerably higher yields of 9–15 kg m^{-2} were recorded by Gonnella et al. (2005) for purslane under floating system cultivation. In this case, a considerable portion of shoots, made up of leaves and succulent stems, was harvested.

As happens in other leafy vegetables, acceptable contents of nitrate and oxalates are required to meet quality standards. This topic has been extensively studied in purslane grown in soilless culture systems (Fontana et al. 2006; Palaniswamy et al. 2002, 2004) as well as the influence of harvest intervals on fatty acid content (Mortley et al. 2012). Seed germination methods were also analysed (Fernández et al. 2008). Since this species is moderately tolerant to salinity and drought, it is considered a promising vegetable for agriculture in dry areas or areas where the irrigation water contains high salt concentrations (Franco et al. 2011; Teixeira and Carvalho 2009; Yazici et al. 2007).

Wild Asparagus

Another traditional vegetable with a great potential to become a new crop is wild asparagus (*Asparagus acutifolius*). In this case, cultivation experiments (Fig. 5.3) were conducted in Italy to provide suitable field techniques that support recent attempts of farmers for producing spears from this perennial Mediterranean shrub (Benincasa et al. 2007; Rosati et al. 2005). Since the wild asparagus market already exists in several Mediterranean countries, cultivation may increase the limited availability from the wild. Additionally, the frugality of the wild asparagus allows for a crop virtually free of pests and diseases, perfectly suited for organic or any other natural farming techniques (Aliotta et al. 2004; Benincasa et al. 2007).

According to Benincasa et al. (2007), average spear weight varied from 5.6 to 6 g in mature plants that are 3 years old, and 4–8 spears per plant were collected at regular intervals from March-April to May, reaching average crop yields of 1000–1400 kg ha^{-1} and 2000 kg ha^{-1} from the best plots (crop density of 33,000 plants ha^{-1}). Similar results were obtained by Rosati et al. (2005). In contrast to cultivated asparagus (*A. officinalis* L.), the evergreen and prickly vegetation of wild asparagus poses an obstacle to fast and comfortable harvesting. According to these authors, cutting the vegetation to ease harvest reduces harvest labor by approximately half but may reduce plant vigor and yield and compromise plant

Fig. 5.3 a–d Cultivation experiments of *Asparagus acutifolius* at the Instituto de Horticultura Pontacagnano of Salerno, Italy. Nursery production (**a**) and adult asparagus plants (**b**). Wild asparagus cultivated under olive trees: initial stage (**c**) and adult plants (**d**). (Photographs by Adolfo Rosati; with permission)

longevity (Rosati et al. 2005). However, they hypothesize that better irrigation and nutrition as well as interrupting harvest earlier should allow the plant to recover from the stress of having to replace the evergreen vegetation. The spears could also be directly harvested by the consumers in pick-your-own operations associated with tourism in order to reduce harvest costs (Benincasa et al. 2007).

Since wild asparagus has similar ecological requirements to olive trees, and it grows under both sun and shade expositions, its cultivation as an understory crop could provide economic sustainability in traditional olive cultivation, with no detriment on the yield of either crop (Rosati 2001; Rosati et al. 2009). It would ease pressure on forests and help control soil erosion on agricultural lands.

Strawberry Tree

Some studies have also been conducted in fruit-tree species, although to a lesser extent. For instance, morphological and genetic studies of strawberry tree (*Arbutus unedo*) and breeding programs have been carried out in Italy (Mulas et al. 1998; Mulas and Deidda 1998), Turkey (Celikel et al. 2008), and Tunisia (Takrouni and Boussaid 2010) with the aim of promoting extensive cultivation and preventing deforestation and over-collecting of natural stands. Other candidates for cultivation include *Myrtus communis* for the liqueur industry (Mulas et al. 1998).

5.3 Natural Production of Wild Edibles in Central Spain

Research on natural production and availability of wild edible plants was performed by our research group in central Spain (Molina et al. 2011, 2012, 2014; Molina 2014; Tardío et al. 2011). Field work was conducted during the years 2007–2009 in several outlying villages around Madrid city. We estimated the production per plant (gram of edible fresh matter) and the potential food supplies (production per hectare) of some wild vegetables and fruits traditionally consumed in Spain and other Mediterranean countries. For each species, the sampling areas were limited to the specific places where these plants spontaneously grow. Since plant production is widely influenced by ecological and climatic factors, yield average values were calculated from different data sets obtained during 2 or 3 consecutive years and from two different sites. A detailed description of methodological procedures can be found in the aforementioned references.

5.3.1 Wild Vegetables Growing in Human-Disturbed Areas

Wild vegetables constitute the most important group of wild food plants harvested in the Mediterranean countries according to several ethnobotanical studies (Ghirardini et al. 2007; Nassif and Tanji 2013; Tardío et al. 2006; see also Chap. 4). A remarkable percentage of these leafy vegetables are weeds or ruderal species growing in human-disturbed areas such as agricultural fields, orchards, pastures, fallow lands, vacant lots, and roadsides (Fig. 5.4).

As shown in Table 5.2, some weedy vegetables are very productive, reaching average yields of 260–280 g per plant of sea beet (*Beta maritima* L.) and fennel (*Foeniculum vulgare* Mill.) and 120–130 g per plant of chicory (*Cichorium intybus* L.) and bugloss (*Anchusa azurea* Mill.). Other species show individual plant yields lower than 60 g per plant, such as those of skeleton weed (*Chondrilla juncea* L.), field poppy (*Papaver rhoeas* L.), sow thistle (*Sonchus oleraceus* L.), and dandelion (*Taraxacum obovatum* (Willd.) DC.). Production varied from 50 to 100 g per plant in golden thistle and milk thistle (*Silybum marianum* (L.) Gaertn.), respectively, out of which only the midribs of the basal leaves are eaten. In wild leek (*Allium ampeloprasum* L.), the edible portion formed by the bulb and the pseudostem of overlapping leaves yields approximately 14 g per plant.

Most of the aforementioned species were grouped as non-clonal plants since the aerial parts can be assumed to have developed from a single "rooted unit". Other species that have branching rhizomes, such as sorrel (*Rumex papillaris* Bois. & Reut.) or fiddle dock (*Rumex pulcher* L.), and stoloniferous stems, such as bladder campion, were considered clonal species. They usually grow forming clumps; thus, dense rosettes or patches may have originated from one or more "rooted unit". Yields of clonal species presented in Table 5.2 were referred as gram per 20 × 20-cm quadrat (0.04 m^2). It represents a plant–unit surface comparable to the surface occupied by the basal rosette of the non-clonal species. Among clonal species, yields

Table 5.2 Natural productions of wild vegetables growing in human-disturbed areas (mean ± standard error). (Data source: Molina et al. 2014)

Species	Parts used	Total yield	Units
Non-clonal species			
Allium ampeloprasum	Bulb and pseudostem	13.8 ± 0.6	g/plant
Anchusa azurea	Basal leaves	117.1 ± 8.4	g/plant
Beta maritima	Basal leaves	284.4 ± 24.3	g/plant
Chondrilla juncea	Basal leaves	30.1 ± 2.7	g/plant
Cichorium intybus	Basal leaves	130.7 ± 11.2	g/plant
Foeniculum vulgare	Young leaves and stems	261.7 ± 21.1	g/plant
Papaver rhoeas	Young leaves and stems	58.4 ± 6.1	g/plant
Scolymus hispanicus	Midribs of basal leaves	52.7 ± 4.9	g/plant
Silybum marianum	Midribs of basal leaves	117.1 ± 8.4	g/plant
Sonchus oleraceus	Young leaves and stems	28.3 ± 2.5	g/plant
Taraxacum obovatum	Basal leaves	12.7 ± 0.8	g/plant
Clonal species[a]			
Rumex papillaris	Basal leaves	98.3 ± 4.0	g/quadrat
Rumex pulcher[b]	Basal leaves	86.1 ± 5.1	g/quadrat
Silene vulgaris[c]	Young leaves and stems	20.4 ± 0.8	g/quadrat

[a] In clonal species, yields are referred as gram per 20 × 20-cm quadrat that represent a plant–unit surface comparable to the surface occupied by the basal rosette of the non-clonal species

[b] *Rumex pulcher* subsp. *pulcher*

[c] *Silene vulgaris* subsp. *vulgaris*

Fig. 5.4 Collecting *Allium ampeloprasum* (**a, b**) and *Silybum marianum* (**c, d**) in the borders of pathways (**a**) and in fallow lands (**c**), respectively. (Photographs by María Molina)

Fig. 5.5 Collecting *Apium nodiflorum* (**a, b**) and *Montia fontana* (**c, d**) in irrigation channels nearby farmlands (**a**) and in swampy areas (**c**), respectively. (Photographs by María Molina)

of 85–100 g per quadrat of sorrel and fiddle dock could be obtained, whereas lower production rates were found in bladder campion (20 g per quadrat).

5.3.2 Wild Vegetables Growing in Aquatic Environments

Some wild vegetables occur in damp places, frequently in water, that is, in springs, streams, moist pastures, irrigation channels nearby farmlands, and/or swampy areas. This is the case of fool's water-cress (*Apium nodiflorum* (L.) Lag.) and water blinks (*Montia fontana* L.), as shown in Fig. 5.5. Both species develop branching stems, sometimes prostrate and rooting, and they usually grow forming clumps. The aerial parts, including young leaves and stems, are consumed. As can be seen in Table 5.3, natural production rates oscillate between 100–150 g per quadrat.

Table 5.3 Natural productions of wild vegetables growing in aquatic environments (mean ± standard error). (Data source: Tardío et al. 2011; Molina et al. 2014)

Species	Parts used	Total yield[a]	Units
Apium nodiflorum	Young leaves and stems	152.5 ± 11.5	g/quadrat
Montia fontana[b]	Young leaves and stems	105.7 ± 5.1	g/quadrat

[a] Yields are referred as gram per 20 × 20-cm quadrat

[b] *Montia fontana* subsp. *amporitana* Sennen.

Fig. 5.6 Collecting young sprouts of *Asparagus acutifolius* (**a, b**) and *Tamus communis* (**c, d**) in Mediterranean holm oak forests (**a**) and in the wooded edge margins of pasturelands (**c**), respectively. (Photographs by María Molina)

5.3.3 Edible Young Sprouts Growing in Forestlands

Apart from the so-known wild asparagus (*Asparagus acutifolius* and other species of the same genus), there are other climbing plants whose young sprouts are traditionally collected in the Mediterranean region, such as red bryony (*Bryonia dioica* Jacq.), black bryony (*Tamus communis* L.), and hop (*Humulus lupulus* L.). They can be found in forested areas including Mediterranean sclerophyllous and deciduous forests, riverbank forests, and/or wooded edge margins of croplands and pastures (Fig. 5.6). The apical parts of their young stems (spears) are generally consumed cooked.

As shown in Table 5.4, average spear weight barely varied from 1.5 to 2.8 g in these species. However, total yields depend not only on spear weight but on the spear number as well. Apart from the spears that progressively emerge from the subterranean organs during the growing season, the spears that originated from lateral buds when the apical bud is removed can also be collected in red bryony and hop, increasing its productivity. Taking into account the total number of spears and their weight, individual plant yields of 8 g per plant were obtained in the wild asparagus, whereas the production of red bryony was five times higher (40 g per plant). Individual plant yields could not be measured in black bryony. Nevertheless, according to personal observations, the spears of black bryony that originated from lateral buds when the apical one is cut are very thin and they do not achieve harvestable sizes. Thus, harvestable new spears could only be originated from the tuber.

Table 5.4 Natural productions of edible wild sprouts collected in forested areas (mean ± standard error). (Data source: Molina et al. 2012; Molina 2014)

Species	Spear weight (g)	Spear number	Units	Total yield	Units
Asparagus acutifolius	2.76 ± 0.09	2.96 ± 0.25	Spears/plant	8.15 ± 0.76	g/plant
Bryonia dioica	1.76 ± 0.02	23.60 ± 2.25	Spears/plant	40.67 ± 4.74	g/plant
Humulus lupulus	1.69 ± 0.05	63.83 ± 8.31	Spears/m² of plant	79.3 ± 14.7	g/m² of plant
Tamus communis	1.58 ± 0.07	N/A[a]	–	N/A	–

[a] *N/A* not available

Finally, in the clonal species *H. lupulus,* which usually propagates by vegetative growth by means of branching rhizomes, approximately 79.3 g m^{-2} of spears could be obtained in the natural patches of vegetation formed by hop.

5.3.4 Wild Fruits Growing in Forestlands

Wild fruits are also an interesting food resource of Mediterranean forestlands. Perennial species with edible fruits can be found in sclerophyllous and deciduous forests, riverbank forests, and/or wooded edge margins of croplands and pastures. Apart from dry fruits and seeds, such as acorns, chestnuts, hazelnuts, and pine nuts, there is a large set of fleshy fruits traditionally consumed in the Mediterranean region (Fig. 5.7).

The natural production rates of some of them are presented in Table 5.5. For instance, average fruit weight of strawberry tree and hawthorn (*Crataegus monogyna* Jacq.) was 3.69 g and 0.36 g, respectively. A total of 4–4.4 kg per tree could be obtained in these species. Other plants, such as blackberry (*Rubus ulmifolius* Schott),

Fig. 5.7 Wild fleshy fruits of *Arbutus unedo* (left) and *Crataegus monogyna* (right) growing as understory species in Mediterranean forests. (Photographs by María Molina)

Table 5.5 Natural productions of wild fruits growing in forested areas (mean ± standard error). (Data source: Molina et al. 2011; Molina 2014)

Species	Fruit weight (g)	Number of fruits	Units	Total yield	Units
Arbutus unedo	3.69 ± 0.08	1136 ± 150	fruits/tree	4.39 ± 0.63	kg/tree
Crataegus monogyna	0.36 ± 0.01	11,109 ± 1572	fruits/tree	4.00 ± 0.56	kg/tree
Rubus ulmifolius	1.01 ± 0.02	504 ± 51	fruits/m^2 of plant	0.51 ± 0.05	kg/m^2 of plant

produce 500 fruits m^{-2} of approximately 1 g each. Potential yields of 0.51 kg m^{-2} are expected in the natural patches of vegetation covered by this clonal species with branching rhizomes.

5.3.5 *Potential Food Supplies of Wild Edibles*

Taking into account individual plant yields (Tables 5.1–5.4) and plant density estimates (Molina 2014), the approximate figures of the potential food supplies that these species could offer in their natural habitats are presented in Fig. 5.8. Among leafy vegetables and sprouts, yields lower than 100 kg ha^{-1} were observed in *Scolymus hispanicus* (28 kg ha^{-1}) and *Sonchus oleraceus* (86 kg ha^{-1}) and *Asparagus acutifolius* (6 kg ha^{-1}), *Tamus communis* (13 kg ha^{-1}), and *Bryonia dioica* (91 kg ha^{-1}), respectively. Yields varied between 100 and 500 kg ha^{-1} in leafy vegetables such as *Allium ampeloprasum, Anchusa azurea, Chondrilla juncea, Cichorium intybum, Rumex papillaris,* and *Silene vulgaris;* sprouts such as those of *Humulus lupulus;* and fruit species such as *Arbutus unedo* and *Crataegus monogyna*. Other leafy vegetables such as *Beta maritima, Papaver rhoeas, Rumex pulcher*, and *Silybum marianum* obtained yields from 500 to 1000 kg ha^{-1}. The species which reached the highest yields were *Foeniculum vulgare* (1760 kg ha^{-1}), *Montia fontana* (2140 kg ha^{-1}), and *Rubus ulmifolius* (2416 kg ha^{-1}).

5.4 Cultivation Experiments on Wild Leafy Vegetables at IMIDRA (Madrid, Central Spain)

Cultivation experiments aimed to explore the agronomic feasibility of some traditional leafy vegetables were also conducted by our research group at the Madrid Institute for Research in Food and Agriculture (IMIDRA) in Spain. Crop yields from five culturally important wild species were assessed: skeleton weed (*Chondrilla juncea*), chicory (*Cichorium intybus*), fiddle dock (*Rumex pulcher*), golden thistle (*Scolymus hispanicus*), and bladder campion (*Silene vulgaris*).

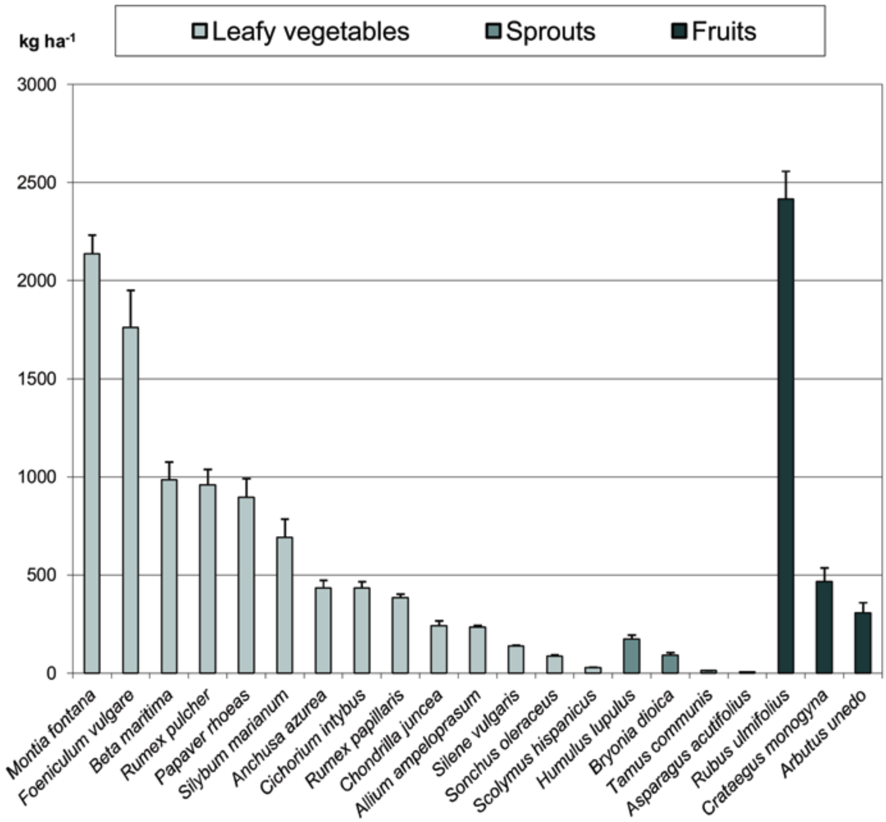

Fig. 5.8 Potential food supplies estimations of some traditional wild edible plants in the Mediterranean region. Yield rates are exclusively referred to the specific natural habitats where each plant occurs spontaneously (kg ha^{-1}; mean ± standard error). (Data source: Molina et al. 2011, 2012, 2014; Molina 2014; Tardío et al. 2011)

5.4.1 Cultivating Wild Vegetables

Seeds from two different sites (two accessions per species) were collected in summer 2009 and sown at the end of winter 2010 in a nursery. Jiffy pots located in plastic trays were sown with several seeds and thinned, leaving one plant per pot for being transplanted to the field in spring at the end of March (Fig. 5.9). We used a randomized design with four replications. The 2.40 × 0.8-m (1.92 m^2) elementary plot included 24 plants, placed in two rows separated 40 cm and 20 cm within them, with corridors of 2.6 m width among the four blocks (Fig. 5.9). Labor requirements were limited to occasional drip irrigation at the driest periods and hand weeding.

Due to the late nursery and transplant in 2010, crop yields of these five perennial species were measured during the second and third year after the plantation (2011–2012). In general, 5 plants per plot, that is, 40 plants per species (5 plants × 4 blocks

Fig. 5.9 Cultivation experiments at Madrid Institute for Research in Food and Agriculture (IMIDRA), Spain. Seedling of *Silene vulgaris* ready for being transplanted to the field (**a**). Randomized block design with four replicates was employed (**b**). Individual plot of *Cichorium intybus* (**c**). Harvesting 20 × 20 cm quadrats of *Silene vulgaris* (**d**). (Photographs by Javier Tardío)

× 2 accessions), were harvested, and the fresh edible part was immediately weighed. In the clonal species *Silene vulgaris,* we collected the edible plant material of five 20 × 20-cm quadrats. The number of harvest episodes per year varied depending on the capacity of the species for regrowth after harvesting and the annual weather conditions. Harvest began in spring, and in some species, such as *Cichorium intybus, Rumex pulcher,* and *Silene vulgaris,* a maximum of two episodes of harvest in springtime and one in autumn were performed. In *Chondrilla juncea* and *Scolymus hispanicus,* only one harvest in spring was conducted.

5.4.2 Production Under Cultivation

As shown in Table 5.6, most of the selected species showed crop yields around 5000–7000 kg ha^{-1} year^{-1}, except *Chondrilla juncea* (1674 kg ha^{-1} year^{-1}). *Scolymus hispanicus* stood out for its high yield per plant (279 g on average), whereas *Silene vulgaris* showed the highest degree of tolerance to be harvested several times per year (2.5 harvest episodes per year on average). Overall, *Cichorium intybus* obtained the highest yields because of the combination of high rates of production per plant (159 g on average) and high tolerance to be harvested several times throughout the year (two harvest episodes per year on average).

Table 5.6 Crop yields of five wild leafy vegetables under experimental culture conditions during 2011–2012 (mean ± standard error)

Species	g/plant-quadrat	kg/ha[a] per harvest	Number of harvests	Total yield (kg/ha[a])
Chondrilla juncea	75.9 ± 7.54	1674 ± 333	1.0 ± 0	1674 ± 333
Cichorium intybus	159.0 ± 6.15	3508 ± 271	2.0 ± 0.6	7016 ± 543
Rumex pulcher[b]	127.5 ± 5.51	2813 ± 243	1.8 ± 0.3	4923 ± 425
Scolymus hispanicus	279.0 ± 17.73	6155 ± 782	1.0 ± 0	6155 ± 782
Silene vulgaris[c]	60.5 ± 2.03	2668 ± 90	2.5 ± 0.3	6670 ± 225

[a] Considering the whole surface of the experiment
[b] *Rumex pulcher* subsp. *pulcher*
[c] *Silene vulgaris* subsp. *vulgaris.* In this species, yield refers to a 20 × 20-cm quadrat

According to other cultivation experiments previously mentioned (Fernández and López 2005), *Silene vulgaris* can hold a greater number of harvest episodes per year, and consequently, crop yields could be almost duplicated. It could also be possible in other species such as *Cichorium intybus,* although our experience indicates that an excessive harvest could degenerate the culture prematurely since the plants become exhausted due to a repeated collection of the same individuals. In our opinion, the yields of *Chondrilla juncea* could be considerably increased in better environmental conditions. Our experiments were performed on clay loam soil, developing small plants, but higher yields would presumably be obtained on sandy soils according to the specific soil preferences of this species.

5.4.3 Comparison with Natural Production

Crop yields of these five traditional wild vegetables can be compared with those obtained in their natural populations and previously presented in Table 5.3. Plant yields of cultivated versus growing wild plants are represented in Fig. 5.10. As shown in the figure, slightly higher figures of production per plant were obtained for *Cichorium intybus* and *Rumex pulcher* under culture in comparison with yield rates of these species growing wild. However, yields of cultivated *Scolymus hispanicus, Chondrilla juncea,* and *Silene vulgaris* duplicate or even triplicate its natural yield rates. As shown in Table 5.6, between 1.8 and 2.5 harvest episodes on average were performed in cultivated *C. intybus, R. pulcher,* and *S. vulgaris,* reaching total crop yields around 5000–7000 kg ha^{-1} $year^{-1}$. Overall, we can conclude that even under non-intensive culture conditions, comparable to those of organic farming, the yield rates of these wild vegetables can be considerably increased.

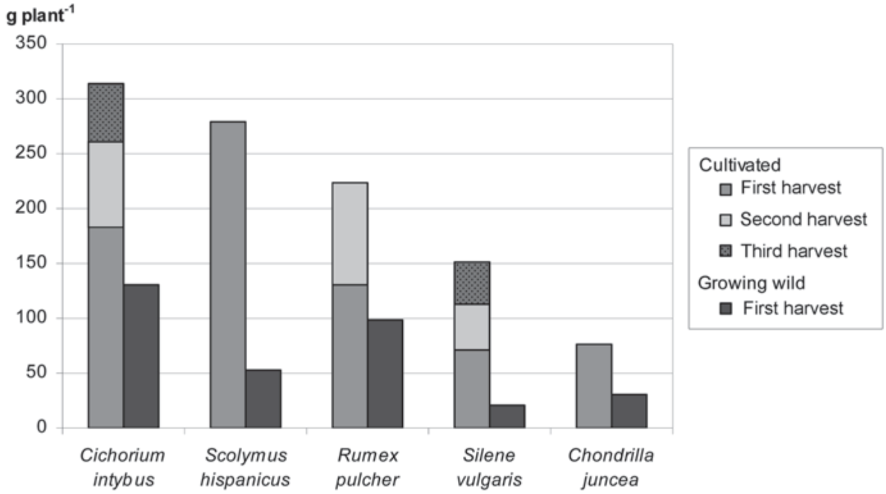

Fig. 5.10 Average plant production of five wild vegetables under culture and growing wild in g/plant, except for *Silene vulgaris,* in gram per 20 × 20-cm quadrat

5.5 Opportunities and Current Challenges for Gathering and Cultivating Wild Food Plants

5.5.1 Gathering in the Wild

The gathering of wild edible plants is a complementary food resource that also offers social benefits to local communities, such as contact with nature; reinforcement of social relationships and family ties; entertainment; physical, emotional, and spiritual well-being; revitalization of local identities and traditions; etc. (Emery et al. 2006; Menendez-Baceta et al. 2012). Therefore, the sustainable harvesting of wild food plants might be encouraged as a multifunctional use of biodiversity.

Most of the wild food plants traditionally consumed in the Mediterranean region are non-endangered species commonly found in disturbed areas and forestlands. Since the aerial parts of wild vegetables are collected before flowering and fruiting, intense harvesting might impact the abundance of their natural populations, especially in annual herbs. Nevertheless, as shown in Chap. 4 of this book, many of the wild vegetables are perennial herbs, in which their harvesting usually leaves the subterranean organs intact and prevents the plants from being exhausted due to a repeated collection of the same individuals. Even in the case of the bulbous plant *Allium ampeloprasum,* whose collection might be considered destructive, our experience shows that many small bulbs produced around the central bulb remain in the collecting place (Molina et al. 2014). Many other weedy vegetables are annual and fast-growing species that are never completely collected, allowing the self-regeneration of their populations. Neither does the extraction of wild fruits represent a significant threat to ensure the long-term maintenance of natural stands in widely distributed species.

According to our estimations, the yield rates of wild food species growing in their natural environments were considerably high in most cases. It suggests that the impact of harvesting might be relatively low and that it would be possible to increase this practice to develop alternative commercial products, as proposed by Farfán et al. (2007). As commented in Sect. 5.2.1, the extraction rates found by these authors in Mexico were in most cases lower than 20 % of the local availability.

Our results may indicate that the production of Mediterranean wild edible plants showed a great heterogeneity of yield rates depending on life and growth forms, distribution areas, or parts used. Our yield rates of wild vegetables (30–2140 kg ha^{-1}), edible sprouts (6–170 kg ha^{-1}), and fruit species (300–2400 kg ha^{-1}) were slightly lower than those reported in the bibliography of other non-Mediterranean territories (Table 5.1). These differences may be due to several reasons. One of them would be the specific morphological characteristics of each species. For instance, the edible leaves of *Montia fontana* are smaller (0.03–0.2 cm long) than those of the related species *Claytonia perfoliata* (0.5–4 cm long), which consequently obtained higher yields. However, we can also find remarkable intraspecific variation in several studies, even in the same country. As shown in Table 5.1, the production of *Amaranthus hybridus* varied from 45 kg ha^{-1} in the report of Pérez-Negrón and Casas (2007) to 3000 kg ha^{-1} in that of González-Amaro et al. (2009), both in Mexico. These differences might be due to ecological and climatic factors that can influence the local availability of wild species but also due to the application of different methodological procedures that should be taken into account for comparison purposes.

The potential food supplies obtained in our field studies were calculated from a limited number of localities of central Spain. Therefore, they obviously are neither representative of Spain nor of the Mediterranean region. We should also note that the yield rates shown in Fig. 5.8 exclusively refer to the habitats and places where each species occurs spontaneously. Although some species could be locally abundant, they are not necessarily common on a country basis. For instance, *Montia fontana* was one of the most productive species according to Fig. 5.8, but the aquatic environments where it naturally occurs do not cover large areas, and additionally, its distribution is mainly limited to noncalcareous soils. Other wild vegetables growing in human-disturbed areas and with no specific soil preferences such as *Cichorium intybus* or *Papaver rhoeas* are more widely distributed on a country basis.

The changes in land uses and management practices could affect the local availability of these species. According to local perceptions, the abundance of some wild edible plants have diminished in the past decades due to deforestation, urban spreading, the abandonment of traditional agricultural practices, and the use of modern agricultural practices such as deep ploughing and pesticide spraying (Celikel et al. 2008; Laghetti 2009; Polo et al. 2009; Takrouni and Boussaid 2010). Since the risk of contamination by car exhausts or pesticide spraying could compromise the safe consumption of wild edibles in some cases, weedy vegetables could be collected in organic farms in order to guarantee food safety and to increase crop profitability (Molina et al. 2014).

5.5.2 Cultivation

As we have previously pointed out, the cultivation of traditional wild food species could represent an interesting alternative for the most culturally appreciated species, particularly of those that are scarce on a country basis. Rather than forage them, some species could be intentionally grown in order to satisfy their demand. It would contribute to ensure food quality and to avoid the contamination risks that wild vegetables growing on roadsides and in agricultural areas are exposed to (Molina et al. 2014). Cultivation would also help to control the risk of parasites in some aquatic plants growing in areas frequented by cattle.

However, there are some problems that could limit the success of growing traditional wild vegetables. Firstly, one of the limitations that can be found is the low seed germination rates or even seed dormancy that appears in some species (Benincasa et al. 2007; Casco 2000). This is not a general problem in wild vegetables since most of them are weeds. However, there are some cases in which it is an important problem, such as in *Asparagus acutifolius,* whose seeds have a strong dormancy and do not germinate easily. In this species, pre-germination treatments and a suitable technique for production of transplants have been proposed (Conversa and Elia 2009; Rosati and Falavigna 2000). Vegetative propagation could also be appropriate for avoiding seed germination problems, besides maintaining favorable morphological features. This vegetative propagation can be carried out by means of stolons as in *Silene vulgaris* (Alarcón 2013), rhizomes as in *Ruscus aculeatus* and *Smilax aspera,* or tubers as in *Tamus communis* (D'Antuono and Lovato 2003). Since requirements of seeds and seedlings of many wild edible plants are still not well known, further research is needed.

Secondly, available information on cultural systems and techniques for commercial production of traditional wild vegetables is also scarce (Benincasa et al. 2007; Casco 2000). More research is needed to know which are the most suitable cultural systems, field techniques, substrates, irrigation systems, and labor requirements for growing these species according to their yield potential and their agronomical characteristics.

Thirdly, labor costs derived from cultivation of traditional wild edibles have been poorly assessed and deserve more attention. It should be taken into account that the cost of labor is today one of the main drivers of land use change in Europe since labor costs are sometimes higher than potential profits, and it has lead to the abandonment of agricultural lands in some territories (Rosati et al. 2009). In this way, some authors indicate that traditional wild vegetables could supply a specialized market in which high quality and product differentiation represent a competitive strategy that allows for a higher price. For instance, the spears of *Asparagus acutifolius* collected from the wild are sold at US$ 9–32 kg^{-1} in Italy, depending on season and market (Benincasa et al. 2007). Bunches of wild asparagus of about 250 g are sold at 5 € in some Spanish regions (Molina et al. 2012). According to Benincasa et al. (2007), it represents two to four times the price of the cultivated asparagus (*A. officinalis*). Agronomic trials conducted by these authors showed that harvest efficiency of *A. acutifolius* was approximately of 1.2 kg of spears per h of labor, and it increases to 3 kg per h when the prickly evergreen vegetation is previously cut and removed. In the latter case, harvest would cost approximately one third of the gross income of the crop, suggesting that the crop could easily be economically viable. Fernández and López (2005) estimated the labor costs, including hand weeding and harvesting costs, for *Silene vulgaris* as 18 € m^{-2}, and concluded that a minimum sale price of 7.5 € kg^{-1} would make the crop profitable. According to these authors, the young leaves and stems of *S. vulgaris* collected from the wild are sold in Spanish local markets at 6–8 € kg^{-1}. Apart from these and other limited examples, the economic viability of growing traditional wild edibles for the agricultural market has been poorly addressed.

5.6 Concluding Remarks

Wild edible plants are a significant food resource that has been widely underestimated, despite their interest in promoting food security and rural development. Particularly, the gathering of wild vegetables and fruits is deeply rooted in the Mediterranean food traditions, and, as some authors have suggested, the consumption of wild edibles have probably contributed to the so-called health benefits of the Mediterranean diet (Trichopoulou and Vasilopoulou 2000).

Although information on natural yield rates of Mediterranean wild edible plants is scarce, the available data presented in this chapter suggest that some of the wild food plants traditionally eaten in the Mediterranean region are abundant and productive species that could contribute to enhance food diversity in contemporary diets. More research is needed to have a wider characterization of their natural production and abundance. Besides, the main factors that could determine local supplies should also be addressed. For instance, urban spreading, changes in land uses and management practices, and deforestation could affect the local availability of these plants.

Apart from traditional harvesting for domestic consumption, some culturally important species could also be collected for commercial purposes, given the renewed interest for traditional food products. Although there are no available data on the quantities of wild food plants harvested in the Mediterranean region, results suggest that the impact of harvesting might be relatively low, and they could possibly tolerate higher extraction rates. Sustainable levels of harvest should be established, taking into account the edible parts used and their production rates as well as the specific habitats where they naturally occur. Moreover, safety issues may be addressed to ensure food quality, such as contamination risks derived from car exhausts or pesticide spraying.

Wild edible plants are a good reservoir of potential new crops too. Cultivation experiments could contribute to assess the agronomic potential of culturally appreciated wild species, especially of those that may be more prone to overexploitation. It would help to ease pressure on natural stands, providing new options for employment and income generation. Particularly, cultivation under organic conditions of wild vegetables might be an interesting alternative and a complementary economic resource for Mediterranean farmers. Since wild species are well adapted to local environments, they can ensure steady productions under adverse environmental conditions. Some of them are tolerant to drought and salinity, and they are considered promising vegetables for agriculture in marginal areas. Nowadays, health claims and product differentiation may represent successful commercial strategies for the cultivation of traditional wild edible plants (D'Antuono et al. 2009). Thus, domestication opportunities should also be considered, taking into account nutritional characteristics, cultural traits, and consumer acceptance.

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