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in

Porqueddu C. (ed.), Ríos S. (ed.).
The contributions of grasslands to the conservation of Mediterranean biodiversity

Zaragoza : CIHEAM / CIBIO / FAO / SEEP
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 92

2010
pages 9-23

Article available on line / Article disponible en ligne à l'adresse :

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To cite this article / Pour citer cet article

Ríos S., Laguna E. **Adaptations for the survival of perennial legumes in Western Mediterranean regions: Some promising native species of the Valencian Community (Spain).** In : Porqueddu C. (ed.), Ríos S. (ed.). *The contributions of grasslands to the conservation of Mediterranean biodiversity.* Zaragoza : CIHEAM / CIBIO / FAO / SEEP, 2010. p. 9-23 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 92)

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Adaptations for the survival of perennial legumes in Western Mediterranean regions: Some promising native species of the Valencian Community (Spain)

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Abstract. The South-Eastern corner of the Iberian Peninsula contains a highly diversified flora as a result of a combination of several factors such as climatic and edaphic diversity, the presence of high mountains ranges and the proximity to North Africa. Leguminosae is the second largest botanical family in Spain, presenting a high richness, because it has a large number of endemisms, many of them with particular ecological, morphological and chemical adaptations. The Valencian Community, placed between S and E of Spain, contains over 350 Spanish endemic species. Sixty of them are exclusive endemisms of the Valencian territory and 31 belong to the legume family (*Anthyllis*, *Astragalus*, *Genista*, *Ononis*, *Lathyrus*, *Colutea*, *Cytisus*, *Onobrychis*, *Medicago*, etc.). Some of them have potential perspectives for a good forage development as *Medicago suffruticosa* subsp. *leiocarpa*, a native herbaceous perennial legume which has an excellent digestibility, palatability, resistance to direct grazing, persistence and reseeding capacity surpassing other commonly used perennial legumes. Also there are other potential uses with environmental application as restoration of slopes. Some assays done with *Hippocrepis valentina*, a suffruticous valencian chamaephyte, confirm these capacities. Another legume, a calcicolous therophyte *Lupinus mariae-josephae*, an endemism recently discovered, has a significant interest for genetic improvement in the genus *Lupinus.* The limitations of these endemic resources are the absence of scientific studies about its productivity and quality, genetic safety and toxicity as well as current legal restrictions because they are included into the Valencian Catalogue of Endangered Flora. We must not forget their climatic and edaphic adaptability to our territory, so it's expected they give best results in their ability to forage production, their environmental applications and in soil protection purposes.

Keywords. Perennial legumes – Biodiversity – Native species – Endemism – Mediterranean flora – Spain.

Adaptations pour la survie des légumineuses pérennes dans la région méditerranéenne occidentale : Quelques espèces autochtones prometteuses de la Communauté de Valence (Espagne)

Résumé. *La région de la pointe sud-est de la Péninsule ibérique présente une flore hautement diversifiée suite à une combinaison de plusieurs facteurs, tels que la variabilité climatique et édaphique, la présence de chaînes montagneuses et la proximité de l'Afrique du Nord. Les légumineuses sont la seconde grande famille botanique la plus grande en Espagne. Cette famille présente une grande quantité d'endémismes, avec des adaptations écologiques, morphologiques et chimiques particulières. Dans la Communauté de Valence située entre le Sud et l'Est de l'Espagne, existent 350 espèces endémiques espagnoles, dont 60 sont exclusives de Valence et 31 sont des légumineuses (*Anthyllis*,* Astragalus*,* Genista*,* Ononis*,* Lathyrus*,* Colutea*,* Cytisus*,* Onobrychis*,* Medicago*, etc.). Certaines d'entre elles possèdent les meilleures perspectives potentielles pour un bon développement fourrager.* Medicago suffruticosa *subsp.* leiocarpa *est une légumineuse persistante, herbacée sauvage, ayant une digestibilité et une palatabilité excellentes et une grande résistance au surpâturage. Elle présente également une persistance importante et une capacité de réensemencement plus grande que d'autres légumineuses cultivées couramment. D'autres applications potentielles sont la restauration environnementale et le contrôle de l'érosion. Quelques essais sur* Hippocrepis valentina*, un petit arbuste endémique de Valence, confirment des caractéristiques potentielles semblables. D'autre part, on présente des données préliminaires d'une autre légumineuse annuelle calcicole,* Lupinus mariae-josephae*. Cette plante est un endémisme récemment découvert, très utile pour*

l'amélioration génétique. Les limitations de ces ressources sont l'absence d'études scientifiques sur la productivité et la qualité, la sécurité génétique et la toxicité ainsi que quelques restrictions légales car elles appartiennent au catalogue de la Flore endémique de Valence. Hormis ces restrictions, nous attendons les meilleurs résultats pour l'amélioration des pâturages et pour la restauration environnementale.

Mots-clés. *Légumineuses pérennes – Biodiversité – Espèces indigènes – Endémisme – Flore méditerranéenne – Espagne.*

I – Introduction

The Iberian Peninsula shows a complex orography with many mountains reaching 2000 m a.s.l., with two ranges (Sierra Nevada y Pirineos) overcoming 3000 m a.s.l. They have diverse geological materials, as well as different kind of climates and microclimates. All these factors joined to the anthropic activity (in the last milleniums) have allowed the survival of a huge plant richness, specially assembled in the South and East of Spain.

Some of the current taxa are growing in a very restricted habitat and are survivors of the past climate periods [e.g. *Medicago citrina* (Font Quer) Greuter*, Hippocrepis valentine* Boiss, etc.], and for this reasons they are excellent bioindicators for further climate changes. They are as well valuable for their use as fodder (Chebbi *et al*., 1994, 1995; Laguna and Jiménez, 1995; Sobrino, *et al.*, 2000; de Andrés *et al*., 2001; Juan, 2002; Correal *et al*., 2008). The study area comprises more than 250 Leguminosae taxa, being the major perennial species close to 60%. Of these perennial Leguminosae more than 45% are endemic, exclusively from the Iberian Peninsula and other (20%) shared with the North of Africa (Ríos, 1991; Ríos *et al*., 1992).

It is very interesting to check in Leguminosae how the endemic element is concentred in perennial legumes, being almost inexistent in the annuals [just *Trifolium obscurum* Savi subsp. *isodon* Murb., can be considered as an Iberian-maghrebian endemism (Ríos, 1991)]. This phenomenon can be explained because due to the different climate changes that affected the Mediterranean area during the Tertiary (Lesins and Lesins, 1979), the areas around the large Tethys sea (which during the Tertiary covered part of the present Mediterranean zone) became a centre of speciation for many plant families during the Pleistocene and Holocene, after the Alpine uplift and the Oligocene changes. In this period only a few legume tribes survived to endure severe climatic conditions (e.g. Tribe *Genisteae*, *Hedysareae*, *Loteae*, *Viciae* and *Trifolieae*). There are genera such as *Anthyllis*, *Trigonella*, *Coronilla, Hippocrepis*, *Ononis*, *Genista*, *Onobrychis*, *Hedysarum*, *Medicago*, *Astragalus*, etc., almost exclusive to the Mediterranean and Irano-Turanic Regions (Raven and Polhill, 1978; Lesins and Lesins, 1979).

This speciation process is distinctly bipolar in two areas: the Eastern Mediterranean/Irano-Turanic zone and the Western Mediterranean or Ibero-Magrebi zone. During this process, in the sea level decreasing phase, one big band of arid sandy territory was very favourable for the annual legumes. In the increasing sea level phase, many of the coastal areas were submerged and only the current high mountains formed islands. In these, the perennial legumes were evolving and diversifying. Some of the perennial legumes gained more spaces in the Mediterranean (e.g. *Medicago marina* L., *Lotus creticus* L.*,* etc.), but the most were relegated to a reduced geographical distribution, being the origin of our current endemic plants (Lesins and Lesins, 1979). This process were more complex during the glaciations occurred in the Quaternary period. In the glacial periods, due to the advance of the ice from North to South, the Eurosiberian flora penetrated through the Iberian Peninsula, rising the high mountains. Otherwise, in the interglacial periods, warmer and drier, the Northern-African flora cross over Europe through Spain, increasing the plant diversity.

This Geologic History have given endemic taxa even in widespread species such as *Trifolium repens* L., that has the subsp. *nevadensis* (Boiss.) D.E. Combe, endemic of the Spanish high

mountains. Other good example is the major development of some Leguminosae groups such as the Tribe *Genisteae*, or the Section *Suffruticosae* of the genus *Medicago*, endemic of Spain, Morocco and South of France (Pyrinean), the woody *Hippocrepis* group Balearica-Valentina endemic of the Valencian Community and Balearic Islands, or *Onobrychis stenorhiza* DC, only present on the clay arid soils of South-Eastern Spain. Finally, all perennial legumes around the Mediterranean sea can be considered such as true survivors (Raven and Polhill, 1978; Lesins and Lesins, 1979).

In the other hand, the presence of morphological, physiological or chemical adaptations that protect perennial legumes of overgrazing are frequent (Ríos, 1991; Ríos *et al.*, 1992). According to Wilson and Harrington (1980), there are no browse species of both high quality and high palatability because plants would quickly succumb to the concentration of grazing. The forages with a high digestibility and relative low intake, apparently have unpalatability factors that reduce consumption. Only the perennial legumes that grow in meadows and wetlands show a different behaviour because in this special habitat it is possible to maintain high productivity under overgrazing conditions (e.g. *Trifolium repens* L., *T. pratense* L., *Medicago lupulina* L., etc.). Other legumes such as *Medicago sativa* L., *M. Suffruticosa* Ramond ex DC., *Melilotus albus* Medik., etc., show as main adaptation to droughts, a very deep roots systems (taproot), combined with a crown or stolons below the soil surface (Ríos *et al.*, 1991, 1992a, 1993; Cocks, 2003; Small, 2003).

Inside Spain, the Valencian Community is one of the higher biodiversity territories, showing over 350 Spanish endemic species. Sixty of them are exclusive of the valencian territory (Laguna, 1994, 1998, 1999, 2005a) and 31 are endemic plants belonging to *Leguminosae*. Several of these perennial legumes have a good fodder potential but only *Medicago citrina* (Font Quer) Greuter, *Medicago suffruticosa* Ramond ex DC. and *Bituminaria bituminosa* (L.) C.H. Stirt (Ríos *et al.*, 1991, 1992, 1993; Robledo *et al.*, 1993; Chebbi *et al.*, 1994; García Camarero, 1999; Juan *et al*., 2003; Coca *et al.*, 2004; Correal *et al*., 2008), have preliminary works of domestication. In general terms, the fodder value of the Valencian endemic legumes is limited due to these two factors:

(i) Low social interest because grazing in the Valencian Comunity is commonly a marginal activity, being the attention focused in other economic activities (turism, diverse industries and services) (Laguna, 1994, 1998).

(ii) Valencian natural pastures have low fodder quality and low palatability due to climatic reasons.

Exempting the Castellon province, that has more fodder tradition (even cattle), there exist a few adapted cattle local races.

Regarding sheep, the main local race is "Guirra" sheep (also "Sudat" or "Roja levantina"). Despite their excellent adaptation and their productive potential (López Rodríguez, 1998; Jaramillo, 2007;) they are in a strong regression (Cifré *et al*., 1997; Mas de Noguera, 2002; Rodríguez *et al*., 1998). On the contrary, the goat local races ("Blanca celtibérica" in mountain areas and "Murciano-granadina" in riparian-valley areas) are increasing.

Other possibilities for perennial legumes are found in bare soil restoration as well as public mountains fire lanes and protected areas management: the controlled grazing in natural pastures is a good option to maintain biodiversity and low cost management without any mechanical treatment that produce soil erosion, improving the plant diversity and creating threatened animal habitats (Urios and Ríos, 2001).

According to this, establishment of perennial legumes pastures in marginal areas can improve wild ungulate fodder for hunting, reducing their costs and increasing biodiversity.

II – Main adaptative morphologies of Iberian perennial legumes to drought and grazing pressure

1. Diversity and major life form of perennial legumes of Spain

The Spanish flora is one of richest of Europe and Legumes family, with 562 autoctonous taxa present (10% of the total, Castroviejo *et al.*, 2001), occupies the second place. In Southeast Spain about 150 species of legumes have been identified (Ríos *et al*., 1991). Also Valencian Community, is a region with major biodiversity of Spain.

Western mediterranean area (Ibero-Maghrebian zone) could be considered as centres of legumes diversity and germplasm interest for forage legumes (Gintzburger and Le Houérou, 2003) in all Mediterranean climate areas of the world.

Regarding life form, the 40% of the legumes are annual (therophyta), a low number for a typical Mediterranean country (Cocks, 2003), but the high mountainous orography and the very different climatic types present in Iberian Peninsula have favoured the perennial forms.

Perennial legumes (60%), are divided into herbaceous perennial, woody plants and geothamnic legumes, which represent respectively 51%, 45% and 13% (Figs 1a and 1b). Some of the woody legumes have leafy stems (34%), but many present retamoid stems (45%) and other are thorny shrubs and chamaephytes. It means that 1/3 of the perennial legumes are thorny or hardy fibres that reduce fodder quality (Table 1).

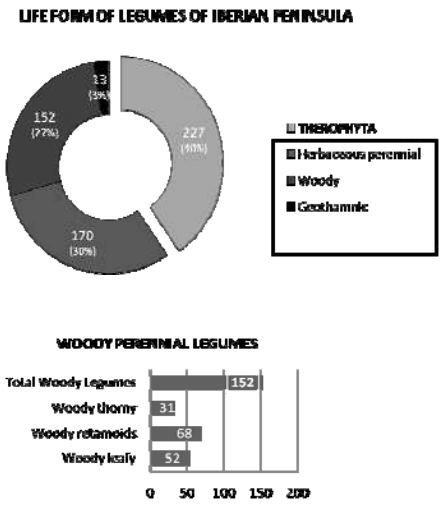


Fig. 1. Percentage of life forms of Leguminosae of Iberian Peninsula (incld. Balearic Islands).

From a landscaping point of view (Ríos, 1991; Ríos *et al.* 1992), many of thorny and retamoid legumes are dominant in different plant communities like the local called "retamar", "aulagar", "piornal", etc.

On the contrary, despite their plant richness, the perennial herbaceous legumes and the leafy woody (Table 1), appear in a restricted habitat, where sometimes are scarce and no dominant plants for what their contribution to biomass production is low.

However, these species are the better option for improvement native legumes and breeding crops.

Table 1. Main life form of perennial legumes in Spain

Life form (tipe)	Life form (subtipe)	Rankjaer†	Plant model	Observations
1. Herbaceous plants	Underground root	Geophyta	*Glycyrrhiza glabra*	Aerial parts died in cool season
	Stems with stolons	Hemicriptophyta	*Trifolium repens*	Meadows and moist soil. Moor effective vegetative and seeds reproduction
	Taproot with dense crown	Hemicriptophyta	*Melilotus albus*	Aerial parts died in cool season
	Both, taproot dense crown plus stolons	Hemicriptophyta	*Medicago suffruticosa*	Crown of leaves present
2. Geothamnic†† plants	Aerial herbaceous stems but below the ground level, present woody stems and rootstock	Chamaephyta or hemicriptophyta	*Hedysarum costaetalentii*	High mountains, good adaptations to drought and overgrazing
3. Woody plants				
3.1. Leafy stems	Evergreen trees	Macrophanerophyta	*Ceratonia siliqua*	Leaves rich in tannins, but pods are a good fodder
	Big shrubs or little trees	Nanophanerophyta	*Colutea arborescens*	Some loose the leaves in winter
	Little shrubs	Chamaephyta	*Ononis fruticosa*	Some loose the leaves in summer or present succulent leaves
3.2. Less or no-leafy green stems (photosyntetical)†††	Retamoids (like *Retama*)	Nanophanerophyta or Chamaephyta	*Retama sphaerocarpa*	Stems unpalatable, but flower and fruit are eaten by sheep and goats
	Like retamoids plants with stems winged	Chamaephyta	*Chamaepartium sagittale*	Acid soils, grazing by cattle
	Thorny erect shrubs	Nanophanerophyta or Chamaephyta	*Genista scorpius*	Stems thorny are unpalatable, but flower and fruit are eaten by sheep and goats
	Cushion thorny plants	Chamaephyta	*Erinacea anthyllis*	Stems thorny are unpalatable, but flower and fruit are eaten by sheep and goats

†According to Raunkjaer (1934).

††According to Bocquet and Aeschimann (1981).

†††In the past, after cutting stems by farmers, retamoids and thorny legumes were used as a emergency fodder for very bad years (Rodrigáñez, 1949).

2. Perennial legumes adaptations to drought and overgrazing

In dry Mediterranean climatic conditions (aridity and very irregular rainfall) the annual legumes (with higher productivity in Atlantic, wetter areas) present low biomass production and a scarce contribution to herbivorous fodder. Neither the seasonality of their stocking rate allow a permanent grazing but occasional and randomly due to interannual variability. On the contrary, perennial legumes have a more regular behaviour, their fodder production is directly related to the climatic conditions but maintaining enough biomass to ensure the reproductive success.

This ecological trait of the perennial legumes also depend strongly on individual plant longevity, and mostly perennial legumes combine vegetative and seed reproduction.

The key to survival of the perennial legumes in Mediterranean areas is their ability to resist drought (Cocks, 2003). But in general, all of them present many adaptive defences: anatomical, chemical, phenological, etc., which complete a good pool of strategies to survive to herbivorous pressure (Table 2). Some of these are climatic adaptations to drought such as:

(i) Minimization of leaf area and reduction of the total number of leaves.

(ii) Deep taproot and crown.

(iii) Succulent leaves (e.g. *Ononis tridentata* L.).

(iv) Total or partial dioecious as well as summer dioecious in dry season (e.g. *Ononis fruticosa* L.).

(v) Summer dormancy (e.g. *Anthyllis cytisoides* L.).

Table 2. Main adaptations of Mediterranean perennial legumes to drought and overgrazing

Adaptation tipe form	Adaptation subtipe	Observations	Plant model
1. Climatic adaptation	1.1. Drought tolerance	- Reduction leaf area or number of leaves	*Genista valentina*
		- Present deep taproot and crown	*Melilotus albus*
		- Present succulent leaves	*Ononis tridentata*
		- Present dioecious total or parcial	*Ononis fruticosa*
	1.2. Frost tolerance	- Present summer dormancy	*Anthyllis cytisoides*
		- Present winter dormancy	*Medicago sativa*
		- Cushion shape (to guard against to strong and cold winds)	*Erinacea anthyllis*
2. Phenological defenses	2.1. Amphicarpia	- Aerial and subterranean pods are produced at the same times	*Vicia amphycarpa*
	2.2. Geocarpia	- Only subterranean pods are produced	*Trifolium subterraneum*
	2.3. Geothamnia	- Herbaceous plant with woody stems and rootstock below the soil level	*Hedysarum costaetalentii*
	2.4. Summer dioecious	- In dry season, leaves lie down and regrow with new rain	*Anthyllis cytisoides*
	2.5. Winter dormancy	- In cool season, leaves lie down and regrowth in spring	*Colutea arborescens*
	2.6. Seasonal partial toxicity	- Edible plants became poisonous in flowering and fruiting	*Dorycnium pentaphyllum*
	2.7. Annual life form	- Short life is the best strategy to survive each season	*Medicago minima*
3. Anatomical defences	3.1. Thorns	- Very spiny stems, green and without leaves	*Genista scorpius*
	3.2. Retamoids	- Stems with hard fibre to difficult to normal intake	*Retama sphaerocarpa*
	3.3. Sticky glands	- Sticky stems and leaves to make unpalatable plants	*Ononis natrix*
	3.4. Woody stems without browsing biomass	- Edible parts of the plants are scarce	*Ononis aragonensis*
4. Chemical defences	4.1. Aromatic scents	- Bad smells, to make unpalatable	*Bituminaria bituminosa* p.p.
	4.2. Glycosides compounds	- Cytisine, genistine, etc., modify the heart rhythm	*Spartium junceum*
	4.3. Cyanide precursor compounds	- After digestion, to make metabolic poison	*Anagyris foetida*
	4.4. Coumarins	- Altering blooding processes	*Melilotus officinalis*
	4.5. Saponins	- Foaming in rumen	*Anthyllis vulneraria*
	4.6. Tannins	- Antinutritive compounds	*Glycyrrhiza glabra*
	4.7. Alkaloids	- Metabolics poisons	*Cytisus* sp.pl.
	4.8. Metal toxic accumulation	- Presence of Selenium	*Astragalus* sp.pl.

Other strategies to escape to drought conditions are the phenological defences such as amphicarpia (aerial and subterranean pods are produced at the same times) and geocarpia (only subterranean pods are produced). Frost tolerance is present in *Medicago sativa* L. and other species of the genera, like a winter dormancy to avoid frost injury. Also cushion shape and thorny stems are adaptations to guard against the strong and cold winds in the top of high mountains (e.g. *Erinacea anthyllis* Link, *Genista longipes* Pau, etc.). A particular adapted life form is called geothamnia (Bocquet and Aeschimann, 1981). In this case, an herbaceous plant have woody stems and a rootstock below the soil level, to protect all the young buds underground (Table 2). Finally other legumes, that are commonly edible during almost the whole year, change their toxicity during the flowering and fruiting period (e.g. *Dorycnium pentaphyllum* Scop.) to ensure the complete reproduction.

Anatomical defences like thorns (very spiny stems, green and without or scarcely leaves) or retamoids stems (hard fibre to difficult normal intake) are successful adaptive life forms to survive. This species are very abundant in Southeast Spain. They form dense scrublands covering thousands of hectares in which they are the dominant species. The abundance of these shrub legumes in the secular overgrazed Spanish Mediterranean rangelands could be explained by heavy defences, and also by their ability to colonize disturbed soils and abandoned cropping areas. Plant with a densely sticky glands in stems and leaves are very unpalatable, because their surface is mostly covered by died insects, dust, rubbish, etc. (e.g. *Ononis natrix* L.). The presence in perennial legumes of many antinutritive and poisonous compounds, chemical repellents etc., is a widespread defence. Aromatic scents or bad smells, glycosides, cyanide precursor compounds, coumarins, saponins, tannins, alkaloids and metal toxic accumulation are frequent (Table 2).

3. Forage quality of Iberian perennial legumes

Most perennial legumes of Spanish flora are woody shrubs which may be browsed by herbivorous to a larger or smaller extent, depending on their quality and palatability. Certain native legumes may have a good forage quality (energy, protein, digestibility, etc.) but a relatively low intake due to the presence of unpalatability factors. Whereas, others may have a low quality but a good palatability that favours their consumption (Ríos *et al.*, 1992). Combining the available data and according to Ríos *et al.* (1991) (Table 3) there are three categories of perennial Mediterranean legumes:

A. Perennial legumes of low palatability and high feeding value (LP/HFV)

This group is made up by species with anatomical defences to avoid overgrazing [e.g. *Genista umbellate* (L'Hér.) Dum. Cours.]. The presence of thorns or very fibrous stems and the excessive lignification may be also the cause of a low intake. Such defences against grazing have made possible their extensive growth forming large thickets in the secondary stages of natural vegetation.

B. Perennial legumes of high palatability and low feeding value (HP/LFV)

Low protein and low digestibility avoid overgrazing, as it forces the herbivorous to search other forage resources to equilibrate their diet. In such way, the plants escape from hardy grazing, allowing them to grow extensively too (e.g. *Anthyllis cytisoides* L.).

C. Perennial legumes of high palatability and high feeding value (HP/HFV)

There are the best native legumes group. Such species have almost disappeared with traditional overgrazing practices, for what they can only be found in areas where livestock have limited or excluded access, in inaccessible mountain areas or in special wet habitats (e.g. *Colutea arborescens* L., *Medicago* sp.pl.) and also because these species have a good regrowth rate.

Table 3. Forage quality of main perennial legumes of South and East of Spain

Perennial legumes forage quality types	Plant model	Observations
Low palatability and high feeding value (LP/HFV)	*Genista umbellata*	Anatomical defences to avoid overgrazing
High palatability and low feeding value (HP/LFV)	*Anthyllis cytisoides*	Low protein and low digestibility avoid to overgrazing
High palatability and high feeding value (HP/HFV)	*Colutea arborescens*	To avoid overgrazing: - living in inaccessible mountain areas - present a good regrowth rate - live in special wet habitat

Note: Data according to Ríos *et al.* (1989, 1991, 1992). Palatability was evaluated in replicated pen feeding trials with sheep flock with free access to edible fresh samples of perennial legumes. Feeding value was calculated with crude protein and *in vitro* digestibility analysis.

III – Some examples of promising Valencian legumes

1. Perennial *Medicago* (Sect. *Suffruticosae* and Sect. *Dendrotelis*)

Medicago suffruticosa Ramond ex DC. s.l. is a perennial legume that combine a deep taproot that stores nutrients, with the presence of a soil level crown, where the growing buds persists. Moreover it is able to produce roots in the stems nodes, forming a dense tuff strongly joined to the soil. (Ríos *et al.*, 1991, 1992a,b).

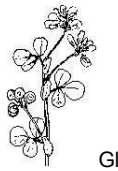
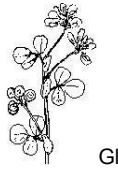
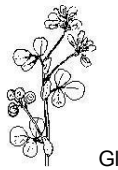
It belongs to the Sect. *Suffruticosae,* almost endemic of Spain (Pyrenees and Corbier Mountains, Eastern Iberian Peninsula and Atlas Mountains in Morocco), where is located more than the 80% of its distribution area, as well as of the whole taxa that is limited to two species: *M. hybrida* (pour) Trautv. and *M. suffruticosa*. Ramond ex DC. The last one has a huge intraespecific variability, with two subspecies and four botanical varieties (Table 4).

The Sect. *Suffruticosae* is relatively rare and lonely inside the genus, due to the presence of exclusive metabolites (β-zeacarotene), and the crossing incompatibility with the other closely *Medicago* sections (Ignasiak and Lesins, 1975; Lesins and Lesins, 1979).

Currently, only *M. suffruticosa* Ramond ex DC. subsp. *leiocarpa* (Benth.) Urb. have been studied with preliminary plant selection and pre-breeding work. This plant presents good palatability, crude protein content and digestibility with similar values, or even overcoming, to alfalfa and sainfoin. Also it has a good forage yield, grazing resistance, cold tolerance and great seed production as well as seedling recruitment. For these reasons this species is one of the more promising native perennial legumes (Ríos *et al.*, 1991, 1992a,b). However, a better research and germplasm collection is needed, as well as an assessment of the ability of these plants to be adapted to different kind of soils and climatic conditions (alkaline and acid soils). Accessions of this species are present in diverse important gene banks of the world (Small, 2003), however no paper exists on this subject.

Within the Sect. *Dendrotelis* we have *Medicago citrina* (Font Quer) Greuter, a very interesting Valencian-Baleric endemic species which has been widely studied regarding its biology (Robledo *et al*., 1993; Chebbi *et al*., 1995; Laguna and Jiménez, 1995; Juan *et al.*, 1999, 2003, 2004; Juan and Crespo, 1999; Pérez Bañón *et al.*, 2003; Crespo *et al*., 2005) and its potential as a fodder legume (Chebbi *et al*., 1994; Lefi *et al*., 2004a,b,c,d). But also *Medicago citrina* (Font Quer) Greuter is strictly protected in Spain and specially in its origin area –Valencian Community and Balearic Islands– having legal problems for its big scale extension. The native area of distribution is included into diverse kind of protected areas (Crespo *et al.*, 2005) so that

Table 4. Main differences of *Medicago* Sect. *Suffruticosa* taxa present in Spain

Taxa (species)	Taxa (subsp./var.)	Leaves and stems	Pods	Habitat	Soil/altitude
1. *M. hybrida* (Pourr.) Trautv.		 Glabrous	 Falcate pods, glabrous	Pastures/decidous forest (*Fagus*, *Quercus*, etc.)	Calcareous. Moist and deeply soil with more organic matter/1600 m.o.s.l.
2. *M. suffruticosa* Ram. ex DC.	subsp. ***Suffruticosa*** var. ***suffruticosa***	 Glabrous	 Hairy, sticky, central hole conspicuous	Pastures in open areas (climax vegetation: *Fagus* and *Abies* forest, *Pinus sylvestris* forest)	Siliceous. Moist and deeply soil with more organic matter/2500 m a.s.l.
3. *M. suffruticosa* Ram. ex DC.	subsp. ***Suffruticosa*** var. ***villosa*** Benth.	 Pubescents	 Hairy, sticky, central hole conspicuous	Pastures in open areas (climax vegetation: *Pinus sylvestris* and *Quercus ilex* forest)	Calcareous or siliceous. Deeply soil with more organic matter/2000 m a.s.l.
4. *M. suffruticosa* Ram. ex DC.	subsp. ***leiocarpa*** (Benth.) Urb. var. ***leiocarpa***	 Glabrous	 Glabrous, central hole incospicuous	Pastures and scrublands in open areas (climax vegetation: *Quercus ilex* and *Pinus halepensis* forest)	Calcareous. Shallow soils with some organic matter/1600 m a.s.l.
5. *M. suffruticosa* Ram. ex DC.	subsp. ***Leiocarpa*** var. ***segobricensis*** Pau	 Glabrous	 Pubescents, central hole incospicuous	Pastures and scrublands (*Cistus* sp.pl.) in open areas (climax vegetation: *Quercus suber* and *Pinus pinaster* forest)	Siliceous. Shallow soils with some organic matter/1600 m a.s.l.

it lacks preservation matters due to direct anthropogenic activities. *Medicago citrina* is an outstanding case because the variability studies have demonstrated the high genetic distance between its relatives within *Dendrotelis* Section (*M. arborea* L. and *M. strasseri*) (Rosato *et al.*, 2008) and their hybridization incapacity due to the different chromosomatic number (Juan, 2002). So far, its fodder assessment is only focused on the Columbretes Islands population; it presents the lowest portion of variability of this hexaploid species, being necessary the study of other populations.

Field assays done years ago in different places of the Valencian Community did not reported any invasive behaviour. So, in the future, we will be able to extensive use *M. citrina* (Font Quer) Greuter without any ecological and legal risk.

2. A new annual calcicolous and lesser know endemic *Lupinus*

Lupinus mariae-josephi H. Pascual is an annual Valencian exclusive endemism which has been no studied as a fodder plant due to its recent discovery (Fos *et al.*, 2006, 2007; Laguna *et al*., 2006; Navarro *et al.*, 2006). It shows an extreme case of endemic plant with fodder potential where it is necessary to complement its potential use with the natural or induced disappearance risk and its legal protection. Basic ecologic and distribution data of this threatened species are pointed out in Laguna *et al*. (2009). Unlike the other *Lupinus* species, this plant grows on less carbonated soil surfaces, but derived of carbonated rocks with pH values overcoming 7. It is very interesting due its potential in *Lupinus* crop genetic improvement.

The CIEF – Generalitat Valenciana have tuned the germination protocols of this taxon and will develop in 2010-2012 new populations establishment tests sowing pre-germinated seeds.

The biomass apparent production has important fluctuations although in good years or after favourable situations the natural populations can rise densities higher than 10,000 individuals/ha, with sizes up to 40-45 cm (op. pers.). It has been spotted in ignited areas, with high and fast nutrient availability due the ash and the punctual strong recruitment of new plants favoured by the fire effect.

In a short term the utilisation of this species in the Valencian Region is limited for its legal status (strictly protected, attached to the Valencian Catalogue of Threatened Flora Species; DOCV, 2009). The apparent localisation of new populations and the development of a preservation plan (in further years by the Biodiversity Service of the Generalitat Valenciana) will allow to reduce the protection range and will facilitate its more extensive use during the next 10-15 years.

It is also advisable to include the study of different fodder use parameters (palatability, productivity, toxicity, etc.) in further research projects.

3. Endemic and lesser known group of great *Hippocrepis*

Some scrubs offer frequently the advantage of the very low woody stem, favouring the natural selective browse in dry environments, where good plants like legumes with these traits are scarce. In its natural habitat *H. valentina* Boiss. is a rupicolous plant with scarce browse biomass but in culture condition increase its size up to 50 cm or more and shows a dense cushion form with high yield production. The risk of some species becoming weeds in cultivated conditions need a strong survey in the first phase of the field plot study, specially the ability of the plants to escape to another open area. Other problem is the risk of genetic contamination or introgression produced by free pollination or hybridization process without any control. All these problems can be minimized by previous research regarding the behaviour of controlled induced hybrids with closed relates. In the same case, the genetic distance studies can provide important information about these matters.

A good example is *Hippocrepis valentine* Boiss., traditionally included within a *Hippocrepis balearica* Jacq. group restricted to Balearic Islands, but morphological (Crespo, 2000) and

genetic differences (Roselló *et al*., 2002) are really quite important. For these reasons *H. valentina* Boiss. is revealed as a potential phytogenetic resource for a new line of perennial legumes fodder crops and a good plant for revegetation of crop marginal areas and control of soil erosion. Despite the lack of information about the chemical composition of these *Hippocrepis* group, we believe that they are very palatable plants and maybe free of antinutritive compounds (Group 3 of Table 3).

IV – Conservation network for helping perennial legumes research

The Valencian Comunity has the honor of having performed the pioneer plant protection figure of "Microrreservas de Flora" (plant microreserves) since 1994. This is a little natural reserve up to 20 ha, rich in plant biodiversity and exclusive or representative part of the regional flora. This territory can be public or private and it is permanently destined to the preservation of endangered flora, development of scientific research programs and divulgation and education activities. Legal details, design and management of this protection figure are well explained in Laguna (2001), Laguna *et al*. (2001a, 2004) and Serra *et al.* (2004). Deltoro *et al*. (2006), according to the recommendations of Dulloo *et al.* (2008) for plant genetic reserves. About 273 plant microreserves are currently legal established in the Valencian Community as a good representation of the particular Valencian flora (Laguna, 2008). For pastures ecosystems conservation, the Valencian plant microreserve net allows the possibility of establishing models to maintain natural plant communities with controlled grazing by wild or domesticated herbivorous (Laguna *et al*., 2001b; Laguna, 2005b). The plant microreserves can be a source of natural population seeds for different purposes previous authorization. Now the Valencian microreserve net protect a representative population of all the species present in Table 5 (except hybrids). In the case of *Medicago citrina*, almost all the known populations are present at least into a plant microreserve protection figures or even in another higher range protection spaces.

V – Conclusions

Perennial legumes of the Iberian Peninsula and Balearic Islands constitute a high biodiversity centre, traditionally less studied and scarcely known. A deficient botanical exploration (increased during the last years) and the lack of applied researches regarding Spanish native flora have made difficult a wide development and use of our own phytogenetic resources. Several genus such as *Medicago*, *Onobrychis*, *Hedysarum*, *Colutea*, *Hippocrepis*, *Lupinus*, *Trifolium*, etc., have many endemic taxa in our territory, but also infraspecific races and genetic lines adapted to hardy environmental conditions are present. For these reasons these plants stand as a current high valuable phytogenetic resource, as well as a good reserve for the future. Due to their high adaptability, it is foreseeable the rising of optimum results for a big demand of fodder perennial legumes beyond the pasture research, reaching the environmental and soil protection applications.

Table 5. Endemic Legumes present in the Valencian Community

Taxa (species and subspecies)	End.	Life form	Size	Habitat	Flowering	Rareza	Protec.
1. Anthyllis lagascana	2	NF	4-8 dm	MS	III-VI	RR	PNC
2. Anthyllis onobrychioides	3	CS	4-12 dm	MS,R	IV-VI	R	NP
3. Anthyllis terniflora	3	NF	3-8 dm	MS	IV-VI	M	NP
4. Anthyllis x *fortuita (A. lagascana* x *terniflora)*	1	NF	3-8 dm	MS	III-V	RR	NP
5. Anthyllis x *intermedia (A. cytisoides* x *terniflora)*	3	NF	3-8 dm	MS	III-VI	R	NP
6. Astragalus alopecuroides grosii	3	CS	1-3 dm	PS, MS	III-V	RR	VU
7. Astragalus hispanicus	3	CS	1-4 dm	MS	III-VI	R	NP
8. Astragalus monspessulanus canescens	3	HR	1-2 dm	PS	IV-VI	R	NP
9. Astragalus sempervirens muticus†	3	CS	2-4 dm	MSM	V-VII	R	NP
10. Colutea arborescens hispanica	3	MF	2-3 m	BU	III-V	M	NP
11. Cytisus heterochrous	3	MF	1-4 m	BM	IV-VI	M	NP
12. Cytisus scoparius reverchonii	3	NF	5-18 dm	MCM	IV-VI	R	NP
13. Genista cinerea ausetana	3	NF	3-8 dm	MSM	IV-VI	R	NP
14. Genista pumila pumila†	3	CP	2-4 dm	MCM	IV-VI	R	NP
15. Genista pumila rigidissima†	3	CP	1-3 dm	MCM	IV-VI	R	NP
16. Genista umbellata	4	NF	3-7 dm	MS	III-VI	RR	VU
17. Genista valentina jimenezii	3	NF	3-10 dm	MS	III-VI	R	VG
18. Genista valentina valentina	2	NF	4-15 dm	MS	III-VI	R	NP
19. Hippocrepis bourgaei	3	CS	1-4 dm	MS, PS	II-VI	M	NP
20. Hippocrepis commutata	3	CS	1-4 dm	MS, PS	III-VI	M	NP
21. Hippocrepis scabra	3	CS	1-4 dm	MS, PS	II-VI	M	NP
22. Hippocrepis squamata	3	CS	0,5-2 dm	MS, PS	III-VI	R	NP
23. Hippocrepis valentina	1	CS	1-4 dm	R	I-V	R	NP
24. Lathyrus pulcher	2	HE	3-12 dm	PVM	IV-VI	M	NP
25. Lotus carpetanus	4	HE	1-4 dm	PVM	VI-VIII	RR	NP
26. Lupinus mariae-josephae	1	TE	1-4 dm	PC, MC	IV-VI	RR	VU
27. Medicago citrina	2	NF	0,5-2 m	MNL	XII-V	RR	VU
28. Onobrychis stenorhiza	3	CS	1-4 dm	MS, PS	III-VI	M	NP
29. Ononis fruticosa microphylla	3	NF	3-12 dm	MS	IV-VII	M	NP
30. Ononis rentonarensis	1	NF	3-8 dm	MS	VII-XI	RR	NP
31. Ononis tridentata angustifolia	3	NF	3-10 dm	MSG	V-IX	R	NP

End: type of endemic plants.
1: Exclusive endemism of the Valencian Region (CV); 2: Almost exclusive endemism of the Valencian Region; 3: Iberian endemism of wide distribution well represented in CV; 4) Iberian endemism of wide distribution with isolated population.
Life form: names according to Raunkjaer (1934) in Mateo and Crespo (2009).
CP: Cushion shrub chamaephyte; CS: Shrub Chamaephyte ; HE: stem Hemicryptophyte; HR: Rosulate hemicryptophyte; MF: Mesophanerophyte; NF: Nanophanerophyte; TE: Terophyte.
Habitat: adapted from MATEO and CRESPO (2009).
BM: Mixed forest and borders; BU: Shady forests and thickets; MCM: High mountain thickets on limestone soils; MS: Dry thickets at middle-low altitudes; MSG: Dry thickets on gypsicolous soil; MSM: High mountain dry thickets; MNL: Nitrophilous coastal thickets; PS: Dry pastures; PVM: Mesophilous, cool or high mountain pastures; R: Rocky slopes and crevices.
Flowering period: I=January, ... XII=December).
Rarity: Degree according to Mateo and Crespo (2009).
RR: Very rare; R: Rare; M: Moderately frequent; C: Frequent; CC: Very frequent.
Protection degree: according to Decreto 70/2009 of Valencian Government.
From major to minor intensity: EPE: Catalogued Endangered; VU: Catalogued Vulnerable; PNC: Non-Catalogued Protected; VG: monitored; NP: Non Protected.
Systematics according to Mateo and Crespo (2009).
†Thorny plants, which browsing is limited to the stage when the plants have tender buds.

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