Dehesa ecosystem: Production and preservation

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Dehesa ecosystem: Production and preservation

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SUMMARY - The Dehesa is an ecosystem in which species of herbs, bushes and trees coexist in a semi-desert regime, contributing to the feeding of domestic and wild animals. The improvement and exploitation of these agro-sylvopastoral systems must be founded on the principles of preservation of the environment and the idea of creating systems that can be maintained with a correct usage of natural resources. Fertilization of the natural pastures, the introduction of new pasture species and varieties, the favouring of the species of bush that have a forage value and the preservation of the arboreous stratum are methods which will allow us to preserve this ecosystem.

Key words: Dehesa, pastures, forages, Iberian Peninsula.

RESUME *- "Ecosystème type Dehesa : Production et conservation". La Dehesa est un écosystème où des espèces d'herbes, buissons et arbres coexistent dans un régime semi-désertique, en contribuant à la nutrition des animaux domestiques et sauvages. L'amélioration et l'exploitation de ces systèmes agrosylvopastoraux devront être fondées sur des principes de préservation de l'environnement et dans le but de créer des systèmes qui peuvent être préservés en faisant un usage correct des ressources. Les méthodes qui nous permettent la préservation de cet écosystème sont : la fertilisation des parcours naturels, l'introduction de nouvelles espèces et variétés, l'amélioration d'espèces de buissons de valeur fourragère et la préservation de la strate arborée.*

Mots-clés *: Dehesa, pâturage, fourrages, Péninsule Ibérique.*

Characteristics and situation

There are wide extensive areas in the southwest of the Iberian Peninsula showing special and determining characteristics which gave place to a certain kind of ecosystem known as "dehesa". We have evidence of the use of the word "dehesa" since the Middle Ages (13th Century), etymologically meaning "defended, fenced and protected for the breeding and rest of labouring cattle".

We could set a definition of "dehesa" as an ecosystem in which species of herbs, bushes and trees coexist or can coexist in a semi-desert regime, contributing to the feeding of domestic (sheep, cattle, pigs, goats and equine cattle) and wild animals (big game and small game hunting), and also to the preservation of the environment, in an extensive regime. Some of the strands we have mentioned may not appear, but there will always be the herbaceous strand (pastures). Therefore we may talk of forested or unforested "dehesa".

It is a multi-productive ecosystem (agro-silvo-pastures) with an extensive character, which features herbaceous communities (not individuals) and uses the final product as a means of transformation and improvement (re-usage), assuring its perpetuity (sustained systems).

There is always a herbaceous strand (pasture), very often coexisting with arboreal species (forested "dehesa") and bushes.

There is a great variety of herbaceous species (pastures) in the "dehesa", with a marked predominance of annual over the limited number of perennial species. Herbaceous species belonging to the gramineous, leguminous, compound and other families are very abundant.

The arboreal species of the "dehesa" belong to the *Quercus* gender, of which the most common are the holm oak (*Q. ilex*) and the cork oak (*Q. suber*).

The bushy stratum, which can occasionally appear in this kind of ecosystem, can be made up of isolated species or of individuals of different species belonging to the Cistus, Rosmarinus, Quercus, Retama and Lavandulae genders, as well as other types.

The "dehesa" is populated with different kinds of species of domestic animals (sheep, cattle, pigs and goats). Autochthonous breeds are specially abundant. There are also wild species of both big game and small game hunting. The great variety and abundance of reptile species, birds and animals, with no interest from a productive point of view, is specially important.

This ecosystem makes up about six or seven million hectares in the southwest of the Iberian Peninsula, extending itself over Extremadura, western Andalusia, the south of Castilla Leon and the west of Castilla la Mancha in Spain (about 5 million hectares), as well as the Alentejo and the north of the Algarve (from 1 to 1.5 million hectares) in Portugal.

It is characterised by a semi-arid Mediterranean climate, with annual rainfall ranging between 400 and 700 mm, dry, hot summers and cold, humid winters, with a great diversity between years. Pedologically speaking, it consists of brown meridian soil over a layer of deep rock (Siberian and igneous rocks), easily erodible and poor in nutrients. The original soil is acid although there is a reduced surface of "dehesa" over basic soils in the province of Cadiz.

This physical environment, together with the animals and vegetables that make up the "dehesa", give it its characteristic frailty, low fertility and low profitability.

Creation

The "dehesa" results from the continuous strain of cattle against the recession of the environment in an extensive regime (San Miguel, 1995). At the same time, man's technology, primitive in the beginning and developing with time, but always rationally controlled (correct pasturing, furnishing the soil with nutrients, progressing in the working of machinery, etc.), has contributed to maintain the woody and bushy vegetation in the areas destined for them, thus creating high quality pastures, together with the presence of scattered trees and a controlled number of bushes (areas of maximum slope, erodible, protected areas, etc.).

The phases gone through in the creation of the "dehesa" are: (i) clearing of the forest; (ii) control of wooden vegetation (trees and bushes) and establishing of pastures; and (iii) improvement of pastures.

In many "dehesas" these steps have already been taken, totally or partially. Perhaps in the old times it was necessary to go through all three of them, and even today there are certain areas where the three of them must be used, but in most "dehesas" it is the first step which must be applied or which is being applied continuously. Sometimes it is necessary to apply the second and third phases, and it is even possible to think that these two steps (especially the second one) can be reversible if a correct and successive technology is applied.

The improvement and exploitation of these agro-silva-pasture systems must be founded on the following principles: the need to watch for the preservation of the environment and the idea of creating systems that can be maintained with a correct usage of natural resources.

Therefore the "dehesa" must be populated by animals (both domestic and wild) which can profit from it, while, at the same time, forming the basis of its correct preservation. The pastures or herbaceous strata are the most important components of this double (and at the same time complementary) aim, and they must therefore be looked after with special care.

The pastures

The main characteristic of the pastures of the "dehesa" is low production, due, as always, to the climate. The diversity of rainfall in one year, as well as in between years, with spring making up to as much as 70% of the year's total production,scarce or almost non-existent production during autumn and

winter and very strong contrasts between different years, all add up to form the most important production characteristics, generally speaking, of the southwest of the Iberian Peninsula.

We may find this productive diversity of pastures within very short geographical distances, with differences even reaching more than 250% as five year average in different tests (Olea *et al.*, 1989). The annual average production of these pastures is about 1,440 kg DM ha^{-1}, although there are huge oscillations depending on different pedologic and climatological factors (Olea *et al.*, 1989). At the same time, natural pastures are in general of a poor quality, thus negatively conditioning animal production and handling systems.

Analyses of quality have been carried out by calculating the degree of brute protein that the pastures contain, as well as by measuring the digestibility of organic matter (DOM) and, indirectly, by measuring the proportion of leguminous plants present in the total production output. The average annual results for the southwest of Spain are shown in Table 1.

Table 1. Average annual results for the southwest of Spain

Natural pastures	Brute proteins			DOM			% of leguminous		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
	14.8	8.5	10.3	63.3	49	55.2	24	4	8.5

Due to the low quality values shown by these tests, usage of this pasture for ruminants during the months of June to December is very limited, thus conditioning handling systems, and giving maintainable forage, trees (fruits from *Quercus ssp.* during autumn and winter) and bushes which can be used for forage, a very important role to play in cattle feeding.

The limited production of the pastures of the "dehesa" makes the improving of the quantity as much as the quality of production necessary. This improvement must include a set of integrated actions with the aim to obtain: (i) an increase in production output, in terms of quantity as well as in quality; and (ii) an increase in the vegetal covering of the soil, while maintaining biodiversity.

It seeks a growth in the quantity of production through seasonal increases during critical periods of time, as well as an important improvement in quality, thus allowing a better handling of natural resources and saving of those foods that complete the system, plus an improved vegetal covering of soils, specially during critical times when the risk of erosion is highest. These measures must persist for a certain number of years, always holding sufficient levels of production.

Methods of pasture improvement can be such as the following: (i) fertilisation of natural pastures with a correct handling; and (ii) introduction and fertilisation of varieties and species with a correct handling.

The choice of which method should be used depends on: (i) productive potential; and (ii) components of the natural flora.

Methods of improvement by fertilising natural pastures must be employed on soils with very little productive potential and hard climate (except rain and cold), that is, as long as there is an abundance of flora or, at least, there are enough components which are interesting from a pasturing point of view (leguminous species, high quality gramineous species, etc.). In areas with a higher productive potential, totally lacking adequate flora, with recently ploughed soils and terrain where previous extensive cropping has been abandoned, it is advisable to improve pastures by introducing new species and fertilising.

Fertilisation of natural pastures

Fertilisation and correct handling of the existing natural pastures is very useful provided that the flora is adequate, that is to say, when the productive potential is high enough to compensate fertilisation. It is important to point out that any fertilisation must be carried out according to correct technical indications, together with a proper handling.

The influence of nutritional factors is determining upon the nature and profitability of the pastures (Jiménez Mozo and Martínez Agrella, 1982). These soils are characterised by low content of organic matter and extractable phosphorus. The level of nitrogen content is not high enough to satisfy the demands of gramineous pastures, which indicates the low contribution from spontaneous leguminous species. The kinds of fertilisation most commonly used are mainly phosphoric with important residual effects and always seeking minimal use of nitrogen. We can recommend the following doses for this area:

First year: 27 UF P2 O5 ha^{-1} (equivalent to 150 kg ha^{-1} of superphosphate of lime at 18%).

A research project is currently being carried out seeking to obtain a better understanding of the strategy of phosphorus usage on pastures (method and time of application) and other forms of ecological phosphorus.

The need of potassium in this kind of pastures is greater in granite soils. Jiménez Mozo and Martínez Agrella (1982) have estimated that 20 or 25 UF of K2 O ha^{-1} per year are enough to satisfy this need in shepherding conditions.

Regarding oligo-elements and secondary elements which must be provided to these pastures, many researchers have pointed out the importance of supplying calcium and molybdenum, and, more recently, other elements such as sulphur, but tests using this element have given diverse results, many of them highly disputable. Studies carried out by Moreno *et al.* (1994) on different annual leguminous species by controlling leaf content and productive response confirm this diversity of results in the "dehesa".

Introduction of species and varieties and fertilisation

This consists of the introduction of pasture species and varieties designed to endure and to improve the output of forage production. This kind of improvement, given that the new species and varieties are introduced together with correct fertilisation and proper handling, are of great importance to the whole southwest of the Iberian Peninsula, as the annual leguminous is its most important component.

The utilisation of perennial gramineous species such as the "dactilo" (*Dactylis glomerata*), "falaris" (*Phalaris aquatica*), "festuca" (*Festuca arundinacea*), etc. currently occupy a secondary place, due to the initial low fertility of the soils, thus making it necessary to recover them first with leguminous plants. In addition, their utility will always be less generalised.

Annual leguminous species

**Subterranean clover (Trifolium subterraneum): Three subspecies*

A mixture of 3 to 5 well chosen varieties must be used, always suited to the characteristics of the environment into which they are going to be introduced. Generally speaking, the varieties of subterranean clover that have worked best in the southwest of Spain (research results from the past six years) have the following characteristics: (i) short to medium vegetative cycle; (ii) great capacity of seed production and very hard seeds; and (iii) long flowering length.

The Department of Pastures and Forage of the SIA of Extremadura has obtained and commercialised through its genetic improvement program six varieties of Subterranean clover which fulfil satisfactorily these conditions (González López, 1994) (Table 2).

Table 2. Pasture leguminous species in the selection program of the SIA of Extremadura

Species	Subspecies	Varieties
Trifolium subterraneum	subterraneum	Coria†, Areces†, Cubillana†, Zujar†
Trifolium subterraneum	brachycalcinum	Valmoreno†, Gaitan†
Hedysarum coronarium	-	Late-creeping††, Early-erect††, Late-erect††
Medicago polymorpha	inermis	1 variety††
Trifolium glomeratum	-	2 varieties††
Ornithopus compressus	-	1 variety††

† Commercialised; †† Final phase of selection

Other annual leguminous species

We include in this group a number of leguminous species which are important in natural pastures once they have been improved and properly selected. Specially important are the following:

Trifolium glomeratum: The varieties to be used must be greatly productive and of little seed hardness. Two varieties appear in the final selection (Table 2).

Ornithopus compressus: The same usage criteria as the above.

Medicago polymorpha and *Medicago murex*: Using long cycle varieties (Table 2). Also using adequate Rhizobium.

Other Medicagos very interesting for basic soils, such as *M. truafula*, *M. rugosa*, etc.

Trifolium michelianum: Specially the Paractana variety, very interesting for acid and calcidic soils (Crespo, 1993).

Other *Trifolium* such as *hirtum, incarnatum, striatum*, etc., all of them of great interest.

Hedysarum coronarium: *defectorea* variety, for basic soils.

Where fertilisation is concerned we can make the same commentaries as for natural pastures.

Applying the improvement methods shown, contrasting results have been obtained in different areas of the southwest of Spain, results that can be analyzed from the points of view of quality and quantity.

The average response to these improvements in real conditions of the southwest of Spain (Olea *et al.*, 1989) is shown in Table 3.

Table 3. Average response to the improvements of real conditions in southwest Spain

Kind of pasture	Response			Annual production kg DM ha^{-1}
	Min.	Max.	Aver.	
Natural fertilised pasture	25%	110%	55%	2.238
Introduced pasture	23%	144%	86%	2.670

Pastures improved by any of the two methods shown have acceptable quality (measured by the level of brute protein, the DOM and, indirectly, by the percentage of leguminous produced) and superior to the natural unimproved pasture. The maximum, minimum and average annual weighted results (over 12 areas) are shown in Table 4.

This quality reaches its maximum at the beginning of the vegetative cycle, decreasing at the end, when the pasture dries up.

Arboreous stratum

Around 50% of the surface of the "dehesa" (Spain and Portugal) is tree covered, forming scattered forests or groups of quercines. Holm oak (*Q. ilex*) and cork oak (*Q. suber*) are the most abundant species

of trees. In other areas, such as those with basic soils and warmer climate, or "dehesas" with a colder climate in winter, etc., other species of *Quercus* may also appear, such as the Q. *pyrenaica*, the Q. *lusitanica*, etc.

Table 4. Maximum, minimum and average annual weighted qualities (12 tests and 5 years) in the southwest of Spain

Kind of pasture	% of leguminous			% Brute Proteins			% DOM		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
Natural	24	4	8.5	14.9	8.5	10.3	63.3	55	2
Fertilised	48	12	18	17.8	9.7	11.6	68.4	55.0	58.9
Introduced	70	9	36	19.2	9.2	13.6	69.6	54.0	62.5

The arboreous stratum of the "dehesa" contributes to maintaining the stability of the system, decreases the risk of erosion, becomes part of the feeding process for animals in extensive systems and, generally speaking, is of great environmental importance.

This scattered and open forest must be integrated with pastures in order to obtain a stable unitary system, which for both stratums is the result of the above mentioned pressure of cattle. It is therefore very important to obtain an adequate arboreous density, reaching thus the optimal climate for a "dehesa". This density varies with the ecological characteristics (soil, weather, etc.) of a given place, as is well known to scientists. The ideal recommended density can range from 30 to 150 trees ha^{-1}, depending on the environmental characteristics. An average density figure can be 50 to 70 trees ha^{1} .

The tree-pasture-animal interaction is in many ways positive, and it is very convenient to study and handle it correctly, because the consequences in the production output, as well as to the vegetal surface and environment preservation, can be very dramatic and only slowly reversible.

The arboreous stratum has many positive effects on pasture, such as increasing the fertility of the soil, improving climatic conditions, etc.

The bushy stratum

This appears in many different ways, both in the composition of the flora and its actions, and therefore also in its concepts and treatments. There can be areas where its presence is beneficial whatever the composition of the flora may be, due to environmental reasons (flora, fauna, biodiversity, etc.), and there are other areas where its presence is not advisable if the species cannot be used for animal feeding.

Species belonging to the *Cistus, Lavandulae, Quercus, Retama*, etc. genders are the most important components of the bushy stratum of the "dehesa". Generally speaking, we may say that the bushy stratum is more important from an environmental point of view than from an alimentary one.

It is important to select and favour those species that have a forage value, specially those native to these ecosystems, because they can be part of a supplementary food storage for animals in times of low pasture production, as well as fulfilling environmental needs of preservation, especially in certain areas and strategic spots of a "dehesa" (steep slopes, places where animals shelter, etc.).

Preservation of the "dehesa"

Generally speaking, the "dehesa" is well preserved, perhaps one of the best preserved in the Mediterranean. Only in certain areas and in specific conditions we can find a risk of degradation and erosion.

Studies carried out by a team from the Faculty of Geography in Caceres, the SIA of Extremadura and also by the EIA of Badajoz, prove that the greatest risks come from hydraulic erosion in autumn and winter and from degradation of the vegetal cover due to bad planning in farming and agriculture.

The presence of a dense, abundant and well used vegetal cover is of the greatest importance to reduce these risks.

The technical activities that are being carried out in the "dehesa" have a huge impact on the vegetal cover throughout the year (Table 5).

Table 5. Increase in vegetal cover (%)

Treatment	November	February	March	April
Ploughed	---	---	---	---
Introduced and fertilised pasture (first year)	18	76	83	99
Burnt	25	68	74	79
Fertilised natural pasture	82	95	97	99

Traditional agricultural labours keep the soil uncovered for long periods of time, increasing the risk of erosion. During years with high levels of annual rainfall (1990/91) this risk increases in all activities.

Autumn is the season in which this risk is highest, specially in rainy years.

Therefore, having a dense vegetal cover is very important in order to produce more and preserve better. This cover is specially important during the months of autumn.

Usage and handling

Usage and handling of these pastures is very important and the consequences to production and preservation can be of great significance, so they must be submitted to the technical considerations that we have explained. Handling, from a shepherding point of view, must grant maximum technical and economical efficiency in the exploitation of the occupied surface, as well as in environmental preservation.

Australian bibliography (Quinlivan, 1975; Ewing, 1972) and our own experience and research on handling of improved dry pastures, such as the ones we are reviewing, firmly recommend continuous or deferred shepherding, always avoiding strong pasturing pressure during spring (time of flowering). It is sometimes advisable to reserve the grazing pasture during spring and autumn, once every certain number of years, so as to obtain a better production of seeds and implantation.

We would also recommend shepherding that maintains the animals on the pastures for as long as it is possible, reducing in this way the leak of nutrients from the system. Exploitation must be carried out "very well" in winter and "very badly" in spring (Table 5).

This deferred shepherding on quality pastures (with a high level of leguminous species) provides an important production in spring, thus allowing its usage in critical times (summer and autumn-winter) as pasture and seeds, and it is therefore important to adjust the system according to this pasturing cycle. The aim is the best exploitation possible of natural resources, so it is logical that the times of maximum production and maximum grazing requirements should coincide. That way the remains of spring pastures (pasture and seeds) can be used for animal feeding in autumn and winter, thus achieving the minimal exterior dependence of the system. This usage is possible in summer and autumn if pastures are of a high quality; with low quality natural pastures, losses and rejection would be great, making it impossible to establish this handling philosophy. Obtaining quality pastures with high annual protein (18%) and DOM (63%) values can maintain the animals with "offers" of around 500 kg DM per sheep and year, while with low quality pastures (12% Brute Protein and 45% DOM) it is necessary to "offer" more than 830 kg DM per sheep and year (Olea *et al.*, 1989).

With this handling, vegetation will be more and more productive, and, without losing its biodiversity, will be more firm and "rooted" in the soil (greater vegetal cover), constituting a harmonic unity with trees and bushes (if there are any) which contributes to the seasonal feeding of wild, as well as domestic, animals.

Sometimes this unity of pasture, trees and bushes can produce a limited output in critical times of the year (summer and winter), making it necessary to use forage crops, forage bushes, leaves and tree fruits (Quercines) and even extensive crops (cereals and grain leguminous). If it should be necessary to use forage or extensive crops, they must be used in those areas of the "dehesa" which are the most adequate for them (gentler slopes, better soils, etc.). Species such as cabbage, oats, lupine, Italian ray-grass, etc. are interesting to use as forage in critical periods.

The primary aims of these ecosystems must always be to focus on being self-sufficient and sustainable.

Future prospects of the "dehesa"

The "dehesa" ecosystem is one of the best preserved in the world in these environmental conditions, but it is necessary to establish more firmly, if that be possible, the double role that must be played by the farmer of this area: (i) as a producer (traditional crops and other productions); and (ii) as a protector of the environment and of the landscape.

This is only possible with a high level of "extensification" of the system, and the "dehesa" which is already, to a certain extent, set in that frame, plays and must play an important role, even a leading one. In this sense, one can say that the "dehesa" (including areas of marginal crops which are being incorporated) must have as objectives of usage: (i) to extend and diversify the flora - biodiversity; (ii) to make maximum usage of natural resources (pastures, trees, bushes, etc.); (iii) to diversify traditional productions (meat fed with pastures, Iberian pork, cheese, honey, pollen, etc.) and non traditional products (hunting, fishing, country tourism, etc.); and (iv) to provide quality and elitist products.

In other words: we must not produce more but cheaper, diversifying and preserving the ecosystem.

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