Sustainability of organic and conventional beef cattle farms in SW Spanish rangelands ('Dehesas'): a comparative study

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Abstract

Organic production in Spain has increased substantially in recent years due to several factors, such as the growing interest of the European Union towards preserving sensitive ecosystems; the potential role of organic production in the socio-economic development of rural areas and the growing consumers' demand for safer and higher quality foods.
Within this framework, this paper analyzes the beef sector of SW Spanish rangelands (dehesas). These are traditional systems characteristic of the Iberian Peninsula where native herbaceous vegetation and evergreen species of Quercus provide the basis for extensive beef farms. Although traditional management in dehesa farms is of vital importance for the sustainability of this particular ecosystem, in the last years many farms have turned to organic production, trying to take advantage both of new subsidies and of new market trends.With this study, we try to evaluate the sustainability of conventional and organic beef production systems in dehesas in Extremadura (SW Spain), trying to determine the level these systems are contributing both to the preservation of this sensitive ecosystem and to the socioeconomic development of the region. To this end, we apply a methodological adaptation of the MESMIS methodology to 90 dehesa beef farms located in Extremadura (SW Spain). MESMIS is based on the evaluation of basic attributes of sustainability that allow one to make a simultaneous and comparative analysis of different types of farms.
It has been found that organic farms are the most sustainable, obtaining higher scores than conventional farms in stability and self-reliance, and similar scores in productivity, adaptability, and equity. Organic dehesa beef farms show little dependence on external products and services and are more adapted to their environment (lower stocking rates for an optimal use of the system's feedstuff production), those being the clues for their enhanced sustainability.

Introduction

The Spanish 'dehesa' is an agroforestry system that is characteristic of the SW Iberian Peninsula (Figure 1) where native herbaceous vegetation and evergreen species of the genus Quercus provide the foundation for extensive farming enterprises that mainly include beef cattle but also sheep and Iberian pigs (Gaspar et al., 2009). This ecosystem occupies a wide area in Spain, with approximately 5.8 million hectares (ha) and 0.5 million ha in Portugal (Joffre et al., 1999).

Dehesa soils are acid, shallow, sandy loams of low fertility because of insufficient organic matter and a marked lack of phosphorus. The climate is continental Mediterranean, with long, hot and dry summers (July temperature is usually over 26ºC, the maximum often surpassing 40ºC); and mild winters with a mean temperature of 7.5ºC. The annual mean temperatures vary between 16ºC and 17ºC. Annual rainfall has an irregular pattern and varies between 300 mm and 800 mm, with large variations between years (Espejo & Espejo, 2006).

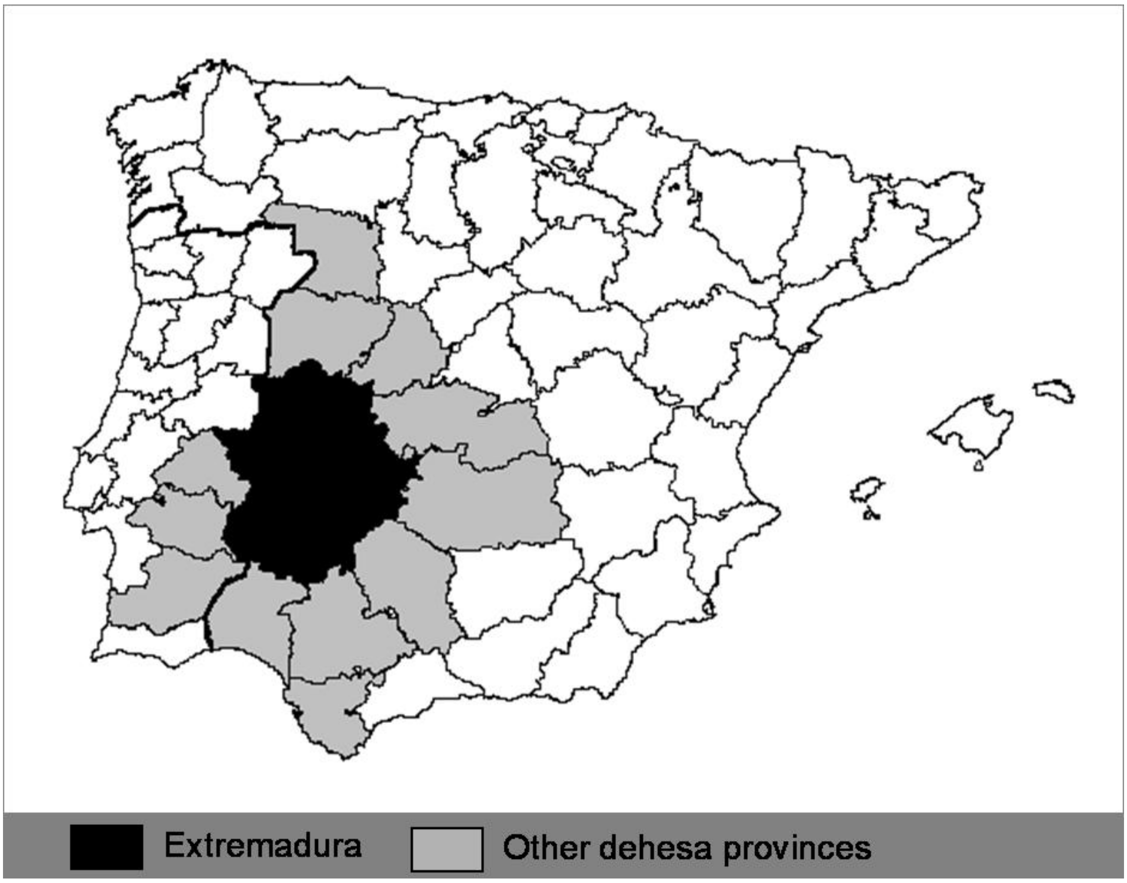

Figure 1: Dehesa location in Spain and Portugal.

The origin of these systems is human intervention in the natural Mediterranean forest. Man's cultural practices in these woodlands have eliminated the shrub layer and cleared the arboreal stratum to allow the growth of pasture for livestock. Indeed, human intervention has been essential to maintaining the dehesa ecosystem as such, since the use of appropriate cultural practices (such as a level of grazing suited to the system carrying forage production or forest regrowth) maintains the wooded layer, thus avoiding shrub invasion and increasing the system's efficiency (Coelho, 1992).

Sometimes, human intervention can also have negative effects, mainly due to overgrazing. This has been the case due to the Common Agricultural Policy (CAP) reforms of 1992 and Agenda 2000 which have led to certain negative changes as some farms have become more intensified (Escribano et al. 2001, 2002). The 1992 CAP reform linked livestock subsidies to the animal, inducing the farmers to increase the stocking rate of their farms in order to maximize the amount of subsidies. This was possible because the maximum stocking rate fixed by this reform (1.4–1.6 Livestock Units/ha) was far higher than average rate of dehesa farms (0.37 LU/ha).

Traditionally, dehesa livestock farming systems are based on different agricultural uses such as livestock, crop farming (oats, barley and peas, mainly for re-use as animal feed), hunting and forestry (cork and firewood). This system commonly includes a mixture of different livestock species (beef, sheep and pigs) grazing together for a better use of the natural resources and raised for extensive meat and live animal production. The diversity and the integration of these activities has been decisive to the economic and environmental persistence of dehesa farms (Olea and San Miguel-Ayanz 2006; Ronchi and Nardone 2003).

This ecosystem and the livestock systems of dehesa allocated in SW Spain play an important environmental and social role, as they contribute to fix rural population, also increasing rural incomes and maintaining this characteristic natural and cultural heritage.

However, in the last years, and due to the strong increase in input prices and the above mentioned intensification, the system has shown a clear loss of sustainability. This fact has also occurred in other farming systems, in which the intensification aimed at increasing productivity and reducing costs led to a loss of competitiveness of the traditional livestock systems as they became estranged from their previous semi-natural rearing conditions (Thompson, 1997; Napolitano et al., 2005).

Within this context, many farms have turned to organic production, trying to take advantage both of new subsidies and of new market trends. The ecosystem's characteristics allow an easy conversion to organic production of dehesa beef farms. In fact, in the region under study we can find at present 103 organic beef farms (4.27% of Spanish organic beef farms and 7.86% of organic cows) (MARM, 2010). These figures reflect a growth in accordance with that of the Spanish organic sector, which grew around 52% in the last decade.

Taking into account the aforementioned importance of the dehesa ecosystem, and the role of cattle in its preservation, the comparative assessment of the sustainability of conventional and organic farms has a great interest. It will allow us not only to forecast the chances of survival of farms, but also how to fulfill the society's demands, taking into account the farms' characteristics, the market trends and the foreseeable scenarios with the upcoming CAP. To this end, we apply a methodological adaptation of the MESMIS methodology to 90 dehesa beef farms located in Extremadura (SW Spain). MESMIS is based on the evaluation of basic attributes of sustainability that allow one to make a simultaneous and comparative analysis of different types of farms in order to develop sustainability indices that can be easily understood by farmers and managers and that might be used in their decision making related to the livestock sector and local development.

The study will analyze the role of these farms in the preservation of a sensitive ecosystem and their contribution to the socio-economic development of the region. Finally, it will let us know if it would be possible to continue with this type of production, taking into account the features of this particular area.

2. Methodology

2.1. Study area and data collection

The study area was the region of Extremadura. It has a low population density, and approximately 2.2 million ha (more than 50% of the utilized agricultural area) is considered to be dehesa.

The data used in this work were collected by means of questionnaire surveys of holders of dehesa farms in Extremadura conducted in 2011. The sample consisted of 90 dehesa beef farms (45 organic and 45 conventional). The farms selected were representative of the different subsystems found in the dehesa area, and they were selected at random following forestry, livestock, and economic size criteria.

2.2. Evaluation of the Farms' Sustainability

We have carried out the evaluation of sustainability of dehesa beef farms applying the adaptation of the Framework for the Evaluation of Management Systems incorporating Sustainability Index (MESMIS) (Masera et al., 1999) to dehesa systems developed by Gaspar et al. (2009).

The MESMIS methodology is based on six principal steps. The first three steps are devoted to characterizing the systems, identifying critical points, and selecting attributes that can be obtained through the sample and which are relevant for the deep analysis and accurate assessment of the sustainability. These attributes will then be used to create, define and calculate specific indicators which allow us to evaluate the sustainability of farms as a whole: from an economic, social and environmental view. In the last three steps, the chosen indicators are integrated (through qualitative, quantitative, or multiple-criterion techniques) in order to obtain a specific value that measures the sustainability of the system.

Our evaluation was based on five basic attributes of sustainability that will be described below. They were chosen as being the attributes that most coincided between authors and the best suited to the needs and characteristics of the present study. In the following paragraphs we shall describe the attributes chosen, whose indicators are shown in Table 1.

Adaptability or Flexibility: This is the system's capability to continue being productive when faced with changes in the environment, such as a new economic scenario. In this sense, it is important to mention that extensive livestock farms linked to land (like dehesa farms) present critical points that may hinder their adaptability, such as the fragile equilibrium and their dependence on suited land uses and on livestock-linked subsidies.

Self-Reliance: This is the system's capacity to regulate its interactions with the outside. For measuring this capacity, we first needed to know the farms' dependence on external inputs and subsidies. The smaller the need for purchases and subsidies, the more self-reliant the system is.

Equity: This is the system's capacity to distribute fairly, both intra- and intergenerationally, the profits and costs related to the management of its natural resources (Masera et al. 1999; Lopez-Ridaura et al. 2002). This attribute refers to the income distribution in the production systems. Equity has been identified as one of the socioeconomic properties that socially sustainable agroecosystems have to fulfill (Okey, 1996)

Stability: This term refers to the system's property of possessing a state of dynamic economic stability and the system's capacity to overcome changes in the environment (Okey, 1996). It implies that it is possible to maintain the profits provided by the system at a nondeclining and constant level (without many oscillations) over time. It is normally associated with the notion of constancy of output (or profits).

Productivity: This is the capacity of the agroecosystem to provide the required level of goods and services. It represents the value of the attribute (yields, earnings, etc.) in a given period of time. The economic indicators considered within this attribute were mainly income and balancing indicators (value added, net operating surplus, entrepreneurial income, and profitability rate) and the basic indicator of gross output.

Table 1 presents all the indicators used, together with their units.

Table 1: Indicators selected for each attribute, and their units.

Attributes	Indicators[1]	Units
Adaptability	Wooded UAA per total UAA	%
	Pasture UAA per total UAA	%
	Subsidies per total income	%
	Cows per bull	Cows
	Level of studies	Nº
	Number of activities	Nº
	Farmer's age	Years
Self-reliance	Owned UAA per total UAA	%
	Cultivated UAA per total UAA	%
	Animal feedstuff	€/ha
	Veterinary expenses	€/ha
	Intermediate consumption[2]	€/ha
Equity	Total AWU per 100 ha UAA	AWU/100 ha
	Permanent AWU per 100 ha UAA	AWU/100 ha
	Temporary AWU per 100 ha UAA	AWU/100 ha
	Family AWU per 100 ha UAA	AWU/100 ha
	Total AWU per 100 cows	AWU/100 cows
Stability	Total stocking rate	LU/ha
	Land fixed capital	€/ha
	Breeding livestock fixed capital	€/ha
	Percentage of autochthonous cattle	%
	Percentage of autochthonous sheep	%
	Percentage of Iberian pigs	%
Productivity	Sales of livestock	€/ha
	Other sales	€/ha
	Net value added[3]	€/ha
	Net operating surplus[4]	€/ha
	Net entrepreneurial income[5]	€/ha
	Replacement rate	%
	Mortality rate	%
	Calves weaned per cow	%
	Lambs weaned per ewe	%
	Piglets weaned per sow	%

[1] UAA indicates utilized agricultural area; LU, livestock unit; and AWU, annual work units.
[2] Value of all goods and services used as inputs in the production process, excluding fixed assets whose consumption is recorded as fixed capital consumption.
[3] Measures the value created by all the agricultural output after the consumption of fixed capital. That output is valued at basic prices and intermediate consumption is valued at purchaser prices.
[4] Measures the yield from land, capital, and unpaid labor. It is the balance of the generation of income account, which indicates the distribution of income between the factors of production and the general government sector.
[5] Obtained by adding the interest received and then deducting rent (i.e., farm and land rents) and interest payments, measures the compensation of unpaid labor, remuneration from land belonging to units, and the yield arising from the use of capital.

2.3. Computation of Sustainability Indices

The following phase consisted of transforming the values obtained for the different indicators into homogeneous sustainability indices. This involves identifying their maximum possible or optimal values with respect to sustainability, and their required or acceptable minimum values.

In the present work, we established certain optimal values for each indicator, selecting in each case the maximum, minimum, or percentiles of the sample according to both the opinion given by experts in the field whom we consulted and the literature reviewed. Subsequently, we applied a methodological adaptation of the AMOEBA method (Ten Brink et al. 1991) to establish series of criteria to transform the original indicator values into percentage-of-sustainability indices to be applied to each farm. Finally, each farm is assigned a score for each attribute of sustainability, calculated as the mean of its corresponding indices. After that computation, the more closely the index approaches 100%, the greater the farm's sustainability.

3. Results

Table 2 gives the mean values obtained for each of the selected sustainability indicators, classified according to attribute for the two farm groups (conventional and organic).

Table 2: Mean values of the sustainability indicators for the two farm types.

	Indicators	Organic (n=54)	Conventional (n=58)	Optimal	Criteria[1]
Adaptability	Wooded UAA per total UAA	0.59	0.64	1.00	Max.
	Pasture UAA per total UAA	0.41	0.35	0.00	Mín.
	Subsidies per total income	0.34	0.39	0.26	C25
	Cows per bull	26.14	27.40	18.00	C25
	Level of studies	3.33	3.77	5	Max.
	Number of activities	1.90	1.90	5	Max.
	Farmer's age	47.22	47.85	30.00	Rec.
Self-reliance	Owned UAA per total UAA	0.62	0.65	1.00	Max.
	Cultivated UAA per total UAA	0.13	0.08	0.30	P90
	Animal feedstuff	54.16	71.50	9.71	C25
	Veterinary expenses	4.13	7.82	1.95	C25
	Intermediate consumption	113.51	131.21	52.63	C25
Equity	Total AWU per 100 ha UAA	1.09	0.85	1.16	C75
	Permanent AWU per 100 ha UAA	0.17	0.16	0.20	C75
	Temporary AWU per 100 ha UAA	0.13	0.10	0,33	P90
	Family AWU per 100 ha UAA	0.79	0.60	0.78	C75
	Total AWU per 100 cows	2.80	2.40	3.49	C75
Stability	Total stocking rate	0.45	0.47	0.33	Rec.
	Land fixed capital	4063.79	4135.12	4188.60	C75
	Breeding livestock fixed capital	243.61	211.80	356.83	C75
	Percentage of autochthonous cattle	0.30	0.23	1.00	Max.
	Percentage of autochthonous sheep	0.91	0.90	1.00	Max.
	Percentage of Iberian pigs	0.96	0.94	1.00	Max.
Productivity	Sales of livestock	216.62	227.40	378.07	P90
	Other sales	20.81	10.10	57.66	P90
	Net value added	200.61	249.61	425.07	P90
	Net operating surplus	259.60	320.70	536.81	P90
	Net entrepreneurial income	237.20	294.85	497.04	P90
	Replacement rate	11.47	14.37	10.00	Rec.
	Mortality rate	0.04	0.04	0.00	P10
	Calves weaned per cow	0.76	0.80	0.95	P90
	Lambs weaned per ewe	0.88	1.10	1.26	C75
	Piglets weaned per sow	10.65	9.76	13.33	C75

[1] max., maximum value; min., minimum value; C75, upper quartile; C25, lower quartile; P90, 90th percentile; P10, 10th percentile and rec., experts' recommendation.

Table 3 presents the calculated sustainability indices, with values that can range between 0 and 100 such that the closer to 100, the better the farm in terms of sustainability. Table 3 also shows the results of the Analysis of Variance, which was applied to the sustainability indices to determine if significant differences in the sustainability indices between organic and conventional beef farms were found.

Table 3: Mean values and significance of the sustainability scores for the four farm types.

	Indicators of sustainability (%)	Organic (n=54)	Conventional (n=58)	Signific.[1]
Adaptability	Wooded UAA per total UAA	62.61	58.80	
	Pasture UAA per total UAA	60.78	59.46	
	Subsidies per total income	62.61	66.82	
	Cows per bull	68.58	64.87	
	Level of studies	66.53	75.38	
	Number of activities	37.96	38.08	
	Farmer's age	65.08	66.50	
	ADAPTABILITY	61.90	63.04	
Self-reliance	Owned UAA per total UAA	56.13	70.25	
	Cultivated UAA per total UAA	21.90	28.92	
	Animal feedstuff	50.70	36.03	
	Veterinary expenses	67.79	43.19	***
	Intermediate consumption	63.81	55.09	
	SELF-RELIANCE	52.79	50.83	
Equity	Total AWU per 100 ha UAA	66.57	52.49	*
	Permanent AWU per 100 ha UAA	26.54	36.78	
	Temporary AWU per 100 ha UAA	10.16	9.70	
	Family AWU per 100 ha UAA	50.12	42.12	
	Total AWU per 100 cows	68.54	56.26	*
	EQUITY	62.49	51.41	*
Stability	Total stocking rate	70.84	68.15	
	Land fixed capital	93.23	90.32	
	Breeding livestock fixed capital	57.36	48.72	
	Percentage of autochthonous cattle	31.70	22.08	
	Percentage of autochthonous sheep	80.82	99.80	
	Percentage of Iberian pigs	95.89	94.44	
	STABILITY	65.32	59.68	
Productivity	Sales of livestock	48.62	54.81	
	Other sales	19.45	14.64	
	Net value added	54.79	50.69	
	Net operating surplus	51.20	50.58	
	Net entrepreneurial income	49.59	49.65	
	Replacement rate	51.54	50.23	
	Mortality rate	43.19	26.00	
	Calves weaned per cow	77.34	83.33	
	Lambs weaned per ewe	62.30	84.05	*
	Piglets weaned per sow	83.39	62.28	
	PRODUCTIVITY	50.27	48.59	

[1]*P,0.05, **P,0.01, ***P,0.001.

Adaptability. As can be observed in Table 3, there are no significant differences for the attribute Adaptability between organic and conventional farms. The only indicator that showed bigger difference was "Level of studies" which rated higher for the conventional than for the organic farms, as usually conventional farms are bigger and can afford professional managers.

Self-Reliance. Although with no significance, some differences were found between the two types of farms regarding to their self-reliance that deserve some comments. The main differences correspond to their expenses (veterinary and feedstuff) and their intermediate consumption, all of them favoring organic farms. In general terms, organic farms (with lower stocking rates) have less intermediate consumption and need less feedstuff to buy, so that they would be more sustainable in regard to this attribute. Regarding veterinary expenses, organic farms are more dependent on natural medicines, which usually are cheaper than modern medicines.

Equity. It is the only attribute that shows significant differences, with organic farms being more equitable. Conventional farms are those with the most permanent labor, and therefore contribute most to stable employment, whereas in organic farms the income distribution is less equitable, being fundamentally to family labor. Nevertheless, the organic group is that which uses the most labor (both per animal and per ha) so that it is the group that scores the highest in Equity.

Stability. Although organic farms were found to be more stable than conventional ones, the difference is not significant. As the indicators for this attribute show the system's capacity to maintain the profits provided by the system at a nondecreasing level over time, under normal or average conditions, the stocking rate plays an important role. The maintenance of a stocking rate that is suited to the resources provided by the system will clearly contribute to stability, and in this sense organic farms are the most sustainable in terms of this indicator.

Productivity. As can be observed in Table 2, conventional farms are more productive than organic ones. This is balanced by the higher value of "Other sales", linked to the multiple activities of these farms.

4. Conclusions

The indicator-based comparative evaluation of the sustainability of organic and conventional beef farms has allowed us to establish levels of sustainability in technical, economic, social and environmental terms for both organic and conventional dehesa systems in Extremadura. Organic dehesa farms have been found to be the most sustainable, obtaining higher scores than conventional farms in stability and self-reliance, and similar scores in productivity, adaptability, and equity. Organic dehesa beef farms are systems that depend little on external products and services (intermediate consumption and veterinary expenses are lesser than in conventional farms) and which are more adapted to their environment (lower stocking rates), those being the clues for their enhanced sustainability.

The present context, with the uncertainties about the EU's subsidies (just some organic farms are getting subsidies due to this activity), the new trends of the CAP (lower stocking rates, environmentally friendly production systems) and the increasing price of feedstuff and labour, draws a promising future for organic dehesa beef farms in Extremadura. Nevertheless, these farms must overcome some important issues such as the fattening of organic calves (almost nonexistent today), the production of their own feedstuff and the adoption of more environmentally friendly agricultural practices.

References

Coelho, I.S. (1992). Valores económicos e ambientais do montado. In: Temas de Economia e Sociologia AgrÁrias. Intituto Nacional de Investigac¸ao AgrÁria, Lisboa: 17-43.

Escribano, M., Rodríguez, A., Mesías, F. J. & Pulido, F. (2001). Farm size effect on economic indicators in extensive sheep farms. Livestock Research for Rural Development 13: 1-6.

Escribano, M., Rodríguez, A., Mesías, F.J. & Pulido, F. (2002). Niveles de cargas ganaderas en la dehesa extremen˜a. Archivos de Zootecnia 51(195): 315-326.

Espejo, M. & Espejo, A. M. (2006). Los sistemas tradicionales de explotación y la aplicación de innovaciones tecnológicas de la dehesa. In Gestión ambiental y económica del ecosistema dehesa en la Península Ibérica. M. Espejo, M. Martin, C. Matos and F. J. Mesias.Mérida, Spain: Junta de Extremadura, Consejería de Infraestructuras y D.T.

Gaspar, O., Mesías, F.J., Escribano, M. & Pulido, F. (2009). Assessment of the sustainability in dehesa farms according to size and livestock prevalence. ITEA 105(2): 117-141.

Joffre, R., Rambal, S. & Ratte, J. P. (1999). The dehesa system of southern Spain and Portugal as a natural ecosystem mimic. Agroforestry Systems 45: 57-79.

López-Ridaura, S., Masera, O. & Astier, M. (2002). Evaluating the sustainability of complex socio-environmental systems: the MESMIS framework. Ecological Indicators 2(1-2): 135-148.

MARM. (2010). Valor y volumen de los productos ecológicos de origen nacional en la industria agroalimentaria española. Available at http://www.marm.es/es/alimentacion/temas/la-agricultura-ecologi-ca/Valoraci%C3%B3n_de_la_Producci%C3%B3n_Ecol%C3%B3gica_Espa%C3%B1ola_(2009)_tcm7-132015.pdf.

Masera, O., Astier, S. & López-Ridaura, S. (1999). Sustentabilidad y manejo de los recursos naturales. El marco de evaluación MESMIS. México, México: Mundi-Prensa, S.S., Gira, IE-UNAM.

Napolitano, F., Pacelli, G., De Rosa, C., Braghieri, A. & Girolami, A., (2005). Sustainability and welfare of Podolian cattle. Livestock Production Science 92: 323-331.

Okey, B. (1996). Systems approaches and properties, and agroecosystem health. Journal of Environmental Management 48: 187-199.

Olea, L. & San Miguel-Ayanz, A. (2006). The Spanish dehesa. A traditional Mediterranean sil-vopastoral system linking production and nature conservation. In Sustainable grassland productivity. Grassland science in Europe. J. Lloveras, A. Gonzalez-Rodriguez, O. Vazquez-Yañez, J. Piñeiro, O. Santamaria, L. Olea, and M. J. Poblaciones. Volume 11. Badajoz, Spain: Sociedad Española para el Estudio de los Pastos. 3-13.

Ronchi, B. & Nardone, A. (2003). Contribution of organic farming to increase sustainability of Mediterranean small ruminants livestock systems. Livestock Production Science 80:17-31.

Ten Brink, B. J. E., Hosper, S. H & Colin, F. (1991). A quantitative method for description and assessment of ecosystems: the AMOEBA approach. Marine Pollution Bulletin 23: 265-70.

Thompson, P.B., 1997. The varieties of sustainability in livestock farming. In: Proceedings of the Fourth International Symposium on Livestock Farming Systems, EAAP Publication, vol. 89.Wageningen Press, Wageningen, Denmark, pp. 5-15.