STRUCTURAL CHARACTERIZATION OF EXTENSIVE FARMS IN ANDALUSIAN *DEHESAS**

CARACTERIZACIÓN ESTRUCTURAL DE LOS SISTEMAS GANADEROS DE LAS DEHESAS ANDALUZAS

García, A.[1], Perea, J.[1]*, Acero, R.[1], Angón, E.[1], Toro, P.[2], Rodríguez, V.[1] and Gómez Castro, A.G.[1]

[1]Animal Production Department. University of Cordoba. Animal Production Building. Campus Rabanales. 14014 Cordoba. Spain. *pa2pemuj@uco.es
[2]Pontificia Universidad Católica de Chile. Facultad de Agronomía e Ingeniería Forestal. Av. Vicuña Mackenna 4860. Santiago. Chile. *pmtoro@uc.cl

ADDITIONAL KEYWORDS

Factorial analysis. Farm typology. Livestock farming systems.

PALABRAS CLAVE ADICIONALES

Análisis factorial. Tipología de explotaciones. Sistemas ganaderos extensivos.

SUMMARY

Three types of livestock farming systems are identified in Andalusian *dehesas* using multivariate analysis. One of two conservationist systems, both applying sustainable management criteria, was detected in most of farms: *dehesa farming system* (49% of farms): small extensive cattle and sheep farms, which adapt stocking rates to the availability of the land's natural resources, and occasional use of strategic food supplementation; *mountain farming system* (21%) also relative to small farms, with mainly small ruminants and limited use of technology. The third system was a *yield targeted system* (30%), corresponding mainly to large cattle farms, with greater use of technology and high levels of food supplementation caused by stocking rates that exceed the land's carrying capacity. Typology defined can be used as starting point to base technical and economic characterization of farming systems taking into consideration their current and future viability.

RESUMEN

Mediante análisis multivariante se establecieron tres tipos de sistemas ganaderos en las dehesas andaluzas. En 49% de las explotaciones se detectó un sistema ganadero denominado *conservacionista de dehesa* que corresponde a pequeñas explotaciones de bovino y ovino con bajo nivel de intensificación y carga ganadera ajustada a la disponibilidad alimenticia usando ocasionalmente suplementación estratégica. Las explotaciones (21%) del sistema *conservacionista de sierra y montaña* son también de reducida dimensión, con predominio de pequeños rumiantes y bajo empleo de tecnología. El sistema *productivista* (30% de las explotaciones) corresponde a ganaderías con predominio de bovinos, de mayor dimensión y nivel tecnológico que utilizan elevados niveles de suplementación pues sus cargas ganaderas están por encima de la capacidad de la dehesa. Los tipos establecidos pueden servir de punto de partida para la caracterización técnica y económica de los sistemas ganaderos considerando su viabilidad actual y futura.

INTRODUCTION

The dehesa is a *system of land use and management based mainly on livestock farming, as well as forest and agricultural farming, in Mediterranean grassland areas*

*This study was carried out as part of the Research Project: Prospective study of pastureland in order to develop an assessment methodology for extensive farming and its application to agricultural insurance, developed by Consejería de Agricultura (Junta de Andalucía) and Departamento de Producción Animal (Universidad de Córdoba).

Recibido: 10-11-08. Aceptado: 5-3-09.

which gives rise to an agrosystem in which the combination of agrosilvopastoral management fosters important environmental values such as the sustainable use of land, a balanced landscape and high levels of diversity at different levels of integration (Comisión Técnica de la Dehesa, 2006).

There are 5.8 million ha of dehesa in the SW Iberian peninsula, 21% of which are in Andalusia (Joffre *et al.,* 1999). A large proportion of dehesa is in natural parks and protected spaces (Junta de Andalucía, 2005). These very diverse region host a mixture of agrosilvopastoral production systems, being livestock the primary product (Plieninger and Wilbrand, 2001). The farms on the dehesa, generally mixed, aim to extract the widest variety of available resources using as grazers different native species (Milán *et al.,* 2006), which are very well adapted to the harshness of the Mediterranean climate, the poor quality of the soils and the seasonal nature of food availability (Martín *et al.*, 2001). Hence, livestock grazing systems are characterized by high levels of complexity, diversity and variability, conditioned by technical, social and environmental factors (Martín *et al.*, 2001; Escribano *et al.*, 2002).

Studies of dehesa systems in Extremadura have revealed typological biodiversity (Escribano *et al.*, 2001 and 2002). In Andalusia, where conditions are very similar, the typification of livestock systems has not been previously studied. The farms commonly implement environmentally friendly production practices, like integrated and organic livestock farming. Andalusian dehesa farms are multifunctional systems, where pigs commonly graze alongside other species (Porras *et al.,* 2002). Most areas of Andalusian dehesa are within zones that are protected by the Natura 2000 network (Junta de Andalucía, 2005), where farms play an important role both in the development of these areas and protection of the environment. In order to design strategic plans that incorporate the rational and sustainable management of Andalusian dehesa, it is necessary to understand the production systems associated with this ecosystem (Gibon *et al.*, 1999).

Multivariate statistical techniques that quantify relationships of similarity between structural variables (physical, size, intensification), can be useful for the identification of systems and subsequent classification of farms, as proposed by Gibon *et al.* (1999) and Solano *et al.* (2000).

The aim of this study is to increase knowledge about the diversity and dispersion of livestock farms in order to group them according to their relationships of similarity, both in terms of physical and technical characteristics, and to establish a typology of extensive livestock systems in Andalusian dehesa ecosystem.

MATERIALS AND METHODS

Sample selection and survey data collection design. Following the environmental characterization of dehesas (Junta de Andalucía, 2005), these areas are grouped into 5 geographical zones **(table I)** covering 1.2 million ha of dehesa and around 10 000 extensive livestock farms (IEA, 2003). A randomized and stratified sampling was performed on 206 farms (2% of the population) sampling was representative and proportional to the distribution of zones, species farmed (Iberian pigs, cattle, sheep and goats) and production system used (simple and multifunctional). Information was gathered in 2004 through direct questionnaires to the farmers and visits to the farms, in accordance with the methodology used by Dobremez and Bousset (1995), Frías (1998), Acero (2001) and Milán *et al.* (2003).

Variable determination and database construction. The database generated from the questionnaires is made up of 34 variables **(table II)**, which represents aspects of classification (4), agroclimatic factors (4),

***Table I**. Description of the sample and it predominant type of dehesa according to their predominant tree species and percentage of wooded area.* (Descripción de la muestra y su tipo predominante de dehesa según la densidad y las especies arbóreas predominantes).

Zones	Areas	Dehesa ha	Dehesa %	Predominant type of dehesa	Sample n	Sample %
Campiña	Campiña, Campo de Gibraltar, La Janda	91445	23.71	Normal dehesas with pasture and scrub, and dense dehesas (*Quercus suber and Quercus faginea*)	27	2.03
Grazalema and Ronda	Antequera, La Sierra Sur, Serranía de Ronda, Sierra de Cádiz	99630	21.42	Mixed dense dehesas (*Quercus pyrenaica*, *Quercus faginea* and *Quercus ilex*)	23	2.17
Sierra Sur	Peníbetica, Sierra Sur	15422	2.56	Normal dehesas with pasture and scrub, and dense dehesas (*Olea europea*)	5	2.14
Sierra Morena, W	Andévalo Occidental, Andévalo Oriental, Costa, La Sierra Norte, La Vega, Sierra	431727	27.20	Normal dehesas with pasture and dense dehesas (*Quercus ilex andQuercus faginea*)	62	2.06
Sierra Morena, E	Campiña Baja, Campiña del Norte, El Condado, La Sierra, Pedroches, Sierra Morena	584908	32.01	Open dehesas with pastures and normal dehesas with pasture and scrub (*Quercus ilex*)	89	2.23

Source: *Junta de Andalucía (2005)*.

***Table II**. Variable codes and description.* (Codificación y descripción de las variables).

Categories/Zone		
	1. Campiña; 2. Grazalema and Ronda; 3. Sierra Sur; 4. West Sierra Morena; 5. East Sierra Morena	
Production system		
	S. Simple, only one livestock species; M. Multifunctional, several livestock species on the same farm	
Farm specialization		
	1. Cattle; 2. Pigs; 3. Sheep; 4. Goats; 5. Others (poultry, etc.)	
Vegetation		
	1. Open dehesas; 2. Normal dehesas; 3. Dense dehesas; 4. Olive groves	
Agro-climatology		
AR	Average annual rainfall (mm)	
AT	Average annual temperature (ºC)	
AL	Altitude (m)	
ASG	Average slope gradient (%)	
Physical and intensification variables		
TSA	Total surface area (ha)	
FSA	Farming and livestock surface area (ha)	
POD	Percentage of open dehesas (ha/TSA)	
PDD	Percentage of dense dehesas (ha/TSA)	
PND	Percentage of normal dehesas (ha/TSA)	
RO	Percentage of olive groves (ha/TSA)	
FP	Fodder production (kg DM/FSA)	
CP	Production capacity of the farm (LU_{max}/FSA)	
LU	Livestock units (LU)	
CSU	Cattle stock units (LU)	
PSU	Pig stock units (LU)	
SSU	Sheep stock units (LU)	
GSU	Goat stock units (LU)	
OSU	Other stock units (LU of poultry, etc.)	
PC	Percentage of cattle (CSU/LU)	
PP	Percentage of pigs (PSU/LU)	
PS	Percentage of sheep (SSU/ LU)	
PG	Percentage of goats (GSU/LU)	
PO	Percentage of other species (OSU/LU)	
SR	Stocking rate (LU/FSA)	
CSR	Cattle stocking rate (CSU/FSA)	
PSR	Pig stocking rate (PSU/FSA)	
SSR	Sheep stocking rate (SSU/FSA)	
GSR	Goat stocking rate (GSU/FSA)	
OSR	Other species stocking rate (OSU/FSA)	
SUP	Daily concentrated supplementation (kg/FSA)	

physical characteristics and size (19) and the intensification of the farms (7).

The variables average annual rainfall (AR) and temperature (AT) were obtained from the closest weather station to each farm. Data from 76 stations were used.

Stocking rates (SR) were determined using the methodology proposed by Martín *et al*. (1987) and developed by Escribano *et al*. (1996), transforming the stocking rates into livestock units (LU) in order to make comparisons between farms and species (Pulido and Escribano, 1994, Escribano *et al*., 2002 and Acero *et al*., 2003). The equivalent Livestock Units (LU) are as follows: For cattle; 1 LU: cow older than 24 months; 0.6: cow between 6 and 24 months, and 0.4: cow younger than 6 months. For sheep and goats: 0.15 breeding females, 0.12 adult males and 0.10 animals under a year old. For pigs: 0.5: breeding animals, 0.027: suckling pigs and 0.3: other pigs. For poultry: 0.014: egg-laying hens and 0.007: chickens bred for meat.

The methodology proposed by Le Houerou and Hoste (1977) and adapted by Jiménez (1986) was used to determine pasture production (PP). Finally, the production capacity (CP) of each farm was determined using the methodology described by Martín *et al*. (1986) for pastureland, which establishes the maximum stocking rate for a farm based on prior estimations of pasture production and the feeding requirements of the different species of livestock on the farm.

Variable and factor selection. The most representative primary variables of livestock farming and the geophysical environment were selected (system response variables). The selection of variables was done using the following the steps:

- Determine the degree of association between variables analyzed, using the total and partial correlation matrix, looking for original interrelated variables with no linear dependence (Uriel and Aldás, 2005; Castaldo *et al*., 2006).

- Statistical description of each variable. Variance, coefficients of variation, etc. were calculated; the variables with the greatest discriminatory power for the construction of groups were chosen, in accordance with Álvarez and Paz (1998), who recommended the use of variables with coefficients of variation higher than 60%.

Factor analysis (FA) was used to reduce dimensionality and to indicate the interrelationships between the original variables (Ness, 1997; Hair *et al.*, 1995; Pérez, 2002). The fit of the data to the factorial model was verified using Bartlett's test of sphericity and the Kaiser, Meyer and Olkin (KMO) test. Once the model had been verified, factors were extracted using the principal components procedure. In order to facilitate the interpretation of common factors, a Varimax orthogonal rotation was performed (Uriel and Aldás, 2005). Once the factors had been extracted, the farms were scored and classified.

Typification and characterization of production systems. The farms were classified using cluster analysis, establishing groups of farms that were homogeneous within a group, but heterogeneous between different groups (Júdez, 1989; Castel *et al.*, 2003; Pérez, 2002). The hierarchical cluster technique was used in accordance with Ward's method, and the Euclidean Distance was used to measure similarity between farms (Castaldo *et al.*, 2006).

The number of groups was established based on the dendrogram and the distance between clusters (DC) obtained during the grouping process (Sharma, 1996). Finally, the conglomerations obtained were validated by verifying the stability of the results through comparison with other distance measurements (Squared Euclidean Distance) and other grouping methods (centroid) (Jonson, 1998; Köbrich *et al.,* 2003). Once the typology of farms had been defined, the groups were characterized and compared using a single-factor analysis of variance (ANOVA) and the Student-Newman-Keuls (SNK) multiple range test. Statistical analyses were performed using SPSS software, version 12.

RESULTS AND DISCUSSION.

The size of the farms selected ranged from 6 to 1300 ha and the cattle load fluctuated between 1 and 5000 livestock units (LU) used for meat production. Pasture is extremely important in the production system and contributes around 60-90% of the animals' energy requirements.

FACTOR SELECTION AND FARM CLASSIFICATION

Twelve primary variables (FSA, LU, CP, PP, PS, PG, PS, AR, AT, SR, PC, SUP), that met the criteria detailed in the methodology section, and representative of the dehesa farm structure, were chosen. The factor analysis determined 8 factors that explain 95% of the total variance. From these, the first five factors were extracted, which accounted for 76% of the accumulated variance and presented eigenvalues greater than one. **Table III** shows the factors selected, the factor loadings of the variables, the correlation between the variables and the resulting factors following axis rotation. The farms were classified in accordance with the score obtained for each of the factors.

The first factor explains 21% of the total variance and shows positive saturation with the variables stocking rate and daily food supplementation per farm **(table III)**. This factor differentiates the farms according to the *degree of intensification*. So, 37% of the farms displayed high levels of intensification and are located to the right of the axis; whereas the remaining 63% are on the left of **figure 1** and represent a model with high levels of extensification. Intensive farms are mainly located in the west of Sierra Morena and La Campiña; they mostly farm cattle and sheep and are predominantly simple farms, with only one productive activity. They have large numbers of animals (99 LU)

Table III. *Factor selection and degree of saturation of the variables.* (Selección de factores y grado de saturación con las variables).

Factor	Eigenvalue	Variance (%)	Accumulated variance (%)	Variable	Saturation	Estimated communality
Factor 1	2.56	21.31	21.31	SR	0.98	0.97
				SUP	0.94	0.92
Factor 2	2.18	18.20	39.51	CP	0.98	0.98
				AR	0.90	0.98
Factor 3	1.80	15.05	54.56	PS	-0.92	0.93
				PC	0.86	0.83
				AT	0.64	0.49
Factor 4	1.48	12.35	66.91	FSA	0.85	0.83
				LU	0.80	0.77
				PP	-0.51	0.70
Factor 5	1.10	9.15	76.06	PG	-0.97	0.97

and use a high stocking rate (0.68 LU/ha), which is sustained through the high use of food supplementation (0.29 kg/ha). The more extensive farms, on the other hand, are located in the west and east of Sierra Morena and Grazalema, covering areas of 200 ha, with low stocking rates (0.25 LU/ha). The animals graze on pasture throughout the year, and their food is supplemented in certain seasons or when there is a shortage of natural resources (0.01 kg/ha).

The second factor explains 18.19% of the total variance and presents positive saturation with production capacity and rainfall, classifying the farms according to the potential of the pasture. Hence, high scores for this factor indicate farms with a high *carrying capacity*, whereas low values correspond to areas with low potential. **Figure 1a** shows that 68% of the farms are located in areas with low carrying capacities, in comparison with the 32% that have high carrying capacities. Where the axes cross (F1 *vs.* F2), 38% of the farms are extensive with low carrying capacity in comparison with 7% of intensive farms that have a high carrying capacity.

The third factor explains 15.04% of the total variance and is bipolar: the proportion of sheep stock (negative saturation) is inversely related to the proportion of cattle stock and the average temperature (positive saturation). **Figure 1b** shows the distribution of the farms in relation to the third factor: in the upper half, there are mostly cattle farms (48%) and average temperatures of 16ºC; the negative values for this factor mostly correspond to sheep (34%) and goat (6%) farms with lower average temperatures (15ºC). Therefore, this factor determines the *substitution of activities* and the proportion of land used for cattle and sheep farming. This competitive and substitutive relationship between different activities is in concordance with the findings of Escribano *et al.* (2002) in Extremadura.

The fourth factor explains 12.35% of the total variance and presents a positive single polarity with useful land surface area and the number of livestock units. When comparing factors 1 and 4 **(figure 1c)**, a proportional relationship is observed, whereby increased size corresponds to increased intensification. Large intensive farms have up to 331 ha and 121 LU, with a marked predominance of cattle stock (62%). Therefore, this factor defines the *size of the farm*.

Finally, the fifth factor explains 9.15% of the total variance and displays high specificity and negative saturation with *goat* *stock*. **Figure 1d** shows that most cattle (41%) and sheep (34%) farms obtain positive values for this factor; whereas all goat farms score negatively.

In line with the findings of Milan *et al*. (2003) intensification and farm specialization are the most relevant factors to explain heterogeneity among farms. Of the five factors obtained, four refer to technical variables and farm specialization: the level of intensification (F1), carrying capacity (F2), the substitution of activities (F3) and the importance of goat production (F5). The effect of the size of the farm is ranked fourth, and only explains 12% of the total variance.

TYPIFICATION AND CHARACTERIZATION OF LIVESTOCK FARMING SYSTEMS

The cluster analysis, based on the five factors selected, identifies three groups or production systems in Andalusian dehesas, which is verified using the dendrogram and the distance between the clusters **(figure 2)**. **Table IV** shows the percentage distribution of the farms in relation to the category variables: type I farms are typical of Grazalema and Ronda; type II farms are mainly found in Sierra Morena (west and east) and type III farms are frequently found in Sierra Morena (west) and also in La Campiña.

Type I farms are less intensive, with complex orography, poor access and a greater presence of dense dehesa and Mediterranean woodland. They represented 40% of the farms. For farms in clusters II and III, the topographical conditions are milder: there is better access, widespread pasture and the production systems tend to be more intensive.

Even though most farms are still largely owned and run by families, as we move from

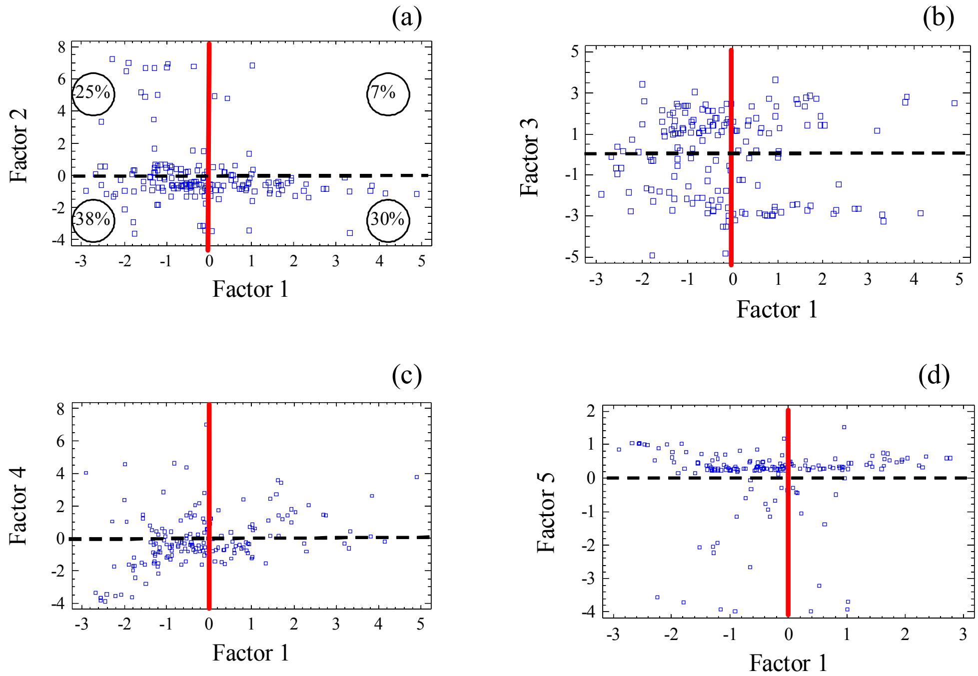

Figure 1. *Projection of farms according to factorial analysis scores.* (Proyección de explotaciones según puntuación del AF).

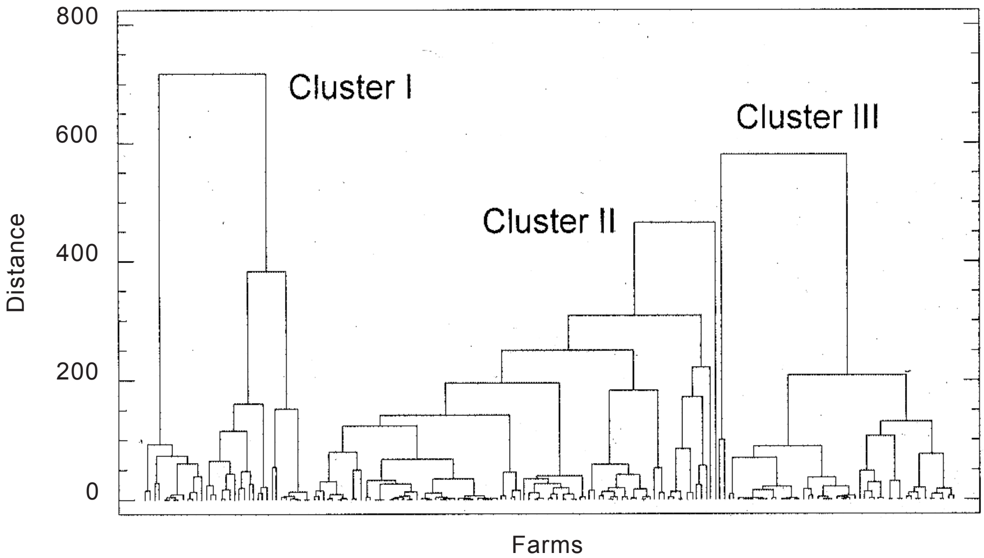

Figure 2. *Dendrogram resulting from cluster analysis with three subsystems.* (Dendrograma resultante del análisis cluster con tres subsistemas).

type I to type III farms, there is an increased presence of hired laborers and the land is often leased rather than owned.

In relation to livestock farming activity, cattle and sheep stock compete for space, and as the system intensifies, cattle production increases and sheep production decreases. Different cattle production strategies are also observed; Type I farms mainly focus on rearing; whereas most type III farms cover the entire production cycle (rearing and fattening).

Sheep and goat stocks appear in less intensive systems (types I and II), reflecting the food potential of the vegetation caused by the substitution of pasture for scrub and dense dehesas. Extensive goat farming is absent in type III farms, which tend to focus on milk production in farms without land.

In Andalusia, Iberian pigs are associated with dehesa and are an extremely important economic product; however, this does not explain the heterogeneity between farms. Similar results were found in dehesa farms of Extremadura (Milán *et al.*, 2006; Gaspar *et al.*, 2008). Several aspects explain the low relation between the variables linked to pig farming and the typology of the dehesa: Iberian pigs are present in most of Andalusian pasture lands, making use of the production of acorns to fatten the animals on fodder (*montanera*); hence their presence does not explain the variability observed moreover, the intensive production of suckling pigs in large stables and the permanent stall housing of the mothers mean that this production stage is displaced out of the *pastoral system of grazing*. As a consequence, the pigs only graze in dehesa during the fattening stage (*montanera*), for less than four months; whereas sheep and cattle are always kept in the pasture; hence pigs do not compete with other livestock activities for space.

Group I. Conservationist mountain systems

This groups represents 21% of farms and consists of small farms (around 32 LU and 127 ha). In these systems, rainfall is high, almost 1300 mm, and the average annual temperature is around 14.8ºC. The farms included correspond to a model in which the land is extremely important in the production of food. They are traditionally managed farms with limited use of technology. Even though their production capacity is the highest of the three groups (0-57 LU/ha), stocking rates are low, which indicates the scant availability of food resources, fundamentally as the result of complex orography.

These farms are chiefly located in steep marginal areas: Antequera and Serranía de Ronda in the province of Malaga and Sierra de Cadiz; where dense dehesa is increasingly important **(table IV)**. In this environment, the farms mostly focus on one activity, or mixed farming with small ruminants, such as goats, which are better able to use the natural resources, and contribute, through *non-productive functions,* to a model of social economy that is an effective way of generating self-employment and persuading the population from these areas to remain there, contributing to endogenous development and sustainability over time (Milán *et al*., 2003). In some of the districts in these areas, farming is the only economic activity, with no other alternative; hence their disappearance would exacerbate its depopulation and degradation.

Vegetation in these areas is extremely diverse, generally native and with abundant flora: Mediterranean woodland, carob trees, wild olives, oaks, cork oaks, fir, Spanish fir, gall oaks, etc., with a predominance of scrub. The pasture has scant tree cover and the herbaceous stratum is very highly developed.

Group II. Conservationist dehesa system

Group II accounts for 49% of the population studied and corresponds to small farms (around 35 LU and 95 ha) in comparison with the other groups, in particular group III. These farms are mainly located in Sierra Morena; in East and West Andévalo, Costa and Sierra (Huelva); La Campiña, La Sierra Norte, La Sierra Sur and La Vega (Seville);

Table IV*. Characteristics of the three production subsystems based on cluster analysis.* (Caracteristicas de los tres subsistemas productivos derivados del análisis cluster).

	Cluster I	Cluster II	Cluster III
Distribution of farms (%)	21	49	30
Zones			
Campiña	-	9.7	25.0
Grazalema and Ronda	58.7	3.2	1.9
Sierra Sur	17.3	-	-
Sierra Morena East	-	18.3	9.6
Sierra Morena West	24.0	68.8	63.5
Production system			
Simple	48.3	73.1	76.9
Multifunctional	51.7	26.9	23.1
Farm specialization			
Cattle	20.7	48.4	61.5
Pig	10.3	6.5	2.5
Sheep	48.3	33.3	35.4
Goat	17.2	10.7	0.5
Other	3.4	1.0	-
Vegetation			
Open dehesas (pasture)	51.7	96.7	96.1
Normal dehesas (scrub)	37.9	3.2	3.9
Dense dehesas	6.5	-	-
Olive groves	3.5	-	-
Physical and intensification variables			
FSA (ha)	127^{a}	95^{a}	376^{b}
LU (LU)	32^{a}	35^{a}	139^{b}
CSU (LU)	29^{a}	34^{a}	129^{b}
SSU (LU)	27^{a}	31^{a}	109^{b}
GSU (LU)	8^{a}	15^{a}	50^{b}
PC (%)	29.3^{a}	46.6^{ab}	60.3^{b}
PP (%)	10.1^{b}	8.9^{ab}	0.8^{a}
SR (LU/ha)	0.32^{a}	0.39^{a}	0.52^{b}
CSR (LU/ha)	0.11^{a}	0.17^{a}	0.33^{b}
PSR (LU/ha)	0.023^{b}	0.028^{b}	0.001^{a}
AR (mm/m^2)	1287^{b}	645^{a}	616^{a}
AT (ºC)	14.8^{a}	15.6^{b}	15.9^{b}
CP (LU/ha)	0.57^{b}	0.41^{a}	0.36^{a}
SUP (kg /ha)	0.28^{a}	0.20^{a}	0.84^{b}

Different letters, in a row, indicates significant differences between clusters ($p<0.001$).

Campiña Baja, La Sierra and Pedroches (Cordoba); Campiña del Norte, El Condado and Sierra Morena (Jaen). Average rainfall and temperature are 645 mm and 15.5ºC respectively. Taking into account the Cabezas *et al.* (1986) climatological classification, the traditional system corresponds to the central group of pasture lands, with average rainfall of 600-700 mm.

Average stocking rates in group II are 0.39 LU/ha, lower than the European average (Colson and Chatellier, 1996) and similar to the stocking rates indicated by Muslera (1992) and Escribano *et al.* (2002) for Extremadura.

These farms apply conservation management criteria, adjusting the stocking rates to the carrying capacity of the land (0.41 LU/ha), using strategic or seasonal food supplementation in periods of shortage. As a consequence, farming activity is adapted to the environment and presents low levels of intensification; the animals are fed using the natural resources available through pasture and fodder.

These farms mostly focus on the individual production of sheep or cattle, which is determined by the resources produced by the land and its orography. Combined farming of several species is relatively infrequent **(table IV)**.

Group III. Yield targeted systems

Group III is made up of large farms (139 LU and 376 ha), with values similar to those recorded in Extremadura (Escribano *et al.*, 2002) and Portugal (Carvalho and Gama, 1999). However, the average stoking rate (0.52 LU/ha) is higher than dehesa farms of Extremadura (Gaspar *et al*., 2009).

The farms are mainly located in the west of Sierra Morena (north of Cordoba and Jaen) and in the districts of La Janda, La Campiña and Campo de Gibraltar (Cadiz), in areas with an average rainfall of 616 mm, and an average temperature of 15.9ºC. This group represents 30% of the population studied and corresponds to specialized production models that use a certain amount of technology.

These farms apply productivity based management criteria, with stocking rates above the carrying capacity of the land. As a consequence, farming activity depends largely on the contribution of food supplements. These farms tend to focus on cattle production, with high levels of intensification and large herds.

In conclusion: five factors explain 76% of the heterogeneity of dehesa farming in Andalusia. The two main factors are: level of intensification and carrying capacity. The most important factor variables are: stocking rate, level of food supplementation, farm's production capacity and average rainfall.

Three livestock farming systems are identified in Andalusian dehesa. The Mountain and Dehesa systems (70% of the livestock farms), apply a conservation management strategy, adjusting stocking rates to the land's carrying capacity or even below this capacity. The Yield Targeted system (30% of livestock farms), corresponds to larger farms, which apply criteria of intensification, with stocking rates above the land's carrying capacity.

BIBLIOGRAPHY

Acero, R. 2001. Modelos avanzados de gestión y optimización de la producción caprina extensiva en la provincia de Jaén. Doctoral Thesis. University of Cordoba.

Acero, R., Martos, J., García, A., Luque, M., Herrera, M. and Peña, F. 2003. Characterization of extensive goat systems through factorial analysis. Proc. of 12th International Symposium of Animal Production and natural resources utilization in the Mediterranean Mountain Areas. Ioannina. 5-7 June.

Álvarez, R. and Paz, R. 1998. Metodología para la tipificación de la producción lechera de caprinos en Santiago del Estero. Argentina. *Arch. Zootec.*, 47: 649-658.

Cabezas, J., Núñez, E. y Escudero, J.C. 1986.

Dinámica de las precipitaciones en los sistemas de dehesa en la provincia de Badajoz. En: MAPA (Ed.) Conservación y desarrollo de las dehesas portuguesa y española. Madrid.

Carvalho, L.M. e Gama, L.T. 1999. Caracterizaçao dos sistemas de produçao de algunas raças bovinas autóctonas portuguesas (Barrosã, Mirandesa, Maronesa, Alentejana, Mertolenga). Proc. of 9º Congresso de Zootecnia. Porto, 10-14 November.

Castaldo, A., Acero, R., Martos, J., Valerio, D., García, A., Pamio, J. y Perea, J. 2006. Tipología de los sistemas de producción de engorde bovino en la Pampa Argentina. *Arch. Zootec*., 55: 183-193.

Castel, J.M., Mena, Y., Delgado-Pertíñez, M., Camúñez, J., Basalto, J., Caravaca, F., Guzmán-Guerrero, J.L. and Alcalde, M.J. 2003. Characterization of semi-extensive goat production systems in southern Spain. *Small Ruminant Res.* 47: 133-143.

Comisión Técnica de la Dehesa. 2006. Pacto Andaluz por la Dehesa. Boja de 4 de abril de 2006. Sevilla.

Colson, F. et Chatellier, V. 1996. Les exploitations bovines françaises sont parmi les plus extensives de l'Union européenne. *INRA Prod. Anim.,* 9: 273-284.

Dobremez, L. et Bousset, J.P. 1995. Rendre compte de la diversité des exploitations agricoles. Une démarche d'analyse par exploration conjointe de sources statistiques, comptables et technico-économiques. Cemagref. France.

Escribano, M., Pulido, F., Rodríguez de Ledesma, A. and Mesías, F.J. 1996. Determination of energetic resources that cover cattle food needs in dehesa systems. *Arch. Zootec.,* 45: 379-393.

Escribano, M., Rodríguez de Ledesma, A., Mesías, F.J. y Pulido, F. 2001. Tipología de sistemas adehesados. *Arch. Zootec.,* 50: 411-414.

Escribano, M., Rodríguez de Ledesma, A., Mesías, F.J. y Pulido, F. 2002. Niveles de cargas ganaderas en la dehesa Extremeña. *Arch. Zootec.* 51: 315–326.

Frías, J.J. 1998. Situación actual y perspectivas de conservación de las razas caprinas en peligro de extinción en la provincia de Jaén. Doctoral Thesis. University of Cordoba.

Gaspar, P., Escribano, M., Mesías, F.J., Rodríguez de Ledesma, A. and Pulido, F. 2008. Sheep farms in the Spanish rangelands (*dehesas*): Typologies according to livestock management and economic indicators. *Small Ruminant Res.,* 74: 52-63.

Gaspar, P., Mesías, F.J., Escribano, M. and Pulido, F. 2009. Assesing the technical efficiency of extensive livestock farming systems in Extremadura. Spain. *Livest. Sci.,* 121: 7-14.

Gibon, A., Sibbald, A.R., Flamant, J.C., Lhoste, P., Revilla, R., Rubino, R. and Sorensen, J.T. 1999. Livestock farming systems in Europe and its potential contribution for managing towards sustainability in livestock farming. *Livest. Prod. Sci.,* 61: 121-137.

Hair, J.F., Anderson, R.E., Tathakm, R.L. and Black, W.C. 1995. Multivariate data analysis with readings. Prentice Hall. New Jersey.

IEA. 2003. Instituto de Estadística de Andalucía. Censo Agrario. Sevilla.

Jiménez, J. 1986. Una aproximación metodológica de un sistema de evaluación de la productividad potencial de un territorio de dehesa del SO peninsular. I Jornada Técnica sobre Conservación y Desarrollo de la Dehesa Ibérica. Badajoz.

Joffre, R., Rambal, S. and Ratte, J.P. 1999. The *dehesa* system of southern Spain and Portugal as a natural ecosystem mimic. *Agroforest. Syst.,* 45: 57-79.

Johnson, D.E. 1998. Applied multivariate methods for data analysis. Brooks Cole Publishing Company. New York.

Júdez, L., Chaib Filho, H. and Pérez Hugalde, C. 1989. A statistical analysis of the evolution of the size of farms in Spain. *Investigación Agraria, Economía,* 4: 155-174.

Junta de Andalucía. 2005. Dehesas de Andalucía. Caracterización Ambiental. Sevilla.

Köbrich, C., Rehman, T. and Khan, M. 2003. Typification of farming systems for constructing representative farm models: two illustrations of the application of multi-variate analyses in Chile and Pakistan. *Agr. Syst*., 76: 141-157.

Le Houerou, H.N. and Hoste, C.H. 1977. Rangeland production and annual rainfall relations in the mediterranean basin and in the african sahelo-sudanian zone. *J. Range Manage.,* 30: 181-189.

Martín, M., Espejo, M., Plaza, J. y López, T. 1986. Metodología para la determinación de la carga ganadera de pastos extensivos. INIA. Madrid.

Martín, M., Espejo, M., Plaza, J. y López, T. 1987. Cálculo de la carga ganadera en la dehesa. En: Campos, P., Martín, M. (Eds.). Conservación y desarrollo de las dehesas portuguesa y española. SGT-MAPA. Madrid.

Martín, M., Escribano, M., Mesías, F.J., Rodríguez de Ledesma, A. y Pulido, F. 2001. Sistemas extensivos de producción animal. *Arch. Zootec.,* 50: 465-489.

Milán, M.J., Arnalte, E. and Caja, G. 2003. Economic profitability and typology of Ripollesa breed sheep farms in Spain. *Small Ruminant Res.,* 49: 97-105.

Milán, M.J., Bartolomé, J., Quintanilla, R., García-Cachán, M.D., Espejo, M., Herráiz, P.L., Sánchez-Recio, J.L. and Piedrafita, J. 2006. Structural characterization and typology of beef cattle farms of Spanish wooded rangelands (*dehesas*). *Livest. Prod. Sci.,* 99: 197-209.

Muslera, E. 1992. La dehesa: características productivas y alternativas ganaderas para su aprovechamiento. FIG-Zafra. Badajoz.

Ness, M. 1997. Multivariate analysis in marketing research. In: Padberg, D.I. Ritson, C. (Eds.). Agro-Food marketing. Albisu CAB Internacional, Oxon.

Pérez, C. 2002. Estadística práctica con Statgraphics. Pearson Educación S.A. Madrid.

Plieninger, T. and Wilbrand, C. 2001. Land use, biodiversity conservation, and rural development in the dehesas of Cuatro Lugares, Spain. *Agroforest. Syst.,* 51: 23-34.

Porras Tejeiro, C., González Sánchez, A., Brun Esquiliche, P., Sánchez Rodríguez, C. y Sánchez Núñez, R. 2002. Estudio Técnico-económico de explotaciones de dehesa en Andalucía. Proc. 6 Jornadas Internacionales de la Sociedad Española de Ovinotecnia y Caprinotecnia. Valencia. 10-13 mayo.

Pulido, F. and Escribano, M. 1994. The dehesa system. Analysis of typical dehesas of south best of Spain. In: Environmental and land use issues in the mediterranean basin. Wissenchaft Verlag. Vauk. Kiel.

Sharma, S. 1996. Applied multivariate techniques. John Wiley & Sons. New York.

Solano, C., Bernués, A., Rojas, F., Joaquín, N., Fernández, W. and Herrero, M. 2000. Relationships between management intensity and structural and social variables in dairy and dual-purpose systems in Santa Cruz, Bolivia. *Agroforest. Syst.,* 65: 159-177.

Uriel, E. and Aldás, J. 2005. Análisis multivariado aplicado. Thomson. Madrid.