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The diversity of sheep production systems in Aragón (Spain): characterisation and typification of meat sheep farms

L. Pardos[1]*, M. T. Maza[2], E. Fantova[3] and W. Sepúlveda[2]

[1] *Departamento de Agricultura y Economía Agraria. Universidad de Zaragoza. Escuela Politécnica Superior de Huesca. Carretera de Cuarte s/n. 22071 Huesca, Spain.*

[2] *Departamento de Agricultura y Economía Agraria. Facultad de Veterinaria. Universidad de Zaragoza. c/ Miguel Servet 177. 50013 Zaragoza, Spain.*

[3] *Carnes Oviaragón S.C.L. Edificio Pastores. Ctra. Cogullada, nº 65. Zaragoza, Spain.*

Abstract

The general aim of the present study was to characterise and typify a group of meat sheep farms that form part of the record data network of an Aragonese co-operative using different variables: sociological, structural, technical, income and costs and economic results. The sample was formed by 56 Aragonese farms. In order to avoid inter-annual variations, data used were the mean data of a five-year period running from 2000 to 2004. A factor analysis was used to reveal the interrelations between different variables that characterise farms. The results of this analysis served as the basis for a subsequent segmentation by applying a cluster analysis. After the establishment of groups, a variance analysis was performed to identify statistical differences in a set of additional variables that were considered necessary to gain practical significance in the typology. Four groups of farms were differentiated, mainly based on structural, technical and economic variables. According to the variables that characterise the defined typologies, the different possibilities of evolution of each of them were analysed to adapt to changing contexts in terms of costs, income, labour and agricultural policy measures.

Additional key words: economic results, multivariate analysis, productivity.

Resumen

La diversidad de sistemas de producción ovina en Aragón (España): caracterización y tipificación de explotaciones ovinas de carne

El objetivo general de este trabajo fue caracterizar y tipificar un grupo de explotaciones ovinas de carne pertenecientes a una red de gestión técnico económica de una cooperativa ganadera aragonesa utilizando variables sociológicas, estructurales, técnicas y económicas. La muestra estuvo formada por 56 ganaderías aragonesas y, a fin de evitar variaciones interanuales, los datos de cada explotación correspondieron a la media del quinquenio 2000-2004. El análisis factorial demostró ser sumamente útil para revelar las interrelaciones entre las diferentes variables que caracterizan a las explotaciones, y ha servido de base para la posterior tipificación mediante análisis clúster. Una vez definidos los grupos, el análisis de varianza ha permitido observar la existencia de diferencias significativas en un conjunto de variables adicionales y con significado práctico. Se han diferenciado cuatro grupos de explotaciones en función fundamentalmente de variables de carácter estructural, técnico y económico. En función de las variables que caracterizan las tipologías definidas, se analizan sus diferentes posibilidades de evolución para adaptarse a contextos cambiantes de costes, ingresos, mano de obra y nuevas medidas de política agraria.

Palabras clave adicionales: análisis multivariante, productividad, resultados económicos.

* Corresponding author: lpardos@unizar.es
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Abbreviations used: CAP (common agricultural policy), CMO (common market organisation), FAP (final agricultural production), KMO (Kaiser-Meyer-Olkin), MWU (man work unit), PCA (principal components analysis), PGI (protected geographical indication), UAA (useful agricultural area).

Introduction

In Spain sheep are mostly reared in extensive or semi-extensive systems due to the hardiness of the autochthonous breeds and their good adaptation to adverse environmental conditions, generally accompanied by the use of grazing land, as well as different forage species and rainfed cereal crops. The systems employed vary, however, depending on the areas, size of farms, and the livestock production orientation (Esteban *et al*., 1997).

In the specific case of Aragón (an autonomous region in north Spain), sheep farming is oriented towards meat production and the production model is associated with grazing chiefly on areas given over to cereal crops, taking advantage of stubble and fallow fields (MAPA, 2003). Aragón's sheep census for 2005 amounted to 2,495,000 sheep spread over a total of 5,789 farms and represented a contribution to the Final Agricultural Production (FAP) of 5.6% (Gobierno de Aragón, 2006).

However, as highlighted by several authors (Blanchemain, 1989; Milán *et al.*, 2003; Pérez *et al.*, 2003) the importance of the sheep-farming sector extends beyond aspects of a strictly economic nature. The capacity to use grazing resources in disadvantaged zones and the employment of family labour outside the large urban centres mean that the sector plays an important role in preventing the depopulation of deprived areas and reducing serious problems of erosion, contributing in this way to the ecological balance (Interovic, 2006). This multifunctionality is very important in less favoured and remote Mediterranean areas where small ruminants are often the last possible activity (De Rancourt *et al.*, 2006).

Systems have rapidly moved to intensive large flocks, focussed on lamb productivity and the use of the *Rasa Aragonesa* breed. The traditional lamb produced is the *Ternasco de Aragón* (De Rancourt *et al.*, 2006). From the study carried out by Sierra (2002), based on a survey of 209 farms in different autonomous communities, it can be seen that over the past few years in Aragón there has been a considerable increase in flock size, a strong incidence of partial stabling affecting 92% of farms, an increase in certain reproduction management practices aimed at achieving greater intensification (ram effect and hormonal treatments), and an improvement in health practices. There has also been a notable renewal of facilities together with improvements in technification and farm machinery. This general trend towards intensification and the introduction of new production techniques is contrary to the objectives or guidelines set out by the common agricultural policy or CAP (Oregui and Falagán, 2006) and chiefly arises from the lack of pastureland that, in turn, is caused by the intensification of agricultural production and a shortage of labour. Greater intensification means that farms are more sensitive to variations in the market.

Aragonese farmers view their work as requiring a great deal of sacrifice whilst obtaining little profitability (Gil *et al.*, 2003) and, as in the rest of Europe, their margins depending entirely or largely on the subsidies received from their states or from the European Union (Gabiña, 2006). Lastly it is worthy of mention that an organisational factor such as the development of the co-operative sector has had notable repercussions on the sector, with 51% of farms using this system to market their production (Chertouh, 2005).

In spite of these general trends, however, there is a wide variety of production systems in practice and it is important to know them to understand the effects that the application of different agricultural policy measures has on the sector as well as investigating the possible strategies adopted by the farms in the face of these policies.

The evolution of the sector has been marked to a great extent over the past decades by the successive reforms of the CAP. The 1992 reform, in particular, advocated the setting up of measures to promote extensification, for environmental reasons, and the reduction of agricultural production, which were not necessarily in line with business objectives (Choquecallata, 2000). Perhaps the major weakness in the previous CMO (common market organisation) was that it encouraged producers simply to keep sheep (and goats) rather than produce products that the market was requiring (Canali, 2006).

In the new CAP Reform, Spain has opted to decouple only 50% of the sheep subsidies from production considering that total decoupling would have a highly negative impact in regions where labour and/or income level are limiting factors (De Rancourt *et al.*, 2006), as is the case of Aragón, where many farms may disappear, with the negative socio-economic and environmental consequences that this would have for these areas. Moreover, given that the chief objective is still the same: to support farmers' income, irrespective of the method of production, it is not acting as an engine of change and will not encourage the maintenance of these systems in the long-term (Caballero, 2001). Furthermore, if different subsidies are allowed depending on the country, heterogeneous situations may arise (Oregui and Falagan, 2006).

The aim of the typologies is to simplify by reducing the number of individual cases to a diversity expressed by a small number of types that enables us to carry out the analysis (Deffontaines and Petit, 1985). For Landais (1998) a type is an abstract generic model, which defines the characteristic features of a series of objects. The term "typology" designates both (a) the science of type elaboration, designed to help analyse a complex reality and to order objects which, although different, are of one kind (farms for instance) and (b) the system of types resulting from this procedure (the farm typology of a given region).

Establishing farm typologies permits: (a) assess trends of change in livestock farming; (b) identify the main constraints to productivity or the main priorities for a specific development policy; (c) use them as a basis for identifying "target groups" in development projects, and (d) as a tool for supporting advisors in their work with individual farmers, allowing them to assess each situation by referring to known functional types (Gibon *et al.*, 1999).

The general aim of the present study is to characterise and to typify a group of meat sheep farms that form part of the record data network of an Aragonese co-operative using a series of different variables. Extracting the most important variation factors has enabled the underlying structure to be analysed and a series of groups to be established, based on the variability that exists. This in turn will provide us with more knowledge about livestock farming systems and their diversity and help in the development of management aids for livestock farmers and tools for advisors.

Material and methods

The data that are analysed have been obtained using the Economic-Technical Data Record Program for meat sheep developed by the *Escuela Politécnica Superior de Huesca* (University of Zaragoza) together with the Livestock Co-operative *Carnes Oviaragón SCL* (Fantova *et al.*, 2007; Pardos *et al.*, 2007; Maza *et al.*, 2008). The sample is formed by 56 Aragonese farms, located in 14 regions of the three Aragonese provinces. In order to avoid inter-annual variations, the farm data used are the mean data of a five-year period running from 2000-2004. It must be noted that the sample of farms considered is not random since the farms' participation in the Management Programme was voluntary. The variables used in the study are shown in Table 1. The basic cha-

Table 1. Mean data of the farms analysed

	Mean	SD[a]
Age of farmer	46.8	9.4
Level of qualification of farmer (scale of 1 to 10)	6.7	1.6
Structural data		
Number of ewes	642.5	299.3
Number of MWU [b]	1.36	0.6
% Family MWU	96	12.4
No. ewes MWU^{-1}	472.4	166.8
Useful agricultural area (ha)	97.8	93.7
Forage UAA (ha)	17.3	22.8
% Owned UAA [c]	61.8	31.9
% Irrigated UAA	24.3	34.0
Rented grazing land (ha)	543.8	779.3
Technical ratios		
No. of births ewe^{-1}	1.19	0.1
Prolificacy	1.35	0.1
% Twin births	32.1	12.0
% Births of more than two lambs	1.3	1.8
Lambs born ewe^{-1}	1.61	0.3
% lamb mortality	10.5	3.5
Lambs sold ewe^{-1}	1.28	0.3
Sales analysis		
Mean lamb price	62.90	2.0
% "Lamb of Aragón" PGI [d]	49.6	29.1
% Sales in first semester	49.0	9.8
% Sales in second semester	51.0	9.8
Income ewe^{-1}		
Lambs	80.42	18.3
Subsidies	32.53	6.7
Other income	4.36	5.6
Total income	117.31	18.8
Feed cost ewe^{-1}		
Sheep feed purchased	18.73	12.2
Lamb feed purchased	11.45	3.9
Autoconsumption in feeding trough	10.43	9.1
Grazing autoconsumption	2.82	2.6
Rent of grazing land	4.52	4.4
Total costs ewe^{-1}		
Total feed	47.95	12.1
Family labour	24.58	8.4
Salaried labour	1.24	3.4
Agricultural social security	3.61	1.1
Health + Reproduction	3.51	1.3
Purchase of breeding stock	2.63	5.2
Loan interests	0.79	1.3
General costs [e]	6.34	2.4
Total costs	90.65	16.3
Economic results		
Gross margin ewe^{-1}	26.66	16.1
Gross margin farm^{-1}	17,129	15,171.8
Gross margin MWU^{-1}	12,594	10,007.5

Economic data stated in the euro value in 2004. [a] Standard deviation. [b] MWU: man work unit. [c] UAA: useful agricultural area. [d] PGI: protected geographical indication. [e] Shearing, quotas to associations and co-operatives, marketing costs, insurance, transport, water, electricity, gas-oil, maintenance and repairs, renting of installations, etc.

racteristics of this Programme are that it evaluates self-consumptions (self-provisioning from the farm itself), including grazing resources as well as family labour. To differentiate the sheep farming activity from other types of agricultural or livestock farming activities realized in these farms, self-consumptions are valued at the market price or, in the absence of said price, at production cost. When valuing family labour (12.096 € MWU^{-1}) spent on the sheep farming activity, the mean wage received by salaried labour is taken into account, having discounted social security contributions. To allow economic results to be compared they are stated in constant euro values for 2004, in relation to the consumer price index.

The statistical methods of the factor analysis and cluster analysis have been used to characterise the farms and different groups have been established. The variance analysis applied has revealed the statistical significance of the groups obtained. The SPSS v.11.5 statistics package has been used. The same methodology has already been used to characterise sheep farms (Milan *et al.*, 2003) and goat farms (Usai *et al.*, 2006).

Factor analyses allow the structure of the interrelations (correlations) between a large number of variables to be analysed, defining a series of common, underlying dimensions, known as factors, with a minimum loss of information (Hair *et al.*, 2000). The principal components analysis (PCA) has been used as the extraction method and the criterion followed for the number of factors to be extracted has been that of the accumulated percentage of total explained variance. A PCA has been chosen as the extraction method since it is an appropriate method of explaining the maximum portion of variance with the minimum number of factors. To help in the interpretation of the factors, a Varimax orthogonal rotation was chosen since it allows simpler and, theoretically, more significant factor solutions to be obtained. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, communalities and Bartlett's sphericity test were used to determine if the factor analysis was *a priori* pertinent and able to provide satisfactory conclusions.

The following variables have been introduced in the analysis: V_1 = Number of ewes; V_2 = Forage UAA (ha); V_3 = Lambs sold per ewe; V_4 = Feed cost per ewe; V_5 = Goss margin per MWU.

In selecting these variables the following criteria have been taken into account. The structure variables chosen were: i) number of sheep in the flock, which, as is widely known, is of great importance since it is one of the main differentiating factors of sheep systems (Chertouh *et al.*, 2003), and ii) the hectares of UAA given over to forage crops, which provides more information than total UAA, since some farms do not give over the whole of their land to livestock feed but also grow other agricultural products for sale.

The technical index selected was the number of lambs sold per ewe and year variable, which amalgamates, to a great extent, other types of indices relating to aspects of reproduction, management and health: fertility, prolificacy, abortion percentage, lamb mortality and replacement stock percentage. Income per ewe is essentially determined by the number of lambs sold since the subsidies per animal only differ if farmers receive benefits for less favoured areas or the agro-environmental aids available.

In relation to costs, feed cost per ewe was chosen, given that this is the greatest cost, representing 53% of total costs. Furthermore, this is a variable that enables systems to be differentiated (Fantova *et al.*, 2007). As for economic results, gross margin per MWU was selected as an indicator of work productivity that includes results per animal and correct flock dimensioning and, as stated by Olaizola *et al.* (1996), is the most significant measurement of the economic results obtained and of the possibilities of farm continuity. On the other hand, Gil *et al.* (2003), analysing a sample of Aragonese farmers, conclude that these also associate the quality of family life with their economic and business objectives. In this line of reasoning, in terms of the choice of variables, Pérez *et al.* (2003) conclude that labour, feed cost and number of lambs produced, together with amortisations and interests and the size of the company are the parameters that have the greatest effect on business profit in meat sheep farms.

With regard to the cluster analysis, its main purpose is to group objects together based on their characteristics so that each object is very similar to those in the cluster in terms of a predetermined selection criterion (Hair *et al.*, 2000). The cluster analysis is thus fundamentally an exploratory technique that evaluates structure, grouping together observations, whilst the Factor analysis groups variables together. The cluster algorithm used has been the Ward hierarchical method, which minimises differences within the cluster and the square Euclidean distance, recommended for this method, has been used as the measure of similitude. In the cluster analysis the factors generated in the factor analysis have been used as variables.

The variance analysis has been useful in establishing the existence of significant differences between the means of the variables characterising each of the groups

formed by the previous procedure. Tukey's means comparison was employed and, to discover if there were any significant differences between the means analysed, the variance homogeneity test (Levene's test) was used and, if the latter revealed significant differences, Welch's robust test for mean equality (Camacho, 2002).

Results

Characterisation of the sample of farms

The description of the farms analysed is carried out with a series of variables that can basically be grouped under the following headings: sociological, structural, technical, income and costs, and economic results. The analysis of structural data (Table 1) shows that the average size of the farms is 624 breeding ewes managed by 1.36 man-work units (MWU), which represents 472 ewes MWU^{-1}. The farms have 98 ha of UAA, which is principally farm-owned, dry land, and they also rent 544 ha of grazing land (woodlands and stubble fields). Of all the available UAA, an average of 17 ha are dedicated to forage crops. The mean age of the farmers is 47 years old and their level of qualification (scale from 1-10), evaluated by the co-operative technicians, is 6.7. The breed raised is *Rasa Aragonesa*, except in the three farms in the sample with permanent stabling, which use prolific breeds. There were 1.19 births per ewe and year; the farms used different reproduction management systems (mostly three lambings in two years) and prolificacy was 1.35 lambs per birth. They sold 1.28 lambs per ewe and year at a mean price of 62.90 € (50% are marketed under the *Ternasco de Aragón* Protected Geographical Indication (PGI)). Income per ewe amounts to 117.31 € and the costs amounts to 90.65 €, with feeding costs (47.95 €) and family labour (24.58 €) standing out in particular. The Gross Margin per animal is thus 26.66 €. With this productivity per ewe, the mean economic results per farm per work unit are 17,129 € and 12,594 €, respectively.

Table 2. Factor analysis: rotated component matrix. In bold, factor loads > 0.5

	Component 1	Component 2
Lambs sold per ewe	**0.933**	0.037
Feed cost per ewe	**0.839**	-0.096
Gross margin per MWU	**0.537**	0.397
Number of ewes	0.004	**0.837**
Forage UAA (ha)	0.030	**0.727**

The factor analysis has generated two factors that explain 65.2% of total variance, which can be considered a good percentage. Table 2 shows the factor loading matrix, i.e., the correlations between each variable and the factor. Factor loads of more than 0.5 are considered to be significant (Hair *et al.*, 2000). The factors generated can therefore be described and interpreted in the following way:

- Factor 1: Explains 38.7% of the variance and is characterised by the variables lambs sold per ewe, feed cost per ewe and gross margin per MWU. It thus relates production intensification with greater feed costs per ewe (flushing, supplementary feed for lactating ewes with longer stabling periods, higher feed cost for lambs) and greater gross margin per MWU.

-Factor 2: Explains 26.5% of total variance and is characterised by the two structural variables selected: forage area and number of sheep in the flock. It can be interpreted that both of these are closely related and that the former variable conditions the mean size of farms.

Farm typology analysis

The factor analysis, apart from its proven use *per se*, has served as the basis for a subsequent segmentation by applying a cluster analysis, using the factors generated. It has been of great use in the present study to differentiate several groups of farms, identifying the most important determining factors.

Several alternatives were tested for the number of groups to be formed in terms of combination distance, attempting to obtain the simplest structure possible representing homogeneous groups. Finally, it was decided to use a distance of 10, which generated four groups with sufficient farms per group (Figure 1). The mean data of the differentiated groups and the results of the ANOVA are shown in Tables 3 and 4.

Description of the differentiated groups:

-Group 1: Formed by the 11 most intensive farms from the point of view of reproduction (it includes the three stabling farms in the sample that raise prolific breeds) and with highly professionally qualified farmers. With flocks of 611.9 sheep and handling 509.9 sheep per work unit, they have large agricultural extensions, comprising mainly dry land (few forage crops areas).

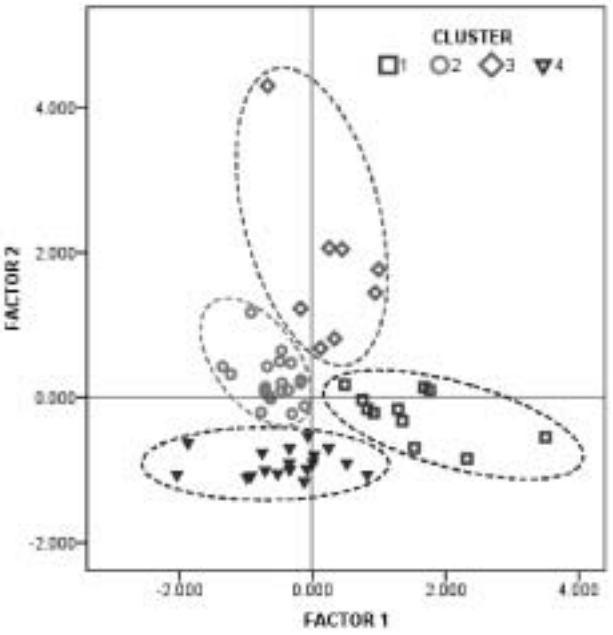

Figure 1. Distribution of farms according to the two factors.

They have the greatest number of births per ewe and per year (1.30) and the greatest prolificacy (1.49) of all of the groups [significant differences in relation to the groups with low economic results per work unit (2 and 4)]. There is a predominance of intensive mating systems and reproduction management (hormonal treatments, ram effect, flushing). They manage to achieve 1.94 lamb births and since lamb mortality is the lowest of all of the groups (indicating the good state of health of flocks and the professional skill of the farmers) they sell, on average, 1.64 lambs per ewe and year ($P<0.001$).

This greater productivity brings higher lamb income as well as total income ($P<0.001$). Feed costs are also higher (($P<0.001$) and feed purchases both for sheep and lambs are particularly notable. The lowest cost is that of rent of grazing land. This results in high total costs per ewe (significant differences with groups 2 and 3).

With its high productivity it is capable of offsetting the high costs and achieving good results per ewe and per work unit (significant difference with groups 2 and 4).

- Group 2: Formed by 19 farms with an average of 747.4 ewes located in rainfed areas. These large agricultural farms rent extensive low-quality rainfed pastures, which form the basis of the livestock feeding system (1,746 ha of winter cereal stubble, rough grazing, coppice, etc.).

These farms, which are extensive from the point of view of reproduction, sell the lowest number of lambs per ewe (1.10) and their income per lamb is the lowest of all of the differentiated groups (significant differences with groups 1 and 3).

Feeding costs and total costs are significantly lower than those of group 1 although there are no significant differences with the rest of the groups. In spite of the fact that the number of sheep MWU^{-1} is not significantly different from the groups with the best results, their low productivity means that the gross margin MWU^{-1} is significantly lower.

- Group 3: Formed by 8 farms with the largest flock size (1,011.6 sheep) and the largest forage crop area (55.1 ha), with significant differences with the rest of the differentiated groups, located in irrigated areas. They handle the largest number of sheep per worker and have large agricultural farms, also renting extensive areas of pastures (including irrigated stubble land).

Although they have a lower reproductive intensification than those of group 1, they are capable of selling 1.39 lambs per ewe and of obtaining € 88.68 income per lamb sale, with significant differences in relation to groups 2 and 4. However, these statistical differences are not maintained if total income is analysed, since these are favoured irrigated areas that do not receive the specific aids for the less favoured areas.

In their feed costs the importance of rented grazing land (€ 9.85) is particularly noteworthy as these are irrigated grazing resources and thus more expensive ($P<0.01$), which means that they require less purchased feed than group 1, in spite of their reproduction intensification (they have the greatest health and reproduction costs) and the fact that their feeding cost and total cost per ewe is significantly lower.

Their good productivity, high number of ewes per worker and flock feed system based on grazing, means that good economic results per MWU are obtained (similar to those of group 1) as well as good economic results per farm.

- Group 4: Formed by 18 farms characterised by having the smallest flock (386.5 ewes) of all of the groups differentiated ($P<0.001$), handling only 364.6 ewes MWU^{-1} with exclusively family labour. They have little UAA (58.8 ha), basically rainfed land, and the farmers have a low level of qualification (significant difference with group 1).

They have low intensification of reproduction, only selling 1.17 lambs per ewe per year, and the greatest mortality of lambs and breeding ewes, which may point

Table 3. Socio-cultural variables, structural data, technical indices and sales analysis of the differentiated groups

	Group 1	Group 2	Group 3	Group 4	Significant differences
Number of farms	11	19	8	18	
Socio-cultural variables					
Age of farmer	49.9	44.2	47.5	47.3	
Level of qualification of farmer	8.0 a	6.5 ab	6.8 ab	6.0 b	**
Structural data					
Number of ewes	611.9 b	747.4 b	1,011.6 a	386.5 c	***
Number of MWU	1.20 b	1.54 ab	1.83 a	1.06 b	**
% family MWU	95	96	89	100	
Number of ewes MWU^{-1}	509.9 a	485.3 a	552.8 a	364.6 b	**
Useful agricultural area (ha)	111.3	118.1	118.7	58.8	
Forage UAA (ha)	8.6 b	16.0 b	55,1 a	7.3 b	***
% Owned UAA	71.1	63.2	60.3	55.5	
% Irrigated UAA	19.2	18.7	41.1	26.0	
Rented grazing land (ha)	572.9	1,745.9	557.6	250.9	
Technical indices					
Number of births ewe^{-1}	1.30 a	1.14 b	1.26 ab	1.14 b	***
Prolificacy	1.49 a	1.29 b	1.40 ab	1.30 b	***
Lambs born ewe^{-1}	1.94 a	1.47 b	1.76 ab	1.48 b	***
% Lamb mortality	9.5	10.4	10.0	11.5	
Lambs sold ewe^{-1}	1.64 a	1.10 c	1.39 b	1.17 c	***
% Mortality of breeding ewes	3.5	4.1	4.3	4.7	
Number of ewes/stud ram	41.8	44.8	42.8	43.9	
Sales analysis					
Mean lamb price	63.43	63.54	63.48	61.65	
% "Lamb of Aragón" PGI	43.8	47.9	59.2	50.8	
% Sales in first semester	46.1	47.9	51.2	50.9	
% Sales in second semester	53.9	52.1	48.8	49.1	

Economic data stated in the euro value in 2004. a,b,c,d: Different letters in the same row differ significantly $P<0.05$. ** $P<0.01$, *** $P<0.001$

to the existence of handling or sanitary problems.

Although feed costs are low, because so few animals per MWU are handled, they have the greatest costs of family labour (€31.74) of all of the differentiated groups ($P<0.001$). If low productivity is also added to this, it can be seen that the economic results obtained are low and the cost per lamb sold is the highest (significant differences with groups 1 and 3).

Discussion

In factor 1 of the analysis carried out, the relationship in the sheep production systems studied, between production intensification, feed costs and labour productivity can be seen. As Riedel *et al.* (2007) pointed out, intensification of production in meat sheep systems leads to an increase in the number of lambs sold per ewe and year and, in turn, this intensification determines the nutritional requirements of the animals throughout the year; however, as it will be shown, the way in which these nutritional requirements are satisfied depends to a great extent on the production system employed. In the sample studied, an analysis of the results indicates that greater production intensification is accompanied by greater feed costs per sheep. Studying the results obtained in the typology, it can be seen that the two most intensive groups from the point of view of reproduction (1 and 3) employ different strategies in relation to the use of feeding resources. Group 1, which clearly carries

Table 4. Economic results of the differentiated groups

	Group 1	Group 2	Group 3	Group 4	Significant differences
Number of farms	11	19	8	18	
Income ewe^{-1}					
Lambs	104.28 a	70.29 c	88.68 b	72.84 c	***
Subsidies	34.36	34.57	28.28	31.15	
Other income	3.58	4.86	4.08	4.43	
Total income	142.22 a	109.72 b	121.04 b	108.42 b	***
Feed cost ewe^{-1}					
Sheep feed purchased	33.46 a	14.31 b	12.18 b	17.29 b	***
Lamb feed purchased	14.61 a	10.29 b	12.06 ab	10.46 b	*
Autoconsumption in feeding trough	9.05	10.40	11.43	10.85	
Grazing autoconsumption	2.89	2.52	2.71	3.15	
Rent of grazing land	2.20 b	4.63 b	9.58 a	3.58 b	**
Total feed	62.21 a	42.15 b	47.96 b	45.33 b	***
Total costs ewe^{-1}					
Total feed	62.21 a	42.15 b	47.96 b	45.33 b	***
Family labour	20.01 b	23.47 b	17.39 b	31.74 a	***
Salaried labour	1.67	1.25	3.36	0.00	
Agricultural social security	2.88 b	3.56 ab	3.38 ab	4.21 a	*
Health+Reproduction	4.01 ab	3.27 ab	4.55 a	2.99 b	*
Purchase of breeding stock	3.67	2.11	0.27	3.59	
Loan interests	0.75	0.85	0.54	0.85	
General costs	6.58	6.52	7.23	5.60	
Total costs	101.78 a	83.18 b	84.68 b	94.31 ab	**
Cost per lamb sold	62.06 b	75.62 ab	60.92 b	80.61 a	***
Economic results					
Gross margin ewe^{-1}	40.44 a	26.54 bc	36.36 ab	14.11 c	***
Gross margin farm^{-1}	24,745 b	19,844 b	36,782 a	5,453 c	***
Gross margin MWU^{-1}	20,621 a	12,886 b	20,099 a	5,145 b	***

Economic data stated in the euro value in 2004. (a,b,c,d) Different letters in the same row differ significantly $P<0.05$. * $P<0.05$, ** $P<0.01$, *** $P<0.001$

out intensification of reproduction to a greater extent, has high purchased feed costs both for sheep and lambs, with little surface area given over to forage crops and little rented grazing land. In this sense, in a sample of Aragonese sheep farms, Riedel *et al*. (2007) found that the duration of the grazing period was the factor that was most clearly and inversely related to intensification of reproduction. Group 3, although less intensive than the previous one, also obtains good results in terms of number of lambs sold. The farms in this group are those that have a greater surface area given over to forage crops, the cost of rented grazing land (essentially irrigated land) also stands out. These farms could be referred to having a different strategy, with less intensification of reproduction but with lower feeding costs than those of group 1, and with a labour remuneration that does not differ significantly to this group. Furthermore, these are the farms with the largest flock size in which the relationship between flock size and forage area is highlighted by the analysis.

The groups with less intensification of production (2 and 4) have little forage area and the difference between the two is based on other structural aspects such as flock size, UAA and area of rented grazing land. The farms in group 2 rent a large area of rainfed pastures on which their livestock feeding system is based. Although they are more extensive from the point of view of reproduction, the feeding costs and total costs per ewe do not different from those of group 3. Remuneration of labour is significantly lower on these farms in spite of the fact

that, in those belonging to group 2, the intensification of capital measured as the number of sheep per labour unit (Riedel *et al*., 2007), does not differ significantly from the groups of farms with the best results (1 and 3). Farms in group 4 have a lower intensification of capital and, because they handle a lower number of ewes per MWU, have high family labour costs which, together with their low productivity, means that they obtain the worst results of all the groups.

A recent work on the efficiency of sheep farms in Aragón carried out by Pérez *et al.* (2007) reveals that the most inefficient farms have the lowest work productivity (measured by the number of sheep per work unit) and the lowest intensification of reproduction. Other studies (Pardos and Oliván, 2000; Castel *et al.*, 2003) state that the continuity of the farms is dependant on their physical size measured by the farm's surface area and flock size. Although it has not been mentioned, group 4 is the group with a significantly smaller flock size, which makes the continuity of these farms even more difficult.

Based on the variables that characterise each of the groups, the different evolution of each of them can be foreseen. Thus group 1, which due to the high intensification of reproduction employed has a high production of lambs per ewe and high feed costs based on purchased resources, will foreseeably be the group that is most sensitive to the current market situation with a reduction in the price of lamb and increase in the price of raw materials. Different authors have shown that the intensification of sheep farms makes them more sensitive to market variations (Choquecallata, 2002) and that this is heightened by the fact that the sheep sector has, for years, been in an increasingly internationalised and competitive environment with the prospect of a progressive lack of protection (Chertouh *et al.*, 2001).

Group 3 may have a comparatively more favourable situation, since it does not depend as much on purchased feed and is less dependant on the aids received. This group is formed by farms located in irrigated areas, which receive less aids and are thus less sensitive to the modulation and to any possible change or future modification to the CAP. Although it is difficult to foresee its evolution, Oregui and Falagan (2006) have observed that the production of small ruminants in Spain reveals a certain tendency to move towards more productive irrigated zones, which may indicate the possibility of employing more viable production systems in these areas.

The groups of farms that employ more extensive production systems (2 and 4) have a lesser dependency on resources outside the farm than group 1, which, in principle, would have a positive effect in terms of lower costs in the current situation of rising prices, and a greater dependency on the subventions received (because these would represent a higher percentage of the total income than in the case of the previous two groups). To improve profitability, the farms in group 2 must improve their productivity or reduce their feed costs and those in group 4 must also improve their production structure (where possible). Furthermore, if a fundamental factor for the sector's continuity such as the quality of life of the farmers is taken into account, the future of these production systems would be in danger due to the harsh conditions of guided grazing (Caballero, 2001) and the lesser possibilities of planning reproductive activities that, to the contrary, are possible in intensive reproduction systems (Riedel *et al.*, 2007). The structural and reproductive characteristics of this type of farm also makes it difficult to apply other methods of handling: fencing of grazable areas, automatic feed system, etc. which imply a considerable reduction in the work load which in turn affects the quality of life of the farmer, as previously mentioned, and the number of sheep handled per MWU, with the consequent repercussion that this has on the results obtained.

Conclusions

The methodology used enables us to define four differentiated groups of farms in terms of their structural, technical and economic characteristics, which has allowed us to acquire a greater knowledge of one part of Aragonese sheep farming systems and their diversity.

The typologies obtained show the relationship that exists, in the sheep production systems studied, between production intensification, feeding costs and labour productivity.

According to the variables that characterise the typologies defined, their possible evolution to adapt to change contexts of costs, income, labour and new measures of agricultural policy, is also different. Thus, group 3, with good productivity and based on flock feeding by grazing in irrigated areas, seems to be the most adaptable group that has the greatest possibility of continuity since it achieves good economic results and is less dependent on external inputs and subsidies. Group 1, which is more intensive from the point of view of reproduction and has a feeding system based on purchased resources that represent a large cost, achieves good eco-

nomic results but is much more sensitive to feed price increases and the current reduction in the price of lamb that the sector is suffering. Groups 2 and 4, that are more extensive in terms of reproduction and more dependent on the grants received, have uncertain possibilities of continuity if subsidies are reduced, if they do not improve their productivity, if they do not reduce their costs or improve their structure (group 4), with the economic, social and environmental consequences that this would entail for Aragón.

The typologies defined may be useful in providing economic, technical assessment for farms and as a decision-making tool at different levels.

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