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The identification of homogeneous groups of cattle farms in the mountains of León, Spain

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Abstract

The aim of this work was to establish homogenous groups of cattle farms in the mountains of León, Spain, using the variables selected in a sister paper (this issue). Principal components analysis (PCA) was used to characterise and compare the different farms studied. Two classifications were established, the first taking into account the first seven axes selected by PCA, and the second by taking into account only the first two. A comparison of these systems led to the latter being selected. The final classification system involves eight groups based mainly on the orientation of production, size, productivity per breeding cow, and productivity per work unit.

Key words: livestock systems, disadvantaged areas, cluster analysis.

Resumen

Agrupación de explotaciones productoras de carne de vacuno en las montañas de León

El objetivo de este trabajo fue establecer grupos homogéneos de explotaciones utilizando las variables seleccionadas en un trabajo anterior (en este número) mediante la realización de un análisis de componentes principales con la finalidad de caracterizar y comparar las explotaciones productoras de carne de vacuno de las montañas de León. Las explotaciones estudiadas se clasificaron considerando los siete primeros factores seleccionados mediante la realización de un análisis de componentes principales y considerando sólo los dos primeros. Las dos clasificaciones obtenidas se compararon optando finalmente por la segunda. Esta clasificación está constituida por ocho grupos. Las explotaciones se clasifican dentro de estos grupos en función, fundamentalmente, de su orientación productiva, de su dimensión y de la productividad por reproductora y por unidad de trabajo.

Palabras clave: sistemas ganaderos, zona desfavorecida, análisis de clúster.

Introduction

This work forms part of a study with the overall aim of establishing a farm typology that allows the current status of the cattle sector in the mountains of León to be analysed.

The establishment of such a typology can be divided into two stages: the first involves identifying the variables responsible for the differences between farms, while the second establishes homogeneous groups according to these variables. Cluster analysis is a descriptive, multivariate, factorial statistical technique for the automatic classification of data. Using a case-variables table, this technique allows cases to be gathered into homogeneous groups known as clusters (Bisquerra, 1989; Carrasco and Hernán, 1993). The variables were identified in earlier work (see this issue).

This paper describes the second of the two stages mentioned above: the establishment of homogeneous groups of farms, using cluster analysis, for characterising the cattle farms of the mountains of León.

Material and Methods

The cluster analysis performed in this work involved the use of classification variables obtained via PCA (see sister paper in this issue; the farms studied and the data obtained are the same for both studies). In the present paper, the analysis of the data collected during

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the three sampling years were considered together - as in its sister paper. Data pertaining to each farm and for each year of the study were taken as single observations, such that cluster analysis was performed with a total of 111 observations (41 for 1996, 35 for 1997 and 35 for 1998). Two cluster analyses were performed with the aim of comparing the classifications obtained, one involving all seven principal components (PC) determined in the first paper, and one in which only the first two were taken into account.

Agglomerative hierarchical cluster analysis was performed using the average link or the centroid methods. The practical use and interpretability of the classifications obtained were compared and the average link method finally selected. The selection of the number of groups resulting from the clustering procedure, or the point of interruption of this process, was based on both mathematical and interpretability criteria. With respect to the mathematical criteria, the pseudo F and pseudo t^2 indicators were taken account. A marked increase in the pseudo F value plus a low pseudo t^2 value was considered to indicate that the groups formed met the objective of obtaining minimum intra-group variance and maximum inter-group variance (Carrasco and Hernán, 1993).

Cluster analysis was performed using the CLUSTER procedure of the SAS package (SAS, 1989). Finally, the groups obtained were compared by analysis of variance using the GLM procedure of the same software.

Results and Discussion

Grouping of farms

When taking into account the seven PCs selected in the prior PCA analysis (which explained 67.1% of the variance), the cluster formation process was detained at cluster 22 according to the pseudo F and pseudo t^2 indicators (Table 1). When only PC 1 and 2 were taken into account (which accounted for 31.1% of the variance), the grouping process was detained at cluster 13 (Table 2). In the first scenario, the number of groups formed was 11; the number of cases included in no cluster was also 11 (Table 3). In the second scenario, the number of groups formed was nine; the number of cases included in no cluster was 4 (Table 4).

Bearing in mind the significance of PC 1 and 2, the classification of the farms with respect to these axes

Table 1. Statistical indicators of cluster analysis taking into account the first seven principal components in earlier PCA analysis

No. of clusters (aggregation level)	Pseudo F	Pseudo r^2
25	12.8	6.9
24	13.1	1.5
23	13.3	3.5
22	13.7	2.0
21	11.7	18.8
20	12.1	3.1
19	12.6	
18	10.3	18.8
17	8.0	20.5
16	8.3	2.2
15	8.7	2.0
14	8.9	4.8
13	8.8	5.6
12	9.0	4.9
11	9.7	
10	8.9	10.0
9	7.5	13.1
8	8.2	
7	7.6	8.5
6	8.2	3.9
5	9.4	1.8
4	9.5	7.6
3	11.9	4.1
2	13.3	9.6
1		13.3

Table 2. Statistical indicators of cluster analysis taking into account the first two principal components in earlier PCA analysis

No. of clusters (aggregation level)	Pseudo F	Pseudo r^2
16	102.4	5.0
15	81.3	43.5
14	65.1	26.7
13	68.9	4.2
12	54.8	52.0
11	59.3	
10	63.2	9.1
9	64.5	16.5
8	55.3	29.2
7	49.3	30.8
6	20.7	96.4
5	25.0	3.2
4	31.0	4.3
3	38.5	13.8
2	37.2	31.9
1		37.2

Table 3. Identification of clustered and non-clustered farms taking into account the first seven principal components in PCA

Group											Not clustered
1	2	3	4	5	6	7	8	9	10	11	
cl 67	cl 48	cl 35	cl 32	cl 30	cl 27	cl 26	cl 25	cl 24	cl 23	cl 22	
		01 a	01 b								01 c
					02 a						
			03 a b c								
							04 a		04 b		
							05 a				05 b c
								06 a b	06 c		
					07 a b		07 c				
							08 a b c				
			09 b				09 a				
											10 a b c
		11 a c	11 b								
		12 c	12 b				12 a				
			13 b c				13 a				
			14 c				14 a				
		15 a c								15 b	
		16 c			16 a b						
					17 a b c						
					18 b c		18 a				
19 b c									19 a		
											20 a
	21 b c										21 a
											22 a
		23 c	23 b		23 a						
					24 c		24 a b				
							25 a c			25 b	
					26 a b c						
							27 a b c				
			28 b c				28 a				
			29 b c				29 a				
			30 a b							30 c	
		31 a	31 c								31 b
					32 a b c						
							33 b	33 a c			
				34 a b c							
					35 a b c						
		36 c	36 a b								
		37 a b c									
					38 b c		38 a				
									39 c	39 a	39 b
						40 a c					
							41 a				

cl: grouping of farms in cluster analysis. a, b, c: indicators of the year corresponding to the information thus marked: a = 1996, b =1997, c = 1998.

involves grouping in terms of orientation of production, farm size, individual productivity per reproducing cow and work unit. However, the type and quantity of produce obtained, as well as farm size and productivity, are not independent of the management and functioning of farms reflected in the remaining PCs. These variables are therefore also taken into account in the classification obtained. Bearing this in mind, and taking into account the interpretability of the classifications obtained using either PC 1 and 2

Table 4. Identification of clustered and non-clustered farms taking into account the first two principal components in PCA

Group									Not clustered
1	2	3	4	5	6	7	8	9	
cl 42	cl 26	cl 22	cl 21	cl 19	cl 18	cl 16	cl 14	cl 13	
			01 a b			01 c			
							02 a		
				03 a b c					
							04 a b		
					05 b c		05 a		
		06 b c					06 a		
							07 a b c		
		08 b					08 a c		
				09 a			09 b		
				10 b c					10 a
			11 a b					11 c	
			12 b c	12 a					
			13 b c	13 a					
			14 c	14 a					
			15 a b c						
				16 b			16 a c		
							17 a b c		
							18 a b c		
									19 a b c
	20 a								
	21 b c							21 a	
			22 a						
							23 a b c		
							24 a b c		
						25 b c	25 a		
							26 a b c		
							27 a b c		
			28 b c				28 a		
			29 b c	29 a					
			30 b c	30 a					
			31 b	31 c			31 a		
							32 a b c		
							33 a b c		
			34 a					34 b c	
							35 a b c		
								36 a b c	
			37 a b c						
							38 a b c		
		39 a				39 c	39 b		
40 a c									
			41 a						

cl: grouping of farms in cluster analysis. a, b, c: indicators of the year corresponding to the information thus marked: a = 1996, b =1997, c = 1998.

or PC 1-7, that associated with PC 1 and 2 was selected.

With the aim of improving the practical use of this classification, and bearing in mind the later linkages formed during the cluster analysis, the following groups were thus joined: groups 1 and 6 as group 1 (these two groups fused at level 10 in the cluster analysis), and groups 3 and 7 as group 3 (fused at level 9). Finally, a further group was added to these seven, group 10, which formed at levels 11 and 5 in the cluster analysis from three

out of four cases not originally grouped (corresponding to the information for farm 19 over the three years of the study, i.e., observations 19a, 19b and 19c).

The final classification therefore involved eight groups: groups 1-5 and 8-10 (Table 5).

Description and comparison of the farm types identified

Tables 6 and 7 show the means for each group, the degree of significance and the residual standard

Table 5. Identification of clustered and non-clustered farms in each group obtained taking into account only the first two principal components in PCA

Group								Not clustered
1	2	3	4	5	8	9	10	
cl 42+18	cl 26	cl 22+16	cl 21	cl 19	cl 14	cl 13	cl 5	
		01 c	01 a b					
					02 a			
				03 a b c				
					04 a b			
05 b c					05 a			
		06 b c			06 a			
					07 a b c			
		08 b			08 a c			
				09 a	09 b			
				10 b c				10 a
			11 a b			11 c		
			12 b c	12 a				
			13 b c	13 a				
			14 c	14 a				
			15 a b c					
				16 b	16 a c			
					17 a b c			
					18 a b c			
							19 a b c	
	20 a							
	21 b c					21 a		
			22 a					
					23 a b c			
					24 a b c			
		25 b c			25 a			
					26 a b c			
					27 a b c			
			28 b c		28 a			
			29 b c	29 a				
			30 b c	30 a				
			31 b	31 c	31 a			
					32 a b c			
					33 a b c			
			34 a			34 b c		
					35 a b c			
						36 a b c		
			37 a b c					
					38 a b c			
		39 a c			39 b			
40 a c								
			41 a					

cl: grouping of farms in cluster analysis. a, b, c: indicators of the year corresponding to the information thus marked: a = 1996, b =1997, c = 1998.

Table 6. Labour, land use, stock base and production characteristics of the farm types identified by cluster analysis (variables used in cluster analysis are in italics; those not in italics are variables considered after the formation of the groups)

	Group 1 (n=4)	Group 2 (n=3)	Group 3 (n=8)	Group 4 (n=25)	Group 5 (n=13)	Group 8 (n=47)	Group 9 (n=7)	Group 10 (n=3)	RSD[a]	P
Labour										
Breeding cows/AUU-cattle[b]	12.96	89.33	23.51	27.68	21.64	13.48	42.14	38.17	7.982	0.0001
Age of owner	53.25	33.67	47.75	44.44	44.85	45.30	53.00	43.00	10.163	0.1478
Age of longest serving worker	53.25	33.67	41.25	39.48	43.23	41.38	39.43	43.00	11.582	0.4572
Stock base										
Breeding cows/farm	26.50	89.33	39.13	34.52	24.54	25.62	58.86	76.33	9.503	0.0001
Dairy cows (%)[c]	100.00	0.00	50.95	3.58	12.16	64.29	0.00	48.67	21.091	0.0001
Mother cows (%)[c]	38.19	80.06	65.95	81.18	69.56	51.31	92.34	80.29	21.361	0.0001
Pardas (%)[c]	100.00	5.73	80.68	31.75	28.68	76.37	25.76	85.67	23.505	0.0001
Crossbreeds (%)[c]	0.00	82.07	14.64	42.72	27.52	13.86	60.56	14.33	20.237	0.0001
LU-other species (%)[d]	0.00	0.00	1.53	3.13	18.03	2.38	6.89	0.00	9.707	0.0001
Production characteristics										
— Milk production										
Litres sold/farm	114,250	0	58,750	3,080	10,230	38,387	0	169,630	16,711.3	0.0001
Litres sold/breeding cow	4,319	0	1,701	77	344	1,600	0	2,271	624.7	0.0001
Dif. litres sold-quota (%)[e]	110.39	0.00	26.22	−6.71	−19.34	12.51	0.00	6.02	38.209	0.0001
% weaned grazing calves[f]	0.00	44.07	0.99	12.19	4.17	3.08	24.46	0.00	18.323	0.0006
— Calf production										
% finished calves[f]	63.69	55.93	72.65	76.12	64.97	65.44	72.80	95.83	33.752	0.7270
% suckling calves[f]	30.36	0.00	23.98	3.77	26.31	31.29	2.75	3.43	28.542	0.0046
% replacement calves[f]	0.00	0.00	0.00	7.92	0.00	0.29	0.00	0.00	13.842	0.0293
% fattened calves[f]	5.95	0.00	2.38	0.00	4.55	0.00	0.00	0.74	11.292	0.9073
Dead calves/calves sold (%)	25.00	40.87	15.10	19.18	29.81	14.98	18.79	39.74	18.577	0.0438
Dead calves/calves born (%)	10.20	17.20	8.34	7.12	15.59	8.54	10.98	20.88	7.211	0.0025
Calves sold/breeding cow	0.42	0.36	0.49	0.44	0.41	0.49	0.49	0.53	0.186	0.7196
Calves born/breeding cow	0.81	0.60	0.77	0.81	0.78	0.79	0.71	0.96	0.143	0.0993
— Land use										
LU-total[g]*/UAA*[h]	0.76	3.17	1.42	1.60	1.29	1.67	1.82	1.53	1.419	0.5311

[a]RSD: residual standard deviation. [b]*AWU-cattle:* Annual work unit (agricultural work performed by one full time worker per year) – specifically with respect to cattle production. [c]*Dairy cows (%), Pardas (%), crosses (%), mother cows (%):* % of dairy cows, *Parda* breed cattle, crossbreeds, cows with premium rights to suckling respectively. [d]*LU-other species (%):* % of the LU-total of a farm made up by sheep, goats and mares calculated according to the conversion indices described in the *Council Regulation (EEC) No. 1254/99, 17 May 1999.* [e]*Dif. quota-litres milk sold (%):* percentage derived from the difference between the number of litres of milk produced by a farm and the number of litres assigned by the quota, over the number of litres assigned by the quota. [f]*Weaned grazing calves, % finished calves, % suckling calves, % replacements, % fattened calves:* percentage of calves sold at weaning before fattening and fed only on milk and pasture; for slaughter; not fattened, 1-2 months old; replacements animals and those resold after their acquisition to another farm after a period of fattening. [g]*LU-total:* Livestock units belonging to the farm in question (number of cows, sheep, goats and mares calculated according to the conversion indices described in the *Council Regulation (EEC) No. 1254/99, 17 May 1999.* [h]*UAA:* utilised agricultural area (ha) (own land/rented land upon which a farmer can depend over the years for agro-stock raising activities).

deviation obtained in the analysis of variance of 53 variables concerning labour, the stock base, and the productive and economic characteristics of the farms.

Six of the eight groups identified can be grouped into two types: farms specialised in the production of calves, and those that combine milk and different types of calf production. Three subgroups can be established within the first of these, largely based on farm size (number of breeding cows), corresponding to groups 2, 9 and 4 (descending scale). Three subgroups can also be established in the second of the above of the farm

Table 7. Economic characteristics (mean annual values for costs, income and profit expressed in Euros) for the different types of farm identified by cluster analysis (variables used in cluster analysis are in italics; those not in italics are variables considered after the formation of the groups)

	Group 1 (n=4)	Group 2 (n=3)	Group 3 (n=8)	Group 4 (n=25)	Group 5 (n=13)	Group 8 (n=47)	Group 9 (n=7)	Group 10 (n=3)	RSD[a]	P
Costs										
Cattle costs[b]/breeding cow	797.39	282.53	61.93	307.00	455.87	524.04	252.81	813.28	205.371	0.0001
— *Sanitary costs*	41.07	16.90	37.6	27.63	27.36	33.61	16.55	55.21	15.954	0.0066
— *Feed*	517.83	98.21	319.49	145.52	198.20	309.06	92.21	566.03	125.542	0.0001
— *Feed bought*	481.78	82.58	253.75	106.87	147.78	264.02	60.59	533.34	114.013	0.0001
— *Pasture*	28.43	11.74	38.53	28.43	32.39	31.79	23.91	20.82	21.320	0.6291
— *Forage*	25.76	22.39	31.75	22.13	26.35	29.44	20.69	43.01	27.394	0.8914
— *Purchase of forage*	18.14	18.50	4.54	11.91	8.32	16.20	12.99	31.14	18.658	0.4221
— *Concentrates*	463.63	64.07	249.21	94.96	139.46	247.82	47.60	502.19	107.967	0.0001
— *Fuel*	16.13	21.43	20.87	14.84	15.84	22.08	21.71	19.26	15.631	0.7051
— *Electricity*	16.43	0.16	12.67	4.49	7.60	13.14	2.46	4.56	4.267	0.0001
— *Social security*	135.53	18.88	58.51	52.52	77.56	81.02	35.09	36.90	26.538	0.0001
— *Studs*	0	2.88	2.43	3.80	2.20	0.55	0.91	4.19	3.548	0.0178
— *Replacement cattle*	5.93	93.44	95.68	15.6	52.37	21.48	31.67	3.34	68.152	0.0579
— *Re-sold animals*	19.80	0	27.64	8.38	27.64	1.42	0.88	11.52	32.693	0.1266
— *Maintenance*	32.59	11.88	21.52	18.57	23.07	25.25	24.39	31.72	17.688	0.6001
— *Insurance*	9.50	18.42	20.47	14.14	20.96	13.11	23.17	72.13	14.275	0.0001
— *Others*	2.59	0.33	2.42	1.39	1.77	2.46	3.45	8.44	2.332	0.0004
Income										
Total income[c]	49,846.12	59,440.53	50,572.48	26,990.28	16,791.35	25,069.86	48,197.14	122,196.22	9,307.534	0.0001
Income cattle[d]/breeding cow	1,930.57	664.64	1,315.74	794.80	679.99	1,001.50	721.53	584.41	216.020	0.0001
— *Calves*	251.21	221.42	318.73	309.71	262.26	292.42	342.70	460.98	138.842	0.3860
— *Adults not for slaughter*	230.28	0	68.27	11.97	9.33	36.88	0	0	84.157	0.0003
— *Adults for slaughter*	25.16	91.31	49.97	35.87	23.66	47.13	33.13	20.76	46.637	0.3494
— *Milk*	1,188.07	0	487.07	20.15	87.78	420.78	0	652.65	175.200	0.0001
— *Subsidies*	116.03	168.40	198.12	215.21	184.18	155.07	241.10	244.88	50.898	0.0001
— *Capitalization of calves[e]*	78.31	88.77	85.02	110.24	18.93	13.23	40.07	88.76	114.964	0.0561
— *Capitalization of adults[f]*	41.52	94.74	98.51	38.62	61.85	33.94	56.31	95.58	102.823	0.7104
Economic and productivity results										
GM-total[g]	29,795.08	33,853.03	28,463.90	16,145.64	6,700.80	12,268.05	32,416.28	61,423.80	8,068.360	0.0001
GM-cattle[h]/breeding cow	1,133.19	382.11	696.43	442.80	224.12	477.45	468.72	771.13	155.862	0.0001
GM-cattle/AWU-cattle	14,604.52	33,853.03	16,507.75	12,587.03	5,449.95	6,527.42	18,212.61	30,711.90	5,334.797	0.0001
GM-cattle without subsidies/breeding cow	1,017.16	213.71	498.31	227.59	39.94	322.38	227.62	526.24	159.312	0.0001
GM-cattle without subsidies/AW-cattle	13,085.27	18,735.57	11,740.72	6,373.98	1,399.41	4,500.61	8,097.95	21,522.32	4,559.991	0.0001
Income subsidies/GM-cattle (%)	10.31	44.84	30.54	51.00	78.67	8.32	64.40	36.41	149.8	0.8569

[a] *RSD:* residual standard deviation. [b] *Cattle costs:* sum of costs for feed, sanitary products, electricity, maintenance of installations, cattle purchases, labour, insurance and other costs derived exclusively from cattle production. [c] *Total income:* sum of *Income cattle* plus that derived from other species or the sale of agricultural products. [d] *Income from cattle:* sum of the income from the sale of calves, adult cattle not for slaughter, adult cows for slaughter, milk, subsidies and from the estimated variation in the number of animals held by the farm (capitalization of livestock). [e] *i. Capitalization of calves:* estimated variation in number of calves for one year. [f] *i. i. Capitalization of adults:* estimated variation in number of breeding cows and studs for one year. [g] *GM total:* total gross margin – the difference between total income and total costs. [h] *GM-cattle:* gross margin for cattle – the difference between income from cattle and cattle costs.

type groups, corresponding to groups 1, 3 and 8 (descending scale), based on farm size and the orientation towards milk production.

Group 5 can be understood as a transition phase between smaller, milk-producing farms and those specialised in the production of calves, while

group 10 represents a subgroup segregated from group 3 because of the large size of its component farms.

Group 1. Farms mainly orientated towards milk production

The main characteristic of the farms of group 1 is the importance of milk production. This group has the highest mean value for litres of milk sold per breeding cow and, with the exception of group 10, the highest mean value for litres of milk sold per farm. A more or less direct consequence of this orientation is the reduced size of the farms (number of breeding cows per farm) and the high degree of intensification with respect to the labour factor (low number of breeding cows managed per worker). With respect to this latter variable, group 1 has the lowest mean value of all eight groups. Other important characteristics of this group include the high mean value for the difference between the milk quota and the actual production of the farms (in all cases above the quota assigned), the fact that all the dairy cows belong to the *Parda* breed, and the relatively small percentage of breeding cows (the lowest mean value for all the groups) with premium rights to suckling.

The two farms in this group (two observations per farm) differed in terms of the importance of calves for slaughter. Farm 5 sold all its calves for slaughter, while farm 40 sold only 14.3% of its calves for slaughter in 1966 and 64.3% in 1998.

The mean values for costs, incomes and gross margin per breeding cow are high for group 1 farms. The most important costs are for feed, which are higher than for the other groups (except group 10), and social security payments. In terms of income, the most important areas are the sale of milk (the highest of all 8 groups) and the high mean income produced by sales of adult cattle *not* for slaughter. Also important is the low mean value for income owed to subsidies (the lowest of the eight groups).

The mean annual gross margin per breeding cow is the highest of all eight groups (whether subsidies were included or not). However, as a consequence of the reduced number of breeding cows managed per work unit, the mean profit per worker is intermediate between the values of the other groups.

Group 2. Farms specialised in calf production with a large number of breeding cows and with high annual work unit values (extensive production systems with respect to the labour factor)

This group includes farms that exclusively produce calves, which have a large number of breeding cows and follow a system that allows many animals to be managed per worker. Of the three groups specialised in calf production (2, 4 and 9), group 2 has the highest mean values for breeding cows per farm and breeding cows handled per work unit. These farms also show a high percentage of breeding cows with premium rights to suckling, and a high number of crossbreed breeding cows: this group has the highest mean value for the variable *% of crossbreed breeding cows*.

The farms included in this group do not market calves, neither suckling calves, fattened calves nor replacement calves. In addition, despite the strong orientation towards calf production, they sell a relatively high percentage of weaned grazing calves. The mean percentage of calves sold in this condition is the highest for all eight groups, though the value for farm 20 was much higher (91.3%) than that of 21 (25.0 and 15.9% in 1997 and 1998 respectively).

Group 2 is also characterised by having the highest mean value for the percentage of dead calves with respect to those sold, the second highest for percentage of dead calves with respect to those born, and the lowest value for calves born per breeding cow. By way of qualification, the high value for *dead calves/calves sold (%)* is, in part, due to including the 1997 value of farm 21 (83.33%). This high figure was due to high mortality at that farm and the relatively small number of calves sold.

One outstanding aspect of the information regarding this group is the advantage taken of the utilised agricultural area (UAA). The high stocking rate per hectare UAA shown in Table 6 corresponds only to that of farm 20; farm 21 had no UAA. The differing conditions of these farms can be explained by bearing in mind that this group includes farms that base the feeding of their breeding cows on the grazing of communal land, producing very little or no forage for themselves.

A more extensive description of the general management practices of these farms shows that breeding cows are generally never stabled, that the grazing for both cows and calves is communal mountainside pasture, that purchased forage is provided in the field

during times of need, that these farms do not raise their own replacement animals, and that in addition to forage distribution the general management of breeding cows is reduced to taking calves away from their mothers at weaning.

With respect to economic characteristics, this group has reduced costs, income and gross margin per breeding cow and year. With respect to production orientation, mean forage costs per breeding cow are relatively high, as are those for replacement animals. Another fundamental characteristic of this group, despite reduced mean annual profits per breeding cow, is the mean value of profits per worker (due to the high number of breeding cows managed). It is the highest of all the groups considered if subsidies are taken into account (except for group 10, without including subsidies).

Group 3. Medium size milk producing farms with a high percentage of breeding cows specialised in calf production

All group 3 farms produce milk, except one specialised in calf production. Excluding group 10 and comparing to the other groups that produce milk (1 and 8), group 3 is that with the highest mean number of breeding cows per farm plus the highest number managed per work unit. This is explained, at least partly, by the presence of a high percentage of cows that are not milked. The percentage of cows dedicated to the sole production of calves (and which are therefore not milked) varies from 0.00 to 75.44% (excluding the farm that produces no milk). Three of the four farms in group 3 that produce milk have different breeds of animal (one for milking, the other not) of different relative importance according to the farm in question.

Other characteristics of this group with respect to the composition of the reproductive herds include the relatively high percentage (compared to group 1) of cows with premium rights to suckling. Although the *Parda* breed is in the majority on all farms, just two farms have only *Pardas*. The mean value for the percentage of crossbreeds is about 15%.

The volume of milk produced by these farms is less than that produced by the farms of group 1 but greater than that produced by those of group 8. The difference between the number of litres produced and the assigned quota follows the same pattern.

Differences also exist between this and other groups with respect to calf production. Only in three of the eight cases corresponding to farms was the entire calf production not destined for slaughter. These animals were mainly sold as suckling calves and came from the dairy herd.

With respect to economic characteristics, group 3 shows a notably lower income per breeding cow per year than group 1. This is mainly due to a lower income from milk sales not compensated by subsidies. Despite the differences in income in terms of breeding cow per year, the *total income* of group 3 is similar to that of group 1 because the former has more cows per farm.

Productivity follows a similar pattern to that of income. Despite having lower costs per breeding cow, group 3 farms have a mean lower gross margin per breeding cow per year than those of group 1. However, the larger number of breeding cows managed per work unit provides them with a similar productivity per worker.

Group 4. Farms specialised in calf production with a low number of breeding cows per farm and annual work unit

Though this group includes farms in the last phase of conversion from milk and calf production to calf production alone, it can be considered to be formed by specialist calf producers. Of the three groups of farms specialised in the production of calves (2, 4 and 9), group 4 has the lowest mean values in terms of breeding cows per farm and of breeding cows managed per worker.

Of these groups, group 4 also has a high percentage of breeding cows with premium rights to suckling, and the highest percentage of breeding cows of the *Parda* breed (and the lowest percentage of crossbreeds).

Compared to the other calf producing speciality groups, group 4 has the fewest calves sold as weaned grazing calves. Compared to all the groups analysed, it has the lowest mean value for dead calves with respect to those born. Finally, the number of calves born to breeding cow is greater than that seen in groups 2 and 9.

With respect to economic characteristics, group 4 has relatively low annual costs per breeding cow (as do groups 2 and 9). Mean income and profits are lower than those of groups 2 and 9 (as might be expected from the differences in the number of breeding cows

per farm). In terms of this last variable, group 4 farms obtain higher mean annual profits than those of groups 2 and 9. A direct consequence of the number of breeding cows managed per work unit, the mean profit per work unit of group 4 is the lowest of the calf-producing specialist groups.

Group 5. Farms in the process of moving towards specialisation in calf production

The main characteristics of this group (which includes farms specialised in calf production and milk and calf production) are their small size and the poor economic results obtained. Group 5 has the lowest mean annual profits per farm, per breeding cow and per work unit. Eight of the 10 farms in this group could be defined, for different reason (including forced abandonment of milk production, new installations, and division between several owners) as being immersed in a brusque transformation process. Group 5 could be considered the transition group between milk producing types of farm (basically group 8) and those specialised in calf production.

Group 8. Traditional mixed farms (production of milk and different types of calf)

The farms of group 8 are closer to what might be considered the traditional systems of exploiting the mountains of León: they produce milk and fattened calves, with many breeding cows being both milked and allowed to suckle their calves. The farms of this group have a low number of breeding cows per farm and work unit. The mean values for these two variables were similar to those of group 1. However, the mean number of litres of milk produced per farm and per breeding cow is much lower than that of group 1.

Compared to group 1, several differences are seen with respect to the reproductive herd, such as group 8's lower mean value for the percentage of *Parda* breed cows (crossbreeds = 15% approximately), and the higher mean value for the percentage of cows with premium rights to suckling.

With respect to economic factors, the most outstanding characteristic of group 8 is the reduced profit obtained per worker. Intensification with respect to the labour factor (group 8 has the lowest mean value for breeding cows managed per annual work unit, AWU) does not translate into high income per breeding cow; productivity per worker is therefore also low. The high degree of intensification with respect to the labour factor can be considered the result of the relationship between two factors: the high labour supply for farms that continue to practice systems close to traditional models for the area, and the high labour demands of these models.

Group 9. Farms specialised in calf production with a medium number of breeding cows per farm and per annual work unit

Group 9 includes farms specialised in calf production. Of the three groups specialised in this area (2, 4 and 9), group 9 takes second place both in terms of the number of breeding cows managed per work unit and breeding cows per farm. These farms have the highest mean percentage of cows with premium rights to suckling. Although some *Parda* cattle remain, crossbreeds dominate.

The farms of this group sell an important percentage of their calves as weaned grazing calves. The mean value for *% weaned grazing calves* of this group is intermediate between those of groups 2 and 4, as are its values for the percentage of dead calves with respect to those born, and calves born per breeding cow.

With respect to groups 2 and 4, group 9 has the lowest mean value for costs per breeding cow per year and an intermediate value for income per breeding cow per year (though the differences were not very great). Group 9 also has the highest mean income from subsidies (expressed in terms of the number of breeding cows per farm). With respect to annual profits, the mean value for group 9 was similar to those of group 2 but very much higher than that of group 4. This is explained by the variation in mean annual profits per breeding cow and the number of breeding cows per farm. The differences in the number of breeding cows per farm and breeding cows managed per worker renders the mean annual profit per worker in group 9 notably lower than that of group 2 but higher than that of group 4.

Group 10 (subgroup of group 3)

Group 10 cannot be considered a farm type in the strict sense since it includes the observations made

over three years on one farm with characteristics atypical for milk producing farms (it is very large). Because of its size, it forms a subgroup of group 3.

Overall remarks

The adaptation of traditional mountain area stock raising systems to current socioeconomic conditions has led to the great diversification of production systems followed (Dobremez *et al.*, 1990; Manrique *et al.*, 1992; Olaizola *et al.*, 1995; Chatellier *et al.*, 2000). The eight types of farm described above are an example of this.

The groups obtained in the cluster analysis can be considered representative of the different states of change of farms with respect to the traditional model for the mountains of León, with group 8 remaining the closest. Two divergent trajectories away from this model (which nowadays brings only small profits) can be identified:

— Specialisation in the production of milk and the intensification of the production system.

— Specialisation in the production of beef and the extensification of the production system.

This is common to many disadvantaged areas where the European Common Agricultural Policy is applied, and has frequently led to the overuse of resources in some areas and underuse in others (Caraveli, 2000; MacDonald *et al.*, 2000).

Group 1 is the most representative of the first of these trajectories. This group is specialised in intensive milk production. A large increase in production per breeding cow is obtained with this system, but an important part of the feed the animals receive is in the form of concentrates which have to be purchased. The increase in production is accompanied by higher productivity per breeding cow. The high labour demands and costs of the system do not allow, however, high productivity per farm or worker.

An increase in the productivity of group 1 farms based on an increase in size would be limited by their own remaining characteristics and by milk production quotas. In response to these production restrictions, these farms have opted to divert some of the milk they produce into feeding calves (Chatellier *et al.*, 2000). Increased calf fattening, the sale of calves to other farms (cows and heifers), and the adaptation of the milk production system towards one based on the use of forage produced by the farm, could provide economic alternatives for this type of farm. An improvement in the use of forage systems (which could lead to a reduction in the purchasing and use of concentrates) might also be of environmental interest (Chatellier and Vérité, 2003).

Like group 1, group 3 mainly contains farms with herds of breeding cows for milk production; they have also increased their size by the addition of animals for calf production. The gross margin per breeding cow in this group is lower than that of group 1, but because of the greater number of breeding cows managed per worker, the productivity per worker is similar. Bearing in mind the restriction in milk production, the only way to greatly increase productivity would be to increase the size of the herd orientated towards calf production.

The second trajectory has been followed by the farms of group 2. These specialise in calf production and obtain the greatest productivity per worker and compensate for bad technical and economic results per breeding cow. The production system is very extensive and farms very large; the number of breeding cows managed per work unit is very high, and costs per breeding cow low. The other two groups specialised in calf production are groups 4 and 9. Owing to their smaller size, group 4 farms have productivity per farm and per worker values lower than those for group 2, while group 9 farms have lower productivity per worker values. Given the current socioeconomic background, and bearing in mind the characteristics of the remaining groups, productivity is most likely to increase in group 4 through an increase in the number of breeding cows and the extensification of the production system (within the limits allowed by the grazing area available).

In general terms, the above information confirms the general theory that recent economic development has led to the increased importance of the productivity of the labour factor in the profitability of production systems (Tirel, 1991; Manrique *et al.*, 1994; Landais and Balent, 1995; Caballero, 2001). The most profitable systems are those based on a greater use of the land and which are less dependent on the labour factor and capital per hectare.

In conclusion, the results obtained show that cluster analysis is useful in the establishment of typologies that reflect the processes of farm development, and for providing criteria for producing and applying stock raising policies adapted to the realities and needs of farms. However, as mentioned in the sister paper, and in agreement with observations made by other authors

(Blanc and Allaire, 1979; Perrot and Landais, 1993; Gibon, 1994; Landais, 1998), there is a need for an empirical knowledge of farms to discriminate (in terms of usefulness and correspondence with reality) between the large number of different results these techniques can produce.

The characteristics of the groups identified coincide with observations made by other authors on the evolution of mountain area stock raising systems with respect to farm size as a basic conditioner of economic viability, the importance of subsidies in the development and profitability of farms, the advantages of maximising the extensification of production systems, the importance of fattening calves as a complementary activity to milk production, and the need to increase the advantage taken of forage-growing areas to reduce production costs (Dobremez *et al.*, 1990; Olaizola *et al.*, 1995; Rodríguez and Alfageme, 1996; Chatellier et al., 2000; Chatellier and Delattre, 2003).

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