Characterization and Typification of Sheep Farms Oriented Towards Meat Production in Aragon (Spain)

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SUMMARY

The general aim of the present study is to characterize a group of meat sheep farms that form part of the management network of an Aragonese co-operative using a series of different variables: sociological, structural, technical, income and costs and economic results. The Factor Analysis has proved to be extremely useful in revealing the interrelations between different variables that characterize farms. Moreover has served as the basis for a subsequent segmentation by applying a Cluster Analysis. Having defined the groups, a Variance Analysis was performed to see if they were also statistically different in a set of additional variables that was necessary to obtain a practical significance. Economic results are not linked to certain feed costs but rather it would appear that productivity is the variable that is most closely related to results. In order to achieve high economic results, productivity must be high or at least average, if feed costs are low. On the other hand, low economic results are related to low productivity or average productivity if feed costs, in this latter case, are high.

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INTRODUCTION

Sheep farming has always been an important activity in the whole of the Mediterranean basin, which is a fundamentally arid or semiarid zone with a characteristic climate that determines temperatures, rainfall and light parameters that are appropriate for sheep production. However sheep farming cannot be described as a homogenous activity in northern and southern Mediterranean countries due to the considerable differences that exist from a demographic, economic, and even ecological point of view. European Mediterranean sheep farming is concentrated particularly in Spain and France. 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, 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).

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. The most tangible result of these measures has probably been an increase in the areas used and a reduction in work in absolute or relative terms, although this evolution has been different depending on the particular region considered.

From the study carried out, based on a survey of 209 farms in different autonomous communities (Sierra, 2002), 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. Aragonese farmers view their work as requiring a great deal of sacrifice whilst obtaining little profitability, either because the prices are low or because there are not sufficient subsidies or because lamb production is low (Gil et al., 2003). Lastly it is worthy of mention that an organizational 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.

AIMS AND METHODOLOGY

The general aim of the present study is to characterize a group of meat sheep farms that form part of the management 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 analyzed and a series of groups to be established, based on the variability that exists.

The data that are analyzed have been obtained using the Economic-Technical Management Program for meat sheep developed by the Escuela Politécnica Superior de Huesca that forms part of the University of Zaragoza together with the Livestock Co-operative Carnes Oviaragón SCL. The sample is formed by 56 Aragonese farms. In order to avoid inter-annual variations, the farm data used are the mean data of a five-year period running from 2000-2004.

The basic characteristics of this Management Program are that it evaluates autoconsumptions (self-provisioning from the farm itself), including grazing resources as well as family labor. Autoconsumptions are valued at the market price or, in the absence of said price, at production

cost. When valuing family labor, the mean wage received by salaried labor is taken into account, having discounted social security contributions. To allow economic results to be compared they are stated in 2004 euros, in relation to the Consumer Price Index.

The statistical methods of the Factor Analysis and Cluster Analysis have been used to characterize 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.

As is well known, factor analyses allow the structure of the interrelations (correlations) between a large number of variables to be analyzed, defining a series of common, underlying dimensions, known as factors, with a minimum loss of information (Hair et al. 2000). In our work, the factor analysis has proved to be extremely useful in revealing the interrelations between different variables that characterize farms in terms of structure, technical aspects, costs and economic results obtained.

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. To help in the interpretation of the factors, we opted for a Varimax orthogonal rotation that 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.

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. It has been of great use in our work to differentiate several groups of farms, identifying the most important determining factors.

As scales of the variables are different, we have opted to typify the data by means of the Z- score method, which converts each score of the original variables into a standardized value with a mean of 0 and a standard deviation of 1. The cluster algorithm used has been the Ward hierarchical method, which minimizes differences within the cluster and the square Euclidean distance, recommended for this method, has been used as the measure of similitude.

The variance analysis has been useful in establishing the existence of significant differences between the means of the variables characterizing 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 analyzed, we used the variance homogeneity test (Levene's test) and, if the latter revealed significant differences, Welch's robust test for mean equality (Camacho, 2002).

RESULTS AND DISCUSSION

-Characterization of the sample of farms

The description of the farms analyzed is carried out with a series of indices that can basically be grouped under the following headings:

Sociological	Structural
Technical: production and commercial	
Income and costs	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 and indicates a high sheep specialization. The farms have 98 ha of useful agricultural area (UAA), which is principally farm-owned, rainfed 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 given over 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 3 farms in the sample with permanent stabling, which use prolific breeds.

Table 1: Mean data of the farms analyzed. Economic data stated in 2004 €

	Mean	DT (1)		Mean	DT (1)
Age of farmer	46.8	9.4	**Income/ewe**		
Level of qualification of farmer (scale of 1 to 10)	6.7	1.6	Lambs	80.42	18.3
Structural data			Subsidies	32.53	6.7
Number of ewes	642.5	299.3	Other income	4.36	5.6
Number of MWU	1.36	0.6	Total income	117.31	18.8
% family MWU	96	12.4	**Feeding cost/ewe**		
No. ewes/MWU	472.4	166.8	Food purchased for ewes	18.73	12.2
Useful agricultural area (ha)	97.8	93.7	Food purchased for lambs	11.45	3.9
Forage UAA (ha)	17.3	22.8	Autoconsumption - manager	10.43	9.1
% Owned UAA	61.8	31.9	Autoconsumption - grazing	2.82	2.6
% Irrigated UAA	24.3	34.0	Rent of grazing land	4.52	4.4
Rented grazing land (ha)	543.8	779.3	**Total costs/ewe**		
Technical ratios			Total feeding	47.95	12.1
No. of births/ewe	1.19	0.1	Family labor	24.58	8.4
Prolificacy	1.35	0.1	Salaried labor	1.24	3.4
% Twin births	32.1	12.0	Agricultural social security	3.61	1.1
% Births of more than two lambs	1.3	1.8	Health + Reproduction	3.51	1.3
Lambs born/ewe	1.61	0.3	Purchase of breeding stock	2.63	5.2
% lamb mortality	10.5	3.5	Loan interests	0.79	1.3
Lambs sold/ewe	1.28	0.3	General costs (2)	6.34	2.4
Sales analysis			Total costs	90.65	16.3
Mean lamb price	62.90	2.0	**Economic results**		
% "Lamb of Aragón" PGI	49.6	29.1	Gross margin/ewe	26.66	16,1
% Sales in first semester	49.0	9.8	Gross margin/farm	17,129	15,171.8
% Sales in second semester	51.0	9.8	Gross margin/MWU	12,594	10,007.5

(1) Standard deviation

(2) Shearing, quotas to associations and co-operatives, marketing costs, insurance, transport, water, electricity, gas-oil, maintenance and repairs, renting of installations, etc.

There were 1.19 births per ewe per year; the farms used different reproduction management systems and prolificacy was 1.35 lambs per birth. They sold 1.28 lambs per ewe per year at a mean price of 62.90 € (50% are marketed under the "Lamb of 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 labor (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.

As previously indicated, applying the Factor Analysis has enabled us to reduce the information available and find an underlying structure that explains a high percentage of the variability of the initial matrix. 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 = Cost of feeding per ewe
- V_5 = Total costs per ewe
- V_6 = Gross margin per ewe
- V_7 = Goss margin per MWU

In selecting these variables the following criteria have been taken into account. The structure variables chosen were: 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 the hectares of UAA given over to forage crops, which we consider provides more information than total Useful Agricultural Area, 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 per 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 favored areas or the agro-environmental aids available.

In relation to costs we have selected two variables: feed costs and total costs per ewe, the former because it is the greatest cost and accounts for almost 53% of the total cost, and the latter because it groups together the rest of the costs contemplated. With regard to economic results, the gross margin per ewe and gross margin per MWU have been chosen. The former reflects productivity per ewe and the second also takes into account the correct dimensioning of the flock and quantifies labor salaries.

In this line of reasoning, in terms of the choice of variables, Pérez et al. (2003) conclude that labor, feed cost and number of lambs produced, together with amortizations and interests and the size of the company are the parameters that have the greatest effect on business profit in meat sheep farms.

Given the size of the sample analyzed and that it is eight times greater than the number of variables selected, a factor analysis is considered to be a suitable procedure. A principal components analysis (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.

Table 2 shows the proportion of total variance, in individual and accumulated percentages, explained by each factor or component, both in the non-rotated and rotated solution. The factor analysis has generated 3 factors that explain 84.5% of the total variance, which can be considered to be a good percentage. Table 3 shows the matrix of factor loadings, i.e. the correlations between each variable and the factor. Factor loadings 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 33.4% of the total variance and is characterized by three variables: Gross margin per ewe, gross margin per MWU and lambs sold per ewe. It can be interpreted that the farms that achieve the best economic results per animal are able to obtain better return (since these variables are highly related), and these results are also linked to the number of lambs sold per ewe, and thus to the productivity that the farms achieve.

Factor 2: Explains 32.1% of the variance and is characterized by 3 variables expressed per ewe: Feed cost, total costs and lambs sold. It thus identifies the intensification of production with higher feed costs and total costs per ewe: “flushing”, supplementary feed for lactating ewes with longer stabling periods, higher feed cost for lambs per ewe and greater reproduction costs (hormonal treatments) and marketing costs.

Factor 3: Explains 19.0% of total variance and is characterized 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.

Table 2. Factor Analysis: Explained total variance

	Initial eigenvalues			Rotation Sums of Squared Loadings		
Component	Total	% of the variance	% accumulated	Total	% of the variance	% accumulated
1	2,508	35,824	35,824	2,338	33,403	33,403
2	2,183	31,181	67,004	2,245	32,071	65,474
3	1,224	17,485	84,489	1,331	19,015	84,489
4	,624	8,921	93,410			
5	,263	3,755	97,165			
6	,122	1,749	98,915			
7	,076	1,085	100,000			

Table 3. Factor Analysis: Rotated component matrix

	Component		
	1	2	3
Number of ewes	,265	-,124	**,751**
Forage UAA (ha)	-,082	,102	**,861**
Lambs sold per ewe	**,575**	**,737**	,012
Feed cost per lamb	,100	**,937**	,046
Total costs per ewe	-,350	**,893**	-,083
Gross margin per ewe	**,965**	-,012	,071
Gross margin per MWU	**,931**	-,005	,106

-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. This statistical technique has enabled us to classify and group together the farms in the sample and to establish representative typologies of different production systems.

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.

Having defined the groups, a variance analysis was performed to see if they were also statistically different in a set of additional variables that was necessary to obtain a practical significance. The mean data of the differentiated groups and the results of the ANOVA are shown in tables 4 and 5.

Description of the differentiated groups:

Group 1: Formed by 20 farms with the most traditional management systems and the least professionally qualified farmers. These are basically farms on rainfed land (83.6% of the UAA) with scarce forage crop area. They adapt the number of ewes to the availability of grazing land (both own and rented) and of labor. The number of ewes per MWU is the lowest of all of the differentiated groups since flock feeding is based on directed grazing (with the shepherd accompanying the flock in displacements), thus less livestock can be managed and there is also the limitation of a scarcity of grazable resources.

These farms are not intensive in terms of reproduction and have the lowest number of births per ewe per year and the lowest prolificacy of all of the differentiated groups. There is a predominance of traditional mating systems with few improvements in reproduction (lower health and reproduction costs per ewe). Due to the low productivity, the number of lambs sold, income from the sale of lambs and total income are the lowest of all of the groups.

Feed costs are low, particularly autoconsumptions in feeding troughs, as they have little forage crop area. This Group differs from the other that has low feed costs (Group 2) in that it has less availability of rented grazing land and more feed has to be purchased outside the farms.

It has low total costs per ewe, in spite of the greater labor cost, since less animals per MWU are managed. However, this group’s low productivity makes the cost per lamb sold the second highest of all of the differentiated groups.

The low productivity in this group conditions low economic results.

Table 4. Socio-cultural variables, structural data, technical indices and sales analysis of the differentiated groups. Economic data stated in 2004 €.

	1	2	3	4	SIG
Number of farms	20	11	10	15	
Socio-cultural variables					
Age	46,5	49,0	51,6	42,3	
Level of qualification	5,7 b	7,0 ab	7,9 a	7,0 ab	**
Structural data					
Number of ewes	585,2 b	884,2 a	621,8 ab	555,6 b	*
Number of MWU	1,33	1,73	1,23	1,22	
% family MWU	98	88	96	99	
Number of ewes/MWU	440,0	511,1	505,5	455,4	
Useful Agricultural Area (ha)	99,8	115,0	110,5	74,2	
Forage UAA (ha)	6,0 b	21,9 ab	6,0 b	36,6 a	***
% UAA owned	56,8	67,4	69,9	59,1	
% rainfed UAA	16,4	27,4	21,2	34,2	
Rented grazing land (ha)	410,4	1075,9	600,2	293,8	
Technical indices					
Number of births/ewe	1,10 b	1,20 ab	1,29 a	1,22 a	***
Prolificacy	1,27 b	1,37 ab	1,47 a	1,35 ab	**
Lambs born/ewe	1,40 b	1,64 ab	1,90 a	1,65 ab	***
% Lamb mortality	10,9	10,8	8,6	11,1	
Lambs sold/ewe	1,11 b	1,23 b	1,66 a	1,28 b	***
% Mortality of breeding ewes	4,6	4,2	3,1	4,5	
Number of ewes/stud ram	45,3	47,4	42,8	39,3	
Sales analysis					
Mean price of lamb	62,51	63,29	63,67	62,62	
% “Lamb of Aragón” PGI	48,6	60,5	47,9	44,2	
% Sales during first semester	48,9	50,8	46,8	49,2	
% Sales during second semester	51,1	49,2	53,2	50,8	

(*) P<0,05 (**) P<0,01 (***) P<0,001
(a,b,c,d) Different letters in the same row differ significantly. (P<0,05)

Group 2: Formed by 11 more intensive farms, with farmers that have a higher level of qualification. They have more total UAA and irrigated land, more hectares of forage crops and, in particular, more rented grazing land than the farms in Group 1. Due to the greater availability of grazable resources they have the largest flock size and number of MWU of all of the differentiated groups.

They are more intensive from the point of view of reproduction than Group 1 and show good results in terms of practical fertility and prolificacy with a sales figure of 1.23 lambs per ewe per year. Most of these farms form part of the prolificacy selection program developed by the Union of Rasa Aragonesa Breeders (UPRA) of Carnes Oviaragón Co-operative. Lamb income and total

income are also higher than in the previous group and, in addition, this is the group with the greatest sales of lambs belonging to the "Lamb of Aragón" PGI.

Feed costs are low and the farms are characterized by low feed purchases and the importance of rented forage areas, which form the basis of flock feeding. In addition, the large flock size means that the costs deriving from family labor per animal and total costs are the lowest of all of the differentiated groups. Moreover, since they are capable of selling more lambs per ewe than Group 1, the cost per lamb sold is lower.

Their low costs determine their high economic results.

Table 5. Economic results of the differentiated groups. Economic data stated in 2004 €

	1	2	3	4	SIG
Number of farms	20	11	10	15	
Income/ewe					
Lambs	69,22 b	77,87 b	105,75 a	80,34 b	***
Subsidies	31,74	33,60	33,32	32,29	
Other income	1,56 b	6,07 ab	2,79 ab	7,88 a	**
Total income	102,52 c	117,54 b	141,86 a	120,51 b	***
Feed cost/ewe					
Sheep feed purchased	16,16 b	11,32 b	32,58 a	18,35 b	***
Lamb feed purchased	10,42 b	9,89 b	14,55 a	11,90 ab	*
Autoconsumption in feeding trough	7,57 b	9,33 ab	8,58 ab	16,27 a	*
Grazing autoconsumption	2,76	2,05	2,70	3,57	
Rent of grazing land	3,66 ab	7,50 a	2,32 b	4,96 ab	*
Total feed	40,57 b	40,09 b	60,73 a	55,05 a	***
Total costs/ewe					
Total feed	40,57 b	40,09 b	60,73 a	55,05 a	***
Family labor	27,32	19,94	20,22	27,24	
Salaried labor	0,52	3,21	1,53	0,55	
Agricultural social security	3,74 ab	3,10 bc	2,71 c	4,40 a	***
Health+Reproduction	2,78 b	3,31 ab	3,70 ab	4,50 a	**
Purchase of breeding livestock	0,90	1,11	3,24	5,63	
Loan interests	0,82	0,39	0,48	1,23	
General costs	6,18	5,77	6,38	6,94	
Total costs	82,83 b	76,92 b	98,99 a	105,54 a	***
Cost per lamb sold	74,62 ab	62,54 bc	59,63 c	82,45 a	***
Economic results					
Gross margin/ewe	19,69 b	40,62 a	42,87 a	14,97 b	***
Gross margin/farm	11523 b	35916 a	26657 a	8317 b	***
Gross margin/MWU	8664 b	20761 a	21672 a	6817 b	***

(*) P<0,05 (**) P<0,01 (***) P<0,001

(a,b,c,d) Different letters in the same row differ significantly (P<0,05)

Group 3: Formed by the 10 most intensive farms from the point of view of reproduction (it includes the 3 stabling farms in the sample that raise prolific breeds) and with highly professionally qualified farmers. They have large agricultural extensions, comprising mainly rainfed land (few forage crops areas) and they adapt the number of ewes to the availability of the labor required to carry out adequate breeding intensification.

They have the greatest number of births per ewe and per year and the greatest prolificacy of all of the groups. There is a predominance of intensive mating systems and reproduction management (hormonal treatments, ram effect, flushing, etc.). They manage to achieve 1.90 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, 1.66 lambs per ewe per year. This greater productivity brings higher lamb income and total income. Moreover, intensive mating systems mean that this is the group with the greatest deseasonalization of production and that which sells most lambs in the second semester of the year.

Feed costs are also higher 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 (only exceeded by the last Group). Nevertheless the high productivity achieved enables them to produce lambs at the lowest cost possible.

High productivity determines this group's good economic results.

Group 4: Formed by 15 farms. They have the lowest UAA of all of the differentiated groups, with a high percentage of irrigated land and forage crops and little rented grazing land (although with a higher rental cost due to the fact that these are irrigated areas. The flock size is determined by feed availability and these farms have the lowest number of ewes.

The production level is similar to that found in Group 2 which includes farms on rainfed land. The same can be said in relation to income from lambs and total income. However, the feed costs are significantly different, particularly those of purchased feed and autoconsumption in feeding

troughs, which, coinciding with the results obtained by Pérez et al. (1998), would indicate a disproportion between the production level and the level of animal feeding, highlighting a certain degree of wastage especially in relation to on-farm resources that farmers do not tend to value. Moreover, a smaller flock size means that higher labor costs are added to the higher feed costs, making this group the one with the greatest total costs.

High costs are a conditioning factor in this group's low economic results.

CONCLUSIONS

There is a high correlation between the results obtained per animal and per MWU and, in the structural conditions that exist in Aragón, it is probably not possible to achieve adequate remuneration of labor if good results per animal are not obtained. Livestock productivity is found to be an important variable since it is closely related with the results obtained per animal and per MWU and also with the costs that denote greater production intensification, which is only logical if we take into account the characteristics of the production systems employed. Lastly, the high correlation existing between the number of animals and the forage area would point towards a certain adaptation of flock size to the surface area given over to forage crops.

With regard to the typology study carried out, the four groups obtained can be grouped together in the following way.

- 2 Groups with high economic results (per ewe, per work unit and per farm) that manage more than 500 ewes per MWU: Groups 2 and 3, the former with average productivity and low feed costs and the latter with high productivity and high feed costs.
- 2 Groups with low economic results with less than 500 ewes per MWU: Groups 1 and 4, the former with low productivity and low feed costs and the latter with average productivity and high feed costs.

It can therefore be concluded that economic results are not linked to certain feed costs but rather it would appear that productivity is the variable that is most closely related to results, as was shown by the factor analysis performed. In order to achieve high economic results, productivity must be high or at least average, if feed costs are low. On the other hand, low economic results are related to low productivity or average productivity if feed costs, in this latter case, are high. Thus, low productivity does not generate good economic results even though costs are low. Farms with an average level of production must work on reducing feed costs and those that achieve high productivity are capable of offsetting these higher costs.

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