Dairy goat grazing systems in Mediterranean regions: A comparative analysis in Spain, France and Italy

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Abstract

In order to maintain small ruminant grazing systems it is necessary to know precisely how they work and what actions can be taken to improve them. The objective of this paper was to characterize, classify, analyse and propose improvements for the dairy goat grazing systems in three countries from the western Mediterranean area: Spain, France and Italy. A multivariate analysis was conducted with 21 indicators obtained from the data collected from 45 farms. As a result of the multivariate analysis, 82.5% of variance was explained by two principal components. The first component included proportion of cultivated pasture area and cultivated pasture area per goat. The second included goats present and forage supply per goat. After conducting a cluster analysis based on these two principal components, farms were classified into four groups. Group 1 was made up of French and Italian farms, which had a smaller territorial base but a high cultivated pasture area per goat, contributing to greater self-sufficiency in feed. However the concentrate per goat was too high in relation to milk production, which was medium. The difference between milk income and feed cost is also medium. Group 2 was basically made up of Italian farms. The farms in this group had the most extensive management systems, with a low use of inputs. However, the milk production was low, meaning that the difference between milk income and feed cost was also low. Group 3 was mainly made up of Spanish farms. On these farms the concentrate supply was excessive and the forage supply was low. The milk production per goat was medium and the difference between milk income and feed cost was small. Group 4 was made up mainly of French farms. The farms of this group had a moderate supply of concentrate although the forage supply was very high. They had a high milk production, which lead to a large difference between milk income and feed cost per goat.

The main weaknesses observed are related to feeding management, particularly grazing, and to the goat productivity. In the former case research on the nutritional utilization of rangelands and pastures and correct feed supplementation is to be encouraged. In the latter, the production capacity of the goats present in these systems should be improved, without forgetting the balance between hardiness and general productivity.

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1. Introduction

Small ruminants have the capacity to turn low quality forage into products of a high feeding value (Lombardi,
It is for that reason that these systems have traditionally been related to grazing, thus increasing the usefulness of farmland unsuitable for cultivation such as mountainous areas (Mena et al., 2005; Papachristoforou and Markou, 2006) or semi-desert regions (Degen, 2007). Small ruminant grazing systems offer a number of environmental, sociological or nutritional advantages.

According to several authors (Pearson and Ison, 1987; Cavallero and Ciotti, 1991) controlled grazing has several positive effects on the environment, as it favours the conservation of the wide variety of vegetation resulting from the different environmental and management conditions, the upkeep of a quality pasture, the conservation of a heterogeneous landscape, the prevention of soil loss due to erosion and the prevention of forest fires, among others.

In economically depressed areas, goat farming also plays an important social role by fixing the population and maintaining traditions and furthermore contributes considerably to multifunctionality (Calatrava and Sayadi, 2003).

Likewise, the products obtained from grazing systems present certain features which differentiate them from other feeding systems, such as the fact that the milk produced in the former is rich with micro-components (fatty acids and vitamins) and volatile compounds (flavours and terpenes) which favour human nutrition and health (Morand-Fehr et al., 2007).

Furthermore, providing that they are managed appropriately, goat grazing systems show a certain level of sustainability, higher than more intense systems (Nahed et al., 2006).

Despite the positive aspects of grazing, small ruminant grazing systems tend to become rapidly intensified (Morand-Fehr et al., 2004; Riedel et al., 2007), as occurs with other species (Bouwman et al., 2005). This is due to several different reasons: the intensification of plant production, the lack of shepherds, the need to eliminate seasonality in meat and milk production, the use of breeds with a highly productive potential, the difficulties that accompany grazing in natural or protected areas and rising land prices (Oregui and Falagán, 2006). If we wish to alter this trend, a deep knowledge of how these systems work becomes necessary so that, on the one hand, their weaknesses can be detected and improvement strategies can be proposed, and on the other, issues external to the systems themselves such as their environmental and social contributions, can be estimated from an economic perspective. If this is carried out in an international context, taking into account different regions from the Mediterranean basin which still host goat grazing systems, both the diagnosis and the improvement strategies will be far more consistent (Morand-Fehr and Lebbie, 2004).

The objective of this paper is to characterize, classify, analyse and propose improvements for the dairy goat grazing systems in three countries from the western Mediterranean basin: Spain, France and Italy.

2. Materials and methods

2.1. Data compilation, selected farms and study areas

Forty-five dairy goat grazing farms belonging to four different regions of three countries from the western Mediterranean basin were selected. The regions were: Provence-Alpes-Côte d’Azur (PACA) and Languedoc-Rossillon in France, Sardinia in Italy, and Andalusia in Spain (Fig. 1). Data corresponds to the monitoring work carried out in 2005.

In each of the regions, the teams participating in this study had previous experience in the collection and analysis of technical and economic data on livestock farms. In France, the Institut de l’Élevage has been collecting and analysing technical and economic information from a network of collaborating goat farms since 2002 (Bossis et al., 2008). In Sardinia, the Associazione Regionale Allocatori della Sardegna, with the collaboration of the Agenzia per la Ricerca in Agricoltura della Sardegna (ARAS), has been monitoring a group of farms in order to conduct the technical analysis of the livestock farming sector of the region (Ligios et al., 2004). In Andalusia (Spain) a team of researchers from the Universidad de Sevilla and the Instituto Andaluz de Investigación y Formación Agraria (IFAPA) in collaboration with goat breeders associations, have been generating technical and economic information since 2004, using the FAO-CIHEAM set of indicators for sheep and goat production systems (Toussaint, 2002), which have been modified for grazing systems (Ruiu et al., 2008).

Regarding the number of farms selected, 8 were chosen in France, 19 in Italy and 18 in Spain. Fewer farms were chosen in France because in the regions studied in many cases the goat farmers were also cheese producers and both activities are not treated separately from the economic point of view.

A common feature of all the farms in this study is that goat livestock graze natural resources throughout most of the year, this therefore being a very important part of their diet.

The 8 farms selected in both French regions are located in mountainous areas (average annual rainfall 780 mm, maximum and minimum temperature 20.6 °C and 2.6 °C, respectively) with Saanen and Alpine breeds (Bossis et al., 2008). The 19 farms in Sardinia (Italy) were spread over the whole island, mainly in mountainous areas of the southeast (average annual rainfall 735 mm, maximum and minimum temperature 20 °C and 10 °C, respectively); Sardinia’s traditional goat systems use animals of the Sarda

Fig. 1. Regions selected to carry out this survey. (A) Andalusia; (B) Languedoc-Roussillon; (C) Provence-Alps-Côte d’Azur and (D) Sardinia.
breed or crossbred with the Maltese breed (Usai et al., 2006). In Andalusia, the 18 farms selected are located in the mountainous range of Grazalema (province of Cadiz) as well as in the mountainous region of Ronda (province of Malaga) (average annual rainfall 600 mm, maximum and minimum temperature 33 °C and 5.4 °C, respectively) where herds of the Payoya breed are predominant (Ruiz et al., 2008).

2.2. Selection of indicators

Of the indicators normally used by each of the participating teams, those calculated in similar ways were chosen as well as those that were comparable following a small modification. A total of 21 indicators were chosen and grouped into six categories: Surface area, Labour, Herd, Feeding, Production and Economy. They refer to a complete year, namely 2005.

Six indicators were used to refer to the Surface area. Total farm area, total area per goat, cultivated pasture area per goat (surface area cultivated for the grazing of animals and/or for the production of green or conserved forage) and natural pasture area per goat (uncultivated surface used for the animal grazing). The first is measured in hectares and the other three in hectares per goat. Furthermore the proportion of cultivated surface area for grazing and the proportion of the surface area of natural pasture for grazing out of the total surface area of the farm (%).

Two indicators were defined for Labour: total labour, measured as the number of year worker units (YWU) per every 100 goats present, and proportion of family labour on the farm in relation to the total labour (%).

For the category Herd, two indicators were used: goats present on the farm throughout the year, which is estimated from the average number of goats older than 1 year or which had their first parturition in that year and replacement rate which refers to the annual rate of female replacement with respect to the goats present on the farm.

Three indicators were set for the Feeding management. Concentrate per goat, which shows all the concentrate given to animals on the farm (except to kids) throughout 1 year, divided by goats present (kg/goat and year); concentrate per litre of milk sold, which is obtained by dividing the concentrate given to animals by the total amount of milk sold from the farm throughout the year (kg/L and year), and forage supply per goat, which refers to the total amount of forage given to animals on the farm throughout 1 year, divided by goats present (kg/goat and year).

As regards Production, only the milk was taken into account as it is the main produce in all farms. The indicators used were: milk sold per farm (L) throughout the year and milk sold per goat present and year (L/goat and year). The indicators were “milk sold” and not “milk produced”, because in many farms located in Andalusia and Sardinia, natural rearing is practised and therefore the kids consume a great deal of the milk produced by their mothers in the first month.

Last, the following Economic indicators were considered: concentrate and forage price, both referring to the average annual value (€/kg); feed cost per goat and year (€/goat and year), which is estimated by dividing the annual expenditure on feeding all the animals on the farm, by the number of goats present; milk price (€/L), annual average price which the farmer receives for the milk; milk income per goat and year (€/goat and year), which are estimated by dividing the annual income resulting from the milk sales by the number of goats present and difference between milk income and feed cost per goat and year (€/goat and year). The cultivated concentrate and forage consumed on the farm were economically valued taking the average price for each region as a reference.

2.3. Classifications and description of production systems

The classification and description of goat systems is based on a method posed by “The International Network on Research Methodologies for Farming Systems” (Berdegué et al., 1990), which has been used by the authors in Ruiz et al. (2008) and comprises the following stages.

2.3.1. Review and selection of indicators

The indicators were selected out of a matrix with 45 records (farms) and 21 indicators (fields). The 14 indicators that had a variation coefficient (VC) higher than 50% were selected. These indicators were the following: total farm area, total area per goat, cultivated pasture area per goat, proportion of cultivated pasture area, natural pasture area per goat, goats present, concentrate per goat, concentrate per litre of milk sold, forage supply per goat, milk sold per farm, milk sold per goat, milk income per goat, feed cost per goat and difference between milk income per goat and feed cost per goat. Furthermore, two indicators with VC lower than 50% but often considered very interesting by goat systems analysis were selected. These indicators were: total labour (VC = 44.23%) and proportion of family labour (VC = 43.98%).

The remaining 16 indicators were analysed in order to identify the groups of indicators correlated among them (Table 1). Once the correlations obtained were analysed, 6 indicators were selected as they were considered interesting in terms of classification and were also representative of other non-selected indicators: proportion of cultivated pasture area, total area per goat, cultivated pasture area per goat, proportion of family labour, goats present and forage supply per goat. The indicators selected were standardized to avoid being influenced by their own differences in scale.

2.3.2. Analysis of principal components

First of all, a factorial data-reduction analysis was carried out with the 6 indicators, using the method of principal components and selecting the factors according to their associated eigenvalues when greater than 1. Thus 78.1% variance was explained and 3 principal components (PC) were obtained. The indicators total area per goat and proportion of family labour, created distortion and did not improve the results.

A second analysis with 4 indicators: proportion of cultivated pasture area, cultivated pasture area per goat, goats present and forage supply per goat, was carried out applying the condition that eigenvalues be greater than 1, leading to the explanation of 82.5% of the variance and two PC.
In order to identify the initial indicators with the PC obtained from the research, a varimax rotation was carried out. This procedure allowed the original indicators to be located within the PC obtained.

2.3.3. Classification of farms and description of goat systems

To proceed with this grouping a $k$-average cluster analysis was performed, using the two PC obtained as a classification criterion. The groups used showed perfectly distanced centroids and interesting common features within the systems of a given group. Finally an analysis of variance (ANOVA) was conducted in order to determine which of the indicators showed significant differences between the groups established.

2.3.4. Contingency analysis

In order to check the trend showing that farms in the same group are situated in any of the regions where they are located, a contingency analysis was conducted as a basis for the chi-squared distribution.

For the all statistical analysis SPSS v.14 software (2005) was used.

3. Results

3.1. Results obtained from the analysis of principal components

The eigenvalues of the two principal components (PC) retained for subsequent cluster analysis were 1.84 for the first PC and 1.46 for the second PC. The relative proportion of variance was 54.0 and 28.5, respectively, and explained 82.5% of the total original variance.

The eigenvectors (weight) for each of the four indicators according to the two PC factors are shown in Table 2. The first PC named “Forage surface area”, would be indicative of the use of the total surface area. It includes proportion of cultivated pasture area and cultivated pasture area. The second PC “Herd size and forage” includes goats present and forage supply per goat.

3.2. Retained clusters and identified goat farming systems

As a result of the cluster analysis, four groups with perfectly distanced centroids were obtained. Group 1 was made up of 8 farms, Group 2 comprised 19 farms, Group 3 consisted of 11 farms and Group 4 comprised 7 farms (Fig. 2). Table 3 shows descriptive statistics of the indicators studied referring to each cluster retained. Fifteen indicators out of the twenty-one analysed were statistically different among the systems observed.

In conclusion, the groups mentioned can be described as follows:

Group 1, “High cultivated pasture area”. They are small farms and they have a high cultivated pasture area per goat. The amount of concentrate and forage supply per goat are medium. The feed cost per goat and the milk income per goat are medium.

Group 2, “Low feed cost per goat and low milk income”. They are medium-sized farms. They have a high natural pasture area per goat. The supply of concentrate per goat is high but the forage supply per goat is low. The feed cost per goat and the milk income per goat are low.

Group 3, “High surface and herd size”. They are big farms. They have a medium–high natural pasture area per goat. The supply of concentrate per goat is high but the forage supply per goat is medium.

Group 4, “Low surface, low herd size”. They are small farms. They have a low natural pasture area per goat. The supply of concentrate per goat is low but the forage supply per goat is high.

Table 1
Main correlations between variables.

<table>
<thead>
<tr>
<th>Selected indicators</th>
<th>Non-selected indicators</th>
<th>$R$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area per goat</td>
<td>Concentrate per goat</td>
<td>−0.351</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Concentrate per litre milk sold</td>
<td></td>
<td>−0.304</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Proportion of cultivated pasture area</td>
<td>Natural pasture area per goat</td>
<td>−0.510</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Cultivated pasture area per goat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion of family labour</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goats present</td>
<td>Total area</td>
<td>0.068</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Total labour</td>
<td>−0.539</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Milk sold per farm</td>
<td>0.874</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Forage supply per goat</td>
<td>Milk sold per goat</td>
<td>0.448</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>Milk income per goat</td>
<td>0.483</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Feed cost per goat</td>
<td>0.580</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Difference between milk income and feed cost per goat</td>
<td>0.390</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Table 2
Eigenvectors (weights) for each of the four variables according to the two principal components (PC) retained for the cluster analysis.

<table>
<thead>
<tr>
<th></th>
<th>PC1</th>
<th>Significance</th>
<th>PC2</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of cultivated pasture area</td>
<td>0.947</td>
<td>0.0000</td>
<td>0.113</td>
<td></td>
</tr>
<tr>
<td>Cultivated pasture area per goat</td>
<td>0.952</td>
<td>0.0000</td>
<td>0.393</td>
<td></td>
</tr>
<tr>
<td>Goats present</td>
<td>−0.071</td>
<td></td>
<td>−0.859</td>
<td>0.0000</td>
</tr>
<tr>
<td>Forage supply per goat</td>
<td>0.214</td>
<td></td>
<td>0.826</td>
<td>0.0000</td>
</tr>
</tbody>
</table>
Concentrate per goat (kg/goat and year) 249.6 ab (Milk sold per farm (L) 39483 b (Cultivated pasture area per goat (ha/goat) 0.26 a (Milk income per goat (Feed cost per goat (Concentrate price (Forage supply per goat (kg/goat and year) 232.7 b (Values with different letters on the same row are different. Difference between milk income and feed cost per goat ( (Forage price (D/L) 0.50 ±0.05) 0.48 ±0.02) 0.48 ±0.01) 0.61±(0.06) ns Milk income per goat (€/goat) 185.1b (±55.2) 106.5b (±15.0) 153.4b (±16.2) 318.8b (±67.5) ns Feed cost per goat (€/goat) 82.8b (±15.7) 50.7b (±5.5) 64.4b (±7.1) 129.1b (±17.1) ns Difference between milk income and feed cost per goat (€/goat) 102.2ab (±41.4) 55.8b (±13.2) 89.0b (±11.5) 189.7ab (±56.5) ns

3.3. Results obtained from contingency analysis

Finally, the outcome of the contingency analysis conducted between the groups and the region where the farms are located, allows us to deduce with a p < 0.001 degree of significance, that there is a tendency for Spanish farms to be placed in Group 3, whereas Italian farms would belong to Group 2, and to a lesser extent, to Group 1, and French farms would belong to Group 4, although, again to a lesser extent, could also match Group 1.

4. Discussion

The indicators that define Component 2 of the multivariate analysis (goats present and forage supply per goat), coincide with two of the indicators accounted for in the principal components of another research conducted only with Andalusian farms (Ruiz et al., 2008). The indicator goats present, is also included within the principal components of a research carried out by Usai et al. (2006) in Sardinia, and thus shows the wide diversity in herd sizes in the Mediterranean area. Likewise, proportion cultivated pasture area and cultivated pasture area per goat (Component 1) indicate diversity in the uses of cultivated areas to feed the herd.

As regards goats present, most farms studied except those belonging to Group 3 are medium (Table 3). The bibliography shows a great variation in herd size in the different regions of the Mediterranean area. Sardinian farms are the most similar to Group 3 presented herein. Group 2, which is the largest group, is characterized by the presence of goats, but also characterized by a high proportion of natural pasture and a low proportion of cultivated pasture area. Group 1 is characterized by a high proportion of cultivated pasture area and a low proportion of natural pasture area.

Table 3 Technical and economic indicators for each cluster (mean and SD).

<table>
<thead>
<tr>
<th>Farms</th>
<th>Cluster</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total farm area (ha)</td>
<td>8</td>
<td>19</td>
</tr>
<tr>
<td>Proportion of cultivated pasture area (%)</td>
<td>53.0 (±7.7)</td>
<td>150.0 (±22.7)</td>
</tr>
<tr>
<td>Proportion of natural pasture area (%)</td>
<td>51.9b (±3.7)</td>
<td>59.0 (±1.8)</td>
</tr>
<tr>
<td>Total area per goat (ha/goat)</td>
<td>0.26 (±0.04)</td>
<td>0.03b (±0.01)</td>
</tr>
<tr>
<td>Natural pasture area per goat (ha/goat)</td>
<td>0.21 (±0.10)</td>
<td>0.63 (±0.10)</td>
</tr>
<tr>
<td>Total labour (YWU1/100 goats)</td>
<td>0.85 (±0.12)</td>
<td>0.82 (±0.07)</td>
</tr>
<tr>
<td>Proportion of family labour (%)</td>
<td>81.3b (±13.2)</td>
<td>89.6 (±5.8)</td>
</tr>
<tr>
<td>Goats present (n)</td>
<td>112.9b (±14.9)</td>
<td>184.2b (±18.1)</td>
</tr>
<tr>
<td>Replacement rate (%)</td>
<td>29.6b (±6.3)</td>
<td>22.0b (±1.7)</td>
</tr>
<tr>
<td>Concentrate per goat (kg/goat and year)</td>
<td>249.6b (±23.1)</td>
<td>171.2b (±27.6)</td>
</tr>
<tr>
<td>Concentrate per litre of milk sold (kg/L)</td>
<td>0.85b (±0.12)</td>
<td>0.89 (±0.16)</td>
</tr>
<tr>
<td>Forage supply per goat (kg/goat and year)</td>
<td>232.7b (±41.8)</td>
<td>89.16 (±12.3)</td>
</tr>
<tr>
<td>Concentrate price (€/kg)</td>
<td>0.20 (±0.01)</td>
<td>0.22b (±0.01)</td>
</tr>
<tr>
<td>Forage price (€/kg)</td>
<td>0.12 (±0.01)</td>
<td>0.16b (±0.01)</td>
</tr>
<tr>
<td>Milk sold per farm (L)</td>
<td>39483 (±10072)</td>
<td>40833 (±6980)</td>
</tr>
<tr>
<td>Milk sold per goat (L/goat and year)</td>
<td>333.5b (±50.7)</td>
<td>213.8b (±24.1)</td>
</tr>
<tr>
<td>Milk price (€/L)</td>
<td>0.50 (±0.05)</td>
<td>0.48 (±0.02)</td>
</tr>
<tr>
<td>Milk income per goat (€/goat)</td>
<td>185.1b (±55.2)</td>
<td>106.5b (±15.0)</td>
</tr>
<tr>
<td>Feed cost per goat (€/goat)</td>
<td>82.8b (±15.7)</td>
<td>50.7b (±5.5)</td>
</tr>
</tbody>
</table>

Values with different letters on the same row are different. * p < 0.05. ** p < 0.01. *** p < 0.001.

Fig. 2. Spatial location of the farms according to the two principal components. First component: lower values indicate less cultivated pasture area per goat and lower proportion of cultivated pasture area. Second component: lower values indicate more goats per farm and less quantity of forage per goat.

Group 4, “High feed cost and milk income”. They are small farms. They have a high natural pasture area per goat. The amount of concentrate per goat is medium and forage supply per goat is high. The feed cost per goat and the milk income per goat are high.
Technical and economic indicators for different types of dairy goat systems.

<table>
<thead>
<tr>
<th>Type of system</th>
<th>Location</th>
<th>Total area per goat (ha/goat)</th>
<th>Herd size</th>
<th>Feed (kg/goat)</th>
<th>Milk (L/goat)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grazing</td>
<td>Andalusia (Spain)</td>
<td>0.73</td>
<td>353</td>
<td>278</td>
<td>52</td>
<td>Ruiz et al. (2008)</td>
</tr>
<tr>
<td>Grazing</td>
<td>Sardinia (Italy)</td>
<td>0.93</td>
<td>118</td>
<td>154</td>
<td>216</td>
<td>Ligios et al. (2004)</td>
</tr>
<tr>
<td>Grazing</td>
<td>Canary Islands (Spain)</td>
<td>0.41</td>
<td>122</td>
<td>319</td>
<td>331</td>
<td>Escuder et al. (2006)</td>
</tr>
<tr>
<td>Grazing</td>
<td>North Morocco</td>
<td>0.34</td>
<td>31</td>
<td>147</td>
<td>0</td>
<td>Chentouf et al. (in press)</td>
</tr>
<tr>
<td>Grazing</td>
<td>France</td>
<td>–</td>
<td>69</td>
<td>280</td>
<td>–</td>
<td>Bossis et al. (2008)</td>
</tr>
<tr>
<td>Intensive</td>
<td>Andalusia (Spain)</td>
<td>–</td>
<td>180</td>
<td>343</td>
<td>231</td>
<td>Sánchez et al. (2006)</td>
</tr>
<tr>
<td>Intensive</td>
<td>Andalusia (Spain)</td>
<td>0.31</td>
<td>382</td>
<td>392</td>
<td>198</td>
<td>Mena et al. (2005)</td>
</tr>
<tr>
<td>Intensive</td>
<td>France</td>
<td>–</td>
<td>231</td>
<td>441</td>
<td>238</td>
<td>Bossis et al. (2008)</td>
</tr>
</tbody>
</table>

As for forage supply per goat, the highest value corresponds to Group 4, which mainly comprises French farms. This value is higher than that obtained by Bossis et al. (2008) in French farms specialized in milk production. The lowest values of forage supply per goat correspond to Groups 2 and 3 (Table 3), being particularly low for Group 3, made up mainly of farms from Andalusia. This data is similar to that obtained in farms with grazing systems of the regions in the study conducted by Ruiz et al. (2008). There are dairy goat farms in the Mediterranean area which even do without forage supply, as shown by Chentouf et al. (in press) in Morocco (Table 4). The low supply of fibre in the farms of Groups 2 and 3 is partly due to the animals obtaining enough fibre through grazing, as they are at pasture all day. Nevertheless, there are times in the year, such as in summer, when there is very little pasture in the fields (Nardone et al., 2004) and the farmers do not take this circumstance into account.

As for milk sold per goat, there are significant differences between groups, those from Group 4 being the most productive and those in Group 2 the least productive (Table 3). There are significant differences in the concentrate per goat, being high in Group 3, medium in Groups 1 and 4 and low in Group 2. Concerning the concentration of concentrates in Groups 1 and 3, a higher milk production is to be expected, as in Group 4 (Table 3). However this is not the case, which could be due to shortfalls in the grazing management, meaning that the animals travel long distances to pasture and therefore use up part of the energy obtained from the concentrates to cover locomotion requirements (Lachica and Aguilera, 2005), or this may be due to an inferior genetic quality of the herds (Dubeuf and Boyazoğlu, 2009). It is also worthy of mention that in Group 4, in general, the farms practise artificial lactation, which increases the amount of milk sold per goat. As for the farms in Group 2, their production matches their degree of extensification and low consumption of concentrates (171.2 kg/goat and year) and forage (89.2 kg/goat and year). These consumptions are not much higher than those of the goats in Morocco (Chentouf et al., in press), especially of concentrates (147 kg/goat), whereas the milk production per goat is 100 kg higher.

Regarding the indicator total labour, in the farms of Groups 1, 2 and 4, the range oscillates between 0.80 and 1. These values are similar to those cited by Sánchez et al. (2006) for intensive Spanish farms and Ruiz et al. (in press) for the grazing systems in Spain and France. However, for Group 3 this indicator has a value of 0.53 YWU, and shows a clear work load for the farmers of this group, which is detrimental to the continuity of this type of farm. In general and likewise observed in this study, family labour is predominant in Mediterranean dairy goat farms (Escuder et al., 2006; Bacarella et al., 2003; Sánchez et al., 2006).

Regarding the economic indicators, milk income per goat is highest in Group 4 farms. As for feed cost per goat, the order of importance is the same as for milk income per goat, Group 4 presenting the highest value, but in this case significant differences have been observed between all the groups. The highest difference between milk income and feed cost per goat also corresponds to Group 4, whilst the intermediate values are observed in Groups 1 and 3 and the lowest value is found in Group 2 (Table 3).

As mentioned previously, Group 4 shows the greatest difference between milk income and feed cost per goat, reaching a high productivity. The productivity of this group is similar to that of the systems of the Canary Islands (Escuder et al., 2006); although it is lower than that of the more...
intensified French dairy systems (Bossis et al., 2008; Jénot, 2006), but it does have the advantage that these systems are globally more balanced, as the animals graze more, which provides environmental benefit (Hadjigeorgiou et al., 2005).

The positive feature of Group 1 is the fact that as the farms have a smaller territorial base than those of the other groups, they cultivate a larger area of pastures, thus increasing the farm’s self-sufficiency for feed. The consumption of concentrates per goat is high in relation to the milk produced per goat and per year, and therefore it is necessary to conduct further research into the feeding management and the productive capacity of the goats.

In the Group 3 farms, there are several deficiencies as mentioned previously: low forage consumption in some seasons of the year and energy expenditure of animals used for locomotion. In order to improve these farms, it is necessary to optimize the use of natural pastures in each season of the year, resorting to cultivated pastures where possible, and supplying more forage in the mangers during periods of greater scarcity.

Group 2 has the most extensive management. The difference between milk income and feed cost per goat is the lowest of all the groups but needs the least inputs (concentrate and forage supply per goat). The only drawback as far as the maintenance of these systems is concerned is the small size of the farms, taking into consideration the low profits per goat, which makes it difficult to earn an adequate income for the family. However, it should be taken into account that these goat herds, on many occasions, belong to farms that also have other animal species (Usai et al., 2006; Gaspar et al., 2007) therefore they should be analysed globally. One aspect that would improve the viability is the participation of the farmer in the added value of the processing, as occurs in other European regions (Bossis et al., 2008).

5. Conclusions

There is a wide diversity in the dairy goat grazing systems studied from France, Italy and Spain, especially in the management of feeding. The determinant technical indicators for their classification are those related to cultivated pastures, farm size and use of forage.

The main weaknesses found are linked to grazing and feeding management and to less productivity of goats which both have repercussions on the economic benefits obtained. Research is to be encouraged on the nutritional utilization of rangelands and pastures, and transfer of results to the livestock sector should be facilitated. Concerning the productivity of goats, work should be carried out to improve it, but without overlooking the balance between hardiness and productivity.

Finally it is necessary to study the differentiated quality of their products and their contribution to the environment, benefits which should have a positive effect on the farmer’s income.

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