PAPER

Diversity in the dry land mixed system and viability of dairy sheep farming

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Abstract

Castilla La Mancha is a Spanish region where sheep farming system is traditionally pasture-based. Recently, this territory has undergone a recession of dairy sheep activity, which changed the type and intensity of land utilization and led to environmental and landscape degradation. The present study analyzed the diversity and viability of dairy sheep of mixed systems. Multivariate analysis was conducted on 157 dairy sheep farms, factor analysis selected 3 productivity factors (level of intensification, land use, size and family labour), and cluster analysis classified farms into three groups. Group 1, smallholders – with the smallest size (405.5 ewes and 564.7 ha), lowest area in ownership (1.5%), and agriculture activity (6.5% crops area): family farms (90.8%) highly dependent on external inputs. Group 2, large-scale farms (1058.7 ewes and 1755.1 ha) – with the lowest stocking rate (0.14 livestock unit/ha) and productivity: non-family farms (39.1%) with low area in ownership (4.1%) and agriculture activity (7.6%). Group 3, mixed-technified – with the highest levels of technology and least use of family labour (27.0%): large-scale farms (1387.4 ewes and 955.8 ha), combining milk production with agricultural activities (55.7% crops area), with the highest area in ownership (63.1%) and the best productivity performance. In conclusion, the dry land mixed system of Castilla La Mancha showed diversity of farms. Improving viability requires a systemic approach where the key tool is grazing, allowing the mixed system to be consolidated as a model that enhances the positive impact of livestock on the environment in the Mediterranean basin.

Introduction

The highest proportion of high nature value farmland in the Mediterranean basin corresponds to Greece, Portugal and Spain which have a ratio between 40 and 80% (Jouven *et al*., 2010). In these places, dairy sheep production is based on small family farms and is mainly characterized by family labour and grazing, where crop and livestock are developed in an integrated manner, in the so called mixed system (Robinson *et al*., 2011). The integration is especially related to the leading role of livestock in the system and the resources used for food (Peyraud *et al*., 2014), where the use of resources takes on special importance, either by grazing or use of by-products (Molle *et al*., 2008; Milán *et al*., 2011).

In the last few decades the dairy sector has experienced a progressive specialization which could be explained by higher intensification and concentration of sheep flocks associated with the reduction in the number of farms and the marked increase in the number of animals per flock (Riedel *et al*., 2007; Gaspar *et al*., 2008). In consequence, the degree of mechanization and the individual productivity have been improved, while the cost of inputs has been decreased due to economies of scale (Castel *et al*., 2011; Riveiro *et al*., 2013). However, there also has been a reduction in the number of flocks due to a significant change in the structure of the dairy sheep sector, with many farmers abandoning the activity (Castel *et al*., 2011; Ripoll-Bosch *et al*., 2012). That intensive system of high inputs is environmentally unsustainable and has negative effects on the climate change, biodiversity loss, soil erosion, higher levels of water consumption, among others is demonstrated (Nahed-Toral *et al*., 2013). Also, this has prompted major changes in the nature and intensity of land use (Caballero, 2009; Jouven *et al*., 2010).

The mixed systems in Mediterranean basin; its ultimate objective is to allow the farmers to make a living from locally adapted dairy sheep production systems, which represent the core of Mediterranean dairy sheep industry (Molle *et al*., 2008).

Mixed systems help to maximize the positive interaction between agriculture, livestock, forestry and environment from an agro-ecological approach, and they have been suggested as a strategy that can effectively ensure the sustainability of the systems as a whole (Nahed Toral *et al.,* 2013). In addition, sheep farming has traditionally been linked to the so-called *non-productive* functions (Milán *et al*., 2003), which recognized that environmental and socioeconomic benefits and social responsibility values are enhanced both by the production and consumption (Riedel *et al*., 2007).

In this context, dairy livestock in the Mediterranean basin is a worthy employment opportunity for a lot of people and responds to a dryland cereal-sheep system, which is the closest approximate version of the Mediterranean system. On the other hand, the progressive concentration and intensification of the mixed system has been described by Riedel *et al*. (2007), Caballero (2009) and Ripoll-Bosch *et al.* (2012), with the consequent change in grazing towards *false grazing systems*, whereby the animals graze daily but most of their nutritional requirements are covered by concentrates and forage given in the stable (Castel *et al*., 2011; Milán *et al*., 2011).

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Castilla La Mancha is a Spanish region with a tradition of a typical pasture-based sheep farming system under continental Mediterranean conditions. In this territory, a notorious recession of dairy sheep activity has been observed in recent decades, which has originated changes in the type and intensity of land utilization and led to environmental and landscape degradation. Consequently, there are a great diversity of farms ranging from the traditional to the highly intensive system (Rivas *et al*., 2014), which they must adjust to the basic payment criteria established by the reform of the Common Agricultural Policy for 2014-2020.

It will be convenient to deep in the knowledge of livestock system diversity, its characteristics, economic, techniques, and its role to the keeping of mixed system. Therefore, this study has a double objective. Firstly, the characterization of the different types of farms in the dry land mixed system from Castilla La Mancha according to the land use, the degree of dependence on external inputs, technology and production structure. Secondly, to analyze the viability of the different types of farms with a view to suggesting measures to make dairy sheep farming more competitive.

Materials and methods

Data collection

The study area was the Spanish region of Castilla La Mancha (38°-41°N; 1°-5°W), whose surface area of roughly 800,000 ha is distributed as follows: 70% arable land, mostly given over to rainfed crops (95%), 20% woodland and 10% natural pastureland. The land is mostly flat. Climate is Mediterranean continental with dry winters and hot and dry summers. Rainfall is concentrated in autumn and spring, and is highly irregular, annual rainfall figure varying between 400 and 1000 mm. Mean winter temperatures range around 5°C, while mean summer temperatures average 25°C (Caballero, 2009).

Information was collected via farm visits and *in situ* interviews which were performed in 2012 by the same person. The survey was carried out on a random sample of 157 farms, representing 17% of existing farms. The interview questionnaire included 203 questions relating to the following aspects: location and use of land (15), facilities and infrastructure (19), flock size (13), labour force (9), feeding (22), grazing (4), breeding management (19), healthcare management (10), milking management and milk quality (53), economic issues (13) and social issues (26), according to the questionnaire used to study organic dairy sheep farming by Toro-Mújica *et al.* (2012).

Farm typology

The development of the typology is made from the methodology proposed by Escobar and Berdegué (1990), used by Toro-Mújica *et al*. (2012), which consists of three stages: review and selection of variables, factor analysis and cluster analysis. 181 variables were analysed; these are related to the production and economic structure, size, use and land possession, diversification of production, organization and flock management, productivity, socio-economic aspects and farm management.

In a first stage, 27 variables were selected, those with a coefficient of variation higher than 60%. Then we analysed the correlation matrix to eliminate uncorrelated variables and the one with lowest coefficient of variation of each pair with linear dependence (Toro-Mújica *et al*., 2012). Through the selection process were obtained the following 10 variables: family labour (%), stocking rate [livestock unit (LU)/ha; LU is a measure of livestock and it is usually defined as equivalent to one adult dairy cow, though in this paper it has been considered that 1 sheep=0.15 LU], lamb productivity (lambs/ha), milk productivity (kg/ha), total surface area (ha), cultivated area per ewe (ha/ewe), total investment per ewe (€/ewe), ownership surface per ewe (ha/ewe), ewes (n), and grazing area (%).

In a second stage, a factor analysis (FA) was used to reduce the number of variables and summarise most of the variability. Once the factors were selected, the orthogonal varimax rotation was applied to relate more easily the selected variables to the extracted factors. The Bartlett sphericity test and the Kaiser-Meyer-Olkin index (KMO) were applied to verify polymerase chain reaction adequacy (KMO>0.7; Gelasakis *et al*., 2012).

In a third stage, the farms were classified into groups using cluster analysis. Firstly, hierarchical groupings were developed based on Ward's method, using the Euclidean, squared Euclidean and Manhattan distances (Köbrich *et al*., 2003). The optimal number of clusters was selected using the Elbow method (Gelasakis *et al*., 2012). The optimal clustering was selected using discriminant analysis and analysis of variance (Toro-Mújica *et al*., 2012). It was chosen the clustering whose discriminant function classified correctly the highest percentage of farms and generated significant differences in the largest number of original variables. Additionally, the chi square test for categorical variables was employed to highlight contrast between groups of farms.

Farm economic viability

The viability of each farm was based on its economic results, and it was calculated according to the general accounting plan. The viability focuses on the ability of the business to generate, over the long term, sufficient profits for guaranteeing the maintenance of the family unit (European Commission, 1991; Argilés-Bosch, 2007). If a farm generated a positive economic return from 2011 to 2013, it would be considered as viable, and non-viable in other situations. A t-test was used to identify the variables affecting farm viability within each group (Toro-Mújica *et al*., 2011). All statistical analyses were performed using the SPSS 19.0 software package (SPSS, 2010).

Results

The dry land sheep mixed system

The sheep production has been the main source for economic activity in 80.2% of the farms. The mean flock size was 868 sheep in 1117.7 ha total farm surface, consisting of 892.3 ha of rented land and 220.4 ha of owned land. The labour force was around 3.4 annual work units (AWU), of which 57.1% was labour family (Table 1). The mean investment per ewe was 1211.7 € (Table 1).

The 83% of the total farm surface was used for grazing and the rest corresponded to cultivated surface (177.8 ha), including rain-fed cereals, vineyard and sunflowers. On average, 64% of feed was externally sourced. The most common feeding system (58%) was a mixture of unified and concentrate, although unbalanced regarding of productivity level or physiological status. The mean consumption of concentrate was around 0.8 kg/ewe/d. The reproduction was planned in 82% of farms and it was based on an average of three season mating. The rest farms (18%) maintained the ram with the ewes permanently throughout the year (Table 2). The mean lambing interval was 341 d (Table 1).

The mean production was of 145.3 kg/ewe per lactation and 1.4 lambs per parity, and it implied a mean of 150.8 kg of milk per ha and 1.6 lambs/ha (Table 1). The mean revenue per sheep was 336.8 €/ewe, while the mean cost was 279.4 €/ewe. This means a mean benefit of 57.4 €/ewe. The mean unit cost was 2.2 €/kg of milk.

Factor analysis

Factor analysis yielded three factors (F), explaining 80.5% of the original variance (Table 3). Table 3 shows the Fs, the variance that each explains, their eigenvalue as well as the loading factor of the different variables with the Fs. The KMO test yielded a value of 0.739, while the result of the Bartlett sphericity test was significant (P<0.05); thus confirming the adequacy of data used for FA (Köbrich *et al*., 2003).

Factor 1 was denominated as productivity factor, accounting for 37.1% of variance and it showed a direct positive relationship between the stocking rate, lambs and milk per surface area. F2 was related to the land use, accounting for 29.2% of the variance and it showed a positive relationship between crop area, total investment and the ownership area, and a negative relationship with the grazing area. The third factor was a size factor and it accounted for 14.1% of total variance. There was a positive relationship between the total surface area and the flock size, while a negative relationship with the family workforce.

Farm typology

Cluster analysis which presented the most significant results was the solution of three groups with Ward's method, based on the Euclidean distances (Figure 1). Table 1 shows the main characteristics of each type.

Group I: smallholder

It comprised 62 farms (39.5%) and had the smallest size (405.5 ewes and 564.7 ha) with the lowest area in ownership (1.5% ownership

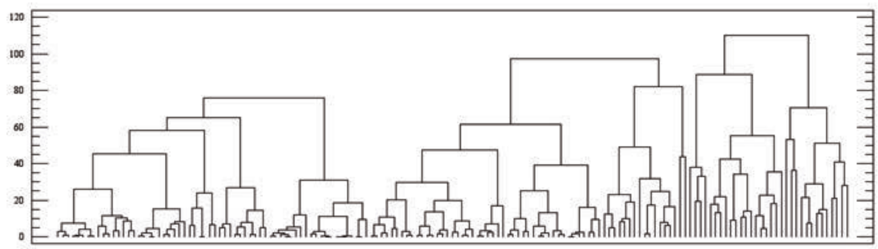

Figure 1. Dendrogram for hierarchical clustering using the Ward's method and the squared Euclidean distance measure.

Table 1. Means±standard deviations and significance level of continuous variables for all farms and groups identified.

Variables	Global	Farms		
		Smallholders	Large-scale	Mixed-technified
Farms, %	100.0	39.5	40.1	20.4
Structural				
Ewes, n	867.7±798.8	405.5±176.6[a]	1058.7±711.0[b]	1387.4±1165.5[b]
Total farm surface, ha	1117.7±1359.9	564.7±291.2[a]	1744.1±1884.2[b]	955.8±776.7[a]
Total labour, AWU	3.4±2.4	2.0±0.77[a]	3.9±1.97[b]	5.2±3.50[c]
Family labour, %	57.1±41.0	90.8±20.2[b]	39.1±33.2[a]	27.0±39.7[a]
Asalaried labour, %	42.9±41.0	9.1±20.2[a]	60.8±33.2[b]	73.0±39.7[b]
Owned surface, ha	220.4±894.5	9.4±24.1[a]	203.5±1259.0[a]	662.5±750.8[b]
Owned surface per ewe, ha/ewe	0.15±0.40	0.02±0.04[a]	0.06±0.23[a]	0.59±0.66[b]
Rented surface, ha	897.3±1147.9	555.4±285.1[a]	1540.6±1561.0[b]	293.4±382.1[a]
Land use				
Grazing area, ha	931.0±1278.5	513.6±288.4[a]	1605.2±1780.6[b]	412.1±412.9[a]
Grazing area, %	83.0±26.0	92.1±16.3[b]	92.4±8.1[b]	46.7±32.5[a]
Cultivated area, ha	177.8±348.0	37.2±67.6[a]	138.5±248.6[a]	527.5±554.9[b]
Cultivated area, ha/ewe	0.17±0.30	0.07±0.12[a]	0.11±0.12[a]	0.50±0.50[b]
Stocking rate, LU/ha	0.19±0.17	0.16±0.17[a]	0.14±0.05[a]	0.35±0.31[b]
Externally feed, %	63.7±30.0	74.5±28.6[c]	62.2±29.7[b]	45.8±23.7[a]
Concentrate, kg/ewe	0.80±0.60	1.0±0.62[a]	0.67±0.60[b]	0.66±0.44[b]
Livestock				
Season mating, n	3.3±1.9	2.3±1.7[a]	3.7±1.7[b]	4.2±2.0[b]
Lambing interval, d	341.4±70.6	344.0±72.2	345.5±72.4	328.1±64.4
Lactation length, d	132.5±33.9	122.0±35.6[a]	137.1±30.1[b]	143.7±31.7[b]
Production trait				
Milk per ewe, kg/L	145.3±54.8	140.4±62.7	151.6±43.7	142.6±58.6
Milk productivity, kg/ha	150.8±131.1	124.2±92.3[a]	117.1±56.8[a]	268.5±212.6[b]
Prolificity, lambs/parity	1.4±0.2	1.4±0.3	1.4±0.2	1.4±0.2
Lambs productivity, lambs/ha	1.1±0.9	0.9±0.5[a]	0.8±0.4[a]	1.9±1.5[b]
Economics				
Income per ewe, €/ewe	336.8±119.7	303.6±87.5[a]	321.6±84.0[a]	431.2±176.2[b]
Cost per ewe, €/ewe	279.4±68.3	267.2±63.3[a]	271.4±45.9[a]	318.9±96.8[b]
Total investment per ewe, €/ewe	1211.7±1770.0	592.1±298.9[a]	751.4±705.1[a]	3318.2±2969.4[b]
Unit cost, €/kg	2.2±1.0	2.2±1.0[ab]	1.9±0.6[a]	2.6±1.3[b]
Result per ewe, €/ewe	57.4±85.5	36.4±67.5[a]	50.2±69.6[a]	112.3±118.4[b]

AWU, annual work units; LU, livestock unit. [a-c]Means within a row with different superscripts differ significantly (P<0.05).

area). The cultivated surface was the lowest of all groups (37.2 ha) and the main economic activity derived from sheep farming (95.2%). It consisted of family farms (90.8% family labour) which generated around 2 AWU. This group had the high dependence on external inputs, where 74.5% of feed was off-farm (Table 1).

It was established two feeding managements according to the animal's production stage. On the one hand, the milking group, which remained stabled and the feeding system used was concentrate and forage (63% of farms), although it was unbalanced by milk production in the 82% of the farms. On the other hand, the *open group,* which was composed of non-pregnant, no-milking pregnant ewes, rams, replacement ewe lambs and ewe lambs put. This group made grazing (98.4%) throughout the year on large rented areas of natural pasture and fallow.

Reproductive management was planned in 72.6% of farms, consisting of the 2.3 season mating; it differed (P<0.01) from that of mixed-technifed group. For the remainder (27.4%), rams are kept with ewes during all year. The lambing interval was 344 d (Table 1). This group showed the shortest lactation length (P<0.05) and the lowest milk yield (140.4 kg/ewe) with an intermediate figure in the milk productivity (124.2 kg/ha); it differed (P<0.01) from that of mixed-technified group (Table 1). The average litter size was 1.4 lambs/parity and the mean productivity was of 1.3 lamb/ha, which was differed (P<0.01) from the mixed technified farms (Table 1). The mean unitary cost was 2.2 €/kg of milk, intermediate for the rest of the groups, although the mean benefit (36.4 €/ewe) was the lowest in the three groups.

Group 2: large-scale farms

This group comprised 63 farms (40.1%). They are large-scale farms (1.058.7 ewes and 1.755.1 ha) with the lowest stocking rate (0.14 LU/ha). It corresponded to non-family farms (39.1% family labour) with low area in ownership (4.1%) and agriculture activity (7.6%). These farms derived most of their entrance from sheep farming (88.8%).

The cultivated area was given over largely to forage crops for livestock feeding. The feeding was balanced according to the production stage in the half of farms. The milking flock and ewes closest to the lambing were stabled and the feeding system was unifeed and concentrate (0.67 kg/ewe/d) in the 69.8% of the cases. The open group was composed of no-pregnant and early-pregnant ewes, rams, replacement ewe lambs and ewe lambs put. This group makes grazing (98.4%) throughout the year on large areas of natural pasture, so as grassland and stubble fields. Sixty-two percent of externally-sourced feed was concentrate and industrial by-products.

The reproductive management was planned at 90% of farms and comprised, on average, 3.7 season mating; it differed (P<0.01) from smallholder group. The lambing interval was 345.5 d (Table 1). Although the milk production per lactation presented the higher level of all groups (151.6 kg/ewe per lactation), the mean duration of lactation was medium in comparison to the rest of groups (137.1 d;

Table 2. Frequencies (%) and significance level of categorical variables for all farms and groups identified.

Variables	Global	Groups			P
		Smallholders	Large-scale	Mixed-technified	
Farms	100.0	39.5	40.1	20.4	
Land use					
Grazing					0.002
No	4.5	0.6	0.6	3.2	
Yes	95.5	38.8	39.5	17.2	
Grazing type					0.000
With shepherd	87.3	38.0	38.7	10.7	
In stockyard	12.7	2.7	2.7	7.3	
Feeding system					0.000
Concentrate+forage	42.0	28.8	12.1	5.1	
Unifeed+concentrate	58.0	14.6	28.0	15.3	
Feeding groups					0.000
No	61.2	32.5	19.7	8.9	
Yes	38.8	7.0	20.4	11.5	
Livestock					
Reproductive planning					0.021
No	17.2	10.8	3.8	2.5	
Yes	82.8	28.7	36.3	17.8	
Production trait					
Income					0.000
Sheep farming	80.9	37.6	35.7	7.1	
Sheep farming and crop	19.1	1.9	4.5	13.4	
Economic viability					0.508
Viable	78.3	29.3	31.8	17.2	
Non-viable	21.7	10.2	8.3	3.2	

Table 3. Factors selected, eigenvalue, variance explained and accumulated, and loading factors of the variables with each factor.

Variables	F1	F2	F3
Family labour, %	-0.163	-0.385	-0.601
Stocking rate, LU/ha	0.961	0.018	0.016
Lambs productivity, lambs/ha	0.958	0.020	0.060
Milk productivity, kg/ha	0.939	-0.000	0.049
Total surface area, ha	-0.312	0.041	0.838
Cultivated area per ewe, ha/ewe	-0.050	0.884	0.004
Total investment per ewe, €/ewe	-0.024	0.901	0.209
Owned surface per ewe, ha/ewe	-0.103	0.850	0.255
Ewes, n	0.385	0.129	0.816
Grazing area, %	-0.423	-0.723	-0.058
Eigenvalue	3.714	2.923	1.414
Variance, %	37.142	29.235	14.148
Variance accumulated, %	37.142	66.376	80.524

F1, factor 1; F2, factor 3; F3, factor 3; LU, livestock unit.

P<0.01). Consequently, both milk (117.1kg/ha) and lamb productivity (1.2 lamb/ha) was the lowest of all groups (Table 1). To an economic level, although this group presented a lower unit cost (1.9 €/kg of milk), it obtained an intermediate benefit (50.2 €/ewe).

Group 3: mixed technified farms

It corresponded to 32 farms (20.4%) and consisted of large-scale farms (1387.4 ewes and 955.8 ha) with higher levels of technology and less use of family labour (27.0% family labour). This group combined milk production with agricultural activities (55.7% crops area), had the highest area in ownership (63.1% ownership area) and obtained the best performance in terms of productivity (268.5 kg of milk per ha and 2.9 lambs per ha).

The feeding was balanced according to the productive and reproductive stage of the flock on the 56.3% of the farms. The milking flock and ewes closest to the lambing were stabled and the feeding system was unifeed and concentrate (0.66 kg/ewe/d). The feeding for the *open group* was also based on pastures although as a differentiation from other groups, technological improvements are implemented as sub-divisions in the pastures area (Table 2). Forty-six percent of externally-sourced feed consisted of concentrate and industrial by-products. This group had the highest stocking rate (0.35 LU/ha) due to the grazing surface (412.1 ha) was the lowest of all groups (Table 1).

The reproductive management was planned in the 87.5% of the farms and comprises, on average, 4.2 season mating. The production per lactation (142.6 kg/ewe) was in between the rest of the groups, although it showed a duration per lactation (126 d) under the rest of the groups.

In the economical aspect, this group presented the highest unit cost (2.6 €/kg of milk) while it obtained the highest economical returns (112.3 €/ewe) from the three groups.

Farm economic viability

The typological group was not associated at a great extent with the economic viability of the farm (P>0.05; Table 2). The smallholders group presented 46 viable farms (74.2%). Viable farms in group 1 owned a flock of a 37.3% higher than non–viable farms and were more productive (Figure 2). Viable farms were also differentiated by the fact that was less dependent on external food and in the number of mating seasons. Besides, the labour at non-viable farms was exclusively family-based, while viable farms employed hired labour.

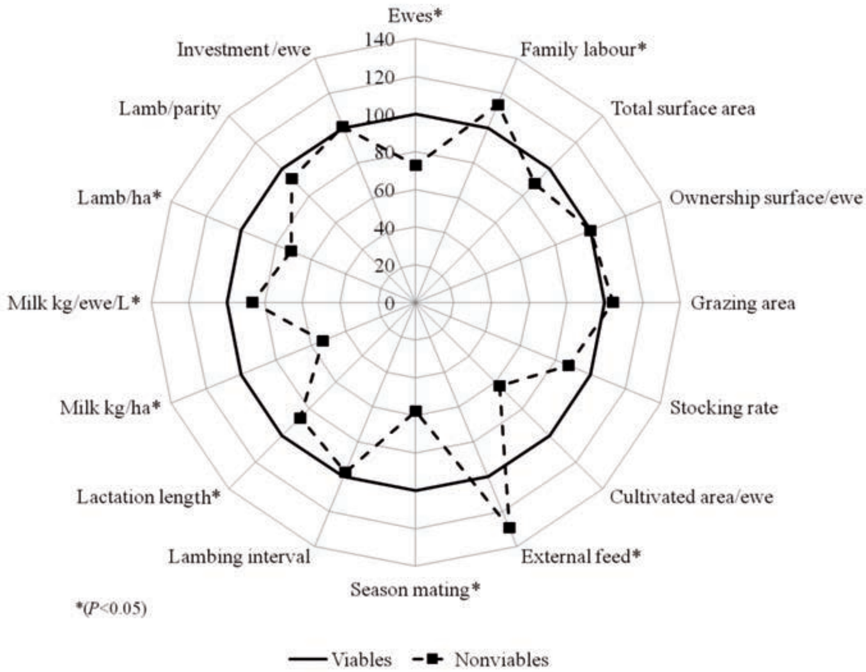

Figure 2. Percentage deviations of non-viable compared with viable farms in smallholder group. Asterisks indicate significant differences.

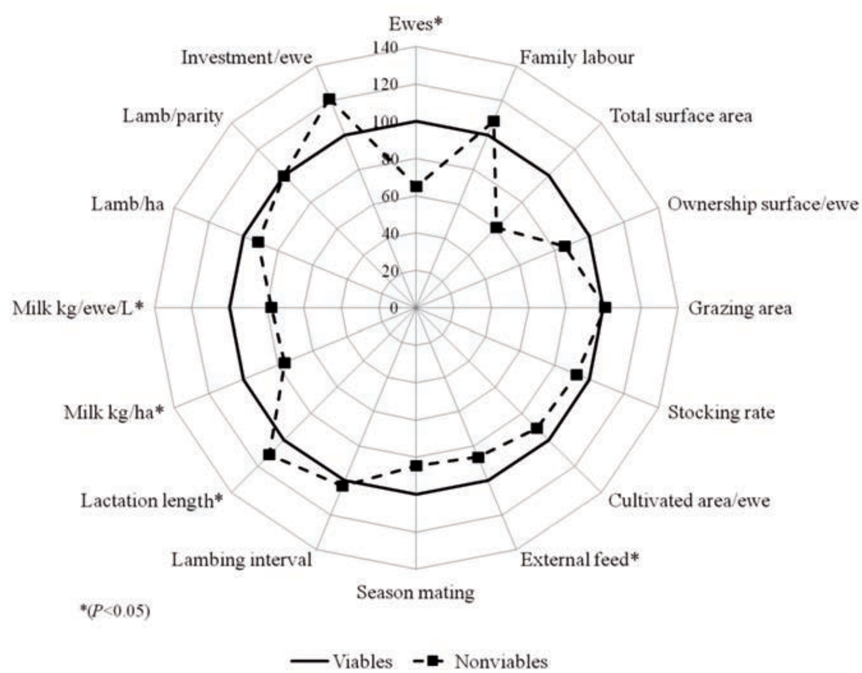

Figure 3. Percentage deviations of non-viable farms compared to viable farms in large-scale group. Asterisks indicate significant differences.

The large-scale farms comprised 50 viable farms (79.4%). Viable farms in group 2 owned a flock a 35% bigger and lactations were shorter and more productive (Figure 3) than in non-viable farms. Viable farms were also differentiated by its less dependence on external food.

The technified mixed farms comprised 27 viable farms (84.4%). Viable farms from group 3 made a less intensive use of land and get lower degrees of production per ha, although based on the offering of less external food (66%). Besides, the predominant labour was employed (Figure 4).

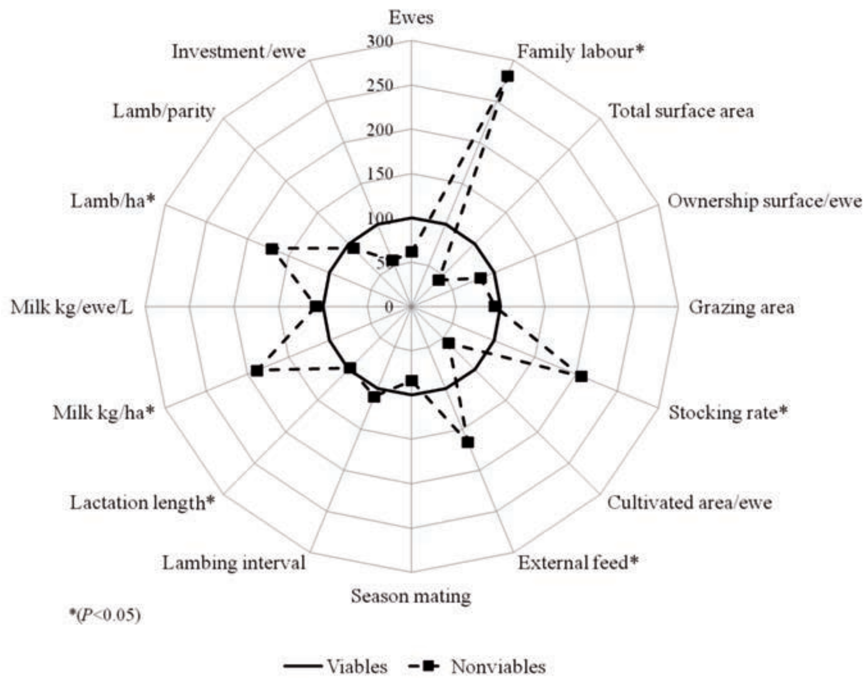

Figure 4. Percentage deviations of non-viable farms compared to viable farms in mixed-technified group. Asterisks indicate significant differences.

Discussion

According to Caballero (2001), sheep production in Castilla La Mancha was a stable system, from data coming from official records for the entire region from 1969-1995. After the entry of Spain in the EU in 1986 some structural changes took place in the sector that collects the typology of cereal-sheep farming systems elabourated by Caballero (2001). The results of this study indicate that sheep has improved its development as productive and economic activity of importance in the mixed system. Apart from this, the production has been substantially improved, especially the milk one. On the one hand, flocks are bigger in size and genetically improved, due to the official programme of milk improvement in the Manchega race (AGRAMA, 2011). On the other hand, technological improvements in the milking and reproduction management have been implemented. Currently the mixed cereal sheep system in Castilla La Mancha is immersed in a dynamic change process, where the trend to reduce the number of exploitations and remaining farms are becoming larger and more specialized in dairy livestock. This article allows to nuance this approach by showing that changes are forcing a farmer to adapt a more competitive situation with less viability of the farms and that reveal a new diversification in dairy farming models with new types of organization; in terms of production practices, work, management and partnership of family farms (Bernard de Raymond, 2013).

The interrelationship amongst natural, agricultural and farming resources that are established in the mix systems are flexible and dynamic and conditioned by the political and economic context of the moment (Argilés-Bosch, 2007). This makes diversity one of the main attributes of any mix system (Robinson *et al*., 2011; Peyraud *et al*., 2014). Diversity must be reduced by defining groups of farms with common characteristics based on the search for the largest difference between groups and the smallest difference within groups (Riveiro *et al*., 2013) where the multivariate statistical techniques provide a means of creating the required typologies, particularly when an exhaustive database is available (Köbrich *et al*., 2003).

Factor analysis (Table 3) showed that the diversity in the mixed system in Castilla La Mancha is mainly linked to land use, the degree of dependence on external inputs, technology and productive structure. These results fit with Milán *et al*. (2003), Gaspar *et al*. (2008), Castel *et al*. (2011), and Toro-Mújica *et al*. (2012).

The subsequent cluster analysis allowed to identify three groups of farms (Table 1): smallholders, large-scale farms and mixed-technified farms. Caballero (2001) built a typology of farms based on the same cereal-sheep mixed system in Castilla La Mancha, where he described three productive sub-systems: *with no land farms*, *small farms* and *big farms*. Although the Caballero typology (2001) was focused in structural aspects, it is a referent to analyze and understand the evolution of the system.

The *with no land farm* would maintain small size flocks (233 ewes) that were located next to the place or in hired lands. It was a system of family subsistence and double productive aptitude. The *small size farms*, with 40 ha as a mean in agricultural surface, were mainly dedicated to the growing of cereals and maintained 322 ewes in mean. They were family farms oriented to mild production. Both groups were concentrated in big areas of pastures named *parceled polygons* ruled under the current regional Pasture and Stubble Act regulating by the Castilla La Mancha government (Caballero, 2009).

The smallholders and large-scale groups identified in this study probably constitute the evolution of the farms that belong to the farms *with no land* and *small farms* identified by Caballero (2001). The main causes for this evolution are the progressive organization around the parceled polygons and the European funds that facilitate the access to land and the increase or the flock size (Ryschawy *et al*., 2012).

Caballero (2001) also described *big farms* ass the ones composed by segregated polygons. These ones own their own land for agriculture (31%) and maintain flocks of 420 sheep in mean with an orientation to the production of milk and meat. The ownership of the land and the structure of farms made it easy the access to the mixed technified system identified in this research.

On the other hand, Toro-Mújica *et al*. (2012) constructed a typology of organic sheep dairy farms in the same mixed system. The research distinguished three different groups with some parallelisms with group smallholders. The smallholder group corresponds to small family that could be classified as traditional improved, according to the FAO classification (Robinson *et al*., 2011). This group is similar to *Semi-intensive, low-investment farms* described by Gelasakis *et al*. (2012) in Chios dairy farms, even if it has a higher average size.

The large-scale and mixed technified groups correspond to large-sized farms (1222 ewes per farm an average) and comprise 60.5% of the farms. These large-sized farms are similar to *Large traditional farm* reported by Riveiro *et al*. (2013) in Assaf sheep farms. Most part of the mixed technified farms have done heavy investments (Table 1), even higher than the reported by Riveiro *et al*. (2013), with a view to maximizing overall farm performance and to taking advantage of technological synergies involving both strands of activity (Milán *et al*., 2011; Riveiro *et al*., 2013). This way some farms include a specialized way similar a dairy cow systems, with a low proportion of grazing the surface, high intensification and full stabling, indicating that the trend towards specialization runs counter to more traditional management practices (grazing), which drives to an environmental unsustainable model and questionable economic viability (Nahed-Toral *et al*., 2013). Similarly, farms with high levels of intensification are more sensitive to the current market uncertainty (Ripoll-Bosch *et al*., 2012; de Rancourt *et al*., 2006).

Apart from this, the increase in the flock size attempts to maintain an acceptable level of income (Riveiro *et al*., 2013). In this study, farms with more ewes corresponded to higher surface (1,350 ha an average), mainly hired and used to pastures (Tables 1 and 2), aspect that constitutes a strength in the Manchega sheep and an advantage for these production systems (Caballero, 2001, 2009). These farms kept a low level of family workforce (33%), indicating that greater farm-size relates with el mayor number of employees; as a difference to the family character shown in the milk sheep farms in the Northeast of Spain by Milán *et al*. (2011), in Greece by Gelasakis *et al*. (2012) and in ecological sheep in Castilla-La Mancha-Spain by Toro-Mújica *et al*. (2012). Apart from these results a considerable proportion of with no land farms (39.1%) are obtained, and these ones correspond to the smallholder group.

Diversification is another way to achieve a reasonable level of income, or a strategy to face uncertainty, including agricultural crops as a complementary activity (Caballero, 2009; Riveiro *et al*., 2013). This option has been observed in only 13% of large-sized farms with large UAA (mixed technified).

By the other hand the classification of farms according to viability enables the evaluation of their challenges of survival (Toro-Mújica *et al*., 2011). Inside each group there is homogeneity and a high percentage of viable farms in which their improvements depend on a systemic focus of the productive process where grazing is the key element.

The smallholder group shows the higher percentage of non-viable farms (10%) and according to the decrease in the returns reported by de Rancourt *et al*. (2006), and the social aspects (that have not been considered in this analysis), even under good economic conditions this type of farms is very likely to disappear when their owner's retirement (Riveiro *et al*., 2013). Opposite to what it is expected, the challenges to family farming do not depend on an increase in the dimension; but they required of deep changes in the managerial functions, in what it should be done (planning), who does it (organization) and how it should be done (managing and control) (Morantes *et al*., 2014), mainly in aspects such as the workforce and the implementation of the best livestock practices (housing and facilities, programming of the mating season, feeding, *etc*.). Unless these problems are previously analyzed and the best practices according to the structural restrictions are considered (Bernués *et al*., 2011), such as fragmentation and land ownership (Caballero, 2009), a great level of risk could be generated in the farm. For example, to increase the size of the flock and implement new reproductive techniques as the artificial insemination or improved genetic males would drive to higher costs and poor reproductive performance. This way, the results of a poor planning, organization, managing and control are frequently associated to the reproductive failure with percentages of empty females in comparison with the inseminated between the el 70 and the 90% (Morantes *et al*., 2014).

The viable farms in the large-scale group have decided to put into practice a feeding system mainly including unified and concentration of lambing seasons. The non viable firms in the large scale group show similar problems to the smallholders groups, although they soften the organization deficiencies by means of their dimension; however they must do an effort in the managerial functions of planning, managing and control mainly in the aspects of managing the feeding and reproduction. This last one, together with the managing of information, are considered to have minor consequences for the farmers' point of view (Morantes *et al*., 2014).

Mixed-technified farms have sufficient arable land to produce their own livestock feed, although in doing so farms use a diversity of organizational strategies. The advantage of the system is that it constitutes an integral model situated in the middle between agriculture and farmer. The advantage of the system is that it constitutes an integral model between the agricultural and farming activities although limited by the capacity of the surface and the dimension that will drive to a low dependence on external inputs (Rivas *et al*., 2013, 2014). An 84% of the mixed-technified farms of low-inputs with grazing coming from the waste of crops of these farms are viable, taking the advantages of economies of scale, and the technological adoption both are a key condition for development. The farms that are not viable in the mixed technified system must reinforce the managerial function of planning mainly in the use of the land and the implementation of technologies that improve the practice of grazing and decrease the dependence on external inputs. At the same time farms must be careful with the organization of work, especially the family workforce must be put into value to increase its productivity (Bernués *et al*., 2011).

Conclusions

The typology constructed allowed to identify and offer a characterization of three groups of farms. Smallholder group consists of small size family farms with high dependence on external inputs. Large-scale group corresponds to non-family farms with low productivity and agriculture activity. Mixed-technified consists of large-scale farms with higher levels of technology and less use of family labour. This group combines milk production with agricultural activities and obtains the best performance in terms of productivity.

The improvement of viability in all groups depends on the systemic focus of the productive inputs, oriented to a rational use of land and a proper adoption of technology, the organization of work and the implementation of best livestock practices. The smallholders and large-scale farms have done a great effort to adapt the environment by transforming the structure of the family firm, by changing their life style and modernizing the reproductive techniques. The viability of both groups requires improvements in the managerial functions, mainly in planning and organization. The mixed-technified farms are those that have shown a better alignment of the use of the land and the reaching of economic results. Any effective strategy aimed at ensuring the viability and sustainability of mixed system should improve the planning in the use of land by means of the knowledge based on the best grazing practices.

The identification of a typology of farms and its classification into viable or not viable constitutes a simple technique for diagnosing and it is useful to promote improvements in the mixed systems.

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