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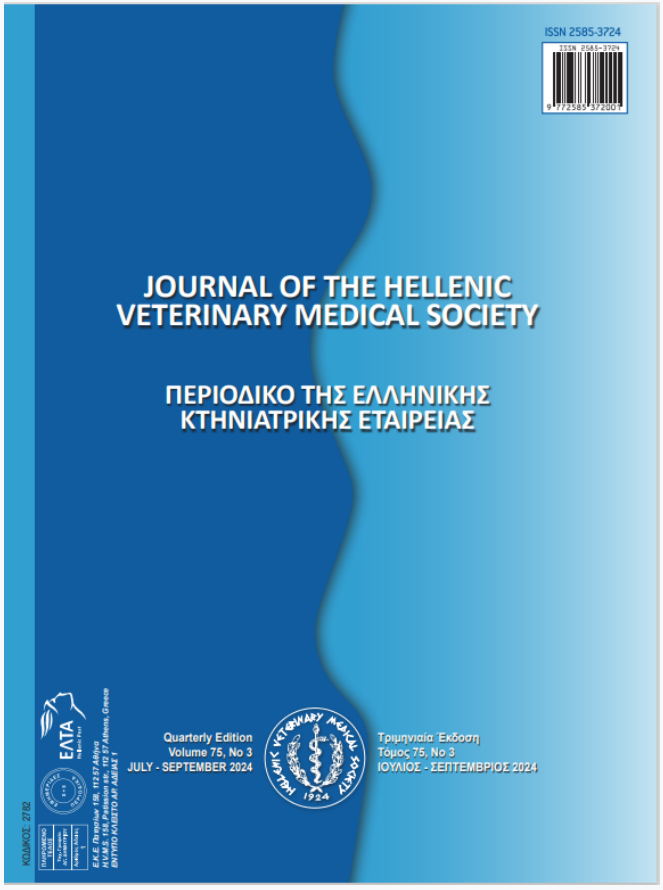

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Research article
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Typology of mixed sheep and goat production system in the regional unit of Larissa, Greece

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ABSTRACT: The study used a structured questionnaire in 162 sheep and goat farms of mixed production systems in the Regional Unit of Larissa from February 2020 - February 2021. The Hierarchical Cluster Analysis application has shown three basic production systems. Cluster 1 consists of medium-sized holdings (233.02 livestock units) that earn additional income from other activities. Cluster 2 consists of relatively large farms (1,825.66 livestock units) with a net profit per female of 2.61 euros. This type of farm breeds livestock based on the semi-intensive and intensive production system and has large rented areas for feed cultivation. At the same time, the contribution of subsidies is incredibly high in shaping their gross income. The holdings' most significant percentage (59.88%) falls under the third cluster. These specialised livestock farming types present the most important net profit per livestock animal. 4% of this holding breed animals are based on the semi-nomadic system, while 100% use common pastures as feed sources.

Keywords: Farm typology; Small ruminant; Production system; Cluster analysis

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INTRODUCTION

European sheep and goat farming faces diverse challenges at global or local scales and constitutes an important sector for many countries, playing important sociocultural, economic and environmental roles (Paraskevopoulou et al., 2020). Greece has 10.1 million heads of small ruminants (14% of the total EU population), 7.25 million sheep and 2.84 million goats (Faostat, 2021), raised on 93,736 farms representing approximately 51% of the national pool of livestock holdings (Hellenic Statistical Authority, 2020). The country ranks as the first sheep milk production area and the fourth (after France, Spain and the Netherlands) goat milk production zone in the EU (Faostat, 2021).

According to the statistical data, Greece is the only developed country in the world where cow milk production is less than that of small ruminant milk (33% versus 67%). In Greece, 88% of the ruminant stock units are milked commercially. The sheep and goat annual milk production (0.95 & 0.37 million tonnes, respectively) and yearly meat production (0.086 million tonnes of sheep & goat meat) have an economic and environmental interest (Faostat, 2021).

The sector contributes 53.9% to the country's gross income from animal production (35.91% sheep farming and 18% goat farming) and 10.84% to the total agricultural sector gross product (Hellenic Statistical Authority, 2020).

This research aimed to study the mixed sheep and goat farming system in the Regional Unit of Larissa with the scope of constructing a descriptive typology with a set of variables related to the applicable production systems. The construction of farm typologies is helpful in dealing with the heterogeneity presented in the farming system followed by the holdings of a specific region (Alvarez et al., 2014). The development of a typology plays a significant role in the research studies of the farming production systems, describing the current situation. In the second stage, the typologies can provide solutions for improvement and efficiency, adapted to the different types of livestock farms (Siegmind - Schultze and Rischkowsky, 2001).

MATERIAL AND METHODS

Study area

The Regional Unit of Larissa (latitude: 39.639° North - longitude: 22.419° East) is located in the north-east area of the Region of Thessaly with a total surface area of 5,390 km^2 (47.1% plain, 25.4% semi-mountainous and 27.5% mountainous). Agriculture plays a crucial role in the region's economy and contributes to the gross domestic product of the study area by 32%. It also employs approximately 27.2% of the economically active population. The study area has a long tradition in the sheep and goat farming sector, thus ranking among the largest and most significant livestock farming areas in Greece. Sheep and goat production has shifted from family farms to agri-business style entrepreneurship since 33% of the farms raise more than 251 heads of sheep and goats. The grazing areas include natural pastures, grasslands, plots with forage plants, fallow lands and various plots with seasonal roughages. One of the main characteristics of the study area was the high biodiversity of the natural flora *(Festuca rubra, Dactylis glomerata, Medicago and Trifolium sp., Stipa sp., Lolium sp., Anthemis arvensis, Spergula arvensis, Vulpia myrus, etc.*).

A highly significant feature of the study area is the certification of cheese products, lamb, and goat meat as Protected Designation of Origin (P.D.O.) and their dynamic market share in targeted foreign countries such as Spain, Italy, and Portugal.

Sampling method

The Ministry of Rural Development and Food database was used as a sampling frame. The sample size was determined through stratified random sampling and, more specifically, through Neyman's optimal allocation sampling (Siardos, 2015; Olayiwola et al., 2013). According to Neyman's allocation, the size of the sample is given by the following formula:

$$n \quad \frac{(\Sigma N_h s_h)^2}{N^2 D^2 + \sum N_h s_h^2} \quad (1)$$

The distribution of the sample in each stratum is given by the following relation (Siardos, 2015)

$$n_h \quad \frac{N_h s_h}{\Sigma N_h s_h} \cdot n \quad (2)$$

Where: n = the size of sample, Nh = the popula-

tion of each stratum, Sh = the standard deviation of the variable in each stratum, N = the total population, nh = sample size in each stratum, D = standard error (d/z, where: d = desired accuracy subjectively determined by the researcher defined ± 50 heads of sheep and goats, z = coefficient of reliability, in practice z = 3 to P = 99.7%).

The strata are represented by the geographical Municipalities of Larissa (Municipality of Agia, Municipality of Elassona, Municipality of Kileler, Municipality of Larissa, Municipality of Tempi, Municipality of Tyrnavos and Municipality of Farsala) and by the number of livestock (1st size class of 1-250 livestock units, 2nd size class of 251-500 livestock units, 3rd size class of 501 and more livestock units).

The total number of sheep and goats was used to calculate the standard deviation. Then, the data were processed and tabulated to assess and estimate the study characteristics (Wright, 2014).

The final sample was calculated at 162 sheep and goat farms in a mixed production system. To ensure adequate power, the minimum required sample size was calculated a priori using the analysis of variance ANOVA methodology and the G*Power 3.0.10 software (Faul et al., 2007). The sample was confirmed from the requirements of the statistical control at the p=0.05 significance level and d=0.20 power factor.

Survey method

A robust formal interview survey was conducted using a detailed questionnaire from March 2020 to February 2021 (Table 1). The questionnaire was pre-tested (in February 2020) with the farmers for final modification, time duration and budgeting before the survey was conducted.

The structure was developed so that the questions follow a logical order and a gradual level of difficulty. The first sections of the questionnaire include simple questions, thus capturing the interest of the farmers and encouraging their participation. The most difficult questions (i.e. economic variables, subsidies, feed cost variables) appear in the middle-off, while in the end, the questions spur the interest of the farmers (Cohen et al., 2000).

Statistical analysis

The statistical analysis was done using IBM SPSS® software package (Gnardellis, 2009). The Hierarchical Cluster Analysis (HCA) was used for the classification and the typology development (Castel et al., 2003; Gelasakis et al., 2012). The Euclidean Distance was used as the base unit of length, and finally, Ward's method was selected. HCA is an organisation of a collection of patterns in clusters based on the degree of similarity (Ward, 1963). The algorithms homogenise the observations in groups according to the methodology (Siardos, 2005).

Analytical techniques were used in the cases of missing values (Rubin, 1976). The above was deemed necessary, and any missing values were replaced with the mean-based method, as described by Verma and Goodale (1995).

Variables selection

The variables used were divided into four categories (Table 2). The first category includes variables re-

Table 1. Main subject areas of the questionnaires used in the survey.

No.	Category
1	General (name, village, contact details, age, education level, etc.)
2	Production system (type)
3	Flock size
4	Reproduction system
5	Grazing system
6	Analytical hand-feeding system (type and quantities per year)
7	Whole farm income (off-farm, livestock, crops) and subsidies
8	Land tenure and land use
9	Milk, meat and sold sheep/goats quantities and prices
10	Labour
11	Sheepherding costs
12	Other costs (depreciation, loans, machineries, etc.)
13	Attitudes and opinions (innovation, technology, economic performance, etc.)

Source: Survey questionnaires.

Table 2. Means, standard error of the means and standard deviation of the selected variables.

Selected Variable	Mean	SEM	SD
Sheep LU	336.75	23.66	301.17
Goat LU	74.68	10.76	136.14
Total flock size LU	409.43	24.99	318.05
Ratio of sheep to goats LU	21.61	2.68	34.06
Sheep female : male ratio	16.73	1.31	4.95
Goat female : male ratio	10.63	1,55	7.01
Total small ruminant-stocking rate (LU/Ha)	0.19	0.01	0.11
Milk production per year (tonnes)	52.35	31.94	40.65
Grazing time (hours/year)	1,229.89	49.06	62.45
Grazing distance (kilometres/year)	1,062.93	86.32	109.87
Farmer age	49.66	0.92	11.66
Annual man working units per LU	0.26	0.11	0.40

LU: Livestock Units, Ha: Hectare
Source: Survey findings.

lated to flock composition, the second includes variables related to the applicable production system, and the third includes variables related to the applied grazing system (hours of grazing and distances). Finally, the analysis used the age and labour units per head (Hamadeh et al., 1996; Milan et al., 2003; Gaspar et al., 2008; Ruiz et al., 2009).

RESULTS AND DISCUSSION

Establishment of the typology

The methodology discovered three cluster groups. The first group comprised 62 farms, the second included three farms, and the third consisted of 97 farms. Table 3 provides for the average of the primary indexes for each cluster. Farms classified in clusters 2 and 3 (61.73%) collect their incomes exclusively from sheep and goat farming and are characterised as specialised types of farms. The first cluster includes farms that earn a large percentage of their incomes from other farming activities, while some income is earned from non-agricultural activities (Kitsopanidis, 1996). According to Gelasakis et al. (2012), farm size does not play any role in the classification of the farming system of sheep farms as intensive or non-intensive. However, for goat farms, according to Gelasakis et al. (2017), the farm size is an essential variable for farm classification in Greece. The financial performance of the three created clusters is presented in Figure 1.

Group 1: <u>diversified type</u>

This group includes 38.27% of the farms, with the largest percentage located in the Municipality of Elassona (50%). The farmers' level of education was low (36.70% of the farmers were not literate). Sheep and goat farming is productive, although not always the primary one. The livestock is characterised as middle-sized (233.02 LU) with cross-breeds of Greek domestic animals (Chios, Karagkouniki, etc.) and other breeds (Assaf, Lacaune, Alpine, Damascus, etc.). Animals are fed large quantities of roughage. These farms have common grazing lands. Moreover, the cultivation areas include 9.8 hectares (± 11.25) of dry lands, 1.05 hectares (± 1.61) of irrigated cultivations and the tiny regions of forages. Forty-four farms rely exclusively on work from family members, while the remaining 29.03% employ hired workers. The average net profit per female livestock animal was 10.92 euros (± 10.41).

Group 2: <u>large farms</u>

This type includes only three farms (1.85% of the total sample) and is characterised mainly by the massive size of sheep and goats (>1,000). Sheep and goat farming is the primary production sector, and the farms hold rented areas for producing roughages and concentrated feeds. The genetic material includes animal cross-breeds of Greek domestic breeds (Chios, Karagkouniki, etc.) and other breeds (Assaf, Lacaune, etc.). Animals graze in common pasture lands, and their feeding is supplemented by concentrates, which consist of both self-produced and purchased sources. Milk production contributes approximately 67% to the final gross income, while the significant contributions from meat sales and subsidies are noteworthy. The farms utilise hired labour, and the system operates under semi-intensive rules. The average net

Table 3. Means of the variables in each cluster.

Variable	Cluster 1	Cluster 2	Cluster 3	p
Number of farms	62	3	97	0.000
Sheep LU	128.75	1,624.33	307.00	0.000
Goat LU	39.42	201.33	64.61	0.032
Total flock size LU	233.02	1,825.66	516.39	0.000
Females in total (LU)	147.00	1,577.00	335.00	0.000
Ratio of sheep to goats LU	19.44	8.07	4.75	0.314
Sheep female : male ratio	12.40	13.93	12.10	0.961
Goat female : male ratio	9.67	11.08	8.84	0.887
Total small ruminant-stocking rate (LU/Ha)	0.26	0.21	0.23	0.047
Milk production per year (tonnes)	33.52	273.87	79.78	0.000
Grazing time (hours/year)	1,260.67	1,063.20	1,222.52	0.000
Grazing distance (kilometres/year)	1,069.64	936.07	1,021.71	0.000
Farmer age	50.43	58.00	47.02	0.035
Annual Working Units per LU	0.27	0.21	0.21	0.054
Economic performance (in euros) of mixed sheep/goat farms in the Regional Unit of Larissa (2020-2021)				
Total cash receipts	45,661,00	342,520.00	104,448.00	0.000
-Total cash costs	21,460.00	133,582.00	53,268.00	0.000
= Farm income	24,201.00	208,938.00	51,180.00	0.000
-Depreciation & family labour	22,592.00	176,443.00	44,145.00	0.000
= Profit in full equity	1,609.00	32,495.00	7,035.00	0.000
/Total farm capital value	28,755.00	631,480.00	50,650.00	0.000
= Rate of return	5.60%	5.15%	13.89%	0.016
Net profit per female in euros	10.92	20.61	20.97	0.27

LU: Livestock Units, Ha: Hectare, level of significance $p \leq 0.05$

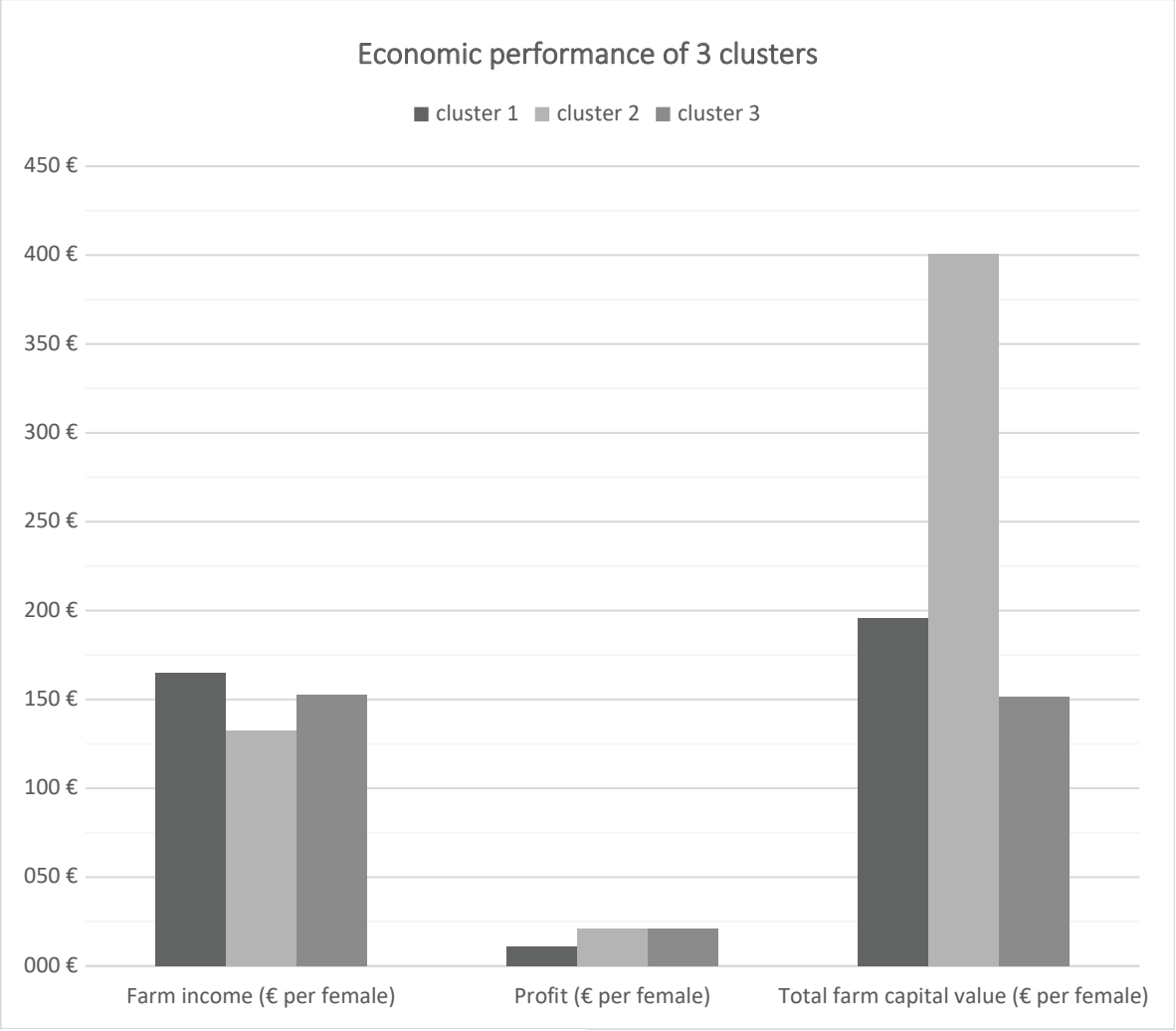
profit per milking animal in this type of farming was calculated at 20.61 euros (± 1.32).

Group 3: specialised farms

The most significant percentage (59.88%) of farms falls under the third cluster, and the production activity is based on family-related work. Consequently, this type of farm has sheep and goat breeding as its core activity. Farmers in this group are younger (47.02 years old) than farmers in the other groups. Most farms are located in the Municipality of Elassona (40.2%), followed by the Municipality of Tyrnavos (28.4%). The production system is semi-intensive (96%) and semi-nomadic (4%). In the semi-nomadic system, animals are transferred from April to October to mountainous pastures in Thessaly, Western Macedonia, and Epirus Regions. Concentrates constitute 55-77% of the total ration. Approximately 81% of farms use areas for the cultivation of forage. Animals graze in both standard and private (43%) pasture lands. The average meat production is calculated at 3.92 tonnes per year per farm. The average net profit was estimated at 20.97 (± 10.08) euros per milking animal.

The number of annual workers in all 3 clusters appears high, which increases labour costs and agrees with the findings of Ragkos et al. (2014) for transhumant sheep and goat farming in Greece. The dairy sheep/goat farming in the study area is a family-driven operation, a fact that has also been recorded by Lianou and Fthenakis (2021). Still, the average farmer age of 49.66 years does not generate optimism for adopting and applying modern management practices. As reported by Pappa et al. (2021), the constraints of the Greek dairy sector are not only the high age level of the farmers but also the lack of proper farmers' training and education.

However, delving into the average balance sheet and profitability statement of Larissa Regional Unit sheep/goat farms reveals a significant challenge. The investment rate of return on capital is merely 0.05% for clusters 1 and 2 and 0.14% for cluster 3. This raises the question: why should any entrepreneur or investor allocate their capital, time, and effort to what seems to be an inherently and structurally unsound business proposal, such as sheep and goat mixed farming? Why do farmers engage in this practice when they could invest their capital in practically anything else



cluster 1: 147 females, cluster 2: 1,577 females, cluster 3: 335 females

Figure 1. Economic performance of 3 clusters.

with potentially better returns? This question underscores that livestock farming exceeds immediate and short-term measurable economic returns. Pulina et al. (2018) and Paraskevopoulou et al. (2020) report that the dairy sheep and goat sector is characterised by insufficient prices for milk and increased production costs. As a result, many farms operate at a loss and base their viability on support from the Common Agricultural Policy. Farmers will have to rationalise their most essential expenses by reducing feed costs and keeping only productive animals in their business, making more efficient use of available pastures and minimising the degree of dependence of their agricultural income on subsidies to increase their productivity and profitability (Vouraki et al., 2020). As commodity producers with no pricing power and facing unlimited competition, farmers' average achievable market price will always be pushed down to variable costs, leaving little to no return on capital.

CONCLUSIONS

The Hierarchical Cluster Analysis created three distinct production systems, as identified in the bibliography by Kitsopanidis (2006). The third cluster encompasses the majority of farms, and this type of farming exhibits the highest percentage of net profit compared to other clusters.

The study highlights the variety of sheep and goat production systems analysed. The primary difference between the groups lies in the size and composition of the flock (ratio of farmed sheep to goats) and economic performance variables and indicators.

However, this study must follow a more detailed

technical, financial, and environmental analysis, combined with market research on the products of sheep and goat farming (meat and milk). Additionally, the study proposes a deeper investigation into the applied production and grazing systems, focusing on feeding strategies.

CONFLICT OF INTEREST

None declared

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