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Agricultural Economics

Estimation of the economic efficiency of Lacaune sheep farms, based on theoretical bio-economic models

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Abstract. *The aim of the present study was to develop theoretical bio-economic models of Lacaune sheep farms and establish their economic efficiency. Based on three main criteria, 15 options were considered and analyzed. Data were processed using the program EWSH2 as a part of ECOWEIGHT Package for calculating economic weights in livestock. Revenues from sales, variable costs, gross margin and profitability before and after subsidies and per ewe were calculated. It was found that raising sheep of the high productive Lacaune breed could generate profit and provide profitability for the studied models of farms, regardless of the level of selection, type of production system, flock size and even the amount of subsidies. Nucleus farms reported the largest gross margin, followed by the basic and commercial farms. Profitability without subsidies showed the highest values for the nucleus flocks of 1000 ewes – 24.24% when adopting semi-intensive production system and 23.14% for the intensive one. With the addition of subsidies, nucleus and basic farms of 1000 ewes were considered the most profitable with 40% and 37.37%, as for both options the semi-intensive conditions were preferable. A tendency for the values of the studied indicators to grow with the increase in the number of ewes in the flocks was observed, as only for the variable costs it was reversed. Due to the lack of studies on economic efficiency of Lacaune sheep farms in Bulgaria, an additional detailed research, based on real data, is advisable to be conducted*.

Keywords: Lacaune sheep, gross margin, intensive production system, profitability, semi-intensive production system

Introduction

The Lacaune sheep originated from the Roquefort region in France as a dual-purpose breed. In the 1960s, it was characterized by low milk yield, and therefore crossed with foreign highly productive breeds such as the East Friesian and Sardinian (Barillet et al., 2001). Thus, in the 1970s, a synthetic line called FSL ($^3/_8$ East Friesian, $^3/_8$ Sarda, $^2/_8$ Lacaune) was created to improve milk characteristics. The French government program for genetic improvement of the breed became fully effective in the 1980s, so the crossing strategy in the Roquefort region was neglected. About 800 000 ewes were available in France up to 2020, and remarkably, the milk production quadrupled to 280 liters per annum by the 1990s.

In recent decades, Lacaune has become one of the high productive dairy sheep breeds in the world, effectively selected in terms of milk yield and composition for more than 30 years (David et al., 2008), and subsequently for somatic cell count and udder morphology (Barillet et al., 2001). In France, Lacaune sheep produce milk for the Roquefort industry (blue cheese), being reared indoors from autumn to spring and grazing on pastures for the rest of the year (Pullina, 2018).

The breed has been preferred in a number of countries in the European Union and raised as purebred or in crossbreeding schemes in order to improve milk production and increase milk revenues and overall profitability of the farms (Ugarte et al., 2001; Makovický et al., 2013; Jimenez et al., 2020). Since 1992, 17 countries officially imported Lacaune germplasm from France (Barillet et al., 2001).

In Bulgaria, the number of purebred animals was reported over 10 000 (Panayotov et al., 2018). The Lacaune Breeding Association was established in 2014, as the initially bred and controlled ewes were about 2 100. For the period 2014-2019, farmers' interest grew significantly and the number of sheep farms increased from 7 to 39.

In order to optimize the selection schemes for breeding and improvement of the Bulgarian Dairy Synthetic Population (BDSP), genetic plasma from Lacaune was introduced in the flocks from the institutes in the structure of the Agricultural Academy (Stancheva et al., 2014).

Due to the great interest in this French breed and the traditionally high share of dairy sheep in our country, we developed several bio-economic models of Lacaune sheep farms. Nowadays, construction of farm models has been a subject of research for a number of authors aiming to investigate some important trends in the sector and make

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predictions over a period of time. The aim of the present study was to develop theoretical bio-economic models of Lacaune sheep farms and establish their economic efficiency.

Material and methods

Three main criteria were met when developing the sheep farm models – level of selection, type of production system practised and flock size.

According to the level of selection, farms were separated into:

Nucleus farms: selling both female and male breeding lambs; 25% of the female and 15% of the male offspring was for own reproduction; 50% of the female and 20% of the male lambs intended for sale were sold as breeding lambs; providing rams for the basic and commercial farms.

Basic farms: selling only female lambs as for breeding; 100% of the male offspring was sold for slaughter; 20% of the female offspring was for own replacement; 50% of the female lambs intended for sale were sold as breeding lambs;

Commercial farms: selling lambs only for slaughter; 20% of the female offspring was reared for flock repair.

Productive traits of the animals in both nucleus and basic farms were supposed to be under the control of a breeding association. As a result, farmers were expected to receive subsidies in accordance to the respective support schemes.

According to the type of production system practised, farms were separated into:

Intensive: keeping animals only in a stall; weaning of lambs immediately after birth and provision of colostrum through a feeding bottle; feeding of milk replacer from the 3rd to the 35th day of birth of lambs, and starter and alfalfa hay after the 7th day of birth; feeding of ewes twice a day through a mixer or feeding strips.

Semi-intensive: raising animals at stall-pasture regimen; weaning of lambs at the age of 35 days, feeding of starter and alfalfa hay after the 7th day of birth of lambs; distribution of fodder to ewes by a trailer.

Milking installation was provided for both intensive and semi-intensive production systems.

Females were intended for artificial insemination according to an individual breeding schedule in nucleus and basic flocks, while in commercial ones natural mating was planned. Ewes and ewe lambs were divided into two groups, the first mated in March-April in oestral season, and the second in September-October in anestral season. In the oestral season, intravaginal sponges were considered necessary for the oestrus synchronization. In the anestral season melatonin implants were provided additionally to the vaginal sponges. In the commercial flocks, synchronization was achieved, using sponges during the natural breeding season.

The size of the farms was dependent on the number of ewes - 300, 500 or 1000. Sheep farms with 300 ewes were treated family type, while the larger ones were expected to need labour from the outside.

Revenues from sales, variable costs, gross margin and profitability before and after subsidies and per ewe were calculated. Fixed costs were neglected in the calculations due to the extreme difference on individual farms. The amount of subsidies was provided accordingly to the pre-set criteria and was indicated for each option. The absolute economic result was represented by the gross margin (revenues from sales - variable costs), and the relative by the profitability (as a ratio of gross margin to variable costs).

The main indicators filled into program inputs are listed in Tables 1-5. Their values were based on surveys of farmers and literature. Data were processed using the program EWSH2, version 1.0.2., as a part of the Package ECOWEIGHT - Programs for Calculating Economic Weights in Livestock (Wolf et al., 2011).

Results and discussion

Based on the three main criteria - selection level, type of production system practised and flock size, 15 bio-economic models for Lacaune sheep farms were developed. Figures 1-7 present the most important results for the main economic indicators, subject of the economic efficiency analysis.

According to the level of selection in the farms, revenues from sales were calculated the largest at the nucleus (Figure 1). For the basic and commercial farms they showed lower values. These results were explained by the fact that animals in the nucleus had the highest milk and reproductive performances, and their offspring had the highest intensity of growth. Moreover, both female and male lambs were sold for breeding at a higher price, while in the basic farms only female lambs were sold as breeding animals.

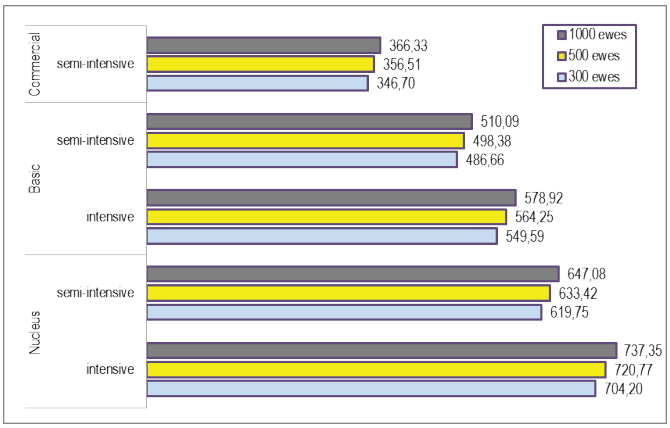

Figure 1. Revenues from sales in different bio-economic models of the studied farms, BGN per ewe (EUR 1 = BGN 1.95)

Regarding the type of production system practised, economic results were more favorable for the intensive one, both in the nucleus and basic farms. This was due to the early weaning of lambs, the extension of the milking period to 240 days and the increase in the amount of milk sold to dairies. For commercial flocks, only semi-intensive production system was adopted and comparisons on this criterion could not be made.

According to the flock size, there was a tendency to increase revenues with increasing the number of ewes on the farm for all levels of selection and type of production system. As a result, the revenues from sales were found the most significant at the

Table 1. Biological indicators used for developing different bio-economic models of the studied farms

Criteria	Flocks				
Level of selection	Nucleus		Basic		Commercial
Production system	Intensive	Semi-intensive	Intensive	Semi-intensive	Semi-intensive
Type of rearing	In stall	Stall-pasture	In stall	Stall-pasture	Stall-pasture
Type of weaning	at birth	on 35th dab	at birth	on 35th dab	on 35th dab
Milk yield per ewe, L	340	280	300	240	200
Milking period, days	240	205	240	205	205
Mature weight of ewes, kg	70	70	70	70	70
Mature weight of rams, kg	100	100	100	100	100
Number of lambs born per ewe	1.60	1.60	1.50	1.50	1.30
Repair of the flock, %	25	25	20	20	20
% mated ewes in oestral season	85	85	85	85	85
% mated ewes in anestral season	78	78	78	78	-
% mated ewe lambs in oestral season	87	87	87	87	87
% mated ewe lambs in anestral season	80	80	80	80	-
Abw of female lambs, kg	4.3	4.3	4.3	4.3	4.3
Abw of male lambs, kg	4.6	4.6	4.6	4.6	4.6
Lw of female lambs at weaning/ at termination of the milk replacer, kg	14.8	14.8	14.1	14.1	13.4
Lw of male lambs at weaning/ at termination of the milk replacer, kg	15.7	15.7	15.1	15.1	14.4
Death rate of lambs from birth to weaning,%	5	2	5	2	2
Adg of female lambs from birth to weaning or termination of the milk replacer, g/day	300	300	280	280	260
Adg of male lambs from birth to weaning or termination of the milk replacer, g/day	320	320	300	300	280
Wool yield, kg/ewe	2.0	2.0	2.0	2.0	2.0
Wool yield, kg/ram	2.5	2.5	2.5	2.5	2.5

*Abw- average birth weight; Adg- average daily gain; dab- day after birth; Lw- live weight.

Table 2. Revenues for the different bio-economic models of the studied farms, BGN

Criteria	Flocks				
Level of selection	Nucleus		Basic		Commercial
Production system	Intensive	Semi-intensive	Intensive	Semi-intensive	Semi-intensive
Type of rearing	In stall	Stall-pasture	In stall	Stall-pasture	Stall-pasture
Type of weaning	at birth	on 35th dab	at birth	on 35th dab	on 35th dab
Milk, BGN/L in farms with:					
- 300 ewes	1.30	1.30	1.30	1.30	1.20
- 500 ewes	1.35	1.35	1.35	1.35	1.25
- 1000 ewes	1.40	1.40	1.40	1.40	1.30
Lambs for slaughter, BGN/kg	4.50	4.50	4.50	4.50	4.50
Female breeding lambs, BGN/kg	10.00	10.00	8.00	8.00	-
Male breeding lambs, BGN/kg	12.00	12.00	-	-	-
Culled ewes, BGN/kg	2.00	2.00	2.00	2.00	2.00
Breeding rams, BGN/kg	1000.00	1000.00	700.00	700.00	500.00
Wool, BGN/kg	0.90	0.90	0.90	0.90	0.90
Subsidies, according to:					
- Transitional national aid for ewes, dependent on production, BGN/ewe	-	-	-	-	39.60
- Coupled support scheme for ewes under selection control, BGN/ewe	73.34 for 300 ewes; 67.47 for 500 ewes; 63.07 for 1000 ewes;				
- Single area payment scheme, BGN/ ha at a density of 1.5/ha,	-	195.70	-	195.70	195.70
- of which rental and cultivation costs, BGN/ha		100.00		100.00	100.00
- "De minimis", BGN/ewe	15.00 for up to 300 ewes; 7.00 for 300 and more ewes				
Discount rate for cash flows, %	8				

*The rates for the subsidies are regulated by the Order of the Minister of Agriculture for campaign 2018; dab- day after birth; AU- animal unit; EUR 1 = BGN 1.95.

Table 3. Price of fresh feed for feeding rations of different categories of animals, BGN per kg

Criteria	Flocks							
Level of selection	Nucleus			Basic			Commercial	
Production system	Intensive	Semi-intensive		Intensive	Semi-intensive		Semi-intensive	
Type of rearing	In stall	Stall-pasture		In stall	Stall-pasture		Stall-pasture	
Type of weaning	at birth	on 35th dab		at birth	on 35th dab		on 35th dab	
Feeding season	year-round	winter	summer	year-round	winter	summer	winter	summer
Ewes								
- lactating with 1 lamb	0.22	0.22	0.17	0.19	0.19	0.15	0.15	0.11
- lactating with 2 or more lambs	0.24	0.24	0.19	0.21	0.21	0.17	0.17	0.13
- flushing	0.20	0.20	0.20	0.17	0.17	0.17	0.13	0.13
- low pregnancy	0.18	0.18	0.13	0.15	0.15	0.11	0.11	0.07
- high pregnancy	0.22	0.22	0.22	0.19	0.19	0.19	0.15	0.15
Rams								
- year-round ration	0.23	0.23	0.18	0.20	0.20	0.16	0.16	0.12
- flushing	0.25	0.25	0.25	0.22	0.22	0.22	0.18	0.18
Lambs till weaning – supplemental feeding	-	0.45	0.45	-	0.45	0.45	0.45	0.45
Lambs from weaning to the end of artificial rearing	1.00	-	-	1.00	-	-	-	-
Female and male breeding lambs in rearing	0.18	0.18	0.13	0.15	0.15	0.11	0.11	0.07
Ewe lambs during flushing	0.20	0.20	0.20	0.17	0.17	0.17	0.13	0.13
Ewe lambs in high pregnancy	0.22	0.22	0.22	0.19	0.19	0.19	0.15	0.15

*dab- day after birth; EUR 1 = BGN 1.95.

Table 4. Costs for labour, veterinary services, etc. for the nucleus and basic flocks, BGN

Level of selection	Nucleus flocks						Basic flocks					
Production system	Intensive			Semi-intensive			Intensive			Semi-intensive		
Type of rearing	In stall			Stall-pasture			In stall			Stall-pasture		
Type of weaning	at birth			on 35th dab			at birth			on 35th dab		
Number of ewes in the farm	300	500	1000	300	500	1000	300	500	1000	300	500	1000
Number of mh/ ewe and year	10			12.5			10.2			12.7		
Number of mh/ ram and year	9			11.5			9.2			11.7		
Number of mh/ lamb in art. rearing and year	0.2			-	-	-	0.22			-	-	-
Number of mh/ breeding lamb and year	8			10.5			8.2			10.7		
Cost per mh, BGN	6.00	6.10	6.15	6.00	6.10	6.15	5.50	5.60	5.65	5.50	5.60	5.65
Milking costs, BGN/L	0.11	0.10	0.09	0.13	0.12	0.11	0.12	0.11	0.10	0.14	0.13	0.12
Shearing, BGN per animal	2.00											
Water, BGN per day	per ewe – 0.02; per ram – 0.03; per lamb till weaning– 0.003; breeding lamb – 0.01											
Synchronization costs, BGN per ewe: estral/ anestral	10 / 13.50											
AI costs, BGN per ewe	2.00											
Costs for veterinary services, BGN per year												
-per ewe	9.00	8.80	8.60	9.00	8.80	8.60	9.00	8.80	8.60	9.00	8.80	8.60
-per ram	2.00											
-per breeding lamb	2.00											
Costs for rams, BGN per ram	1400						1000					
Other costs, BGN/ ewe, ram, lamb/ day	0.09	0.08	0.07	0.07	0.06	0.05	0.09	0.08	0.07	0.07	0.06	0.05

*AI – artificial insemination; dab- day after birth; EUR 1 = BGN 1.95; Mh – manhour.

Table 5. Costs for labour, veterinary services, etc. for the commercial flocks, BGN

Production system	Semi-intensive		
Type of rearing	Stall-pasture		
Type of weaning	on 35th dab		
Number of ewes in the farm	300	500	1000
Number of mh/ ewe and year	13		
Number of mh/ ram and year	12		
Number of mh/ breeding lamb and year	11		
Cost per mh, BGN	5.00	5.10	5.15
Milking costs, BGN/ L	0.15	0.14	0.13
Shearing, BGN per animal	2.00		
Water, BGN per day	per ewe - 0.02; per ram - 0.03; per lamb till weaning - 0.003; breeding lamb - 0.01;		
Synchronization costs, BGN per ewe: only estral	10.00		
Costs for veterinary services, BGN per year			
- per ewe	9.00	8.80	8.60
- per ram	2.00		
- per breeding lamb	2.00		
Costs for rams, BGN per ram	800		
Other costs, BGN/ ewe, ram, lamb/ day	0.07	0.06	0.05

*dab- day after birth; EUR 1 = BGN 1.95

nucleus farms of 1000 ewes and intensive production system - BGN 737.35 and the lowest in the commercial farms of 300 ewes - BGN 346.70. The substantial difference was due to the larger milk production and the sale of breeding lambs in the nucleus.

Revenues from milk are shown in Figure 2. Calculations indicated that the choice of production system was essential for nucleus and basic sheep farms. Intensive farming was associated with higher revenues from milk compared to semi-intensive. Thus, when applying an intensive production system in the basic farms, the results were better in comparison to those calculated for the semi-intensive one in the nucleus. The tendency of the indicator to grow with the increase of the number of the ewes was observed here as well. It was directly related to the increase of milk price due to the larger quantities sold to dairy enterprises. Revenues from milk were the largest at the nucleus farms of 1000 ewes and intensive production system - BGN 464.09 and the lowest at the commercial farms of 300 ewes - BGN 235.55.

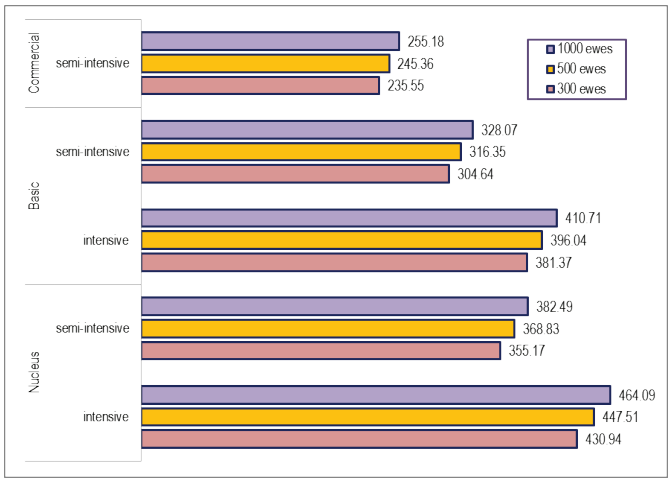

Figure 2. Revenues from milk in different bio-economic models of the studied farms, BGN per ewe (EUR 1 = BGN 1.95)

A tendency of reduction of variable costs by increasing the number of ewes on the farms was found (Figure 3). It reflected the decrease in the costs for milking, veterinary services and other activities that traditionally showed a decline when increasing production volume. According to the level of selection, costs were the largest at the nucleus flocks, which was mainly due to the higher costs for feed, labour, veterinary care and the purchase of rams. Logically, they decreased in the basic and commercial flocks.

Intensive production system required more resources, as keeping animals all year round in a stall was associated with significantly higher costs for feed, as well as for activities not directly related to their performance (mechanization, electricity, transport, materials, services, etc.). Variable costs reached their maximum for intensive nucleus farms of 300 ewes - BGN 617.85, and minimum for commercial of 1000 ewes - BGN 333.52.

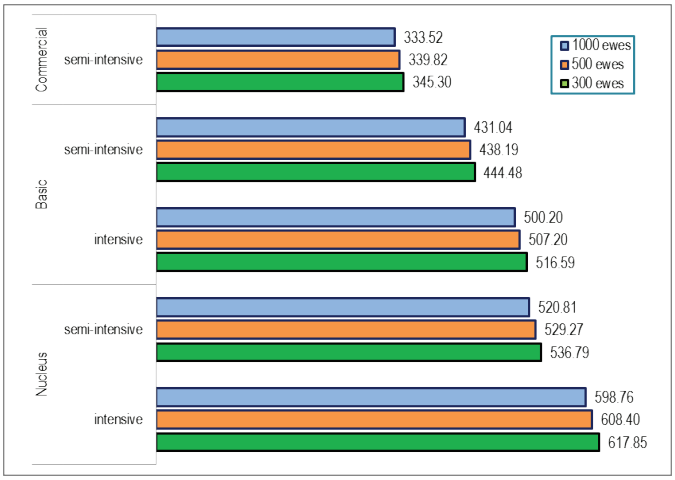

Figure 3. Variable costs in different bio-economic models of the studied farms, BGN per ewe (EUR 1 = BGN 1.95)

Gross margin without subsidies, similar to revenues, showed a tendency of growth with increasing farm size (Figure 4). The

highest values were obtained for the nucleus flocks where both revenues and costs were the largest. However, in relation to the applied production system, there were some differences between nucleus and basic sheep farms. The nucleus intensive system was estimated more profitable than the semi-intensive, while the basic - vice versa, which means that higher variable costs for intensive production brought higher income for nucleus farms, but not for basic ones. The highest profit was found for the nucleus farms of 1000 ewes and intensive system - BGN 138.59 and the lowest for the commercial farms of 300 ewes - BGN 1.40.

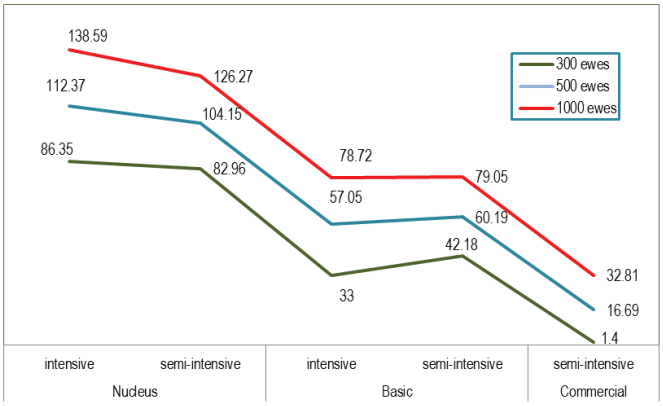

Figure 4. Gross margin without subsidies in different bio-economic models of the studied farms, BGN per ewe (EUR 1 = BGN 1.95)

Based on the results obtained, we could summarize that the higher animal performance was more closely related to a higher gross margin compared to lower variable costs. The values of the indicator established were positive for all considered bio-economic models of farms, but since the calculations did not take into account the fixed costs, we could not indicate which of the analyzed options could generate a positive net margin and remain viable, regardless of subsidies.

The variation in profitability without subsidies shown in Figure 5 is different from that of gross margin, due to the fact that it is a relative rather than an absolute indicator. There was a common tendency to increase the value of the indicator with increasing the farm size, but the results were not definitely the highest for the nucleus flocks. Only rearing of 500 and 1000 ewes appeared to be more profitable in the nucleus than in the basic farms.

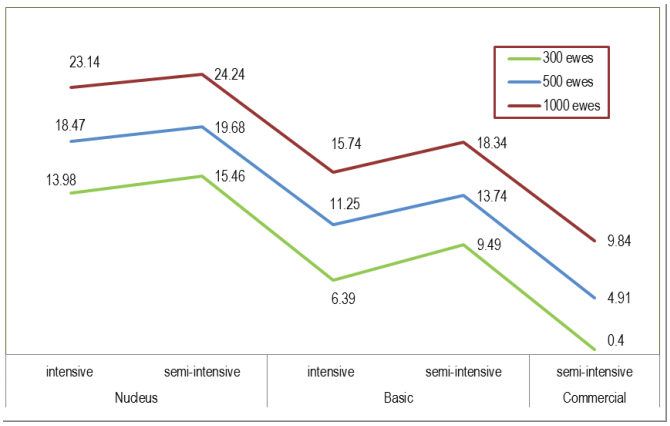

Figure 5. Profitability without subsidies in different bio-economic models of the studied farms, %

Regarding the production system, in both nucleus and basic flocks, better results were obtained for the semi-intensive one, as gross margin was compared to lower production costs, typical of the semi-intensive rearing. Profitability before subsidies reported a maximum for the nucleus farms of 1000 ewes and semi-intensive conditions - 24.24%, and a minimum for the commercial farms of 300 ewes - 0.4%.

With the addition of subsidies, the gross margin value remained the highest for the nucleus farms, but the semi-intensive system was estimated more profitable than the intensive one, excluding the option of nucleus farms with 1000 ewes – BGN 211.06 (Figure 6). The results could be explained by the higher amount of financial support for the semi-intensive farms, including for maintaining pastures. The lowest values were again reported for the commercial flocks, especially for those with 300 ewes - BGN 65.57. They generated lower gross margin and received lower subsidies, as the animals were not under selection control.

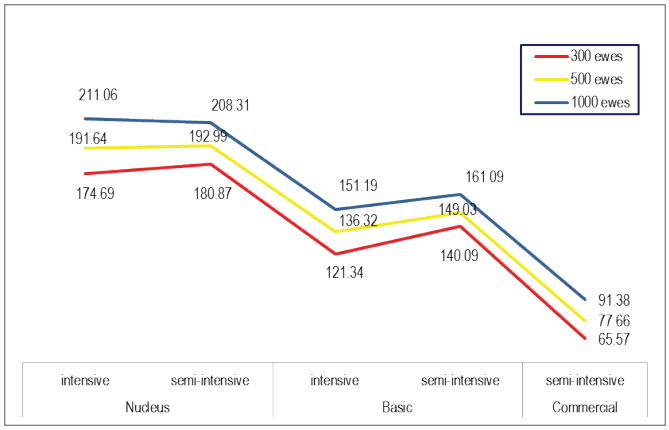

Figure 6. Gross margin without subsidies in different bio-economic models of the studied farms, BGN per ewe (EUR 1 = BGN 1.95)

Profitability after subsidies was definitely higher for the semi-intensive system both at the nucleus and basic farms and increases with the increase of flock size (Figure 7). The most profitable were calculated the nucleus farms of 1000 ewes and semi-intensive system – 40%, followed by the basic farms of 1000 ewes and semi-intensive system - 37.37%. The lowest value was reported for commercial farms with 300 ewes - 18.99%.

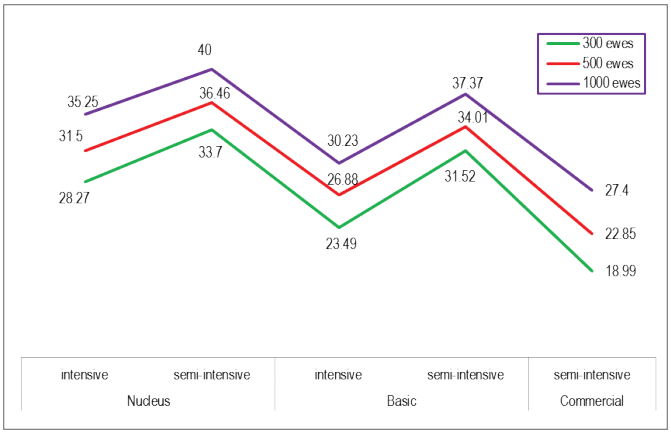

Figure 7. Profitability with subsidies in different bio-economic models of the studied farms, %

Studies of economic efficiency of Lacaune breed in Bulgaria based on real data are currently lacking. For this reason, we could make a comparison to the results obtained for the Bulgarian dairy synthetic population, the most widespread dairy sheep breed in Bulgaria during the last years.

Mihaylova-Toneva (2016) found a loss of BGN 72.82 per ewe in a flock of BDSP, as in her previous study for the same flock Mihaylova-Toneva (2011) indicated a positive result of BGN 110 per ewe. Pamukova and Momchilov (2017) reported a profit ranging from BGN 102,553 to BGN 199,659 in a flock of 277 ewes and 1,000 ha of own land.

Popova et al. (2015), Harizanova-Metodieva et al. (2014), Petrov (2015) and Pamukova and Momchilov (2017) received positive results of the profitability in different flocks of Bulgarian dairy synthetic population. On the contrary, Slavova et al. (2015a,b) calculated values of -26.24% and -10.18%, respectively.

The contradictory results obtained for different farms and periods of time gave us a reason to summarize that an individual approach is required to the studies in this field. Moreover, it is necessary to make additional research for specific management models and animal performance in Lacaune sheep farms in Bulgaria and establish their economic efficiency. This will contribute a lot for the economic analyses of dairy sheep to be more complete and useful recommendations for the farmers to be made.

A good example in this regard is the study of Stankov (2020), analyzing key economic indicators in BDSP and Assaf sheep (which is also well-known for its high milk production). The author found positive values for profit and profitability without subsidies only for the stall rearing of animals. He reports significant differences - BGN 4.85 and BGN 48.85 for the profit per ewe and 1.12% and 11.3% for the profitability without subsidies in favor of the Assaf sheep, and emphasized the need to introduce traits of higher milk yield and fertility from Assaf breed to the Synthetic population.

Conclusion

As a high productive dairy sheep breed Lacaune generated profit and provided profitability for the studied models of sheep farms, regardless of the level of selection (nucleus, basic and commercial farms), type of production system (intensive and semi-intensive), number of ewes on the farms (300, 500 and 1000), and even of subsidies. However, it should be taken in mind that the gross margin was found, disregarding fixed costs in the calculations. In order to gain a more in-depth look at the specific economic circumstances in Lacaune sheep farms in our country, it is advisable additional research on these issues to be conducted.

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