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STUDY ON THE PRODUCTIVITY OF GOATS INCLUDED IN SELECTION BREEDING WORKS IN OUR COUNTRY

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Abstract

The growing interest in goat milk in our country has required the expansion of research in this species, covering various areas such as nutrition, reproduction, exploitation conditions, milk and meat processing methods, and others. The purpose of this study is to analyze the distribution of goats included in selection works in relation to the total number of goats at national level reported by the National Institute of Statistics, with the following aspects being evidenced: the proportion of goats included in selection works, the distribution by breeds of the number of goats in the genealogical register and their average milk/lactation/breed/region production. The study is of a statistical nature and focuses exclusively on the herds in the Genealogical Register on 31.08.2023, and the results show that the South East Region stands out with an impressive herd of goats, representing 36.16% compared to the Centre Region where, in the selection work, only 2.88% goats are included. The conclusions presented provide a detailed numerical perspective and the potential of each region within the national goat milk scene. These consolidating insights are essential pillars for guiding future strategies and developments in this area.

Key words*: breed, goat, milk, quantity, region*

INTRODUCTION

Goats are considered one of the most important species, with remarkable biological and economic significance and are widely distributed throughout the world.

Currently, goat farming and exploitation is expanding significantly globally and plays a key role in the animal products sector (Mazinani et al., 2020).

The extended distribution of this species, especially dairy breeds, is largely attributed to the quality and quantity of milk production obtained from them. Products derived from goats have become essential components of the human diet, mainly due to their high nutritional value (Lohani et al., 2021).

In special, goats are bred to produce milk, which is noted for its quality, rich nutritional value and high digestibility. Goat's milk is similar in composition to human breast milk and can provide a significant proportion of human protein requirements and is considered a valuable remedy for many ailments, particularly lung diseases. It is a rich source of essential nutrients including vitamin A, vitamin B, vitamin D, zinc, magnesium, phosphorus and potassium (Park, 2010).

In various countries around the world, there is a growing demand for the highest quality goat dairy products. The amount of milk produced by a goat is influenced by the conditions of care, diet and level of breeding (Pascal, 2015).

Recently, interest in goat's milk has increased, which has led to the need to expand research in this area, covering aspects such as nutrition, breeding, farming conditions and milk and meat processing techniques.

In the effort to maximize milk production in goats, the adoption of technological farming methods, respectively obtaining prolonged lactation, increasing the number of females by

intensifying breeding, ensuring constant milk production at farm level through dairy farming and breeding biotechnologies, are essential.
According to a study conducted by Rico-Bautista et al. (2019) at an experimental farm of the Francisco de Paula Santander University in Colombia, the CAPRINAPP technology, designed to manage and monitor goat herds and production, has been successfully implemented with a significant impact on milk production and other relevant aspects of agricultural processes.
Another innovative way to improve milk production in arid and desert regions was identified in research by Strahsburger et al. (2021), respectively, the advanced application of molecular markers and genetic technologies to achieve selection and improvement of desired goat traits.
Another method to improve milk production is to explore and adjust milking frequency. (Williams et al., 2012).
Another essential strategy for improving milk production is adjusting the length of the light day which has led to a 15% increase in milk production (Rodríguez-Martinez et al., 2011).
The integration of modern technologies to manage nutrition, health and environmental conditions can be essential to ensure sustainable growth in milk production.
The study by Anghel et al. (2020) shows that dietary adjustment in multiparous goats positively influences milk quantity and quality.
To improve milk production in goat farming, one of the efficient technologies is breeding. By carefully selecting animals with superior genetic characteristics, such as increased milk production capacity, this method contributes to improved performance.
Nucleus farms play an important role in implementing genetic improvement, where animals with desired traits are identified and bred. By transferring these animals to production farms, the aim is to continuously increase the quality and yield of the herd. In essence, genetic improvement is a key strategy for optimising milk production growth in goats.
The increased interest in goat breeding and exploitation has also been evident among Romanian goat farmers. In order to maximize their productive potential, they have made use of research results and adopted various strategies, including importing specialized breeds for milk production, as well as adhering to the Breeding Programs of the Breed Genealogical Registries and complying with the conditions of the Breeding Programs in selected breeding (Nadolu et al., 2022).
In an evolving agricultural landscape, with a significant increase in interest in goat milk products, breeding has become an essential pillar for improving and optimising performance in goat farming.
The purpose of the present study is to analyse the distribution of goats included in the selection works in relation to the herds of the National Institute of Statistics, as well as the evolution of the average milk production of the goats in the Genealogical Register with the identification of the factors influencing the expression of the productive potential.

MATERIALS AND METHODS

The biological material analysed in this study belong to Carpathian, White of Banat, Saanen, Alpine, Anglo-Nubian and Murciano-Granadina breeds. The study focuses exclusively on herds in the Genealogical Register on 31.08.2023. The choice of this date was motivated by the need to use the most recent information available.
For the elaboration of this article, the information accessible online through the website of the National Institute of Statistics, more precisely in the Tempo-Online data platform and through the database of the Breed Genealogy Register, was used.
Statistical significance analysis of the differences between the means of milk production from 2019-2023 was performed using Single Factor ANOVA from Excel 2007.
Milk production control was performed by the standard A4 method (cf. ICAR, Ord.22/2006), for three consecutive months, two controls per day, morning and evening, and milk yield/lactation was calculated according to the Fleishman formula:

$$MS = I_0M\left(\frac{M1 + M2}{2}\right) + I1\left(\frac{M2 + M3}{2}\right) + .. + In\text{-}1\left(\frac{Mn\text{-}1 + Mn}{2}\right) + InMn$$

in which:
MS- milk production per lactation (ml);
M1, M2, M3- the quantity of milk (ml) at the 24 hours control;

I_0- the interval (days) between the milking start date and the date of the first control;
I_1, I_2, I_{n-1}- interval between controls (days);
I_n- the interval in days between the date of the last control and the end of lactation.
The process of collecting the data provided by the Genealogical Registry involved strong collaboration with goat breeders to make sure that the data provided is trusted.
Evaluation of individual goat performance, including milk production and reproductive efficiency, was an integral part of this data collection. Through this study, the evolution of purebred goat herds and milk production of goats included in the Genealogical Breed Register is highlighted.

RESULTS AND DISCUSSIONS

At the end of 2022, there will be 206.792 goats in the Breed Register of the six breeds: Carpathian, White of Banat, Saanen, Alpine, Anglo-Nubian and Murciano-Granadina, representing approximately 13.93% of the total number of goats in the country, respectively 1,492,544 which suggests that improvement in purebred by selection has captured the interest of goat owners who have understood that this is a way to make breeding more efficient in the long term.
As a result, many breeders have abandoned crossbreeding, which results in better yields for only 2-3 generations and have turned to specialists in research institutions and professional associations that run Genealogical Registries to improve the genetic structure of their herds through well-defined breeding programmes that promote high-productivity, respectively positive breeding value and apply mating schemes that take into account the avoidance of inbreeding.
The same trend of fluctuation in goat numbers can be observed globally, with an impressive increase in numbers on every continent.
Over the last 10 years, Asia has become the major player in the goat farming industry, with a significant increase in herds of over 200 million goats.
China and India, which together account for more than 35% of the global goat population, have had a major impact on this development (FAOSTAT, 2022).
At European level, Romania places the fourth largest number of goats in Europe and the country with the highest number of goats is Turkey, followed by Spain and Greece (EUROSTAT, 2022).
In Romania, the goat population is continuously increasing, mainly due to the quality and quantity of milk production, which provides nutrition for the families and additional income from the sale of milk and other milk products (Figure 1).

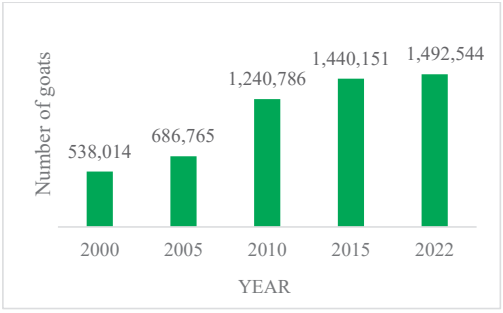

Figure 1. Evolution of the number of goats in Romania (NIS, 2022)

The evolution of goat populations in Romania illustrated in Figure 1 has been marked by significant changes over the last two decades. From initial growth in the years 2000, the sector has fluctuated, with an increasing trend in 2010, when the number of goats doubled.
The ascending trend continued in the following years, reflecting the adaptation of the agricultural sector, with an important role played by the legislative context to stimulate and maintain the sector in Romania.
Within the regions of our country, the proportion of goat herds included in selection breeding compared to the total herd of goats at national level highlights their demographic variation, reflecting the diversity and importance of the goat sector in each region (Table 1).
From the data presented in Table 1, large differences between regions can be observed. The herd of goats included in selection breeding in the South-East Region stands out with the highest percentage, reaching 20.6%. This indicates an increased interest and significant investment in breeding in this region, suggesting a proactive approach to improving goat performance.

Table 1. Evolution of goat populations within regions (2022)

REGION	Total national goats (NIS) (number head)	Total goats R.G. (number head)	Percentage of goat R.G./NIS%
NORTH WEST Region	113,795	10,453	9.18
CENTRAL Region	125,146	5,265	4.2
NORTH EAST Region	240,008	21,574	8.9
SOUTH-EAST Region	380,991	78,483	20.6
SOUTH-MUNTENIA Region	269,234	31,568	11.7
BUCHAREST-ILFOV Region	4,305	0	0
SOUTH-WEST OLTENIA Region	280,872	53,121	18.9
WEST Region	78,193	6,328	8.1
TOTAL	1,492,544	206,792	13.9

South West-Oltenia and South Muntenia regions follow in the ranking, with 18.9% and 11.7% respectively.

On the other part, the West and Centre regions registered lower percentages, 8.1% and 4.2% respectively.

These variations highlight not only demographic differences but also the unique attitudes adopted by goat farmers in the different regions of Romania.

These figures suggest that breeding is an essential component of goat breeding in these regions and that breeders pay particular attention to selection to improve the performance of their animals.

Regarding the distribution of breeds in the breeding work by selection in the year 2023, the main remark falls on the predominance of the Carpathian breed in the Genealogical Breed Register (Figure 2).

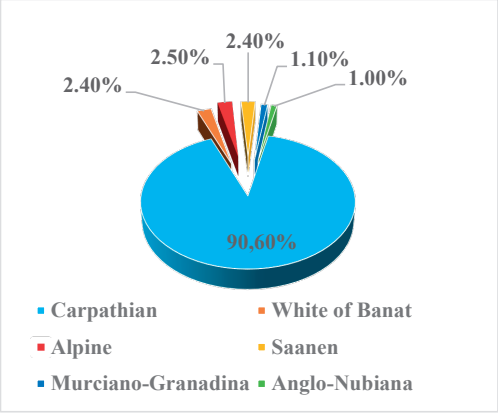

Figure 2. Percentage distribution of goat breeds registered in the Genealogical Register (2023).

Thus, in 2023, the local Carpathian breed stands out with a percentage of 90.60%, White of Banat, another local breed, represents 2.40% and the Saanen, Alpine, Anglo-Nubian and Murciano-Granadina breeds together account for 7% of the total number of goats included in the breeding work

Over the last 5 years, the evolution of goat herds enrolled in breeding programmes in the Genealogical Registry of goat breeds has been ascending (Table 2).

Table 2. Evolution of goat herds enrolled in breeding programmes in the Genealogical Register (2023)

YEAR	Number goats					
	CR*	AB*	AP*	SN*	MG*	AN*
2019	179,693	3,736	4,193	4,799	1,195	428
2020	158,120	4,864	4,507	5,162	1,932	1,069
2021	172,896	3,821	4,555	4,869	1,690	1,230
2022	189,116	5,121	4,596	4,769	1,715	1,475
2023	196,645	5,176	5,395	5,286	2,281	2255

CR*-Carpathian, AB*-White of Banat, AP*- Alpine, SN*-Saanen, MG*-Murciano-Granadina, AN*- Anglo-Nubian

In the last 5 years, there has been an encouraging evolution of goat herds registered in breeding programmes, both for local breeds such as Carpathian and White of Banat and for imported breeds such as Alpine, Saanen, Murciano-Granadina and Anglo-Nubian.

Local breeds, having a significant contribution to the country's genetic patrimony, have shown a steady increase, reflecting conservation efforts in the low-numbered White of Banat breed and improved yields in the Carpathian breed.

At the same time, imported breeds, with high genetic potential, have also seen a steady increase in the number of herds registered in breeding programmes, the aim of which is to increase their productive performance in the soil and climate conditions of our country, so as to reach the production levels reported by the countries from which they come.

In the regions of Romania, the analysis of the distribution of herds registered in the breeding by selection programme in 2023 opens a window on the complexity and adaptability of husbandry practices at regional level (Table 3).

Table 3. Distribution of goat herds in the breeding programme by breeds and regions (number head 2023)

R*	CR*	AB*	AP*	SN*	MG*	AN*	%*
NV*	6,451	128	1,332	1,344	45	0	3.7
C*	5,138	408	342	236	141	0	2.88
NE*	23,164	259	2,864	1,309	442	1,126	13.4
SE*	76,189	0	863	1,157	116	158	36.16
SM*	29,141	216	662	871	1,183	649	15.1
SVO*	48,166	0	174	228	18	0	22.3
SV*	1,297	3,145	0	410	110	258	2.4

R*- Region,
CR*-Carpathian, AB*- White of Banat, AP*- Alpine, SN*-Saanen, MG*-Murciano-Granadina, AN*- Anglo-Nubian;
NV*- NORTH WEST Region, C*- CENTRAL Region, NE*- NORTH EAST Region, SE*- SOUTH-EAST Region, SM*- SOUTH-MUNTENIA Region, SVO*- SOUTH- WEST OLTENIA Region, SV*- WEST Region
%*- Total number of goats R.G./Region

The regional distribution of the goats included in the selection breeding programme shows that the South East and South West Oltenia regions are home to more than half of the goat population registered in the Genealogical Breed Registers.

This is due, on the one part, to the people living in these areas with specific occupations strongly connected with animal husbandry and on the other, to the climatic conditions suitable for animal husbandry.

The Centre region has the lowest percentage (2.88%) of goats registered in the Genealogical Registers, due to the higher concentration on breeding other species.

Analysing the distribution of goat herds included in the breeding programme by breed and region for the year 2023, some significant trends and differences between regions can be observed.

The South East Region shows an impressive 36.16% of goats compared to the Centre Region where only 2.88% of goats are included in the breeding programme.

All goats registered in the programme of improvement by selection of the Breed Genealogical Registers are also subjected to individual quantitative milk production control, respectively the standard A4 method, two controls per day, morning and evening, for three consecutive months and the milk production/ lactation of each goat is assessed by applying the Fleishman formula.

From the analysis of the last 5 years, variations in the average total milk production obtained from goats registered in the Genealogical Breed Register of the six breeds: Carpathian, Banat White, Saanen, Alpine, Anglo-Nubian, Murciano-Granadina were observed and the main factors influencing these variations were identified.

It should be pointed out that in these animals included in the Breeding Programmes, in which milk production has been monitored, no important changes in the improvement of this trait in such a short time can be recorded because its heritability is 0.25. It should also be noted that the variation in milk production per total animals included in the Genealogical Breed Registers, including those newly registered and not traced by parentage, was tracked to determine the improvement in milk production character.

From Table 4 it can be seen that the number of Carpathian goats subject to milk production control had an upward trend with the exception of 2022 when from the analysis of the Genealogical Register platform it was observed that a large number of animals were reformed and many females entered first lactation.

The number of goats under control ranged from 117.073 head in 2019 to a maximum of 138.087 head in 2023 and the average annual milk production also increased from 144.17 to 175.04 kg milk/head/year. The decrease in the average quantity of milk is noteworthy due to the increased number of primiparous females, but mainly due to the nutritional factor.

Over the years, goat breeders who have joined the Genealogical Registers with their animals have been advised and have understood the importance of external factors, related to farming technology, which influence milk production, in particular the respect of milking times and the administration of supplementary feeding (good quality pasture or even the administration of feed supplements) so that the animals can express their productive potential. The influence of the feed factor, respectively the expression of the productive potential, can also be observed by comparing the average production of each year to the multiannual average production of the 5 years analysed, 163.52 kg/head/year, which is exceeded in the last three years of milk production control. Statistical analysis of the evolution of milk production in Carpathian goats, over the 5 years, does not indicate significant differences from year to year ($P>0,05$).

Table 4. Evolution of the average milk production of the Carpathian breed (kg/milk/goat)

Year	Number of animals controlled	Total quantity of milk (kg/year)	Average quantity of milk (kg/head/year)
2019	117,073	18,528,803.78	144.17*$^{0.22}$
2020	119,713	19,021,914.25	158.9*$^{0.24}$
2021	136,353	23,528,605.94	172.56*$^{0.77}$
2022	126,009	21,033,947.53	166.92$^{*0.15}$
2023	138,087	24,170,932.06	175.04$^{*0.20}$
Average over the last 5 years			163.51
Average over the last 4 years			160.64

The last 5 years for White of Banat goats over the last 5 years show a greater variation, with considerable fluctuations from one year to the next (Table 5). The number of White of Banat goats is very small, as the breed is in genetic conservation, and the herd included in breeding and genetic conservation works subject to control of productive performance has shown variations due to the migration of animals between breeders. Additionally, from the herds of goats registered in the Genealogical Register, the goats that respected the genealogical conditions of paternity were subjected to control in order to avoid cosangvinization. The individual annual average White of Banat goats in 2019 was 211.79 kg/head/year, much higher than in previous years, a value mainly due to the large number of multiparous females, some of which were subsequently removed from breeding work and therefore from milk production control. Statistical analysis of the evolution of milk production in White of Banat goats during the 5 years indicates significant differences ($P<0.05$) in 2021 and 2022.

Starting in 2020 and 2021, primiparous goats entered into directed breeding programs were retained for breeding on parentage criteria, with matings matched on parentage and productive performance criteria, respectively positive breeding value. What should be pointed out in the case of local breeds of goats, Carpathian and White of Banat, is the way they are exploited, respectively the traditional system, with the goats kept on pasture for 8-10 months, depending on climatic conditions.

This influences milk production, in drought years, such as 2022, when the quality of pastures and grazing land was poor, if the feed ration was not supplemented properly and consistently, the goats could not express their productive potential.

Table 5. Evolution of average milk production of the White of Banat breed (kg/milk/goat)

Year	Number of animals controlled	Total quantity of milk (kg/year)	Average quantity of milk (kg/head/year)
2019	3,196	676,873.30	211.79*$^{0.1}$
2020	1,704	257,257.39	150.97*$^{0.84}$
2021	3,325	517,009.45	155.49**$^{0.01}$
2022	1,838	292,565.66	159.18**$^{0.01}$
2023	2,066	406,622.83	196.82$^{*0.88}$
Average over the last 5 years			174.85

A special situation is encountered in the case of goats specialized for milk production coming from imports and registered in the Breed Genealogical Register of our country. In this situation, the main aim of the Breeding Programmes is to improve milk production under the farming conditions specific to our country.

The main challenges for the expression of the productive potential are the adaptation of the animals to the pedo-climatic conditions specific to our country and the adoption by the goat keepers of exploitation conditions as close as possible to those offered in the countries where the animals come from.

Table 6. Evolution of average milk production of the Anglo-Nubian breed (kg/milk/goat)

Year	Number of animals controlled	Total quantity of milk (kg/year)	Average quantity of milk (kg/head/year)
2019	763	197,932.4	254.42$^{**0.03}$
2020	544	132,922.78	244.34$^{**0.04}$
2021	1,116	307,032.3	275.12$^{*0.48}$
2022	828	217,337.63	262.49$^{*0.58}$
2023	987	321,261.38	327.48$^{*0.56}$
Average over the last 5 years			272.83

As far as the Anglo-Nubian breed is concerned, it is bred in small holdings of up to 50 head, but in a modernized traditional rearing system, with mares kept with their mothers for 4-5 months and weaning of goats much earlier than the breed standard of up to 300 days of lactation.

As can be seen from Table 6, average annual productions range from 244.34 kg/head/year (2020) to 327.48 kg/head/year in 2023, with an upward trend, indicating a good adaptability to climatic, exploitation and feed codifications.

Statistical analysis of the 5 years of lactation monitoring in Anglo-Nubian goats in the Genealogical Register and average milk production shows significant differences in 2019 and 2020 ($p<0.05$), the following 3 years not registering significant differences ($p>0.05$).
A particular situation is also found in the case of goats of the Murciano-Granadina breed, for the exploitation of which the owners, in smaller numbers, but with herds of between 10 and 150 head/farm, have adopted the modernised traditional or semi-intensive farming system.
In the case of the semi-intensive system of only 4 farms (with 100-150 goats) the conditions of exploitation for expressing the productive potential characteristic of the breed are closer to those in the countries of origin of the animals, the productions being close to the data declared in the countries of origin.

Table 7 Evolution of average milk production in the Murciano-Granadina breed (kg/milk/goat)

Year	Number of animals controlled	Total quantity of milk (kg/year)	Average quantity of milk (kg/head/year)
2019	492	125,792.70	$255.68^{*0.99}$
2020	623	144,926.59	$232.63^{*0.80}$
2021	785	199,332.13	$253.93^{*0.73}$
2022	1,057	246,017.7	$232.75^{*0.74}$
2023	1,583	373,226.85	$235.77^{**0.01}$
Average over the last 5 years			247.41

The number of farms with traditional system being high, the average individual production for the 5 years is low 247.41 and the annual average does not register significant differences ($p>0,05$) regardless of the number of animals whose milk production is monitored in the herd books, recording a minimum of 232.63 kg/head/year (2022) and a maximum of 255.68 kg/head/year (2019). Significant differences ($p<0.05$) in milk production were statistically observed in the year 2023.
In the case of Saanen and Alpine goats, the farming systems vary according to the size of the farm and the financial capacity of the breeders.
These two species have easily introduced and spread to all areas of our country.
The large differences in milk yields over the last 5 years are due to farming systems, with a small number of farms with more than 300 goats (n=5 farms) operated intensively and more than 20 farms with between 20 and 150 goats. In the case of small herds, the farming system adopted is traditional or traditionally modernised.

Table 8. Evolution of average milk production of the Saanen breed (kg/milk/head)

Year	Number of animals controlled	Total quantity of milk (kg/year)	Average quantity of milk (kg/head/year)
2019	2,667	638,901.4	$239.56^{**0.006}$
2020	2,483	767,885.33	$309.26^{*0.24}$
2021	2,796	1,037,084.34	$370.92^{*0.80}$
2022	3,583	1,336,264.34	$372.95^{**0.06}$
2023	3,191	1,161,477.19	$363.99^{**0.01}$
Average over the last 5 years			331.33

Table 8 shows the milk production of Saanen goats and Table 9 shows the milk production of Alpine goats. For both breeds, during the last 5 years, the average annual individual milk production has increased, which indicates a good adaptability to the specific pedo-climatic conditions of our country, but without reaching the productions specified by the herd books of the countries of origin (France, Austria, Hungary, Germany).

Table 9. Evolution of the average milk production of the Alpine breed (kg/milk/head)

Year	Number of animals controlled	Total quantity of milk (kg/year)	Average quantity of milk (kg/head/year)
2019	2,105	464,392.00	$220.62^{**0.001}$
2020	1,596	476,937.29	$298.83^{*0.54}$
2021	2,968	951,739.10	$320.67^{*0.18}$
2022	2,977	949,792.09	$319.04^{**0.006}$
2023	3,125	876,084.54	$280.35^{**0.01}$
Average over the last 5 years			287.90

The statistical analysis of the evolution of the average annual production in the Saanen and Alpina breeds indicates significant differences compared to the average milk production for the 5 years analysed ($p<0.05$), except for the years 2020 and 2021 where there are no significant differences ($p>0.05$).
In the year 2023, a slight decrease in average annual individual production is observed, due to the management of a slightly deficient forage, which is also observed on all farms throughout the country, amid the decrease in the financial capacity of owners.

In the Saanen breed, the average individual production increases from 239.56 to 372.95 kg/head/year in 2019-2022.
According to the data provided by the herdbook and presented in Table 9, the average annual individual production of Alpine goats increases from 220.62 kg/head/year in 2019 to 319.04 kg/head/year in 2022.

CONCLUSIONS

The goats of local breeds included in the selection work for improvement in the pure breed have registered an annual increase of 30.87 kg/head/year in the Carpathian breed during the 5 years analysed and 45.85 kg/head/year in the White of Banat breed during the last 4 years. This progress is the result both of selection work based on filiation and breeding.
In the case of specialised breeds for the production of imported milk, the main objective is to adapt to the pedo-climatic conditions specific to our country and to adopt farming systems as close as possible to those of the animals' countries of origin. By abandoning the traditional system and adopting similar housing and feeding measures to those of the farms of origin, an increase in average annual milk production was observed over the 5 years for all 4 imported breeds.
Saanen and Alpine goats on farms with herds of more than 300 head benefit from intensive farming conditions that allow the breed-specific productive potential to be expressed, as reported in the herd registers of the countries of origin.
Selection work for purebred improvement of milk production id directly influenced by external factors of maintenance and feeding of the problem goats.

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