EVALUATION OF REPRODUCTIVE INDICES AND MILK PRODUCTION IN CARPATHIAN GOATS UNDER REPRODUCTIVE ACTIVITY MODULATION

L. Marinică[1,3,4*], A. H. Anghel[1,2,3], O. C. Dordescu (Preșa)[2,4], C. Pascal[4]

[1]National Association of Goat Breeders of Romania, Constanța, Romania
[2]Institute of Research-Development for Sheep and Goat Breeding Palas, Constanța, Romania
[3]Faculty of Natural Sciences and Animal Sciences "Ovidius University" of Constanta, Constanța, Romania
[4]"Ion Ionescu de la Brad" Iasi University of Life Sciences, Romania

Abstract

Goats represent a species of major interest for animal husbandry in Romania, and the Carpathian breed plays an essential role as an indigenous genetic resource, valued for its adaptability and dual-purpose use. The age at first kidding and the time of mating directly influence productive and reproductive performances. The aim of this study was to evaluate the impact of reproductive activity modulation on milk and meat production in Carpathian goats registered in the Genealogical Register. The research was carried out on two groups of 50 primiparous goats each: group 1 was artificially inseminated on induced estrus between August 15–30, while group 2 was naturally mated on estrus between September 15–30, monitoring fertility and prolificacy. Productive indices were recorded during the first lactation. The results showed superiority for group 1 compared to group 2: fertility 94% vs. 90%, prolificacy 155.32% vs. 141.66%, and a milking period longer by 30 days (the suckling period being 70 days in both groups). These differences confirm that reproductive modulation directly influences milk production and reproductive indices, highlighting the importance of reproductive management strategies in breeding programs to increase economic efficiency and better exploit the productive potential of the Carpathian breed.

Key words: *goats, fertility, prolificacy, milk*

INTRODUCTION

The Carpathian breed is considered the oldest and most representative goat breed in Romania, playing an essential role in preserving the national genetic heritage and zootechnical diversity.

It accounts for over 90% of the country's total goat population, thus representing the main nucleus of the indigenous caprine population. Widespread across all geographical regions, the Carpathian breed was formed over centuries through natural selection and traditional breeding practices, which have given it a distinct identity and strategic value for the Romanian goat sector [1].

In recent years, the breeding of this indigenous population has gained importance, creating an opportunity for the development of the national goat meat market [2]. The Carpathian breed is characterized as a dual-purpose type, valued for both milk and meat production, and its milk is appreciated for its high fat and protein content, which provide superior technological and nutritional qualities [3].

From a morphological and productive perspective, Carpathian goats display substantial variability, which reflects both their extensive ecological distribution and the historically low intensity of selective breeding applied to this population [4].

*Corresponding author: lauralaviniamarinica@gmail.com
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Over time, the Carpathian breed has maintained its importance within the national herd due to its ability to efficiently utilize local feed resources and to adapt to the specific conditions of traditional farming systems. However, the genetic potential of this breed can be fully expressed only through the implementation of modern breeding and reproductive management strategies that lead to the improvement of both productive and reproductive performance.

Reproductive efficiency is a key determinant of the profitability of goat production systems, directly influencing fertility, prolificacy, and milk yield. Estrus synchronization and the use of artificial insemination are considered effective tools for improving reproductive indices and enabling breeding outside the natural season, thus ensuring a constant availability of dairy products throughout the year [5].

The implementation of estrus induction and synchronization protocols enables the control of reproductive seasonality, allowing artificial insemination to be performed at any time of the year. Additionally, the strategic staggering of kidding periods according to commercial objectives ensures a continuous supply of dairy and goat meat products to the market [6]. The primary purpose of using artificial insemination is to improve goat herds by introducing valuable genetic material from proven males, thereby accelerating the dissemination of genetic progress within the population.

Studies dedicated to the Carpathian breed show that the economic success of farms largely depends on proper reproductive management. Controlling the breeding season and optimizing the mating age are essential measures for stabilizing production, as the availability of meat and milk is directly linked to reproductive parameters [7].

Hence, reproductive performance becomes the "key" to zootechnical efficiency, and indicators such as age at first kidding, kidding interval, and prolificacy rate are systematically monitored to support management decisions [8].

Furthermore, several authors emphasize that indigenous breeds, including the Carpathian, may exhibit early sexual maturity, allowing the use of young females for reproduction well before full physiological maturity, thereby accelerating genetic progress [9].

The present study aimed to evaluate the effect of reproductive activity modulation on the reproductive and productive performance of primiparous Carpathian goats.

The main reproductive indices (fertility and prolificacy), as well as the lactation duration, were monitored under two reproductive management strategies: artificial insemination after induced estrus and natural mating during the normal breeding season.

The interpretation of the results seeks to highlight the potential of controlled reproductive techniques to enhance the genetic potential of the Carpathian breed within traditional farming systems.

MATERIAL AND METHOD

The biological material consisted of 100 primiparous females belonging to the Carpathian breed, registered in the Genealogical Register of the Carpathian breed.

The animals were divided into two equal batches (n = 50), differentiated according to the applied reproductive management strategy.

Batch 1 was composed of primiparous goats aged approximately 7 months, in which estrus induction followed by artificial insemination was carried out between August 15 and 30.

Both batches, consisting of females aged between 7 and 8 months and weighing 30-35 kg, were formed from individuals bred at an early age.

The selection of this age and weight range aimed to evaluate the effect of early kidding on reproductive indices, milk production, and lactation length. This approach was intended to highlight how early reproduction may influence productive performance and to assess the sustainability of such a practice under traditional and commercial production systems.

Batch 2 included primiparous goats aged 8 months, naturally mated during spontaneous estrus between September 15 and 30.

Estrus induction and synchronization in the females from Batch 1 were carried out according to the methodology described by Nadolu et al. [10]. For estrus synchronization and induction, Chronogest CR intravaginal sponges with a concentration of 20 mg (Intervet), impregnated with 20 mg fluorogestone acetate -cronolone (FGA), were used. The sponges were kept in the vagina for 11 days.

At the time of sponge removal, each female received 400 IU pregnant mare serum gonadotropin (PMSG) and artificial insemination was performed 43±1 hours after sponge withdrawal.

Artificial insemination was carried out using fresh semen collected with the aid of an artificial vagina from Carpathian bucks included in the breeding and genetic improvement program of the Racial Genealogical Register.

The hormonally synchronized females in Batch 1, treated with the Chronogest–Folligon protocol, were inseminated intracervically 43±1 hours after sponge removal using a pipette and a self-illuminated vaginoscope, which allowed visualization of the vaginal ostium and assessment of cervical dilatation. Each insemination dose had a volume of 0.25 mL. After treatment administration, the animals were monitored at 8-hour intervals to identify signs of estrus (restlessness, repeated sniffing, acceptance reflex in the presence of the buck). Estrus occurred, in most cases, within 24–48 hours after completion of the treatment.

The collected data were centralized and statistically analyzed using descriptive methods (mean, standard deviation, coefficient of variation) and mean comparisons between batches were performed using one-way analysis of variance (ANOVA Single Factor), with the level of statistical significance set at $p < 0.05$.

Milk production control was performed by the standard A4 method (cf. ICAR. Ord.22/2006) [11], for three consecutive months, two controls per day, morning and evening, and milk yield/lactation was calculated according to the Fleishman formula [12]:

$$MS = I_0\frac{(M1+M2)}{2} + I_1\frac{(M2+M3)}{2} + \ldots + I_{n-1}\frac{(Mn-1+Mn)}{2} + InMn$$

where,
MS -milk yield per lactation;
M1, M2, Mn – milk quantity recorded during the 24-hour control;
I0 – number of days between the start of milking and the date of the first control;
I1, I2, In-1 – number of days between two consecutive controls;
In – number of days between the last control date and the end of lactation.

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RESULTS

Young goat stock plays an essential role in herd dynamics and in supporting the genetic progress of the breed. Determining the optimal moment for the first mating is a decisive factor in achieving consistent reproductive and productive performance, while also contributing to the longevity and viability of the females within the herd.

The reproductive performance of the goats from Batch 1, in which the estrus induction and synchronization protocol followed by artificial insemination was applied, was slightly superior to that recorded in the naturally mated females from Batch 2.

The fertility rate was 94% in Batch 1, compared with 90% in Batch 2, indicating a favorable reproductive response to the application of the hormonal treatment. The average prolificacy was also higher in Batch 1 (155.32%) than in Batch 2 (141.66%), suggesting effective stimulation of ovarian function and a more uniform synchronization of ovulation (Table 1).

Table 1. Reproductive performance parameters in Carpathian primiparous goats under different reproductive management strategies

Specification	U.M.	Batch 1	Batch 2
Number of adult goats	INDIVIDUALS	50	50
Number of goats mated		50	40
Number of miscarried goats		3	4
Number of born goats		47	36
Number of born kids		73	51
Number of kids born live		60	48
Number of dead kids		13	3
Fertility index	%	94	90
Prolificacy index		155.32	141.66

The differences highlighted in Figure 1 reflect the direct influence of the reproductive technique on the analyzed reproductive indices.

Batch 1, in which the estrus induction and synchronization protocol followed by artificial insemination was applied, recorded higher fertility and prolificacy values compared with the naturally mated batch.

These results suggest that estrus synchronization and induction followed by artificial insemination led to more uniform ovulation and more efficient fertilization, thereby reducing reproductive losses.

In the case of natural mating (Batch 2), the slightly lower values may be attributed to individual variations in the estrous cycle and the less uniform timing of mating-factors that directly influence pregnancy success and the number of kids obtained per female.

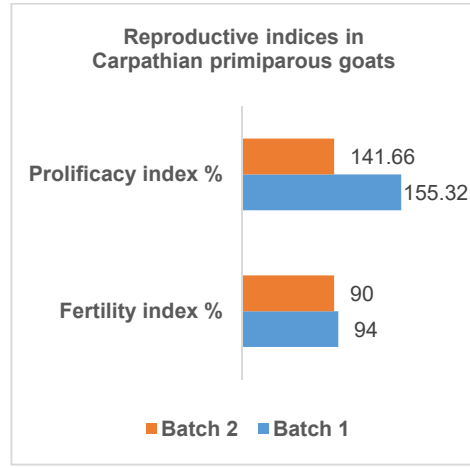

Figure 1. Reproductive indices in Carpathian primiparous goats

In the specialized literature, numerous studies indicate that milk production in goats is influenced by age, reproductive status, and management conditions [13]. It is also emphasized that the application of modern reproductive technologies can contribute to more uniform lactations and improved production persistence by reducing individual variation during the first months after kidding [14]. The goats in Batch 1, artificially inseminated between August 15 and 30, exhibited grouped kiddings starting in January, which allowed for a relatively uniform onset of lactation. During the first 60–70 days after kidding, the milk was almost entirely consumed by the kids, which limited the possibility of accurately assessing the milked yield during this period. After the separation of the kids from their dams, milk production was monitored monthly over a period of three consecutive months, starting in May, with controls performed at regular intervals of 28 days.

The quantities of milk obtained at the morning and evening milkings were individually weighed for each goat.

The results of milk yield monitoring in the primiparous females from Batch 1 are presented in Table 2.

At the first control, conducted in May, the average milk yield per primiparous female ranged between 0.71 kg/milk/day and 1.12 kg/milk/day, with a mean of 0.91 kg/milk/day. At the second control, carried out in June, individual milk yield increased markedly, with values between 0.82 kg/milk/day and 1.25 kg/milk/day, and a mean of 0.99 kg/milk/day, contrary to the specialized literature, which generally reports higher values.

At the third control, conducted in July, milk yield values ranged between 0.62 kg/milk/day and 1.05 kg/milk/day, with a mean of 0.88 kg/milk/day, which was lower than in the previous two controls.

Following the Single-Factor ANOVA analysis applied to the individual production values, no significant differences were found between the mean yields corresponding to the three controls ($p = 0.1815$; $p>0.05$).

The coefficient of variation, which reflects the dispersion of milk yield, ranges between 19.78% and 15.9%, indicating a moderate level of variability. The higher values recorded at the first control highlight the presence of greater differences in milk production among females during the early stages of lactation, a period strongly influenced by individual adaptation after kid separation and by the postpartum physiological status.

Table 2. Average milk production and lactation length in primiparous Carpathian goats from Batch 1

Specification (Kg/milk/day)	Min. (Kg/milk/day)	Max (Kg/milk/day)	$\overline{X} \pm STD$ (Kg/milk/day)	CV %	Lactation duration (days)
Control 1	0.71	1.12	0.91±0.18	19.78	289
Control 2	0.82	1.25	0.99±0.12	12.12	
Control 3	0.62	1.05	0.88±0.14	15.9	

The goats from Batch 2 were naturally mated, which resulted in a more heterogeneous distribution of the kidding period and, consequently, a less uniform onset of lactation compared with Batch 1. The characteristics of this batch influenced the establishment of milk production, and individual variations were more evident during the first weeks after kid separation. Milk yield was monitored over three successive controls, carried out at regular intervals of 28 days. The quantities milked in the morning and evening were recorded individually, and the obtained values are presented in Table 3. between 0.71 and 1.12 kg/milk/day, with an average of 0.91 kg/milk/day.

At the second control, yields varied between 0.82 and 1.25 kg/milk/day, with an average of 0.99 kg/milk/day.

At the third control, individual values ranged between 0.62 and 1.05 kg/milk/day, the average being 0.88 kg/milk/day.

Following the Single-Factor ANOVA analysis applied to the individual production values in Batch 2, we found statistically significant differences between the mean yields of the three controls ($p = 0.0296$; $p<0.05$).

The coefficient of variation ranged between 19.78% and 15.9%, indicating a moderate variability among individuals. The higher level of variability observed at the first control suggests marked differences in the rate of lactation establishment, influenced by individual variations in kidding time, physiological recovery, and adaptation to milking. The progressive decrease in the coefficient of variation in the subsequent controls reflects a gradual homogenization of milk production as lactation advances.

Table 3. Average milk production and lactation length in primiparous Carpathian goats from Batch 2

Specification (Kg/milk/day)	Min. (Kg/milk/day)	Max (Kg/milk/day)	$\overline{X}$ ± STD (Kg/milk/day)	CV %	Lactation duration (days)
Control 1	0.80	1.16	0.91±0.11	12.92	258
Control 2	0.83	1.18	0.99±0.12	13.8	
Control 3	0.76	1.05	0.88±0.11	13.62	

DISCUSSIONS

The results obtained in the present study regarding the reproductive performance and milk production of primiparous Carpathian goats are partially aligned with the data reported in the Romanian specialized literature. The fertility and prolificacy values recorded in Batch 1 fall within the characteristic intervals for autochthonous goat populations and are supported by previously published findings. For example, Gavojdian et al. [15] reported an average prolificacy of 148% in the Carpathian breed, a value that confirms the high reproductive potential of this population. The superior prolificacy recorded in the present study (155.32% in Batch 1) may be interpreted as a combined effect of the estrus induction and synchronization protocol, which promotes more uniform ovulation, together with the optimization of the mating moment. Although moderate, this difference reflects the direct impact of reproductive biotechnologies on reproductive performance. Moreover, the variations observed between the two batches are consistent with the observations of the same author, who emphasized that reproductive management and the organization of the breeding season significantly influence pregnancy success and the number of kids obtained per female.

The higher prolificacy observed in Batch 1 also falls within the specific interval for the Carpathian breed, and the values obtained in this study are consistent with those reported by Pascal for flocks raised in the north-eastern region of Romania [16]. In his study, the author indicated an average prolificacy of 129.6% and a fertility rate of 97.4%, values considered representative of the reproductive performance of local populations managed under traditional systems. The differences recorded between the two batches are in line with findings from Romanian studies on goats, where the application of reproductive biotechnologies has led to improvements in key reproductive indices. In this context, Nacu et al. [17] demonstrated the effectiveness of hormonal estrus-synchronization protocols in goats, achieving high fecundity rates, while Nadolu [10] reported gestation rates exceeding 70% in Carpathian goats following artificial insemination with fresh semen, confirming the potential of these technologies to enhance reproductive efficiency in local herds.

The average daily milk yield obtained in primiparous Carpathian goats, both in Batch 1 and Batch 2 (0.88-0.99 kg/milk/day across the three controls), falls within the intervals previously reported for this breed under traditional production systems. The study by Răducuță et al. showed that Carpathian goats raised under extensive conditions produced an average of 0.92 kg/milk/day, while those kept under semi-intensive conditions reached an average yield of 1.09 kg/milk/day [18]. Compared to these findings, the daily averages recorded in the present study are closer to the values reported under extensive systems; however, the lactation duration was longer particularly in Batch 1 (289 days) and moderately higher in Batch 2 (258 days) suggesting relatively good lactation persistence in the primiparous goats evaluated.

The evolution of daily milk yield across the three controls with maximum values recorded at the second control and a

decrease at the third is consistent with the observations of Pascal et al. [19], who reported that more than 70% of total milk production in Carpathian goats is obtained during the first 150 days of lactation, the period corresponding to peak production, followed by a gradual decline in milk secretion in the latter part of lactation.

The lactation durations recorded in this study (289 days in Batch 1 and 258 days in Batch 2) are comparable to those reported in the Romanian literature for the Carpathian breed. Zamfir et al. [20] documented lactation periods of up to 282-289 days in this breed, while Chetroiu et al. [21] reported durations ranging approximately between 247 and 269 days, depending on parity. The coefficient of variation values obtained in both batches across the three controls indicate a moderate level of variability, similar to that reported for other Carpathian goat groups in the early stages of lactation- a period in which postpartum influences, differences in adaptation to milking, and the timing of kidding contribute to increased dispersion in individual values [21].

CONCLUSIONS

The application of the estrus induction and synchronization protocol followed by artificial insemination resulted in improved reproductive outcomes, with Batch 1 recording higher fertility and prolificacy compared with the naturally mated Batch 2. These results confirm the effectiveness of reproductive biotechnologies in enhancing key reproductive parameters in primiparous Carpathian goats.

The prolificacy recorded in Batch 1 (155%) reflects the strong reproductive potential of the Carpathian breed and aligns with values reported for other autochthonous goat populations managed under traditional systems.

The average daily milk yield obtained in both batches (0.88-0.99 kg/day) indicates the moderate productive capacity characteristic of the Carpathian breed. The relatively small differences between batches suggest a similar post-kidding adaptation and a uniform establishment of lactation across management groups.

The evolution of milk yield across the three control points followed the typical lactation curve of Carpathian goats, with peak production observed in mid-lactation and a subsequent decline, consistent with previously documented patterns for this breed.

The lactation durations recorded demonstrate a high level of lactation persistence, particularly in Batch 1. This extended milking period may offer advantages in traditional farming systems where prolonged lactation contributes to improved milk availability.

The moderate variability in individual milk yield, reflected by coefficients of variation between 12% and 14%, is typical for unimproved local goat populations and may be influenced by factors such as kidding season, early primiparity, and postpartum physiological adaptation.

Overall, the findings highlight the importance of integrating effective reproductive management strategies with systematic monitoring of milk performance, especially in primiparous females, to maximize the productive potential of the Carpathian breed within traditional production systems.

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