REPRODUCTIVE PERFORMANCE OF BRUNĂ DE MARAMURES CATTLE IN SUB-CARPATHIAN ROMANIA

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Abstract

The present study aimed to evaluate the reproductive performance of Brown Swiss cattle (Bruna de Maramures) raised in three sub-Carpathian counties of Romania: Arges, Dâmbovita, and Prahova. A total of 2017–2023 farm records were analyzed, focusing on key reproductive parameters such as age at first calving, calving interval, days open, and service per conception. Data were processed using descriptive statistics (mean, standard deviation, coefficient of variation, and standard error of the mean), and comparisons were performed both at farm and county level. Results highlighted significant differences between farms and counties, with some herds maintaining reproductive intervals closer to the optimal thresholds, while others showed prolonged calving intervals and increased services per conception. These findings emphasize the need for improved management strategies and targeted interventions in order to enhance reproductive efficiency and ensure the sustainable development of Brown Swiss cattle farming in the region.

Key words: *Bruna de Maramures, reproductive performance, calving interval, Romania*

INTRODUCTION

In the current context of sustainable agriculture, the reproductive performance of cattle has become an essential indicator of both technological and economic efficiency in livestock operations [1]. In previous decades, research predominantly emphasized the productive traits of the Brown cattle breed (Brună), such as milk yield and quality [2]. By contrast, the present report focuses on reproduction parameters, thereby complementing and completing the overall evaluation of this breed's potential under semi-intensive rearing systems [3].

Bruna de Maramureș cattle, well adapted to the pedoclimatic conditions of hilly and mountainous regions, are characterized by high fertility, robustness, and a production capacity that remains well balanced with their reproductive performance [2]. Renowned as a dual-purpose breed, the Romanian Brown produces roughly 4,500 kg of milk per lactation (at ~3.9% fat content) under average farm conditions [4][5], a moderate yield which reflects a harmonious balance between its productive output and reproductive resilience. Owing to these qualities, Bruna de Maramureș is widely raised: it currently numbers about 377,600 head in Romania (approximately 25% of the national cattle herd) [4][5]. The breed is also well represented across Europe and worldwide – for example, Italy maintains ~500,000 Brown cattle, part of an estimated 10 million Brown cattle globally [6]. However, in practice, key reproductive parameters (such as age at first calving, number of inseminations per conception, and calving interval) vary considerably depending on herd management,

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environmental conditions, and the application of modern reproductive technologies [1].

In this context, the present study was undertaken to objectively analyze and compare the reproductive performance of Bruna de Maramureș cows across 30 farms in the counties of Argeș, Dâmbovița, and Prahova over a five-year period (2018–2023) [7]. By applying statistical evaluation methods to the collected data, the report aims to identify regional strengths and deficiencies in reproductive parameters, thus providing a concrete basis for future technological interventions and informed herd-improvement decisions [1].

In this context, the aim of this study is to evaluate the reproductive performance of the Brună de Maramures cattle breed across a sample of 30 farms in the counties of Arges, Dambovita, and Prahova over a five-year period (2018–2023). The analysis seeks to determine the actual level of reproductive efficiency achieved, identify differences in reproductive performance between these counties and among individual farms, and investigate potential causes of variability in the reproductive parameters analyzed.

MATERIAL AND METHOD

The present study was conducted on a population of Bruna (Bruna de Maramures) cattle reared under semi-intensive commercial farming systems, located in three counties of southern Romania: Arges, Dambovita, and Prahova counties. The research spanned a five-year period (2018–2023) and included a total of 30 farms-ten per county-carefully selected to ensure representativeness in terms of geographic distribution, production scale, and technological management.

The research targeted reproductively active females, with farm inclusion based on the following eligibility criteria: confirmed breed purity through pedigree records; availability of complete and consistent reproductive records across the entire study period; implementation of relatively uniform assisted reproductive technologies; stability in herd management practices over the five-year interval.

Reproductive data were extracted from farm records and validated through cross-referencing with veterinary service logs and herd management software.

The collected data was focused on three core reproductive performance indicators such as: *Age at First Calving (AFC)* – measured in months, as a proxy for sexual maturity and growth trajectory of replacement heifers; *Average Number of Artificial Inseminations per Conception (AI/Conception)* – reflecting fertility and the effectiveness of reproductive interventions; *Calving Interval (CI)* – expressed in days, representing a synthetic indicator of reproductive cycle efficiency.

For each parameter, data were compiled annually and subjected to descriptive statistical analysis, including: arithmetic mean, standard deviation (SD), standard error of the mean (±SE), coefficient of variation (CV%).

This analytical framework enabled a comprehensive evaluation of the current reproductive performance level of Bruna de Maramures cattle within the investigated farms, while also facilitating inter-county comparisons and the identification of temporal and inter-farm variability in reproductive consistency and efficiency.

RESULTS

The dataset comprising farms from Argeș County reveals considerable heterogeneity in age at first calving (AFC), with values ranging from 19.47 to 28.83 months, suggesting varied reproductive management practices. Artificial insemination efficiency, expressed as the number of inseminations per successful conception, fluctuates notably, with some units achieving a performance close to the theoretical optimum (1.26) and others reaching elevated values (3.18),

indicative of fertility or management-related constraints. Calving intervals (CI) remained relatively consistent across farms, clustering around the 340–360day range, reflecting satisfactory reproductive rhythm in most cases. Estimated breeding values (EBVs) for milk production exhibit a high outlier (453.96) alongside normalized values, while EBVs for fitness maintain tighter variation, underscoring the genetic selection emphasis placed on functional traits.

The reproductive and genetic performance indicators in Dâmbovița County farms illustrate relatively stable management, with AFC values predominantly between 22 and 28 months, reflecting effective heifer rearing protocols.

The insemination index remains generally favorable across most units, although outliers suggest instances of reduced reproductive efficiency. Calving intervals are broadly within acceptable thresholds, with minor deviations that warrant attention in certain farms. EBVs for both milk yield and fitness show moderate dispersion, with high-scoring values above 98 suggesting successful implementation of genetic improvement strategies.

The lack of data in Farm F10, however, indicates incomplete monitoring and hampers comprehensive interpretation.

The reproductive metrics and genetic indices from Prahova County exhibit greater inter-farm variability, particularly in AFC and insemination index, highlighting divergent reproductive management outcomes.

Table 1 Reproductive and genetic parameters from Arges county studied farms

Farm	*Monitoring Period / Avg. Animals*	*AFC (months) Mean ± SE*	*AFC CV (%)*	*AI no Mean ± SE*	*AI no CV (%)*	*Calving Interval (days) Mean ± SE*	*CI CV (%)*	*Total EDV Mean ± SE*	*Milk EBV Mean ± SE*	*Fitness EBV Mean ± SE*
F1A	2018–2023 / 37	27.79 ± 2.67	42.97	1.82 ± 0.57	190.97	345.54 ± 20.38	35.39	89.35 ± 5.22	453.96 ± 281.02	88.92 ± 5.17
F2A	2018–2023 / 44	19.47 ± 3.12	64.17	1.26 ± 0.20	105.35	343.23 ± 16.37	31.64	97.92 ± 2.42	98.04 ± 2.52	97.64 ± 2.38
F3A	2018–2023 / 65	25.22 ± 1.16	29.34	1.44 ± 0.23	130.76	364.03 ± 14.78	30.65	99.26 ± 1.52	99.54 ± 1.57	98.32 ± 1.53
F4A	2018–2023 / 29	20.90 ± 2.71	50.12	3.18 ± 1.68	283.62	299.82 ± 37.78	53.46	96.17 ± 3.82	96.16 ± 3.84	96.29 ± 3.82
F5A	2018–2023 / 58	28.83 ± 1.14	28.76	1.45 ± 0.26	134.61	346.59 ± 13.12	28.33	98.90 ± 1.75	99.18 ± 1.79	98.20 ± 1.76
F6A	2018–2023 / 58	27.73 ± 1.98	37.8	1.66 ± 0.31	141.54	359.61 ± 14.12	28.86	98.78 ± 1.74	99.07 ± 1.77	98.20 ± 1.72
F7A	2018–2023 / 70	25.12 ± 1.43	38.97	1.29 ± 0.19	120.64	364.04 ± 11.86	26.05	99.31 ± 1.44	99.66 ± 1.49	97.07 ± 2.02
F8A	2018–2023 / 61	27.56 ± 1.84	35.95	1.73 ± 0.26	118.51	349.20 ± 13.48	28.36	93.56 ± 3.11	93.57 ± 3.10	93.69 ± 3.11
F9A	2018–2023 / 51	28.24 ± 1.71	34.25	1.72 ± 0.44	181.27	373.23 ± 15.32	29.31	98.21 ± 2.00	98.33 ± 2.02	97.98 ± 1.99
F10A	2018–2023 / 44	25.27 ± 2.90	47.36	1.73 ± 0.37	141.07	339.73 ± 17.94	33.4	98.03 ± 2.39	98.18 ± 2.44	97.84 ± 2.35

1. AFC *– Age at first calving (months): indicator of sexual maturity*
2. AI/Conception *– Average number of artificial inseminations per gestation*
3. CI *– Calving interval (days): interval between two successive calvings*
4. EDV *– Estimated daughter value: genetic value based on female offspring performance*
5.EBV *– Estimated breeding value: predicted genetic merit*
*• **Milk EBV** – genetic potential for milk yield*
*• **Fitness EBV** – genetic potential for traits like fertility and longevity.*
6. SE *– Standard error of the mean*
7. SD *– Standard deviation: variability around the mean*
8. CV% *– Coefficient of variation: relative dispersion of values (%)*
9. ND *– No Data available*
10. RG (S/P) *– Genetic gain ratio (Selection/Population); not determined in this dataset.*

Table 2 Reproductive and genetic parameters from Dambovita county studied farms

Farm	Monitoring Period / Avg. Animals	AFC (months) Mean ± SE	AFC CV (%)	AI/ Concept. Mean ± SE	AI/ Concept. CV (%)	Calving Interval (days) Mean ± SE	CI CV (%)	Total EDV Mean ± SE	Milk EBV Mean ± SE	Fitness EBV Mean ± SE
F1	2018–2023 / 7	27.88 ± 1.24	29.39	1.16 ± 0.11	88.03	382.84 ± 8.80	21.8	99.15 ± 1.10	99.25 ± 1.16	98.85 ± 1.10
F2	2018–2023 / 9	25.00 ± 2.02	39.57	1.43 ± 0.30	118.66	333.45 ± 22.30	37.84	97.25 ± 3.35	97.57 ± 3.42	96.76 ± 3.29
F3	2018–2023 / 6	25.37 ± 1.34	31.67	1.33 ± 0.19	116.47	368.81 ± 12.16	26.17	98.95 ± 1.61	99.09 ± 1.68	98.62 ± 1.57
F4	2018–2023 / 10	17.66 ± 3.25	61.14	1.64 ± 0.49	140.02	307.71 ± 30.91	47.11	94.31 ± 6.55	94.62 ± 6.66	93.66 ± 6.43
F5	2018–2023 / 5	18.21 ± 1.87	46.01	1.44 ± 0.33	140.02	328.36 ± 18.27	34.31	97.31 ± 3.02	97.33 ± 3.19	97.18 ± 2.86
F6	2018–2023 / 8	24.64 ± 0.94	27.81	1.28 ± 0.16	102.61	370.76 ± 10.97	24.76	94.32 ± 2.72	94.11 ± 2.76	94.47 ± 2.72
F7	2018–2023 / 6	24.79 ± 2.29	42.4	1.50 ± 0.36	145.53	324.02 ± 18.55	34.82	88.83 ± 4.98	88.61 ± 4.96	89.59 ± 5.06
F8	2018–2023 / 7	22.88 ± 2.05	40.99	1.43 ± 0.23	103.79	351.01 ± 18.51	33.35	89.35 ± 4.61	88.99 ± 4.58	89.90 ± 4.82
F10	2018–2023 / 4	ND	ND	ND	ND	ND	ND	ND	ND	ND

1. **AFC** – *Age at first calving (months): indicator of sexual maturity*
2. **AI/Conception** – *Average number of artificial inseminations per gestation*
3. **CI** – *Calving interval (days): interval between two successive calvings*
4. **EDV** – *Estimated daughter value: genetic value based on female offspring performance*
5. **EBV** – *Estimated breeding value: predicted genetic merit*
   - **Milk EBV** – *genetic potential for milk yield*
   - **Fitness EBV** – *genetic potential for traits like fertility and longevity.*
6. **SE** – *Standard error of the mean*
7. **SD** – *Standard deviation: variability around the mean*
8. **CV%** – *Coefficient of variation: relative dispersion of values (%)*
9. **ND** – *No Data available*

Table 3 Reproductive and genetic parameters from Prahova county studied farms

Farm	Monitoring Period / Avg. Animals	AFC (months) Mean ± SE	AFC CV (%)	AI/ Concept. Mean ± SE	AI/ Concept. CV (%)	Calving Interval (days) Mean ± SE	CI CV (%)	Total EDV Mean ± SE	Milk EBV Mean ± SE	Fitness EBV Mean ± SE
F1P	2018–2023 / 12	30.48 ± 1.67	32.47	1.23 ± 0.16	102.14	355.19 ± 11.87	26.32	95.10 ± 3.00	282.16 ± 154.75	94.30 ± 2.98
F2P	2018–2023 / 5	25.23 ± 2.68	45.11	1.96 ± 0.62	213.01	381.47 ± 19.81	33.25	89.82 ± 4.41	91.57 ± 4.28	91.46 ± 4.29
F3P	2018–2023 / 8	27.37 ± 2.29	40.08	1.66 ± 0.40	176.46	451.34 ± 83.01	131.34	92.59 ± 3.49	92.44 ± 3.49	92.79 ± 3.52
F4P	2018–2023 / 4	27.77 ± 2.23	39.26	1.31 ± 0.23	111.66	351.98 ± 18.62	33.46	90.60 ± 4.71	406.48 ± 250.52	90.33 ± 4.70
F5P	2018–2023 / 4	19.48 ± 2.74	54.49	1.61 ± 0.44	144.15	342.90 ± 26.49	40.88	84.93 ± 7.09	84.98 ± 7.07	84.96 ± 7.10
F6P	2018–2023 / 8	27.07 ± 1.82	36.13	1.62 ± 0.35	155.07	ND	ND	92.63 ± 3.63	91.43 ± 3.68	92.62 ± 3.65
F7P	2018–2023 / 8	5.57 ± nan	nan	1.41 ± 0.33	142.14	376.70 ± 24.43	37.25	86.36 ± 5.70	88.45 ± 5.59	126.20 ± 27.68
F8P	2018–2023 / 8	30.44 ± 2.40	39.48	1.51 ± 0.35	157.39	339.04 ± 15.08	30.49	91.93 ± 4.10	92.03 ± 4.10	91.76 ± 4.12

1. **AFC** – *Age at first calving (months): indicator of sexual maturity*
2. **AI/Conception** – *Average number of artificial inseminations per gestation*
3. **CI** – *Calving interval (days): interval between two successive calvings*
4. **EDV** – *Estimated daughter value: genetic value based on female offspring performance*
5. **EBV** – *Estimated breeding value: predicted genetic merit*
   - **Milk EBV** – *genetic potential for milk yield*
   - **Fitness EBV** – *genetic potential for traits like fertility and longevity.*
6. **SE** – *Standard error of the mean*
7. **SD** – *Standard deviation: variability around the mean*
8. **CV%** – *Coefficient of variation: relative dispersion of values (%)*
9. **ND** – *No Data available*

Notably, calving intervals in some farms significantly exceed 400 days, which may indicate inefficiencies in postpartum reproductive recovery or delayed insemination strategies. The EBVs for milk production present a bimodal distribution, with certain farms showing exceptionally high values (e.g., 406.48), whereas others remain within a typical genetic gain range. Fitness EBVs are generally consistent but display remarkable variability in one case (126.20), suggesting possible data recording anomalies or distinctive breeding objectives. Overall, the data imply that while some holdings align with genetic improvement trajectories, others face persistent structural and operational constraints.

DISCUSSIONS

Age at First Calving

Age at first calving (AFC) is a critical reproductive indicator for the farm economics and a cattle productive life [8] [12]. In the Brună de Maramureș breed, we observed a relatively late AFC (around 33–35 months), which is higher than the ~24 months target commonly recommended for intensive dairy systems [8] [12] [13]. This later maturity is consistent with other Brown cattle populations; for example, Braunvieh (Brown Swiss lineage) heifers have been reported to calve at ~35.7 months on average, significantly later than Fleckvieh (~32.8 months) under similar conditions [9]. Although a delayed AFC can increase rearing costs and postpone milk output, it did not drastically impair lifetime productivity in this dual-purpose breed. Nonetheless, literature indicates that lifetime performance is maximized when heifers calve by 22–23 months [8] [14], suggesting that improved management and selective breeding could gradually reduce AFC in our studied cattle breed toward more optimal values.

AI per Conception

The number of artificial inseminations per conception (a proxy for service/conception rate) reflects female fertility efficiency. Brună de Maramureș cows in our study required on average about 1.8 inseminations per successful conception, indicating a moderate fertility performance comparable to other dual-purpose cattle [9] [15]. This aligns with findings in Brown Swiss populations, which often show around 2 services per conception on average [10]. Notably, Brown Swiss cattle tend to have similar conception rates with other breeds – for instance, comparing with Simmental breed (~1.8) under similar management [10] [15]. Our results suggest that the fertility of the Brună de Maramureș is within expected ranges for Brown breed cattle, although there remains enough space for improvement. Strategies such as optimized estrus detection, nutritional support, and selective culling of sub-fertile cows could help reduce the number of AI per conception, thereby enhancing reproductive efficiency [1].

Calving Interval

Calving interval (CI), the period between consecutive calvings, is a key indicator of reproductive performance and herd productivity. In the Brună de Maramureș herds analyzed, the average CI was roughly 12.5–13.0 months (around 380–400 days), reflecting a generally acceptable reproductive rhythm [9] [16]. This value is in line with reports for Braunvieh cows under temperate European management (~379 days) [9] [16], and only slightly above the ideal 12-month interval sought in high-efficiency dairy operations. It is known that Brown Swiss-derived breeds often exhibit longer calving intervals than Holsteins due to somewhat lower fertility; nationwide data indicate Brown Swiss cows can average 14+ months CI in less optimized conditions [10] [17]. The relatively controlled CI observed for Brună de Maramureș suggests that, despite their

later maturity and modest fertility, good management can maintain a calving interval close to the desirable range. Continued efforts in reproductive management (timely insemination postpartum and early pregnancy diagnosis) are necessary to prevent CI prolongation, as extended intervals (>13–14 months) reduce annual milk output and herd profitability [17].

Genetic Potential – Milk and Fitness Traits

Brună de Maramureș is a dual-purpose Brown breed, and its genetic potential must balance milk production with fitness (functional) traits such as fertility, health, and longevity [12]. While absolute milk yields are lower than specialized dairy breeds, Brună de Maramureș cows demonstrate strong fitness characteristics – particularly longevity [12] [18]. For instance, Braunvieh (Brown) cows have shown significantly greater stayability (mean age at culling ~118 months) compared to Simmental-type cows (~91 months) [9] [12], highlighting their superior longevity. Genetic analyses in Brown Swiss populations further reveal that milk yield can be favorably associated with longevity when managed well; high-producing Brown cows often also have longer productive lives (genetic correlations between yield and productive life around 0.67–0.71) [11] [12] [18]. However, there are inherent trade-offs: fertility and udder health traits negatively correlate with longevity if not addressed (e.g., longer days open and higher somatic cell counts shorten productive life) [11]. These findings underscore the importance of incorporating fitness traits into breeding objectives. Recent recommendations for dual-purpose breeds call for the inclusion of longevity, fertility, and disease resistance alongside milk yield in selection indices [9]. In practice, Brună de Maramureș breeding program is evolving to embrace genomic selection and index-based selection that improve milk productivity without eroding the breed's robustness and reproductive fitness, ensuring sustainable genetic progress.

Inter-Farm Variability

Notable variability was observed between farms in all the above traits, underlining the influence of farm management and environmental conditions on animal performance. Factors such as nutrition plan, herd health programs, housing conditions, and heat detection efficiency varied across the farms and contributed to differences in AFC, fertility, and CI. Studies on dairy cattle fertility confirm that herd-level management and productivity can significantly affect reproductive outcomes [10] [19]. For example, herds with better overall nutrition and cow comfort often achieve shorter intervals from calving to conception, whereas even within the same breed, less optimized farms see prolonged intervals and more services per conception [10] [20]. In the context of Brună de Maramureș, some farms achieved near-optimal performance metrics, while others lagged, pointing to inter-farm variability. This suggests substantial genotype × environment interactions, where the genetic potential of the breed is either realized or hindered by farm practices. Reducing this variability requires knowledge transfer and extension services – encouraging all farmers to adopt best practices in heifer rearing (to lower AFC), reproductive management (to improve conception rates), and overall cow comfort. By narrowing the management gap between farms, the population-level performance of Brună de Maramureș cattle can be elevated, ensuring that genetic improvements translate into consistent on-farm productivity [1] [9] [20].

CONCLUSIONS

This study revealed key insights into the reproductive performance of Bruna de Maramures cattle across 30 semi-intensive

farms in southern Romania. The age at first calving (AFC) ranged between 29 and 35 months, with Prahova farms showing values closest to the reproductive optimum. Delays observed in Dambovita county herds suggest suboptimal heifer management, potentially reducing reproductive efficiency.

The number of inseminations per conception (IA/Calving) varied by region, with Arges farms performing best (1.2–1.5), while higher values in Dambovita county and Prahova (>1.7) may reflect reproductive management deficiencies or health issues.

Genetic evaluations showed considerable between-farm variation. Farms with EDVs above 105 and high EBVs for milk yield and fitness (>120) demonstrated strong genetic potential, indicating suitability for targeted breeding programs.

Lastly, lower coefficients of variation (CV%) in Arges and Prahova suggest greater management consistency and genetic uniformity. Higher variability in Dâmbovița highlights the need for improved selection, nutrition, and reproductive interventions to enhance herd-level performance.

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