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The Influence of Season and Age on Specific Semen Traits and Reproductive Behavior in Carpatina Breed Bucks

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Abstract: This study explores how age and seasonal changes impact semen characteristics and reproductive behavior in Carpatina breed bucks. Males were divided into three age groups: young (14–23 months; L14), adult (3–4 years; L34), and older (5–6 years; L56). Scrotal biometry was determined using a measuring tape, and testicular volume was evaluated by fully submerging the testes in a water-filled container and measuring the displaced water. Semen analysis was conducted on samples collected each season, with volume, color, and acidity being assessed. The evaluation of specific semen characteristics (motility, sperm concentration, normal spermatozoa) was conducted using a Computer-Assisted Semen Analysis (CASA) system, and testosterone levels were measured in blood samples collected at the start of each season. Behavior and sexual reflexes were evaluated based on mating desire and the bucks' reaction to the presence of females. Key findings indicate that testicular volume varies significantly with both age and season, with the most pronounced differences between younger bucks and the older groups, especially during autumn. Semen quality parameters such as ejaculate volume, sperm concentration, and motility also showed seasonal fluctuations, with younger bucks having lower sperm concentrations. Testosterone levels were observed to increase with age, peaking in autumn. Behavioral observations revealed that younger bucks exhibited less intense sexual activity, although this improved during autumn. Additionally, a significant correlation was identified between body weight and testicular volume in adult bucks (R = 0.942, p-value = 0.016 for L34; R = 0.797, p-value = 0.022 for L56), suggesting that age plays a crucial role in reproductive potential. Our findings highlight that, while bucks are capable of year-round reproduction, autumn provides optimal conditions for semen quality and reproductive performance. This research has valuable implications for optimizing breeding programs, contributing to genetic advancement, and improving management strategies in goat farming, especially within temperate continental climates.

Keywords: buck semen; semen traits; testicular size; Carpatina goat breed; sexual behavior

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1. Introduction

In the area where this study was conducted, goat farming has seen significant growth recently. The Carpatina breed is well adapted to the local environment, demonstrating exceptional organic resistance to microclimatic factors such as temperature fluctuations, humidity, and variations in feed availability. This breed is known for its hardiness, allowing it to thrive in rugged, mountainous areas. It is primarily raised for both milk and meat production, with its milk being valued for its high nutritional content, including good fat and protein levels, making it suitable for dairy products. Additionally, the meat of the Carpatina breed is appreciated for its tenderness and flavor, contributing to its value in local markets. The breed's adaptability, combined with its dual-purpose nature, makes it an integral part of the local farming systems in the Carpathian region [1].

Male goats, known as bucks, play an essential role in producing future generations of offspring. Effective management in goat farming includes situations where bucks are utilized for breeding outside their natural reproductive season. In these instances, certain semen traits may deviate from refqce values, potentially leading to negative effects on reproductive success [1]. Another important aspect of goat farm management is the timing of using young bucks for breeding. Although bucks typically reach puberty between five and eight months of age [2,3], they are generally not used for mating until the next breeding season in most seasonal breeds [4]. Delaying their use until they reach 12–15 months results in lost time and resources, impacting not only the generation interval but also genetic progress in the herd [5–7]. This effect is primarily due to annual changes in photoperiod, which vary according to latitude and create distinct reproductive and non-reproductive seasons worldwide [8]. Other external factors that vary with the season, such as temperature, relative humidity, rainfall, and nutrition, also affect the reproductive function of bucks [1,9].

Understanding the effects of these influencing factors is essential, as bucks play a key role in enhancing the genetic quality of the local populations from which they originate. The breeding buck is considered to be half of the herd, as he is responsible for the conception rate and the degree of genetic improvement in the kids [10,11]. Buck fertility is a critical factor in goat farm management, as a single buck is typically used to breed with numerous does. Consequently, any issues affecting a buck's fertility can have significant implications for the overall productivity and success of the breeding program [7]. Most studies examining factors that influence bucks' breeding quality have focused on populations in Western countries, where data are more readily available. However, research conducted in Central and Eastern European countries remains limited, and findings from these regions show considerable variability. This lack of consistent data highlights the need for more region-specific studies to better understand the factors affecting bucks' fertility in different climates and management systems. In this context, the aim of this research was to analyze how age and season affect the semen characteristics, as well as the morphology of the testes, sexual behavior, and reflexes, in Carpatina breed bucks. These studies are both useful and necessary, because goat farming in many parts of the world is in a process of development and modernization. Additionally, the research is justified by the fact that, in this part of the European Union, goat populations are increasing, and in some countries the annual growth rate exceeds 1% [12].

Knowing seasonal variations in some semen characteristics provides useful information for farmers who want to plan breeding activities outside the natural period [1]. By collecting semen, followed by conditioning and storing it through cryopreservation, it becomes possible to use it in other seasons or periods of the year, with positive effects on improving reproduction rates, as evidenced in several studies and research papers [6,8,9,13–15].

The purpose of this research was to determine how the age and season influence key semen characteristics, as well as testicular morphology, sexual behavior, and sexual reflexes, in Carpatina breed bucks. Additionally, this study assessed the correlation between these variables and the main semen quality parameters. This information aims to optimize the selection of reproductive bucks with desirable semen traits, leading to a reduction in the number of bucks needed for breeding, and lowering maintenance costs.

2. Materials and Methods

2.1. Ethical Approval

The present study was approved by the Scientific Research Ethics Committee of the Research and Development Station for Sheep and Goat Breeding, Popăuți-Botoșani (registration number: 278, date: 10 March 2023). Furthermore, during both the handling and sampling of biological materials, all ethical requirements were observed, ensuring that the animals undergoing experimental procedures did not experience painful treatments or go through periods of stress and discomfort.

2.2. The Research Area and Climatological Conditions

The geographical area where the research was conducted is located in the northeastern part of Romania, with the geographical coordinates 47°47′45″ N and 26°40′43″ E [16]. The natural vegetation is characteristic of the forest–steppe zone, mainly consisting of agricultural land and ancient grasslands that have replaced former forests.

The climate is temperate and continental, strongly influenced by air masses of Asian origin. The winters in the area are harsh and cold, and strong winds predominate from the northeast. Summers, by contrast, are extremely hot, with temperatures often exceeding 35 °C and a relative humidity of around 65%. Precipitation varies throughout the year, with the highest rainfall occurring during spring and autumn. In spring, temperatures fluctuate between 9 °C and 25 °C, while in autumn they range from 8 °C to 20 °C, with relative humidity levels exceeding 75% [17].

2.3. Animal Selection and Management

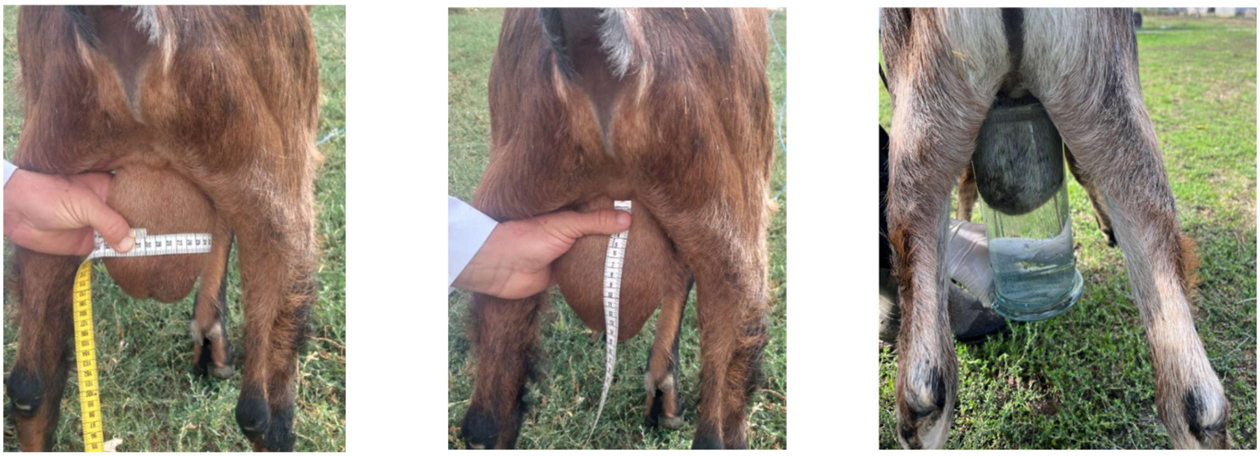
The research animals were 18 Carpathian breed bucks, all meeting the necessary conditions for reproductive use. To assess the influence of two variables—age and season—on semen traits and other reproductive functions, the bucks were divided into three groups (L14, L34, and L56). Each buck was identified and underwent a thorough veterinary examination, including an assessment of genital integrity. The grouping was based on age at the start of the study, with each group containing six bucks. Group L14 consisted of young bucks aged 14 to 23 months, Group L34 included adult bucks aged between three and four years, and Group L56 comprised bucks aged five to six years.

2.4. Experimental Design

The experimental period lasted 12 months, from March 2023 to March 2024, and covered the four annual seasons typical of the Northern Hemisphere, located at the intersection of the 45° northern latitude and 25° eastern longitude meridian: spring (21 March–20 June), summer (21 June–20 September), autumn (21 September–21 December), and winter (21 December–20 March) [18]. Throughout the research, the bucks were housed under identical conditions, with each group having free access to an outdoor paddock for exercise. During the entire study, sanitary/veterinary and animal welfare regulations were strictly observed. The feeding of the three groups was carried out using forage rations that met the nutritional requirements recommended by the HYBRIMIN diet optimization program. For each group, the nutritional requirements were determined based on body weight as follows: for the group of bucks under two years of age (L14), the requirements were 10 MJ of metabolizable energy (ME) for ruminants, 170 g of crude fiber (CF), and 80 g of crude protein (CP); for adult bucks aged between three and four years (L34), the requirements were 11.3 MJ of ME for ruminants, 190 g of CF, and 90 g of CP; for bucks aged five to six years (L56), the requirements were 12.7 MJ of ME for ruminants, 220 g of CF, and 100 g of CP. Clean water was provided from sanitary sources and available at all times, and salt licks were placed in the housing areas assigned to each group.

2.5. The Scrotal Biometry

Measurements related to testicular circumference (TC), testicular length (TL), and testicular volume (TV) were taken individually at the beginning of each season over three consecutive days. The testicular circumference was determined by gently pulling the testicles downward toward the lower part of the scrotum and then placing a measuring tape around the widest point (Figure 1a), with the result expressed in centimeters. Testicular length (TL) was measured by determining the distance between the point of insertion near the abdominal attachment and the end of the third distal portion of the scrotum (Figure 1b), also expressed in centimeters. Testicular volume (TV) was determined using the water displacement method (Figure 1c), expressed in cubic centimeters (cm^3). For this measurement, the testicles were completely submerged in a container filled with water, and the residual water displacement was used to calculate the desired volume.



(**a**) (**b**) (**c**)

Figure 1. The determination of scrotal circumference (**a**), testicular length (**b**), and testicular volume (**c**).

2.6. Semen Analysis

The evaluation of semen was carried out on samples collected from each buck immediately after the start of each season. The collection was performed by experienced personnel using the artificial vagina method. To avoid contamination of the semen, the prepuce was sanitized before collection. Collection took place once per day for four consecutive days. To ensure a uniform interval between collections, the semen was collected at 8 a.m. every day. The collected samples were stored in a water bath at a temperature of 35–37 °C and transported to the laboratory within a maximum of ten minutes for evaluation.

2.6.1. The Volume, Color, and pH of the Ejaculate

The volume of semen collected was measured directly using the graduated container used during collection. The color of the seminal fluid was assessed visually and assigned a score ranging from 1 to 4 according to a model presented by Jha et al. [19], as follows: 1 = watery; 2 = milky; 3 = yellowish-white; 4 = cream-white. The degree of semen acidity (pH) was estimated from the collected samples using a colorimetric method, using indicator paper (phenolphthalein paper) and comparing it with a color scale.

2.6.2. The Evaluation of Specific Characteristics of Semen

For the analysis of semen-specific traits, a CASA analyzer was used (CEROS II CASA, IMV Technologies, L'Aigle, France), endorsed with a 10× objective for negative and positive phases, and compatible with specimen chambers of 20 µm depth. Motile sperm and total concentration were analyzed using WHO 5-phase slides, equipped with Animal Breeders II Software (version 1.13.7; Hamilton Thorne, Beverly, MA, USA). The system also included a Trinocular Zeiss Axiolab A5 microscope (Carl Zeiss Microscopy GmbH, Jena, Germany) with 100× magnification. Additionally, the used slides, coverslips, and chamber were pre-warmed to 37 °C for at least 10 min before the sample analysis. The initial sperm concentration was measured by diluting each sperm sample 1:100 in a 0.025% glutaraldehyde solution. Before assessing motility or viability, 200 × 10^6 spermatozoa/mL semen samples were carefully mixed and re-diluted to a final concentration of 50 × 10^6 spermatozoa/mL using TRIS extenders for motility and viability evaluation. The analysis was conducted on 3 µL samples loaded onto Leja 4-chamber 20 µm slides. To these samples, 1 µL of propidium iodide and 1 µL of acridine orange were added. After application, the samples were gently mixed for homogenization. The homogenized mixture was covered with a coverslip, and images were captured under the microscope. This procedure resulted in the differentiation of dead and live cells, which were highlighted in red and green, respectively, through staining.

2.6.3. Assessment of Blood Testosterone Levels

The level of testosterone was determined from blood samples collected on the same day that semen collection was performed (during the first four days of each season at 8 AM). The collection was preceded by a needle incision into the jugular vein at an angle of approximately 20 to 30 degrees relative to the skin surface, to collect blood from the jugular vein of each male, with a volume of 10 mL being collected each time. After collection, the samples were stored in individual tubes and transported to the laboratory. There, they were centrifuged (4000 rpm), and the resulting serum was frozen at −20 °C until the testosterone levels were determined. The determination of testosterone was performed using the radioimmunoassay (RIA) method, utilizing TESTO-RIA-CT (DIAsource ImmunoAssays, Ottignies-Louvain-la-Neuve, Belgium) and a commercial kit (KIP1709) that facilitates the quantitative measurement of testosterone (T) protein in serum and plasma, with a detection range from 0.1 ng/mL to 20 ng/mL and a sensitivity of 0.05 ng/mL.

2.7. The Sexual Behavior and Reflexes

To properly assess the sexual behavior and reflexes of bucks, they were isolated from females throughout the experimental period. Contact with females occurred only at the beginning of each season. The females used in this study were clinically healthy but infertile and, for certain reasons, had not become pregnant in the previous breeding season.

Behavior was analyzed using a method described by Goshme et al. [20], focusing on the following aspects: the reaction and desire of the buck to mate, the time taken to approach the female, the attitude adopted in the presence of the female, and the reaction time of the bucks upon the introduction of the female into a pen measuring 5 × 6 m. The assessment of the behavior manifested and how the bucks reacted in the presence of infertile females was based on assigning scores according to the following types of manifestation:

Excellent (5): Typical behavior observed in the buck when introduced into the testing pen includes a high level of eagerness to mount, restlessness, and provocative movements. The buck shows an intense desire to mate immediately, appearing agitated and difficult to control.

Very good (4): Sexual reflexes are considered optimal when the buck shows a strong desire to mate within three minutes of introduction to the testing environment. The buck is often restless, aggressive, and difficult to control, indicating heightened sexual arousal and readiness to mate.

Good (3): The buck typically sniffs the females and expresses a desire to mate within the first five minutes of being introduced to them. Although it may be agitated during this time, it remains relatively easy to control compared to a more intense response.

Weak (2): The time required for the buck to initiate mating extends to approximately ten minutes. During this period, the buck remains docile and is relatively easy to handle, indicating a more calm state of sexual arousal compared to more aggressive or impatient individuals.

Very weak (1): The male buck exhibits delayed and incomplete sexual reflexes, with the time required to display a desire to mate extending beyond ten minutes. This extended response time suggests a lowered level of sexual arousal or potential issues with reproductive readiness, as the buck's response to the presence of females is slower and less intense compared to more responsive individuals.

The manifestations of erection and ejaculation reflexes were evaluated according to the technical standards presented by the National Agency for Zootechnics in Bucharest [21], with points awarded as follows: 1 = lack of erection or incomplete erection of the penis; 2 = satisfactory erection, not seeking the vulva, ejaculation in the furrow; 3 = well-defined erection, evident seeking of the vulva, no ejaculation; 4 = well-defined erection, energetic seeking of the vulva, delayed ejaculation; 5 = immediate erection of the penis in the presence of the female, energetic seeking of the vulva, rapid ejaculation with obvious spurting.

2.8. Statistical Data Processing

Experimental data were input in a column-type database and processed within the GraphPad Prism v. 9.4.1. software (Palo Alto, CA, USA) to obtain statistical descriptive values (mean, standard error) and to compare the three groups' performances, using the ANOVA single-factor test followed by Tukey post hoc processing. The Mann–Whitney U test for independent groups was used to compare scorings of semen color, sexual behavior, and sexual reflexes (discontinued variables), and one-to-one comparisons were carried out (within each season, between the age groups). Also, Pearson correlation coefficients and the level of significance for the correlations were computed using the same software package. Correlations were calculated within groups, between body weight and certain testicular traits, and between the ejaculate volume and certain quality traits of the semen.

3. Results

3.1. Body Weight and Scrotal Measurements

Body weight (BW) is an important indicator that has a direct relationship with many traits affecting reproductive activity in males. In all established groups, the evolution of both body weight and scrotal measurements was monitored each season (Table 1). Therefore, at the beginning of each season, both BW and the changes occurring at the testicular level were determined, specifically concerning testicular circumference (TC), testicular length (TL), and testicular volume (TV).

Table 1. Mean (±SE) body weight and different measurements of the testicles in relation to age and season.

Season	Traits	Animal Group		
		L14	**L34**	**L56**
Spring	BW (kg)	$49.58^{a} \pm 1.53$	$63.72^{dx} \pm 1.41$	$74.78^{dz} \pm 0.88$
	TC (cm)	$25.90^{a} \pm 0.82$	$31.12^{d} \pm 0.37$	$32.71^{d} \pm 0.63$
	TL (cm)	$9.21^{a} \pm 0.06$	$10.73^{d} \pm 0.22$	$10.56^{c} \pm 0.29$
	TV (cm^3)	$209.70^{a} \pm 0.44$	$219.48^{b} \pm 2.99$	$225.66^{d} \pm 1.91$
Summer	BW (kg)	$51.26^{a} \pm 1.48$	$67.38^{dx} \pm 1.70$	$75.38^{dy} \pm 0.92$
	TC (cm)	$26.16^{a} \pm 0.19$	$33.72^{d} \pm 0.42$	$33.90^{d} \pm 0.23$
	TL (cm)	$9.41^{a} \pm 0.10$	$10.90^{d} \pm 0.31$	$10.60^{c} \pm 0.14$
	TV (cm^3)	$212.70^{a} \pm 1.52$	$226.58^{c} \pm 3.27$	$227.46^{c} \pm 1.12$
Autumn	BW (kg)	$54.46^{a} \pm 1.34$	$68.38^{dx} \pm 1.68$	$76.01^{dw} \pm 0.81$
	TC (cm)	$26.62^{a} \pm 0.40$	$34.66^{d} \pm 0.38$	$34.58^{d} \pm 0.37$
	TL (cm)	$9.50^{a} \pm 0.17$	$10.96^{c} \pm 0.35$	$10.57^{b} \pm 0.12$
	TV (cm^3)	$215.30^{a} \pm 0.93$	$230.98^{d} \pm 2.03$	$229.8^{d} \pm 0.25$
Winter	BW (kg)	$53.56^{a} \pm 1.14$	$67.68^{dx} \pm 1.33$	$74.98^{dy} \pm 0.79$
	TC (cm)	$25.64^{a} \pm 0.23$	$33.54^{d} \pm 0.27$	$34.16^{d} \pm 0.37$
	TL (cm)	$9.20^{a} \pm 0.23$	$10.58^{c} \pm 0.21$	$10.30^{c} \pm 0.14$
	TV (cm^3)	$209.18^{a} \pm 0.51$	$220.48^{c} \pm 2.51$	$224.26^{d} \pm 1.47$

Notes: BW—body weight; TC—testicular circumference; TL—testicular length; TV—testicular volume. Statistically different: ^{ab} for $p < 0.05$; ^{ac} for $p < 0.01$; ^{ad} for $p < 0.001$ between L14 and L34, L56; ^{xw} for $p < 0.05$; ^{xy} for $p < 0.01$; ^{xz} for $p < 0.001$ between L34 and L56.

BW showed values that varied according to the age of the bucks and the season in which this trait was evaluated. The differences between two-year-old bucks (L14) and those older than three years (L34 and L56) were highly significant in each season ($p < 0.001$). Additionally, the difference recorded in the analysis of BW specific to bucks from the L34 and L56 groups indicated very significant differences in spring ($p < 0.001$), distinct significant differences in summer and winter ($p < 0.01$), and significant differences at the beginning of autumn ($p < 0.05$).

In contrast, for TC and TL, the differences recorded between L34 and L56 were not significant, indicating that, after the age of three years, neither season nor age influences testicular dimensions anymore.

As a result of the intensification of spermatogenesis, at the beginning of autumn, testicular volume (TV) records its highest value. The differences recorded between L34 and L56 were minimal and statistically non-significant ($p \geq 0.05$). Between L14 and L34, the differences were significant in spring ($p < 0.05$), distinctly significant in summer and winter, and very significant in autumn ($p < 0.001$). Additionally, the differences in TV between L14 and L56 were very significant ($p < 0.001$) in each season, except for the difference recorded in the summer season, which was distinctly significant ($p < 0.01$).

3.2. Characteristics of Semen Quality in Bucks

For the semen analysis, various macroscopic and microscopic analyses were performed. The values obtained for ejaculate volume (EV), semen concentration (SC), live spermatozoa (LS), normal spermatozoa (NS), semen motility (MS), and color of semen (CS), based on age and season, are presented in Table 2.

Table 2. Mean (±SE) differences in the quality traits of the semen of Carpatina bucks.

Season	Traits	Animal Group		
		L14	L34	L56
Spring	EV (mL)	$0.84^{a} \pm 0.03$	$1.22^{d} \pm 0.01$	$1.19^{d} \pm 0.02$
	SC (10^9/mL)	$3.85^{a} \pm 0.04$	$4.12^{c} \pm 0.06$	$4.15^{c} \pm 0.06$
	LS (%)	79.01 ± 1.14	79.60 ± 0.50	80.20 ± 0.20
	NS (%)	$82.40^{a} \pm 1.17$	$89.01^{d} \pm 0.31$	$89.80^{d} \pm 0.20$
	MS (%)	$77.60^{a} \pm 0.72$	$81.20^{d} \pm 0.20$	$80.40^{c} \pm 0.24$
	CS (points)	$2.40^{a} \pm 0.24$	$3.20^{b} \pm 0.30$	3.00 ± 0.31
Summer	EV (mL)	$0.91^{a} \pm 0.42$	$1.27^{d} \pm 0.05$	$1.25^{d} \pm 0.01$
	SC (10^9/mL)	$3.91^{a} \pm 0.04$	$4.24^{b} \pm 0.03$	$4.37^{c} \pm 0.11$
	LS (%)	$81.00^{a} \pm 0.54$	$85.4^{d} \pm 0.24$	$86.00^{d} \pm 0.31$
	NS (%)	$84.80^{a} \pm 0.37$	$90.40^{d} \pm 0.40$	$91.00^{d} \pm 0.54$
	MS (%)	$78.40^{a} \pm 0.08$	$81.64^{c} \pm 0.18$	$81.03^{c} \pm 0.01$
	CS (points)	2.80 ± 0.21	3.60 ± 0.34	3.80 ± 0.44
Autumn	EV (mL)	$1.11^{a} \pm 0.02$	$1.33^{d} \pm 0.06$	$1.30^{d} \pm 0.01$
	SC (10^9/mL)	$4.01^{a} \pm 0.17$	$4.39^{b} \pm 0.13$	$4.43^{c} \pm 0.04$
	LS (%)	$82.20^{a} \pm 0.20$	$85.20^{d} \pm 0.20$	$86.00^{d} \pm 0.31$
	NS (%)	$84.15^{a} \pm 0.22$	$88.20^{d} \pm 0.20$	$88.25^{d} \pm 0.15$
	MS (%)	80.20 ± 1.62	86.20 ± 0.80	86.40 ± 0.74
	CS (points)	3.20 ± 0.20	3.80 ± 0.20	3.80 ± 0.20
Winter	EV (mL)	$0.96^{a} \pm 0.01$	$1.19^{c} \pm 0.06$	$1.22^{c} \pm 0.02$
	SC (10^9/mL)	$3.83^{a} \pm 0.59$	$4.17^{b} \pm 0.03$	3.97 ± 0.10
	LS (%)	79.80 ± 0.37	81.20 ± 0.20	80.80 ± 0.20
	NS (%)	$83.60^{a} \pm 0.68$	$89.60^{d} \pm 0.68$	$89.80^{c} \pm 0.73$
	MS (%)	$71.80^{a} \pm 0.37$	$81.20^{b} \pm 0.19$	80.80 ± 0.20
	CS (points)	2.80 ± 0.20	3.40 ± 0.24	3.20 ± 0.20

Notes: EV—ejaculate volume; SC—semen concentration; LS—live spermatozoa; NS—normal spermatozoa; SM—sperm motility; Sc—semen color. Statistically different: ^{ab} for $p < 0.05$; ^{ac} for $p < 0.01$; ^{ad} for $p < 0.001$ between L14, L34, and L56.

The statistical analysis of the data for EV, CS, LS, NS, and MS indicated that, with respect to the season, there were significant differences ($p < 0.001$; $p < 0.01$) between the group of young bucks (L14) and the two groups of adult bucks of different ages (L34 and L56). In the evaluation of Cs, the differences recorded were not significant ($p > 0.05$), except for the scores assigned to samples collected at the beginning of summer, where a statistically significant difference appeared between L14 and L56 ($p < 0.05$).

The semen traits related to live spermatozoa (LS), normal spermatozoa (NS), and semen motility (MS) were not affected by age ($p > 0.05$). For bucks in groups L14 and L34, the season did not represent an important influencing factor, as all mean values remained statistically insignificant ($p > 0.05$). In contrast, semen concentration (SC) was strongly influenced by age and season. Younger bucks (<2 years) had lower semen cell concentrations than those older than 2 years (Table 2). The color of semen was statistically different (U = 4 and p-value = 0.0476) between L14 and L34 samples ($p < 0.05$) only in spring, according to the Mann–Whitney U test.

3.3. Variations in Testosterone, pH, and Sexual Behavior and Reflexes in Relation to the Season and Bucks' Age

Testosterone (T4) is an important sexual hormone with a major role in the body. The average value for T4 showed increasing levels from the beginning of spring across all groups. Regarding age, the seasonal differences between L14 vs. L34 and L14 vs. L56 were distinctly significant in spring ($p < 0.01$) and highly significant ($p < 0.001$) at the beginning of summer, autumn, and winter (Table 3). The differences between L34 and L56 were non-significant ($p > 0.05$). According to these values, it can be concluded that the level of T4 in the blood influences the reproductive activity with respect to the age of the bucks and the season.

Table 3. Mean (±SE) of differences for testosterone, semen acidity, sexual behavior, and sexual reflexes in Carpatina bucks.

Season	Traits	Animal Group		
		L14	L34	L56
Spring	T4 (ng/mL)	$2.05^{a} \pm 0.06$	$2.42^{c} \pm 0.06$	$2.45^{c} \pm 0.07$
	pH (°T)	6.42 ± 0.24	6.52 ± 0.06	6.57 ± 0.11
	SB (points)	$2.20^{a} \pm 0.20$	$3.60^{b} \pm 0.24$	$3.40^{b} \pm 0.24$
	SR (points)	$2.40^{a} \pm 0.24$	$3.60^{b} \pm 0.24$	$3.2^{b} \pm 0.20$
Summer	T4 (ng/mL)	$2.50^{a} \pm 0.11$	$4.20^{d} \pm 0.06$	$4.02^{d} \pm 0.19$
	pH (°T)	$6.45^{a} \pm 0.24$	$6.82^{b} \pm 0.25$	6.57 ± 0.27
	SB (points)	$2.40^{a} \pm 0.24$	$3.40^{b} \pm 0.24$	$3.20^{b} \pm 0.20$
	SR (points)	2.60 ± 0.24	3.40 ± 0.24	3.20 ± 0.20
Autumn	T4 (ng/mL)	$4.89^{a} \pm 0.31$	$8.98^{d} \pm 0.37$	$8.17^{d} \pm 0.42$
	pH (°T)	$6.53^{a} \pm 0.2$	$6.82^{b} \pm 0.35$	6.77 ± 0.22
	SB (points)	$2.80^{a} \pm 0.20$	$4.60^{b} \pm 0.24$	$4.40^{c} \pm 0.40$
	SR (points)	$2.80^{a} \pm 0.20$	$4.2^{b} \pm 0.37$	$3.80^{b} \pm 0.37$
Winter	T4 (ng/mL)	$2.26^{a} \pm 0.08$	$4.42^{d} \pm 0.11$	$4.23^{d} \pm 0.26$
	pH (°T)	6.51 ± 0.03	6.64 ± 0.08	6.58 ± 0.02
	SB (points)	$2.60^{a} \pm 0.02$	$4.40^{b} \pm 0.02$	$4.20^{b} \pm 0.03$
	SR (points)	2.60 ± 0.24	3.20 ± 0.20	3.00 ± 0.01

Notes: T—testosterone; pH—sperm acidity; SB—sexual behavior; SR—sexual reflexes. Statistically different: ^{ab} for $p < 0.05$; ^{ac} for $p < 0.01$; ^{ad} for $p < 0.001$ between L14 and L34/L56, respectively.

According to the results obtained, it can be specified that the pH of the semen has specific values indicative of semen quality in all groups (Table 3). There were also some significant differences ($p < 0.05$) only between L14 and L34, and only in the analysis of samples collected in summer and autumn.

The sexual behavior and sexual reflexes of bucks are very important aspects that influence the fertilization capacity of the does. In adult bucks from groups L34 and L56, the average scores obtained indicated a seasonal influence on mating behavior. The highest values for sexual behavior (SB) were recorded in autumn, exceeding 4 points in both groups. Young bucks (L14) displayed less intense SB, with a lower score in spring (2.20 ± 0.20) and maximum values in the autumn season (2.80 ± 0.20). Although they expressed a desire to mate, the young bucks became very agitated, and the time taken to mount was significantly prolonged. Significant differences ($p < 0.05$) related to sexual behavior were mostly recorded between younger bucks (L14) and the older ones (L 34 and L56).

Sexual reflexes (SR) are an extremely important trait for males intended for reproduction. Among the three groups, bucks aged between three and four years (L34) exhibited the most intense SR in the presence of females. The differences recorded between L14 and the older bucks in L34 and L56 were significant in spring and autumn ($p < 0.05$) and not significant during summer and winter ($p > 0.05$).

3.4. Variation in Seasonal Relationships Between Different Reproductive Traits in Relation to the Age of Carpatina Breed Bucks

The inclusion among the research objectives of determining the correlations established between BW in each season and some testicular traits (TC, TL, TV, and EV), as well as between EV determined in each season and the main semen traits (CS, LS, NS, MS), was motivated by the desire to conduct a comprehensive evaluation of all aspects that can be used in assessing the quality of breeding bucks. The results obtained show that both negative and positive correlations were established between the BW of the bucks determined at the beginning of each calendar season and some specific values of the main testicular dimensions (Table 4). The data indicate that, for BW recorded in the bucks from the L34 and L56 groups at the beginning of spring, a positive and significant relationship ($p < 0.05$) with TV was observed. When analyzing the correlations between BW at the start of autumn and the values obtained from testicular measurements, the relationships were positive but not significant ($p > 0.05$).

Table 4. The relationship between body weight estimated in each season and certain testicular traits.

Animal Group	BW	Testicular Circumference		Testicular Length		Testicular Volume		Ejaculate Volume	
		R	*p*-Value	R	*p*-Value	R	*p*-Value	R	*p*-Value
Spring									
L14	49.58	−0.201	0.729 NS	0.151	0.807 NS	0.472	0.105 NS	0.549	0.549 NS
L34	63.72	−0.654	0.230 NS	0.256	0.362 NS	0.942	0.016 *	0.327	0.590 NS
L56	74.78	0.763	0.133 NS	0.550	0.336 NS	0.797	0.022 *	0.276	0.652 NS
Summer									
L14	51.26	0.472	0.431 NS	0.519	0.369 NS	0.863	0.072 NS	0.524	0.364 NS
L34	67.38	−0.166	0.789 NS	0.279	0.648 NS	0.819	0.087 NS	0.226	0.971 NS
L56	75.38	0.758	0.137 NS	0.695	0.192 NS	0.060	0.922 NS	0.306	0.615 NS
Autumn									
L14	54.46	0.244	0.691 NS	0.056	0.924 NS	0.624	0.260 NS	0.873	0.053 NS
L34	63.38	0.382	0.524 NS	−0.854	0.065 NS	0.446	0.451 NS	−0.351	0.356 NS
L56	76.01	−0.667	0.208 NS	−0.378	0.529 NS	0.332	0.584 NS	0.572	0.313 NS
Winter									
L14	53.56	0.190	0.758 NS	−0.545	0.341 NS	−0.738	0.154 NS	0.700	0.187 NS
L34	67.68	0.018	0.976 NS	0.603	0.280 NS	0.862	0.059 NS	−0.130	0.834 NS
L56	74.98	0.760	0.134 NS	0.148	0.812 NS	0.061	0.921 NS	−0.635	0.249 NS

Notes: * $p < 0.05$; NS = non-significant.

Regarding the results related to the correlations established between EV collected in each season and sperm traits (CS, LS, NS, and MS), both positive and negative correlations were observed (Table 5). For semen collections performed in the spring from the three groups of bucks, it was found that only the relationship established between EV and CS in L14 was significant ($p < 0.05$).

Table 5. The relationship between ejaculate volume determined in each season and certain semen quality traits.

Animal Group	EV	Spermatozoa Concentration		Live Spermatozoa		Normal Spermatozoa		Spermatozoa Motility	
		R	*p*-Value	R	*p*-Value	R	*p*-Value	R	*p*-Value
Spring									
L14	0.84	0.933	0.0205 *	−0.567	0.318 NS	−0.774	0,131 NS	−0.330	0.587 NS
L34	1.22	−0.397	0.507 NS	0.430	0.469 NS	−0.554	0.331 NS	0.000	0.099 NS
L56	1.19	0.109	0.860 NS	−0.311	0.601 NS	0.415	0.486 NS	0.847	0.069 NS
Summer									
L14	0.91	0.515	0.373 NS	−0.658	0.226 NS	−0.727	0.163 NS	−0.812	0.094 NS
L34	1.27	−0.339	0.576 NS	−0.038	0.951 NS	−0.306	0.615 NS	0.431	0.468 NS
L56	1.25	−0.363	0.547 NS	0.110	0.860 NS	0.318	0.602 NS	0.422	0.574 NS
Autumn									
L14	1.11	−0.889	0.043 *	−0.322	0.579 NS	−0.516	0.373 NS	−0.587	0.114 NS
L34	1.33	−0.259	0.673 NS	0.534	0.353 NS	0.900	0.036 NS	−0.200	0.746 NS
L56	1.30	−0.532	0.355 NS	−0.337	0.579 NS	−0.380	0.527 NS	−0.661	0.224 NS
Winter									
L14	0.96	−0.487	0.404 NS	0.674	0.211 NS	−0.133	0.830 NS	0.625	0.259 NS
L34	1.19	0.890	0.042 *	0.033	0.957 NS	−0.715	0.174 NS	−0.061	0.923 NS
L56	1.22	0.021	0.813 NS	0.399	0.252 NS	0.529	0.163 NS	0.565	0.245 NS

Notes: * $p < 0.05$; NS = non-significant.

For semen collections performed in L34 at the beginning of summer, negative but non-significant correlations ($p > 0.05$) were found between EV and other semen quality traits—with CS (r = −0.339), LS (r = −0.038), and NS (r = −0.306)—and a positive correlation only with MS (r = 0.468).

4. Discussion

4.1. Seasonal Variations in Body Weight and Scrotal Measurements in Relation to Age in Bucks

In all experimental groups, body weight (BW) showed a trend of increasing from spring to autumn. The decrease in live weight was primarily due to the mobilization of body reserves as a result of the effort expended during mating. This weight loss fell within normal limits, knowing that a ram or a buck can lose up to 25% of its body weight during a breeding season [1,22–25]. In Group L14, it was observed that, at the beginning of autumn, BW was 8.96% higher than at the beginning of spring, with average values of 49.58 ± 1.53 kg and 54.46 ± 1.34 kg, respectively. The fact that young bucks (L14) had a BW in autumn representing over 70% of the BW recorded for L34 and L56 indicates that the requirement for body maturity was met, and bucks younger than two years can be safely used for reproduction.

In the adult groups L34 vs. L56, the increase in BW was due to body recovery, as well as the establishment of subcutaneous fat reserves necessary to support the effort exerted during the breeding season. At the beginning of winter, BW in both groups decreased very slightly (<1%) compared to the BW recorded in autumn. The results obtained are similar to other values cited in the specialized literature [22–25], demonstrating that young bucks of the Carpatina breed can be utilized for mating or semen collection before reaching two years of age. Based on these results, it can be stated that both age and season had a major and significant influence ($p < 0.001$, $p < 0.001$, and $p < 0.05$) on the seasonal increase or decrease in BW.

For bucks used in breeding, understanding the changes in testicular dimensions during both the growth phase and the sexually active or resting adult stages provides objective indicators of reproductive readiness. In bucks younger than two years (L14), monitoring changes in testicular size can help determine the optimal age at which they should be introduced into the breeding group. Furthermore, observing the moment when morphological changes in the testes occur, indicated by an increase in reference dimensions, also signals the onset of active spermatogenesis. This physiological shift indicates that the buck is becoming sexually mature and ready for breeding. Tracking these testicular dimensions allows for more precise management of bucks in breeding programs, ensuring that they are introduced at the right age to optimize reproductive success [26,27]. All of the obtained results align with other values cited in the literature. Many scientific articles highlight that changes in specific testicular dimensions are closely related to body weight (BW) and the degree of body development [28–31]. Body size and testicular measurements are proven to be important parameters for assessing reproductive soundness. For the adult groups of bucks older than two years (L34 and L56), the data confirm that the average values of testicular circumference (TC) showed an evolution influenced by both age and season. Thus, starting from the minimum TC values recorded at the beginning of spring (31.12 ± 0.37 cm for L34 and 32.71 ± 0.63 cm for L56), maximum values were reached at the beginning of autumn (34.66 ± 0.38 cm for L34 and 34.58 ± 0.37 cm for L56). The data indicate that body maturity was achieved in the groups with adult bucks, and the recorded evolutions were limited, close, and statistically non-significant ($p > 0.05$). The statistical analysis of the TC data indicates that there were very significant differences ($p < 0.001$) between L14 vs. L34 and L14 vs. L56 at the beginning of each season. The fact that, at the beginning of autumn, TC for L14 showed an average value of 26.62 ± 0.04 cm indicates good development of this organ. In other studies on different breeds raised under different conditions, the evolution recorded for TC was similar in level and direction. Many scientific articles highlight a trend of increasing heritability for TC with age, suggesting that environmental factors influencing traits become less significant in older animals [9,14,32].

The testicular length (TL) values were close and statistically non-significant ($p \geq 0.05$) in each season between L34 and L56. In Group L14, the average value increased by approximately 3% from spring to the end of summer, from 9.21 ± 0.06 cm to 9.50 ± 0.17 cm. The differences between L14 vs. L34 were very significant ($p < 0.001$) in the spring and summer seasons and distinctively significant ($p < 0.01$) in autumn and winter. Between L14 vs. L56, it was noted that the differences in TL were distinctly significant ($p < 0.01$), except for the difference recorded at the beginning of autumn ($p < 0.05$). The obtained values suggest that both age and season are influential factors for some testicular dimensions, including TL. The relationship between testicular size and BW in young individuals undergoing growth is synthetically presented in many scientific articles [33,34]. Some research indicates that the emergence of statistical differences ($p < 0.05$) in TL is mainly due to the age of the bucks. Thus, Abba et al. (2015) [35] confirmed that the average values of TL increased from 8.39 ± 0.68 cm in bucks that had reached 18 months to 9.89 ± 0.61 cm at the age of 30 months.

Testicular volume (TV) is an important indicator, as it is associated with semen production. In all experimental groups of bucks, it was observed that TV was higher at the beginning of autumn, which marks the onset of the natural breeding season for small ruminants in the research area. In Group L14, the average values of TV were lower during the seasons outside the natural breeding period, measuring 209.70 ± 0.44 cm^3 in spring, 212.07 ± 1.52 cm^3 in summer, and 209.18 ± 0.51 cm^3 in winter. At the beginning of autumn, which coincides with the start of the breeding season, TV was 2.60% higher compared to spring and 1.39% higher than the level recorded in summer. The obtained results support the idea that both age and season have a significant influence on TV. The greater increase in size and volume in L14 may also be attributed to the period of growth in body weight (BW) and body dimensions. In the groups of adult bucks (L34 and L56), the increase in TV may have resulted from physiological changes as well as the growth of the testicular parenchyma, which includes increases in the length, width, and thickness of the testes—an aspect highlighted by other bibliographic sources [6,15,36,37].

4.2. Variations in the Quantity and Quality of Semen in Relation to the Age of Bucks and the Season

In regions with a temperate continental climate, seasonal variations in conception and birth rates have long been linked to seasonal changes in semen parameters. It has been observed that both the season and the age of male sheep and goats affect the values influencing semen quality. Ejaculate volume (EV) represents one of the key traits used to express semen quality and contributes to the fertility assessment of bucks. Based on samples collected at the beginning of each season, it was found that EV showed some differences among the groups (Table 2). Additionally, the results indicate that age is a factor affecting EV in bucks. This assertion is supported by the fact that the volume differences between L14 vs. L34 and L14 vs. L56 were very significant ($p < 0.001$) at the beginning of each season, except for the difference determined from samples collected at the onset of winter ($p < 0.01$). In L14, it was observed that, with the intensification of spermatogenesis, EV increased from 0.84 ± 0.03 mL in spring to 1.11 ± 0.02 mL at the beginning of autumn. Since no statistically significant differences were recorded between L34 and L56, it can be said that age influences this trait to a limited extent. The differences registered between the group of young bucks under two years old (L14) and those aged 2–4 years (L34) and 5–6 years (L56) were due to the fact that testicular development in the young bucks was not yet complete. Bucks from L14 can be used for breeding activities, since they have a volume that allows for both natural mating and the fractionation of seminal fluid into straws for artificial insemination. Information in these scientific articles confirms that EV varies throughout the year, being lower in the off-season (0.44 mL) compared to other times of the year (0.86 mL). Higher values recorded during the peak sexual activity season are a result of intensified spermatogenesis, which is influenced by various environmental factors. When these factors reach certain thresholds, they positively affect spermatogenesis, leading to an increase in testicular volume (EV), a phenomenon noted in several specialized studies. Additionally, semen concentration (SC) is a crucial factor when objectively assessing semen quality, as it provides key insights into the reproductive potential of bucks. Monitoring both EV and SC offers valuable indicators for evaluating breeding readiness and fertility levels in bucks.

The obtained values are used for certifying fertility, diagnosing and/or predicting reproductive disorders, processing insemination doses, characterizing seminal samples for trade, and evaluating the effects of treatments regarding semen production (for example, toxicology and nutrition studies). According to the obtained data, no significant differences were found between the adult bucks aged three to four years (L34) and those aged five to six years (L56). This aspect confirms that age has less influence on this trait among sexually active adult bucks.

Between the young bucks in L14 and those in L34, the differences were statistically significant in spring ($p < 0.01$) and significant in summer, autumn, and winter ($p < 0.05$). Between L14 and L56, the differences were statistically significant in spring ($p < 0.01$), while those at the beginning of winter were not significant ($p \geq 0.05$), confirming that age has some influence on the CS of the semen. Since the highest values in all three groups were recorded in autumn ($4.01 \pm 0.17 \times 10^9$ in L14, $4.39 \pm 0.13 \times 10^9$ in L34, and $4.43 \pm 0.04 \times 10^9$ in L56), it can be said that CS is also influenced by the season. For CS in Carpatina breed bucks, the highest values were recorded during the breeding season, which aligns with the findings of a couple of other author collectives [38–41]. CS tended to increase in both breeds at the end of winter and at the beginning of summer and autumn, while it decreased in spring and winter.

Live spermatozoa (LS) is a very important trait, included in any quality analysis of semen and fertility of bucks [1,42–44]. Based on the recorded values, LS has direct effects on the economic and productive activity [44] in goat farms. For LS, it was noted that between L14 vs. L34 and L14 vs. L56, the differences recorded in summer and autumn had a high degree of statistical significance ($p < 0.001$), while they became non-significant in samples collected in spring and winter ($p > 0.05$).

Data processing for NS highlighted some very significant differences ($p < 0.001$) between groups, with the exception of the difference between L14 and L56 recorded at the beginning of winter, which had a different level of statistical significance ($p < 0.01$). According to these values, it can be stated that semen production and its quality are correlated with testicular dimensions, testis weight, and scrotal circumference. The same conclusion was reached in studies conducted by other research groups [8,11,25,45].

Semen motility (SM) is a critical factor that influences the ability of sperm to navigate through the female reproductive tract after sexual contact. In cases where average motility values are low, fertility tends to decrease across various mammalian species, including bucks. Reduced motility impairs the sperm's ability to fertilize the egg, thus lowering reproductive success. This trait is closely linked to semen quality and is a key indicator of fertility. Low motility can be influenced by various factors, including environmental stress, nutrition, and overall health, all of which can negatively impact reproductive outcomes in bucks [43]. According to the obtained data, we observed that motility had very good values in all seasons and in all groups of bucks. Statistical differences were noted between L14 and L34 only in the seasons outside the natural breeding period, being very significant in spring ($p < 0.001$), distinctly significant in summer and winter ($p < 0.01$), and non-significant in autumn ($p \geq 0.05$).

The appearance of these differences between groups shows that the season represents a factor with a greater influence on MS. In L14, the average values for MS reached their highest level at the beginning of autumn (82.20 $\pm$ 1.62%), while the lowest level of motility was found during winter (71.80 $\pm$ 0.37%). The fact that the average motility in L14 exceeded 80% during the autumn season supports the use of young bucks for reproduction without reservations. This high motility rate indicates that the sperm are highly active and capable of successfully fertilizing eggs, making young bucks a viable option for breeding during this period. In 2011, Rachmawati et al. [46] reported much lower sperm motility in Kacang bucks (42.22 $\pm$ 16.41%) and Etawa bucks (65.56 $\pm$ 9.17%).

The *color of semen* (Cs) is influenced by SC, EV, and other factors. In our three groups, it was noted that the season influenced Cs less. Between L14 and L34/L56, significant differences in Cs appeared ($p < 0.05$) only in semen samples collected in spring and summer.

According to the obtained data, we can affirm that the physical aspect of the ejaculates varied from a yellow or yellowish-white color in the summer–autumn period to a cream-white color in other seasons of the year. Consequently, the score assigned was higher for samples collected in autumn (3.20 $\pm$ 0.20 in L14, 3.80 $\pm$ 0.2 in L34 and L56). At the same expression level for this trait, other research groups that analyzed the color and aspect of the ejaculate collected in different seasons and from other breeds of bucks also reached the same level [47–49].

4.3. The Testosterone Levels, Semen Acidity, and Reproductive Behavior in Carpatina Bucks

The presence of testosterone in males is crucial, as it regulates sexual appetite (libido), bone mass, fat distribution, muscle mass, red blood cell production, and spermatogenesis. In bucks located in temperate continental climates, testosterone levels increase and peak in autumn, promoting intense sexual activity and high sperm production. This seasonal fluctuation supports the idea that testosterone levels are influenced by both age and environmental factors such as season. Research has shown that seasonal variations, particularly in the autumn, align with heightened reproductive activity in bucks, confirming this hormone's role in regulating these processes. The average values obtained for T4 in blood serum indicated a favorable disposition for sexual activity in all groups, including the young bucks (L14). This is due to the fact that, in bucks found in areas with a temperate climate, sexual behavior is seasonal, accentuating in autumn and early winter precisely because of the increase in testosterone levels. Compared to the determination of T4 in samples collected in spring, it was noted that, in L14 at the beginning of autumn, there was an increase from 2.05 ± 0.06 ng/mL to 4.89 ± 0.31 ng/mL. In the natural mating season, T4 reaches values > 8 ng/mL in adult bucks. In accordance with these values, we can specify that both age and season are important factors for the variation in T4 levels in blood.

The obtained values are similar to other data cited in several scientific articles. For example, the concentration of T4 in some white goats was 4.30 ± 0.47 ng/mL [50], in other hybrid goats resulting from crossing with Etawah bucks it was 6.82 ± 4.18 ng/mL, and in Kejobong goats the level reached was 12.00 ± 6.56 ng/mL [51]. The onset of increased behavioral manifestations typical of reproduction occurs after an increase in testosterone levels from a minimum value of 2 ng/mL to values even reaching 20 ng/mL [52].

As the pH increases and reaches its maximum values at the beginning of autumn (in L14 it was 6.41 ± 0.2, in L34 it was 7.38 ± 0.35, and in L56 it was 7.14 ± 0.22), this shows a slight influence of the season and less of the age of the reproducers. If pH values < 6.5 are recorded in bucks used for breeding, both motility and sperm metabolism gradually reduce. For sperm quality, a stable pH is essential. Since some specialized articles indicate that the seminal fluid collected from bucks has a pH between 6.4 and 7.2, or an average of 6.8 [53,54], we can conclude that, in our three groups of Carpatina breed bucks, the acidity of the sperm ranged within limits associated with an optimal pH. In conclusion, the small variations in pH between seasons, as well as between groups, cannot be attributed exclusively to the influence exerted by the season or age.

To stimulate their sexual behavior and reflexes, the bucks from the three groups were completely separated from the females. Contact occurred only on planned days for studying sexual behavior and reflexes. Differences in the scores resulting from the evaluation of sexual behavior (SB) between L14 and L34 were significant in summer ($p < 0.05$) and distinctly significant ($p < 0.01$) in autumn, winter, and spring. Between L14 and L56, statistically significant differences ($p < 0.01$) were recorded in all seasons except summer ($p > 0.05$). In the presence of females, they exhibited complete erection and immediately showed mating desire by seeking the vulva; however, they had a faster ejaculation in autumn and a slightly delayed one in the other seasons. Consequently, the score assigned for sexual reflexes (SR) had an upward trend, from 2.60 ± 0.24 points in the winter season for L14 to 2.80 ± 0.20 points in the autumn season. In the case of adult bucks from L34 and L56, it was found that erection was rapid in the presence of females; the bucks immediately sought the vulva, and ejaculation occurred after the jump, resulting in an average score of more than 4 points. In contrast, in summer, under the influence of high temperatures, the average score assigned was 3.40 ± 0.24 points for L34, 3.20 ± 0.20 points for L56, and 2.60 ± 0.24 points for L14. Based on the scores obtained for SB and SR, as well as the recorded differences in approach and behavior, it can be confirmed that both age and season are factors that influence both the behavior and the reflexes of the bucks.

Studies on goat populations in different regions have shown varied behaviors among bucks due to multiple influencing factors, particularly climate and photoperiod. In temperate and subtropical climates, bucks typically undergo a period of sexual rest, with significant changes in behavior influenced by seasonal shifts in light exposure. These behaviors include actions such as nudging, anogenital sniffing, mounting attempts, self-urination, mounting with or without intromission, flehmen responses, and vocalizations. These actions are directly linked to the changes in photoperiod, which regulate sexual activity and reproductive behaviors. Research has demonstrated that these behaviors are crucial indicators of the buck's sexual readiness and can vary significantly depending on environmental factors like climate and seasonal changes. These behavioral shifts are also important in managing breeding programs, as understanding seasonal patterns can help optimize breeding success [55,56]. The same behavior is observed in goats raised in Central Europe, which modify their sexual behavior during a sexual rest period from January to May. In contrast to this type of behavior, the literature mentions that male sheep and goats from tropical regions exhibit active behavior throughout the year [8,29]. This phenomenon is explained by the fact that the main influencing factor is not photoperiod but, rather, nutrition, high ambient temperatures, relative humidity, and atmospheric precipitation [57–59].

4.4. The Relationship Between Seasonal Body Weight and Testicular Measurements, and Between Ejaculate Volume and Sperm Quality Traits, in Carpatina Bucks

Body weight (BW), particularly that of bucks intended for mating, plays a significant role in their fertility, and this is especially important at the start of the natural mating season. Maintaining optimal body condition at this time is crucial, as it supports the physical demands associated with reproduction. Bucks with adequate body condition are better equipped to handle the physical exertion required for mating, which can positively influence their fertility and overall reproductive performance. Research indicates that bucks in poor body condition at the onset of the breeding season may experience reduced libido, lower semen quality, and lower reproductive success. Conversely, bucks in optimal condition are more likely to exhibit strong sexual drive, better semen quality, and higher mating success rates. Proper nutrition and management of body weight prior to the breeding season are therefore essential for maximizing fertility and ensuring efficient reproduction [42,43]. Many studies conducted on various small ruminant populations highlight the role of BW and testicular traits, emphasizing that they represent important criteria in evaluating male fertility in animal production [25,27,36,60]. According to the obtained results, significant and positive correlations ($p < 0.05$) between BW and testicular volume (TV) were found only in groups of adult males over three years old (L34 and L56). This significant correlation suggests that, as BW increases, body development also progresses, leading to an increase in TV. In the case of seasonal BW and scrotal circumference (SC), testicular length (TL), and ejaculate volume (EV), the established correlations were not significant ($p > 0.05$). All of these data are consistent with the findings of Waheed et al. (2011) [61] and Mathapo et al. (2022) [62], contradicting the results of Gemeda et al. (2017) [63], who found that that BW was strongly and significantly correlated with TL in some indigenous goats from Ethiopia. This discrepancy may be due to the different goat breeds, which have specific morphological traits, as well as environmental conditions that can increase variability in many traits. The relationship between BW and testicular circumference (TC) was significant ($p < 0.05$) and highly positive ($r = 0.976$) only in the group of bucks aged between three and four years (L34). This significance aligns with the findings of Ahmed and Kawmani (2019) [64], who reported a significant positive correlation between BW and SC in male sheep and goats.

Age and other factors, such as season and breed, are often associated with sperm quality and fertility in domestic animals. Many studies have evaluated the relationship between male age and sperm parameters, but the effects of age and season have not been comprehensively assessed. Changes in sperm quality from young males to adults and older males have been identified in bulls, rams, stallions, boars, dogs, and stallions [64].

In the present research, the Pearson correlation coefficients obtained for various traits related to reproductive capacity and buck fertility with respect to age and season indicate both positive and negative correlations. Thus, in the spring season, it was found that the correlation between ejaculate volume (EV) and sperm concentration (SC) was significant in L14 ($p < 0.05$), while in L34 and L56 it was not significant ($p > 0.05$). In the summer season, EV was negatively correlated with sperm motility (SM) in L14 ($r = -0.658$) and L34 ($r = -0.038$), while the correlation was positive ($r = 0.110$) in bucks aged between five and six years (L34). In the autumn season, the correlation between EV and SC in young bucks (L14) was high but negative ($r = -0.889$) and significant ($p > 0.05$), with no statistical significance for L34 and L56. Additionally, in L14 and L56, the determined EV levels in the autumn season were negatively correlated with SM (r = −0.331 and r = −0.339) and positively correlated with sperm mass (MS) (r = 0.625 and r = 0.565). In the winter season, the correlation between EV and SC in samples collected from L34 was positive (r = 0.90) and statistically significant ($p < 0.05$), while in the other groups it was not significant. Based on the obtained data, it can be concluded that the main semen characteristics improve in certain seasons and in male sheep and goats of a specific age, and then they decline as the animals age. All of these results, as well as the main conclusion reached, are in full agreement with many specialized scientific publications [65–68].

5. Conclusions

Age significantly influences many traits that determine bucks' fertility. These factors cause changes in semen quality traits, with a notable decline outside the natural breeding period. Also, during non-breeding seasons, there is a decrease not only in body weight but also in testicular size, ejaculate volume, semen concentration, motility, and the percentage of viable sperm. Additionally, changes in blood testosterone levels during these periods suggest that both environmental factors and age have a substantial impact on reproductive behavior and sexual reflexes. The average values recorded for various semen traits, body development, testicular dimensions, sexual behavior, and sexual reflexes suggest that young bucks, aged between 14 and 23 months, are suitable for breeding. However, while bucks can reproduce year-round, their semen quality and mating capacity are typically lower during the winter, spring, and summer compared to the optimal breeding season at the start of autumn. This reinforces the seasonal variation in reproductive performance and the need for careful management to ensure optimal breeding outcomes.

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