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## SEXUAL ACTIVITY AND SPERM PRODUCTION OF CHAROLAIS AND ILE-DE-FRANCE RAMS IN DIFFERENT SEASONS OF THE YEAR

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### Abstract

Sheep (*Ovis aries*) are polyestrous animals with a distinct breeding season. Long artificial selection has minimized the impact of seasonal environmental factors on the sheep reproductive function. The seasonality of reproduction is practically not characteristic of sheep bred near the equator but is well pronounced in the middle and high latitudes. The basic strategy of sheep breeding in Russia is production of young mutton and lamb. As Russia does not have its own gene pool of highly productive specialized meat breeds, the use of the best alien breeds is inevitable. However, experimental data on the reproductive performance of alien meat rams under the conditions of the Central zone of the Stavropol territory is practically absent. Our study aimed to examine sexual activity and sperm production in meat sheep in different seasons in the Central zone of the Stavropol territory. During the breeding (autumn) and non-breeding (winter, spring, and summer) seasons, sperm samples were taken from Charolais rams ( $n = 8$ ) and Ile-de-France rams ( $n = 5$ ) using an artificial vagina. The rams of both breeds showed significant seasonal variation in their sexual activity and sperm production. In winter, the sexual activity of the rams decreased and the time required for the expression of the entire complex of sexual reflexes increased. Compared to autumn, the time of receiving ejaculate from Charolais sheep increased 1.70 times in winter, 2.56 times in spring, and 2.62 times in summer. The Ile-de-France rams showed similar dynamics, but a decrease in sexual activity was less pronounced compared to the Charolais rams. Ile-de-France rams took longer to ejaculate (1.09 times in winter, 1.62 times in spring, and 1.78 times in summer compared to breeding season). Sperm motility in Charolais rams varied from 9.1 points in breeding season to 7.4 points in spring. In winter and summer, the motility was 8.5 and 8.1 points, respectively. The volume of ejaculate and sperm cell concentrations showed similar patterns, being the highest in autumn, the lowest in spring, and intermediate in summer and winter. In autumn, Ile-de-France rams produced the largest volume of ejaculate with maximum concentration and the highest motility of sperm cells, i.e., 1.15 ml, 3.75 billion/ml, 8.57 points vs. 0.98 ml, 3.38 billion/ml, 7.95 points in winter, 0.88 ml, 2.85 billion/ml, 7.55 points in spring, and 0.96 ml, 3.15 billion/ml, 8.19 points in summer. Microstructural analysis detected sperm cells with an intact acrosome ranging from 65 % in summer in Charolais rams to 82 % in autumn in Ile-de-France rams. Therefore, despite significant seasonal variations, Charolais and Ile-de-France rams can produce high-quality semen both in breeding and non-breeding seasons under the climatic conditions of the Central zone of the Stavropol territory.

Keywords: rams, breeding and non-breeding season, sexual activity, quality of semen

Sheep breeding is one of the most important branches of the agricultural sector of the Russian economy. In the pre-reform period (until 1990), industry profitability in the country was 30-50% and was ensured by the state policy regarding the production of fine wool. However, termination of state support in market conditions led to the unprofitability of this production. Since 2001, it has become clear that the future of the industry depends on the development of meat

and partly dairy sheep breeding. In sheep-breeding countries, due to long-term market traditions, the breeding area of existing meat breeds of sheep has rapidly expanded over the past decades, and new breeds of meat and combined productivity have also been bred [1].

The main strategy for the development of sheep breeding in Russia in the medium term will also be based on the economic feasibility of the production of young mutton and lamb. However, currently, Russia does not have a gene pool of highly productive specialized meat breeds that fully meet such modern requirements as polycyclicality, multiple fertility, earliness, high growth energy, and excellent meat qualities. In this regard, it is inevitable to use the best meat breeds of foreign breeding for breeding purposes and create arrays of meat sheep in the regions of the country by industrial crossing with sheep of Russian breeds. The effectiveness of wide replication of the gene pool of sheep of the improving breed for a short time will largely depend on the completeness of the reproductive function of final rams, their high sexual activity, and sperm production. The optimal methodology will be an algorithm that provides for the maximum use of rams in the autumn sexual season for insemination of sheep with freshly obtained and cooled transported sperm and the accumulation of sperm in frozen form in other seasons of the year [2-4].

It is known that long-term artificial selection helped to minimize the impact of the season on the reproductive activity of sheep. The seasonality of reproduction is poorly expressed or does not manifest itself at all in breeds bred near the equator, but is common in middle and high latitudes. The breeding season of females is significantly shorter than that of males and is limited to the period from late summer to January. Rams also show seasonal fluctuations in sexual activity and the quality of sperm production, but their physiological volatility is less expressed. Many factors influence the libido and sperm characteristics of rams: breed, age, conditions of managing and feeding, environmental conditions (photoperiod, insolation, temperature, atmospheric pressure, humidity, etc.) [5-8]. In addition, reproductive management, the professionalism of the technician for obtaining sperm, the method and frequency of sperm selection are of some importance [9-11].

Sheep breeds are characterized by different photoreactivity [12, 13]. Interesting data on seasonality and circadian variations of sexual behavior of rams in tropical latitudes have been obtained [14]. Thus, reducing the length of daylight increases the rate of spermatogenesis due to the production of melatonin, which stimulates the release of gonadotropin-implementing hormones [15, 16].

Seasonal fluctuations in sperm production (ejaculate volume and sperm concentration), testosterone content in the blood, and testicular diameter were studied in dry and rainy seasons on 10 sheep of the Ouled Djellal breed in the Shlef area [17]. It was found that the diameter of the testicles, ejaculate volume, and sperm concentration change in the same way as the level of testosterone in the blood, the amount of which is characterized by high values in the autumn-winter period and low in the spring-summer season. These results reflect the presence of a special seasonal rhythm of functioning of the pituitary gland of rams of the studied breed.

Bravo et al. [18] revealed the presence of sperm subpopulations in Ile-de-France rams with specific movement characteristics in freshly obtained ejaculates and determined changes in the structure of motile sperm subpopulations in different seasons of the year. Malejane et al. [19] report on the seasonal fertility of rams of the most common breeds in South Africa (including the Dorper breed), but information on this issue is very limited.

In Russia, there is very little experimental data on the implementation of

the reproductive function in meat rams of foreign breeding. Moreover, the fragmentary nature and locality of the experiments raise doubts about their reliability and exclude the extrapolation of such results on a larger scale.

In this work, in the conditions of the central zone of the Stavropol Territory, the range of variability of sexual activity and sperm production in Charolais and Ile-de-France meat rams, depending on the season of the year, was established for the first time. The greatest reproductive activity was revealed in the autumn period.

The goal of the work was to study seasonal fluctuations in sexual activity and parameters of sperm production in rams (*Ovis aries*) of meat breeds of foreign selection of Charolais and Ile-de-France in the conditions of the central zone of the Stavropol Territory.

*Materials and methods.* The research was carried out from October 2019 to September 2020 at the experimental station of the All-Russian Research Institute of Sheep and Goat Breeding – a branch of the North Caucasus Federal Research Agrarian Center on breeding rams of meat breeds of foreign selection Charolais ( $n = 8$ ) and Ile-de-France ( $n = 5$ ).

The animals were imported in October 2019 from the UK. After a 30-day quarantine, their sexual activity and sperm production were investigated comprehensively. All rams were provided with the same conditions of management and care. Feeding was carried out according to the rations of the breeding period.

Sperm was obtained using an artificial vagina. The sexual activity shown by the same rams was taken into account by the time spent on the allocation of one ejaculate, i.e., by the duration of the manifestation of the complex of all sexual reflexes – from the entry of the ram into the exercising lot with the female fixed in the machine to the ejaculation reflex.

Each ejaculate was evaluated by volume, motility, and concentration [20]. Ejaculate volume was determined using a graduated pipette (up to 0.1 ml) or in a graduated single-wall ejaculator. Sperm motility was established under a Nikon Ts2R microscope (Nikon, Japan) at a magnification of  $\times 200$ – $\times 400$  in several fields of view in a drop of sperm. The motility index was evaluated on a 10-point scale. The concentration of sperms was determined on an Accucell photometer (IMV Technologies, France) or calculated in a Goryaev counting chamber under a Nikon Ts2R microscope at a magnification of  $\times 400$ , for which the sperm was pre-diluted 200 times with a 3% sodium chloride solution in an erythrocyte blood-count mixing pipette (GEN LLC, Russia).

The length of daylight hours (h) was calculated as the difference between the official sunrise and sunset times on each day of the experiment. Precipitation (mm) and air temperature fluctuations ( $^{\circ}\text{C}$ ) were registered daily. For each parameter, the average values for the season of the year were calculated.

Statistical processing was carried out in Microsoft Excel 2016. The results were expressed as means and standard deviations ( $M \pm \text{SD}$ ). To determine the statistical significance of the differences in the mean values, Student's  $t$ -criterion was used under three conditions of  $p$  probability and different numbers of degrees of freedom.

*Results.* A significant part of the territory of the experimental station where the experiments were conducted is located within the Stavropol upland at an altitude of 350–600 m above sea level (Stavropol Territory, Shpakovsky District). According to the long-term data of the Stavropol meteorological station, the area belongs to the zone of moderate humidification. An important feature of the climate is a rapid increase in temperature in spring and a slow decrease in autumn. From mid-April, a frost-free period is established, which lasts 175–180 days. Summer is quite hot, with an average monthly temperature of  $+20\dots+25$   $^{\circ}\text{C}$ .

Atmospheric droughts are often repeated, and during the summer period, their duration is about 60 days. Only three months of the year have an average air temperature below 0 °C, but even during this period, thaws are often observed. Snow cover appears in late November—early December. Snowfall usually occurs in late March—early April, the period with snow cover and air temperature below 0 °C counts 90-95 days. In some years, no snow cover is observed even in winter. The annual amount of precipitation is 550-600 mm, mainly in summer. A significant part of precipitation quickly evaporates due to high temperatures and exposure to dry winds.

Table 1 shows the average parameters of climatic data for the seasons of the year for the experimental period.

**1. Climatic data in experiments on seasonal fluctuations in sexual activity and sperm production of Charolais and Ile-de-France rams (*Ovis aries*) (Stavropol Territory, Shpakovsky District, September 2019—August 2020)**

Season	Air temperature, °C		Precipitations, mm	Average day length, hours
	min	max		
Осень	-3	+29	97	10.8
Зима	-12	+18	109	9.2
Весна	-9	+22	77	13.8
Лето	+15	+35	46	14.7

Ile de France is one of the most popular French-bred meat breeds in the world, leading in improving both the maternal characters of sheep and the paternal characters of rams. It is positioned as a polycyclic breed; therefore, it is widely used for intensive off-season production of lambs and pasture lambs from early spring lambing. The live weight of rams used in the experiment ranged from 100 to 125 kg. They were characterized by well-developed meat forms: they had a broad head, a short, wide neck, rounded ribs, well-muscled thighs.

Charolais is a meat-wool breed of French breeding. Experimental rams had a live weight from 105 to 140 kg and expressed meat forms: a wide head, a short, muscled neck, a barrel-shaped body with rounded ribs, perfectly muscled thighs.

Numerous observations and experiments conducted in the middle latitudes have proved that gametogenesis (ovogenesis) in sheep practically stops in the period from January to July. Accordingly, animals lack unconditional sexual reflexes (chase, estrus, ovulation). This season is commonly called asexual, or anestrous. With all conventionality of this name, it determines the physiological state of sheep accurately [21].

On the contrary, in rams of most breeds, spermiogenesis and secretion of male sex hormone are carried out continuously throughout the year. This theoretically allows them to be used to obtain sperm or breed all year round. Nevertheless, practical observations and numerous studies show that seasonal environmental and climatic factors can have a noticeable effect on both the sexual activity of rams and the quality of sperm they secrete [15, 22, 23].

In total, in different seasons of the year, 432 ejaculates from Charolais and Ile-de-France ram were received (Table 2). Sexual activity of animals in different seasons remained high. All rams had a well-expressed locomotor reaction to the female fixed in the machine, a courtship complex, embracing reflex, and ejaculation reflex. However, significant variations in the speed and intensity of these processes were observed depending on the season of the year. The tendency to decrease sexual activity was manifested in winter, then intensified in spring and summer, and was expressed primarily by an increase in the time for the manifestation of the entire complex of sexual reflexes.

**2. Activity of sexual reflexes in Charolais ( $n = 8$ ) and Ile-de-France ( $n = 5$ ) rams (*Ovis aries*) as depends on the season ( $M \pm SD$ , Stavropol Territory, Shpakovsky District, September 2019—August 2020)**

Season	Breed	Investigated ejaculates, $n$	Time to receive one ejaculate, s
Autumn	Charolais	88	48.6 $\pm$ 0.15
	Ile-de-France	40	88.5 $\pm$ 0.19
Winter	Charolais	72	83.9 $\pm$ 0.28*
	Ile-de-France	36	96.5 $\pm$ 0.35*
Spring	Charolais	68	124.6 $\pm$ 0.24**
	Ile-de-France	34	143.4 $\pm$ 0.38**
Summer	Charolais	56	127.5 $\pm$ 0.33**
	Ile-de-France	38	157.9 $\pm$ 0.15**

\*, \*\* Differences with indicators in the autumn period are statistically significant at  $p < 0.01$  and  $p < 0.001$ , respectively.

For example, in Charolais rams, the time to receive ejaculate in the winter months increased 1.7-fold compared to autumn months, and in spring and summer months 2.56-fold and 2.62-fold, respectively ( $p < 0.001$ ). Ile-de-France rams showed similar dynamics of the activity of sexual reflexes. At the same time, the decrease in libido intensity was significantly less expressed compared to Charolais rams. In winter, Ile-de-France rams spent 1.09 times more time on the release of one ejaculate than in the sexual season, in spring and summer periods — 1.62 and 1.78 times more time, respectively ( $p < 0.01$ ). Consequently, the sexual activity of Ile-de-France rams was less affected by seasonal factors, unlike the rams of Charolais breed, who needed a significantly ( $p < 0.001$ ) longer time to manifest the full complex of ejaculate release reflexes in spring and summer periods.

Sexual activity of rams is important, however, to obtain high efficiency of insemination, the quality of sperm production is a priority. The researchers examined the volume, motility, and concentration of freshly obtained sperm from 284 ejaculates of Charolais rams and 148 ejaculates of Ile-de-France rams. The sperm motility index was evaluated on a 10-point scale (Table 3).

**3. Evaluation scale of sperm motility in Charolais and Ile-de-France rams (*Ovis aries*)**

Grade class	Scores	Movement description
Excellent	9-10	Dense, very fast-moving waves; 90% or more of the sperm are active
Good	7-8	Vigorous wave movements, but not as fast as at 9-10 points; 70-85% of sperms are active
Satisfactory	5-6	Only small, slow-moving waves; 45-65% of sperm are active
Unsatisfactory	3-4	Waves do not form, some movement of sperms is visible; 20-40% of sperms are alive, but with poor motility
Badly	1-2	About 10% of sperms show signs of weak movement
Dead	0	No movement of sperm

**4. Characteristics of sperm production in Charolais ( $n = 8$ ) and Ile-de-France ( $n = 5$ ) rams (*Ovis aries*) as depends on the season ( $M \pm SD$ , Stavropol Territory, Shpakovsky District, September 2019—August 2020)**

Indicator	Season	Charolais	Ile-de-France
Volume, ml	Autumn	1.2 $\pm$ 0.15	1.1 $\pm$ 0.14
	Winter	1.0 $\pm$ 0.11	1.0 $\pm$ 0.19
	Spring	0.9 $\pm$ 0.17	0.9 $\pm$ 0.12
	Summer	1.0 $\pm$ 0.19	1.0 $\pm$ 0.14
Concentration, $\times 10^9$ /ml	Autumn	3.8 $\pm$ 0.15	3.7 $\pm$ 0.20
	Winter	3.3 $\pm$ 0.18	3.4 $\pm$ 0.27
	Spring	2.9 $\pm$ 0.12	2.8 $\pm$ 0.39
	Summer	2.9 $\pm$ 0.19	3.1 $\pm$ 0.22
Motility of fresh sperm, score	Autumn	9.1 $\pm$ 0.53	8.6 $\pm$ 0.56
	Winter	8.5 $\pm$ 0.46	8.0 $\pm$ 0.73
	Spring	7.4 $\pm$ 0.59	7.5 $\pm$ 0.54
	Summer	8.1 $\pm$ 0.63	8.2 $\pm$ 0.62
Number of sperms with an intact acrosome, %	Autumn	78.0 $\pm$ 2.29	82.0 $\pm$ 3.84
	Winter	75.0 $\pm$ 3.43	78.0 $\pm$ 2.56
	Spring	68.0 $\pm$ 2.18	75.0 $\pm$ 3.17
	Summer	65.0 $\pm$ 2.26	72.0 $\pm$ 2.89

The parameters of sperm production of rams of both breeds in all seasons of the year remained quite high and met the requirements (Table 4). At the same time, some variations were identified.

In rams of the Charolais breed, sperm motility varied from 9.1 in the sexual season to 7.4 points in the spring period, when the lowest value of this indicator was observed. In winter and summer, motility was 8.5 and 8.1 points. Sperm volume and sperm concentration also had the lowest values in spring, while in winter and summer, they occupied an intermediate position.

The quality and quantity of sperm production in Ile-de-France rams had high variability depending on the season of sperm production. The highest indicators of volume, concentration, and motility were in the autumn period (1.15 ml, 3.75 billion/ml, and 8.57 points, respectively), whereas in winter, these parameters were 0.98 ml, 3.38 billion/ml, and 7.95 points, in spring — 0.88 ml, 2.85 billion/ml, and 7.55 points, in summer — 0.96 ml, 3.15 billion/ml, and 8.19 points.

The decrease in sperm quality led to an increase in microstructural damage and abnormalities of sperm. The number of sperms with intact acrosome ranged from 65% in summer in Charolais rams to 82% in autumn in Ile-de-France rams.

The analysis of the data obtained allows making a preliminary conclusion that, despite the significant volatility, rams of the Charolais and Ile-de-France breeds in the climatic conditions of the central zone of the Stavropol Territory can be used to obtain high-quality sperm in all seasons of the year. The highest rates in were observed in the autumn sexual season, which was a predictable natural result. At the same time, low parameters in the spring period turned out to be quite an unexpected fact. In the spring season, the photoperiod (length of daylight) is approximately the same as in autumn; the average ambient temperature, duration of insolation, and humidity are similar to the average autumn indicators. On the contrary, in summer, all these climatic indicators, except humidity, reach the highest values. However, in summer, sperm production in rams turned out to be significantly higher than in spring. Winter and summer periods are transitional, and spring, which differs from autumn only in one natural indicator, serves as an antagonist to the sexual season. If the assumption is correct, then in the realization of sexual function, the main role is played not by absolute climatic indicators (photoperiod, temperature, insolation), but by the positive dynamics of daylight, i.e., an increasing photoperiod. Indirect confirmation of these conclusions can be found in the works of foreign colleagues [22-25]; however, additional research is needed for a more substantiated statement.

The authors consider the obtained data on the dynamics of the main parameters of sperm production in the context of breeds to be extremely important for the adoption of an optimal algorithm for working with rams of the Charolais and Ide-de-France breeds to obtain crossbreed young stock. At the same time, it seemed interesting to study the individual differences of rams in sperm production within the same breed, which can provide theoretical and practical material on the limiting parameters of the main indicators of sperm quantity and quality.

The authors considered a representative sample of rams sufficient to identify a pattern or at least a trend (Table 5).

According to the results of the experiment, both intrabreed individual differences between rams and interbreed variations were found. In animals of the Charolais breed, sperm motility in average annual terms was 8.16 points, with the variability of the indicator between rams from 7.60 to 9.10 points. The same high volatility was observed in terms of sperm volume and concentration: with averages of 1.02 ml and 3.03 billion/ml, the variability ranged from 0.85 to 1.12 ml and from 2.75 to 3.22 billion/ml, respectively. One of the key parameters, the total

number of sperm with rectilinear motion (RM) in the ejaculate with an average value of 2.53 billion varied with more than 50% amplitude: from 2.09 to 3.18 billion.

### 5. Individual parameters of sperm production in Charolais and Ile-de-France rams (*Ovis aries*) ( $M \pm SD$ , Stavropol Territory, Shpakovsky District, September 2019–August 2020)

Breed	Ram No.	Studied ejaculates, $n$	Characteristics of sperm production			The total number of spermatozoa with RM in the ejaculate
			motility, score	volume, ml	concentration, $\times 10^9/\text{ml}$	
Charolais	06894	35	9.1 $\pm$ 0.73	1.1 $\pm$ 0.13	3.1 $\pm$ 0.32	3,2 $\pm$ 0,18
	06943	30	8.2 $\pm$ 0.83	1.0 $\pm$ 0.22	3.2 $\pm$ 0.30	2,8 $\pm$ 0,21
	01181	38	7.8 $\pm$ 0.70	0.9 $\pm$ 0.09	3.0 $\pm$ 0.10	2,1 $\pm$ 0,09
	06947	34	8.3 $\pm$ 0.44	1.1 $\pm$ 0.14	3.1 $\pm$ 0.13	2,8 $\pm$ 0,16
	06860	36	7.7 $\pm$ 0.77	1.0 $\pm$ 0.21	3.2 $\pm$ 0.32	2,5 $\pm$ 0,12
	06917	40	8.5 $\pm$ 0.53	1.1 $\pm$ 0.19	2.8 $\pm$ 0.23	2,6 $\pm$ 0,14
	01011	36	8.1 $\pm$ 0.49	1.0 $\pm$ 0.17	2.9 $\pm$ 0.36	2,3 $\pm$ 0,11
	01029	35	7.6 $\pm$ 0.87	0.9 $\pm$ 0.22	3.1 $\pm$ 0.22	2,1 $\pm$ 0,18
	Total for the breed ( $n = 8$ ):	284	8,2 $\pm$ 0,45	1.0 $\pm$ 0.08	3.0 $\pm$ 0.12	2.5 $\pm$ 0.20
Ile-de-France	01121	32	9.0 $\pm$ 0.53	1.2 $\pm$ 0.23	3.4 $\pm$ 0.31	3,7 $\pm$ 0,21
	01126	27	8.8 $\pm$ 0.68	1.2 $\pm$ 0.13	3.5 $\pm$ 0.37	3,6 $\pm$ 0,26
	01132	29	7.9 $\pm$ 0.88	1.1 $\pm$ 0.22	3.1 $\pm$ 0.41	2,6 $\pm$ 0,12
	01111	26	7.8 $\pm$ 0.61	1.1 $\pm$ 0.21	3.4 $\pm$ 0.30	2,8 $\pm$ 0,14
	04511	34	8.4 $\pm$ 0.77	1.1 $\pm$ 0.19	3.3 $\pm$ 0.33	3,0 $\pm$ 0,21
Total for the breed ( $n = 5$ ):	148	8,4 $\pm$ 0,33	1.1 $\pm$ 0.09	3.4 $\pm$ 0.16	3.1 $\pm$ 0.19	

Note. RM — rectilinear motion.

Ile de France rams had motility volatility ranging from 7.8 to 9.0 points with an average score of 8.38 points. Sperm volume varied from 1.06 to 1.2 ml with an average of 1.12 ml, concentration — from 3.10 to 3.52 billion/ml with an average of 3.34 billion/ml. As an integral consequence of these three parameters, the total number of sperm with RT averaged 3.14 billion with a limit of 2.62 to 3.67 billion.

The decrease in sperm quality in the hot season is to some extent explained by an increase in the temperature of the scrotum and, as a consequence, degeneration of the testes under the influence of high ambient temperatures [26, 27]. It can also lead to infertility or subfertility [28, 29]. There are studies [30, 31], proving that an increase in external temperature affects the absolute temperature in various areas of the testes, thereby determining sperm quality and fertility of animals raised on pastures.

This study revealed that Charolais and Ile-de-France rams had a decrease in the concentration and total number of sperm during the anestrus period. Some foreign studies [32–36] demonstrated differences in sexual activity and parameters of sperm production depending on the season of the year in different climatic zones.

For example, Ibrahim [32] examined a total of 900 sperm ejaculates from 10 rams. The highest quality sperm was obtained in winter (volume — 0.77 ml, pH — 6.95, motility — 4.53 points on a 5-point scale, sperm concentration —  $4932.72 \times 10^6/\text{ml}$ ); however, the authors assess sperm quality as good in all seasons of the year. At the same time, the season of the year had a significant ( $p < 0.01$ ) effect on the sexual behavior of rams: the highest sexual activity was recorded in autumn, the lowest in summer. Benmoula et al. [33] evaluated sperm from five adult rams INRA180 (age 2–3 years). Scrotum circumference, sperm quality, and total protein concentration in the seminal plasma remained relatively constant throughout the year ( $p > 0.05$ ). There were no differences in total sperm motility ( $p > 0.05$ ), while the only parameters showing seasonal fluctuations were the content of cholesterol, total lipids in sperm, and progressive sperm motility. Azawi et al. [34] examined sperm samples from six sexually mature rams of the Avassi breed.

Larger ( $p < 0.05$ ) sperm volume was observed in August ( $1.55 \pm 0.08$  ml) and March ( $1.27 \pm 0.15$  ml). Sperm concentration was the highest ( $p < 0.05$ ) in the breeding season in September ( $4.21 \pm 0.86 \times 10^9$  sperm/ml). Individual sperm motility and percentage of live gametes observed in August and May had the highest values and differed ( $p < 0.05$ ) from those in December and January.

On the contrary, the research by Tomkins et al. [35] showed that in autumn ejaculate volume and percentage of live sperm decreased, and the percentage of abnormal sperm increased, while sperm concentration in the ejaculate showed a greater decrease in summer. Belkadi et al. [36] revealed that the sexual activity of rams was high during the mating seasons (spring and autumn), which was determined by high testosterone content ( $4.89 \pm 2.06$  and  $3.09 \pm 1.35$  ng/ml, respectively). The mean values of ejaculate volume, total motility, the number of live sperm, and scrotal circumference were higher in spring ( $p < 0.05$ ) –  $1.23 \pm 0.26$  ml,  $3.39 \pm 1.07$  points,  $79.16 \pm 15.82\%$  and  $36.29 \pm 1.91$  cm, respectively, sperm concentration in autumn ( $1.19 \pm 0.56 \times 10^9$  sperm/ml compared to  $0.46 \pm 0.13 \times 10^9$  sperm/ml in spring).

Thus, libido and gametogenesis in rams of foreign selection of Charolais and Ile-de-France in the conditions of the central zone of the Stavropol Territory remain high in all seasons of the year. At the same time, wide seasonal variations in indicators of sexual activity and sperm production were noted for both breeds. Rams produced the best sperm in terms of quality and volume in the autumn (sexual) season. In other seasons of the year, sperm production in the main parameters also met the instructional requirements, although a steady trend towards a decrease in the volume, concentration, and mobility of sperm was observed. The decrease in these indicators in winter compared to autumn was the greatest (by 1.5-2.0 times). Consequently, in rams of these breeds, spermatogenesis occurs continuously in all seasons of the year and their sperm can be obtained year-round and used either for insemination of sheep or for preservation in frozen form for long-term storage.

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