PhD THESIS

Research on morphophysiological characteristics and milk quality in a goat population

(SUMMARY OF Ph.D. THESIS)

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Introduction

Romania is a developing country in terms of livestock farming, striving to enhance the goat sector through common agricultural policies due to the multiple benefits derived from raising and exploiting this species. Often referred to as the "poor man's cow," goats have historically been studied alongside sheep in Romania. However, in recent years, due to the increasing interest in the species, goats have started to receive individual attention in production statistics and have become a focus in genetic and breeding studies (Abdelatif et al., 2010).

Welfare is the key term that dominates animal husbandry systems, making the physiological changes in goats crucial for optimizing living conditions and ensuring all necessary elements are provided to support optimal production and comfort (Argüello et al., 2010).

Therefore, as the central element of my research, I chose Carpathian goats and their crossbreeds obtained by crossing Carpathian females with Saanen males. I determined their hematological and biochemical profiles, analyzed the physico-chemical parameters of colostrum and milk from Carpathian goats, and studied the dynamics of body evolution in Carpathian and crossbred kids (Carpathian female and Saanen male) from birth to weaning.

Through this doctoral thesis, I aimed to contribute to ensuring morpho-physiological productivity and milk quality by evaluating the hematological and biochemical blood parameters, the physico-chemical parameters of colostrum and milk, as well as the body evolution dynamics in goat kids.

SCOPE AND RESEARCH OBJECTIVES

The aim of the doctoral thesis entitled "Research on the Morphophysiological Traits and Milk Quality in a Goat Population" was to analyze and compare the recorded values of the hematological and biochemical profiles in primiparous and multiparous females of the Carpathian breed and crossbreeds (Carpathian female and Saanen male), the physico-chemical parameters of colostrum and milk from Carpathian goats, as well as to analyze the dynamics of body evolution in Carpathian and crossbred kids (Carpathian female and Saanen male) from birth to weaning. The objectives of the thesis are represented by:

The objectives of the thesis are represented by:

1. Summarizing the current knowledge related to the goat species, its origin, and evolution;
2. Organizing the experimental setup in livestock farms with an extensive goat farming system;

3. Research on determining the hematological and biochemical profile in Carpathian goats and Carpathian x Saanen crossbreeds;
4. Research on the physico-chemical parameters of colostrum and milk in the Carpathian breed;
5. Research on the dynamics of body evolution in goat kids of the Carpathian breed and crossbreeds (Carpathian female x Saanen male) from birth to weaning.

DOCTORATE THESIS STRUCTURE

The PhD thesis titled "Research on the Morphophysiological Traits and Milk Quality in a Goat Population" comprises a total of 138 pages and is structured into two parts, respectively Part I – "Current stage of knowledge" and Part II – „Personal Contribution".

1. The current stage of knowledge is structured into four chapters
2. The personal contribution is structured in six chapters

PART I - CURRENT STAGE OF KNOWLEDGE

Part I comprises 4 chapters and represents a summary of the current knowledge related to the status of the goat species, its phylogeny and taxonomy, the domestication process, and statistics on goat farming globally, in Europe, and locally.

Chapter I is titled "General Considerations Regarding the Origin of the Goat Species" and includes four subchapters: Phylogeny of Goats; Taxonomy of Goats; The Domestication Process of Goats; and Goats in Mythology and Religion.

Chapter II is titled "The Status of Goat Farming Worldwide." This chapter comprises three subchapters: The Numerical Evolution of Goats Worldwide; Goat Milk Production Worldwide; and Goat Meat Production Worldwide

Chapter III is titled "The Status of Goat Farming in Europe" and includes three subchapters: The Numerical Evolution of Goats in Europe; Goat Milk Production in Europe; and Goat Meat Production in Europe.

Chapter IV is titled "The Status of Goat Farming in Romania" and includes three subchapters: The Numerical Evolution of Goats Locally; Goat Milk Production in Romania; and Goat Meat Production in Romania.

PART II - PERSONAL CONTRIBUTION

Part II comprises six chapters and represents the personal contribution. These chapters present the aim and objectives of the research, the biological material and methods used, the study results and their discussions, the general conclusions, as well as the elements of originality and innovative contributions of the thesis.

Chapter V is entitled "Aims and Objectives of the Research," presenting the 5 previously mentioned objectives and the experimental design.

Chapter VI is entitled "Description and Characterization of Livestock Units" including the characteristics of the environment (livestock farms) where the research was conducted.

Chapter VII is entitled "Material and Methods," where the following aspects are presented: biological material, the methods used for each specific objective, as well as statistical methods used for advanced data analysis.

Chapter VIII is entitled "Results and Discussions" and includes 4 subchapters presenting all research results and the discussions based on them.

Chapter IX is entitled "General Conclusions" and includes the general conclusions derived from the research results.

Chapter X is entitled "Originality and Innovative Contributions of the Thesis" and includes the elements of originality and the contributions of the thesis to the scientific community.

RESEARCH RESULTS

Organization of the experimental device

All research experiments and procedures complied with current Romanian (PR 43/2014) and European (EC 2010/63/EU) legislation. The conditions of raising, feeding, and animal welfare were decisive in choosing the biological material [Carpathian breed (Fig. 1.) and Carpathian x Saanen crossbreed (Fig. 2.)] used in the conducted experiments.

Figure 1. Carpathian breed (source: original)

Throughout the research, the health status of the goats was monitored by the farm's veterinarian, with the animals being declared clinically healthy. This aspect was

crucial for the accurate determination of hematological and biochemical parameters, body mass accumulation, and the physico-chemical parameters of goat colostrum.

The Carpathian breed (Fig. 1) is a natural breed originating from Capra Prisca, domesticated in the hilly, sub-mountainous, and mountainous areas adjacent to the Carpathians. It constitutes over 75% of the goat population in Romania and is widespread across all regions due to its resilience, robustness, and adaptability. However, it exhibits significant variability due to the low level of selection practiced (Pascal C., 2003).

The Saanen breed (Fig. 2) originates from Capra Ibex or Capra Prisca and was developed in Switzerland, in the cantons of Gessenay and Haut-Simmental along the Saanen River valley. It represents over 20% of the Swiss goat population and has spread to other countries, where it is raised as a pure breed and contributes to the development and improvement of local populations (Romania, France, England, Germany, USA, Netherlands, Israel, Greece, etc.). It is currently considered the best dairy goat breed in the world (Dărăban, 2016)

Figure 2. Saanen breed (source: original)

Results Regarding the Evaluation of Hematological and Biochemical Profiles in Carpathian Goats and Carpathian X Saanen Crossbreeds

Hematological profiles and erythrocyte indices are essential parameters for assessing the health status and functioning of the blood system in animals. These parameters are used for diagnosing pathologies, monitoring health status, and evaluating responses to treatments. Regular monitoring of hematological profiles and erythrocyte indices in goats is crucial for Diagnosis of Pathologies: Identifying conditions such as anemia, infections, and other hematological disorders; Health Monitoring: Assessing the overall health of goats and the effectiveness of administered

treatments; Management Optimization: Adjusting dietary regimes and environmental factors to maintain optimal health within the goat population.

Biological samples were collected at 24, 48, and 72 hours postpartum from females of the Carpathian breed [Primiparous (C) and multiparous (C Multiparous)] and Carpathian x Saanen crossbreeds [primiparous (CxS Primiparous) and multiparous (CxS Multiparous)] (Fig. 3).

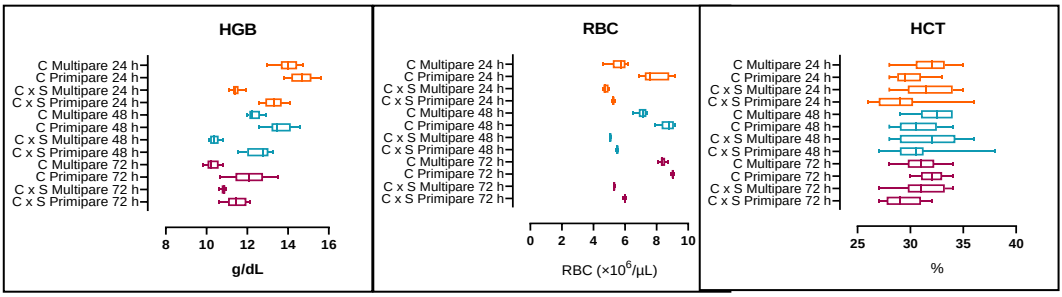

Figure 3. Average values of hemoglobin (HGB), red blood cells (RBC), and hematocrit (HCT) for the two breeds analyzed (Carpathian – C and Carpathian x Saanen – CxS) at 24, 48, and 72 hours postpartum, for primiparous and multiparous females

Thus, for C Multiparous 24h the average hemoglobin (HGB) is 14.01 g/dL (CV% 3.99), for C Primiparous 24h 14.67 g/dL (CV% 3.99), C x S Multiparous 24h 11.44 g/dL (CV% 1.98), C x S Primiparous 24h 13.32 (CV% 3.76), C Multiparous 48h 12.35 g/dL (CV% 2.48), C Primiparous 48h 13.6 g/dL (CV% 4.54), C x S Multiparous 48h 10.39 g/dL (CV% 2.24), C x S Primiparous 48h 12.58 g/dL (CV% 4.60), C Multiparous 72h 10.28 g/dL (CV% 3.23), C Primiparous 72h 12.07 g/dL (CV% 7.47), C x S Multiparous 72h 10.84 g/dL (CV% 1.01) and C x S Primiparous 72h 11.47 g/dL (CV% 4.15). Hemoglobin concentration and hematocrit levels are influenced by parity. Multiparous goats may exhibit elevated levels of HBG and HCT due to physiological adaptations designed to meet the increased demands for oxygen transport and expanded blood volume associated with multiple gestations.

For C Multiparous 24h the average value of erythrocytes (RBC) is 5.60 x106/µL (CV% 8.79), for C Primiparous 24h 7.96 x106/µL (CV% 10.92), C x S Multiparous 24h 4.77 x106/µL (CV% 3.23), C x S Prime 24h 5.26 x106/µL (CV% 1.00), C Multiparous 48h 7.10 x106/µL (CV% 4.12), C Prime 48h 8.70 x106/µL (CV% 5.06), C x S Multipair 48h 5.07 x106/µL (CV% 0.64), C x S Primiparous 48h 5.51 x106/µL (CV% 0, 78), C Multiparous 72h 8.39 x106/µL (CV% 2.17), C Primiparous 72h 9.03 x106/µL (CV% 0.64), C x S Multiparous 72h 5.32 x106/µL (CV % 0.81) and C x S Primiparous 72h 5.99 x106/µL (CV% 1.02). Primiparous goats may show variations in erythrocyte count compared to multiparous goats. This is due to the increased demands for oxygen transport in multiparous goats that have gone through repeated cycles of pregnancy and lactation. Adaptations in erythropoiesis and oxygen-carrying capacity

may be more pronounced in multiparous individuals. In the pre-calving period, the number of erythrocytes in the blood of mother goats decreases (Tharwat et al., 2015).

For goats C Multiparous at 24 h the average RBC, value is 31.7 % (CV% 6.65), for C Primiparous at 24 h 29.8 % (CV% 5.19), C x S Multiparous 24 h 31 .6 % (CV% 7.48), C x S Primiparous 24 h 29.3 % (CV% 9.66), C Multiparous 48 h 32.3 % (CV% 5.06), C Primiparous 48 h 30 .8 % (CV% 6.36), C x S Multiparous 48 h 31.9 % (CV% 8.41), C x S Primiparous 48 h 30.8 % (CV% 9.41), C Multiparous 72 h 30.9 % (CV% 5.79), C Primiparous 72 h 31.9 % (CV% 3.75), C x S Multiparous 72 h 31.1 % (CV% 7.34) and C x S Early pregnancy 72 h 29.3% (CV% 5.81). As with hemoglobin, hematocrit levels are also influenced by parity. Multiparous goats may exhibit increased levels of HCT due to physiological adaptations designed to meet the increased demands for oxygen transport and expanded blood volume associated with multiple gestations.

In the evolution of the state of health of primiparous goats from the Carpathian breed, the biochemical parameter, protein, registers insignificant values when we compare the first 24 hours with 48 hours (p>0.9999), respectively 72 hours (p>0.9999) after calving. Also, the interval from 48 hours to 72 hours (p>0.9999) postpartum, also registers insignificant differences (Fig. 4). TP during parturition, before and after this physiological moment, shows a level located at the lower limit, or even lower, starting to register an increase only from the 7th day after calving (Pugliese A., et al., 1982; McDougal S., et al., 1991; Fernandez S., 2006).

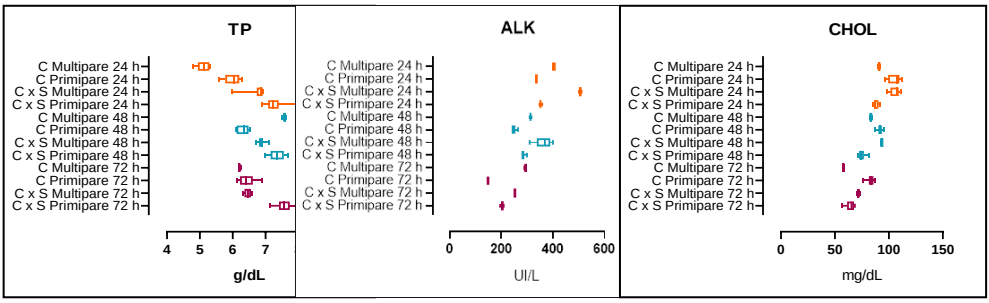

Figure 4. Average values of protein (TP), alkaline phosphatase (ALK), and cholesterol (CHOL) in the two analyzed breeds (Carpathian – C and Carpathian x Saaanen - CxS) at 24, 48, and 72h after parturition, in primiparous and multiparous females

Alkaline phosphatase enzyme for primiparous goats of the Carpathian breed shows differences in the physiological state of the goats in the first 24 hours, higher compared to themselves at 72 hours (p=0.0002) and compared to 72 hours of the physiological state of primiparous goats Carpathian x Saanen. At 72 hours, the ALK level is lower compared to both primiparous and multiparous goats from the Carpathian breed and to primiparous and multiparous Carpathian x Saanen goats at 24 hours and 48 hours postpartum, respectively. Alkaline phosphatase activity

decreases at parturition and is maintained with low values also in the postpartum period for three weeks (Tharwat, M., et all 2015).

The cholesterol level differs in multiparous Carpathian goats at 24 hours with primiparous Carpathian x Saanen goats at 48 hours ($p<0.0001$) and with primiparous goats from the Carpathian breed at 72 hours ($p<0.0001$). The period of calving animals and the beginning of lactation has a significant effect on cholesterol (Skotnicka, et al., 2011), in the period immediately after parturition, lipogenesis and esterification are reduced, while the mobilization of free fatty acids is stimulated by the increase in the secretion of norepinephrine and epinephrine (Sadjadian R., 2013).

Results regarding the evaluation of the physico-chemical parameters of colostrum and milk in goats of the Carpathian breed

Significant differences in total lipid content were evidenced in both primiparous (P) and multiparous (M) groups only when comparing day 1 to day 7 (P-Day 1 vs. P-Day 7: P=0.0573 and M-Day 1 vs. M-Day 7: P=0.751). Total lipid content on day 3 and day 7 did not show statistically significant differences ($P<0.0001$ in both cases). Intergroup comparison (P-Day 1 vs. M-Day 1, P-Day 3 vs. M-Day 3, P-Day 7 vs. M-Day 7) showed no statistically significant differences ($P>0.9999$) (Fig. 5). The fat content is higher in the first days postpartum and remains high until day 5, reaching the normal percentage of fat in goat milk on day 15 (Sánchez-Macías et al., 2014). Compared to mature goat milk, colostrum has a significantly higher protein, fat, mineral, dry matter, and lower lactose concentration.

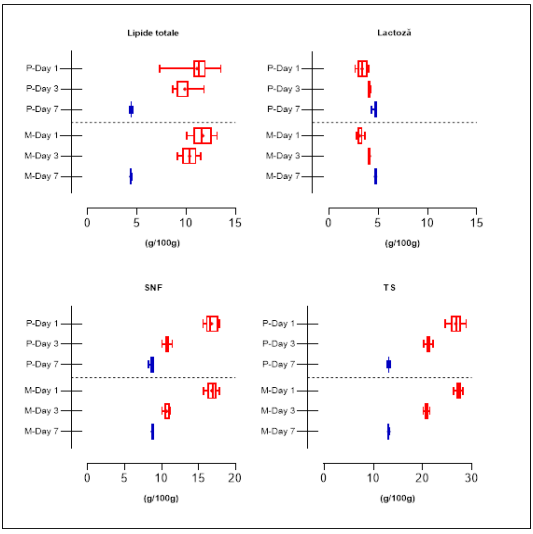

Figure 5. Average values of lipids, lactose, SNF, and TS in goats of the Carpathian breed, in primiparous and multiparous females

Lactose and SNF content showed identical trends to fat content, with intragroup analysis showing statistically significant differences only when comparing day 1 to day 7 (P<0.0001 for both primiparous and multiparous). Intergroup analysis did not show statistically significant differences (P>0.9999) (Fig. 5.). Total dry matter content (DS) showed statistically significant differences in intragroup analysis (primiparous and multiparous groups) (P-Day 1 vs. P-Day 3; P-Day 1 vs. P-Day 7; P-Day 3 vs. M-Day 1 vs. M-Day 7 and M-Day 7: P<0.0001. Intergroup analysis (P vs. M) showed no statistically significant differences (P-Day 1 vs. M-Day 1: P=0.446; P-Day 3 vs. M-Day 3: P=0.7307; P-Day 7 vs . M-Day 7: P>0.9999). SNF content varies slightly during the lactation stage and the change in SNF content is less pronounced, especially in late lactation (Noutfia et al., 2014). Decreasing fat, protein, fat-free dry matter, and total dry matter in milk composition reduce milk quality (Peana et al., 2007; Vlaic et. al, 2024).

Results regarding the dynamics of body evolution in Carpathian and crossbreed kids (Carpathian female x Saanen male) from birth to weaning

The average body weight for Carpathian heifers at calving was 3,249.3 g; on day 2 of 3,350.717 g; on day 3 of 3,473 g; on day 4 of 3,588.08 g; on day 5 of 3,698.71 g; on day 6 of 3829.81 g; on day 7 of 3,948.9 g; on day 21 of 5,744.08 g and day 56 of 9,929.9 g (Fig. 6.). The dynamics of body mass in Carpathian ewes follows an upward trend, but the weight gain from two consecutive days is insignificant, as follows: day two after farrowing with day 3 (p=0.0955), day 3 with day 4 (p =0.3547), day 4 with day 5 (p=0.4201), day 5 with day 6 (p=0.1949), day 6 with day 7 (p=0.2884), excluding these days the value of p is (p<0.0001), compared for each day relative to the following.

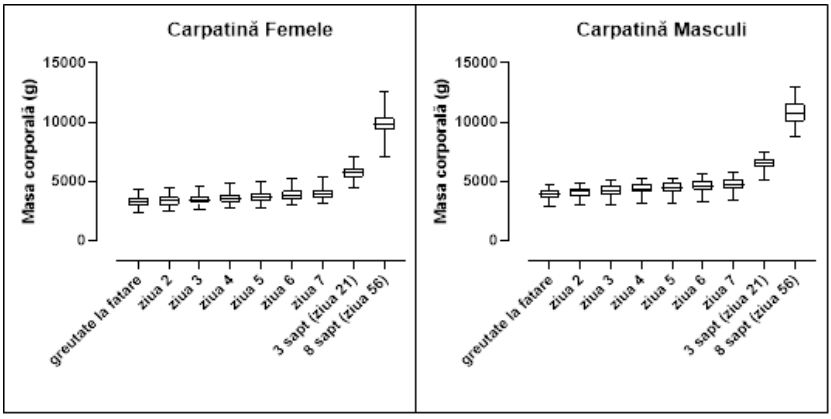

Figure 6. Body mass dynamics in Carpathian kid goats, females and males

The average body weight for male Carpathian kids at calving was 3,909.83 g; on day 2 4,015 g; on day 3 4,144.83 g; on day 4 4,302.5 g; on day 5 4,414.33 g; on day 6 4,579.93 g; on day 7 of 4,700.5 g; on day 21 of 6,462.1 g and day 56 of 10,814.1 g. Analyzing the results obtained in ewes from the Carpathian breed and male kids from this breed, the values obtained follow the same upward trend, with the specification that the weight of males at calving is greater than that of females.

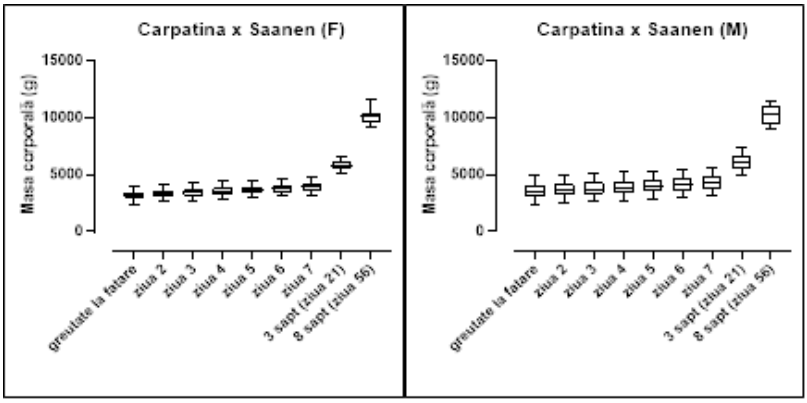

Figure 7. Body mass dynamics in crossbreed Carpathian x Saanen, females and males

The average body weight for Carpathian x Saanen heifers at calving was 3,221.5 g; on day 2: 3,317.61 g; on day 3: 3,429.43 g; on day 4: 3,544.77 g; on day 5: 3,655.57 g; on day 6: 3,772.61 g; on day 7: 3,893.52 g; on day 21: 5,790.54 g and day 56 of 10,072.73 g (Fig. 7.). The average body weight for Carpathian x Saanen male kids at farrowing was 3,573.65 g; on day 2 of 3,653.39 g; on day 3 of 3,758.85 g; on day 4 of 3,868.85 g; on day 5 of 3,978.92 g; on day 6 of 4,086,154 g; on day 7 of 4,204.43 g; on day 21 of 6,075.77 g and day 56 of 10,245.77 g. The Saanen breed is bred as a purebred in the largest farms, while in small farms it is bred for crossbreeding with the native Carpathian breed to improve the production of milk and udder conformation (Kusza et al., 2016; 2018).

Conclusions

The research and experiences in this doctoral thesis took place in Alba County, in two farms with the zootechnical specialty of raising goats. One of the farms, Avram Cătălin Individual Enterprise, is located in Rimetea commune, village. Rimetea owns herds of goats of the Carpathian breed and their crossbreeds (female Carpathian and male Saanen). The other farm, Păcurar Emilia Authorized Physical Person, is located in Livezile commune, village. Poaiana Aiudului owns herds of goats of the Carpathian breed. The period of the experiments was 2018-2022.

Hematological and biochemical parameters were followed in goats from the Carpathian breed and goats mated with Saanen males, in the first hours of parturition (24 hours) and in the following postpartum days (at 48 hours and 72 hours), comparatively, to observe the adaptability and the changes produced in the body on these indicators in the postpartum period, in crossbred goats compared to the Carpathian breed.

The hematological profile and erythrocyte indices are essential parameters for evaluating the health status and the functioning of the blood system of the animals. These parameters are used to diagnose pathologies, monitor health status, and evaluate response to treatments. Regular monitoring of the hematological profile and erythrocyte indices in goats is essential for the diagnosis of pathologies (identification of anemia, infections, and other hematological conditions), monitoring of the health status (evaluation of the general state of health of the goats and the effectiveness of the administered treatments), optimization of management (adjustment of the regime dietary and other environmental factors to maintain optimal health of the goat herd).

Oxidative stress can affect the immune system of goats, weakening the immune response and increasing susceptibility to infection and disease. Reproductively, it can harm fertility and fetal health, leading to abortions and neonatal mortality. Productivity can also be affected, reducing milk production and quality, as well as muscle growth and development. In the long term, oxidative stress can contribute to the development of chronic and degenerative diseases such as arthritis and cardiovascular disease.

Compared to mature goat milk, colostrum has a significantly higher protein, fat, mineral, dry matter, and lower lactose concentration. The lactation stage had significant effects on fat, protein, and lactose content. In general, an increase in protein, fat, ash, SNF, and viscosity was observed, except for lactose and pH, which showed higher values in primiparous compared to multiparous goats.

The repeated and consistent determinations of the body mass indicate an upward trend, each different from the previous one, as follows: the weight at calving of the heifers on the second day of life ($p<0.0001$), on the third day ($p<0.0001$), with the fourth day ($p<0.0001$), with the fifth day ($p<0.0001$), with the sixth day ($p<0.0001$), with the seventh day ($p <0.0001$), with the twenty-first day ($p<0.0001$), and with the fifty-sixth day ($p<0.0001$). The differences are significant for each day compared to its predecessor. By monitoring the weight at regular time intervals, according to the established protocol, in the first week of life daily, then at 21 days and at weaning (period corresponding to day 56), we analyzed the intensity of growth in the female Carpathian breed kids with males and we noticed that there is a difference in this indicator ($p=0.0006$), we also noted a difference in growth intensity ($p= 0.0086$) and in the Carpathian x Saanen kids between females and males.

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