

Influence of climatic elements on the reproductive traits of Romanov sheep in the Bilogora region, Croatia



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Abstract

The study aimed to determine the influence of air temperature, amount of precipitation and sunlight duration on the reproductive traits of the Romanov sheep in the Bilogora region, Croatia. Animals were kept in a fenced rotating pasture with access to stables during the night. Sheep were naturally mated. During three consecutive years (2019-2021), reproductive performance data were collected for four sheep flocks ($n=26-57$). Data on air temperature, sunlight duration, and daily precipitation volumes were obtained from the Croatian Meteorological and Hydrological Service (CMHS), Zagreb, Croatia, from the nearest meteorological recording station, located within 5-15 km of farms. A total of 425 ewes were mated, of which 399 successfully conceived and 851 lambs were born, with an average litter size of 1.63. The average fertility during the study was 93.88%. Lambing distribution was not equally distributed throughout the year as 73% of all lambs were born during winter and spring (winter 51.88%; spring 21.31%; summer 13.53% and autumn 13.28%). Sexual activity

was lowest from the end of March to May, while the peak of sexual activity was from the end of August to October. There was a positive or negative correlation ($P<0.0001$ (Kruskall-Wallis)) between air temperature, sunshine duration and amount of precipitation with certain reproductive traits (number of pregnant and non-pregnant ewes). Daily average air temperatures were highest in summer but drop suddenly at the start of the breeding season in early autumn. Also, the day begins to shorten, and night begins to become longer which is crucial for short-day breeder species such as sheep and goats. Other factors, such as relative humidity and rainfall, can also directly or indirectly impact sexual activity and significantly affect fertility. The results indicate that air temperature, amount of precipitation, and sunlight duration during different months or seasons could influence the reproductive traits of Romanov sheep in Bilogora region, Croatia.

Key words: air temperature; amount of precipitation; reproductive traits; Romanov sheep; sunlight duration

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Introduction

Climate has a significant impact on livestock production and reproduction (Silanikove, 2000; Ramón et al., 2016). Climatic elements (solar radiation, temperature, air pressure, air humidity and evaporation, direction and speed of wind, duration of sunshine, and precipitation) are determined by the general circulation of the atmosphere. They can have negative (or less often positive) effects on animal welfare and productivity (Marai et al., 2007; Bernabucci et al., 2010; Palacios and Abecia, 2015; Abecia et al., 2016; Đuričić et al., 2021b). It is well known that the negative effects of extreme air temperatures on the reproduction of sheep are manifested as infertility and early embryonic mortality, and they depend primarily on the period of exposure and the height of the temperature, but also on the breed, manner of keeping, animal age, feeding, etc. (Boland et al., 2001; Abecia et al., 2016; Macías-Cruz et al., 2016). The effects of precipitation (rain, snow, frost, etc.) on livestock production and reproduction are mainly due to the availability of a certain quantity and quality of food, and forage for grazing sheep (Forcada et al., 1992; Arrébola et al., 2015; Đuričić et al., 2019a). In sheep, continuous exposure to short day lengths significantly advances the breeding season, increases ovulation rate and embryo survival. Sunshine duration is a climatological indicator of cloudiness, measuring the duration of sunshine in given period (usually, a day or a year) for a particular location. The pineal hormone melatonin, which is secreted during the night hours, affects changes in metabolism, appetite, hair growth and reproductive status (Williams and Helliwell, 1993). The main role of melatonin in sheep is the translation of photo signals into endocrine pulses,

the stimulation of the hypothalamus to secrete gonadotropin-releasing hormone (GnRH), and the initiation of the hypothalamic-pituitary-ovarian axis. Reduced day length is the main factor controlling the reproduction of some domestic animals. The sexual activity of sheep and goats is most pronounced during autumn when the days become shorter and the temperature drops (Đuričić et al., 2021a), while the onset of a longer day in early spring reduces reproductive activities (Younis et al., 2019).

Along with Finnish sheep, Booroola Merino or Barbados Blackbelly, Romanov is known as one of the world's most fertile sheep breeds (Mioč et al., 2007; Kutluca Korkmaz and Emsen, 2016, Đuričić et al., 2019b).

The Bilogora region is situated in northwestern Croatia, in a continental climate zone with hot summers and cold winters. Based on the Köppen classification it is classified as Cfa climate with maximal insolation of 2000 hours per year, and 800 mm annual precipitation (Zaninović et al., 2008).

The study aimed to determine the influence of air temperature, precipitation, and sunlight duration on the reproductive traits of the Romanov sheep in the Bilogora region, Croatia.

Materials and methods

Animals

During three consecutive years (2019-2021), the reproductive performance data of four Romanov sheep flocks ($n=26-57$) were collected. Animals were kept in a fenced rotating pasture with access to stables during the night. Sheep were naturally mated. Animals had free access to good quality hay, adequate concentrate, and drinking water.

Ethical approval

The research protocol and animal management were in line with the Directive 2010/63/EU (European Union 2010) on the protection of animals used for scientific purposes. All animals were handled in strict accordance with good animal practices. All procedures performed in the studies involving animals followed the ethical standards of the institution or practice at which the studies were conducted.

Meteorological data

Air temperature, sunlight duration, and daily precipitation volumes were obtained from the Croatian Meteorological and Hydrological Service (CMHS), Zagreb, Croatia from the nearest meteorological recording station, located within 5-15 km of farms. Monthly variations of studied climatic elements from 2019 to 2021 were compared with the long-term average data obtained for the past 70 years (1949-2019) by the CMHS.

Statistical analysis

All data were analysed by Stara 13.1 (Stara Corp. USA) using non-parametric Kruskal-Wallis tests. In the regression analysis, the logarithmic value of the percentage of pregnant sheep showed a linear relationship with the variables month and season.

Results

A total of 425 ewes were mated, of which 399 successfully conceived and 851 lambs were born in an average litter size of 1.63. The average fertility during the study was 93.88%. The distribution of lambs was not equally distributed throughout the year as 73% of all sheep were born during winter and spring (winter 51.88%; spring 21.31%; summer 13.53% and autumn 13.28%). Sexual activity was lowest from the end of March to May, while the peak of sexual activity was from the end of August to October (Figure 1). There was a positive or negative correlation ($P < 0.0001$) (Kruskall-Wallis)

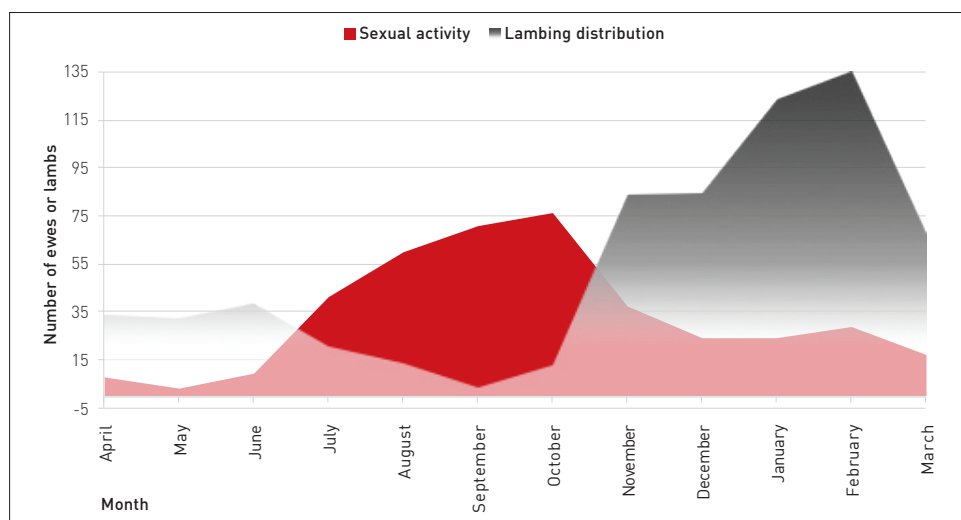


Figure 1. Sexual activity and lambing distribution of Romanov sheep ($n=425$) during three consecutive years (2019-2021) in the Bilogora region

Table 1. Litter size, lambing index, number of total matings, number of pregnant and non-pregnant ewes, fertility, total number of newborns (lambs per ewe and lambs per ewe per year) of Romanov sheep in the Bilogora region during the observed period (2019-2021)

Parameter	2019	2020	2021	TOTAL
litter size	1.62	1.59	1.71	1.63
lambing index	1.30	1.31	1.29	1.30
total matings	133	157	135	425
pregnant ewes	124	148	127	399
non-pregnant ewes	9	9	8	26
fertility	93.23	94.27	94.07	93.88
lambs/ewe/lambing	201	236	217	654
lambs/ewe/year	262	309	280	851

between air temperature, sunshine duration and rainfall with certain reproductive traits (number of pregnant and non-pregnant ewes). Some reproductive traits of Romanov sheep such as litter size, lambing index, number of total matings, number of pregnant and non-pregnant ewes, fertility, total number of newborns (lambs per ewe and lambs per ewe per year) during the observed period are shown in Table 1. The average monthly air temperature (°C), precipitation (mm) and sunshine duration (hours) in the Bilogora region during the observed period (2019-2021) were compared with the long-term monthly average data obtained for the 70-year period (1949-2019) obtained by the CMHS (Table 2).

Discussion

Extreme environmental conditions act in different ways and negatively affect the reproductive traits of livestock. A direct negative impact of climate elements on sheep reproduction is an increased frequency of breeding disorders (delayed sexual maturity, conception failure, increased early embryo mortality, foetal growth and development arrest, abortion,

stillbirth, etc.). Climate changes can also indirectly impact sheep reproduction. Nutritional stress is caused by a reduced amount and quality of food because precipitation is less or absent, long-term dry periods are more and more frequent, which results in poor crop yields and poor grass growth on pastures (Forcada et al., 1992; Arrébola et al., 2015; Kumar et al., 2017; Đuričić et al., 2019a). Exposure to higher air temperatures for a long time can induce heat stress in animals. In our study, the period of lowest sexual activity was in late spring and mid-summer (from the end of March to May) and during very and extremely warm periods with average air temperature 20.8-23.6°C (June to August), though the complete anestrus was not recorded. The peak of sexual activity was during autumn (end of August to October), when the days became shorter, with a shorter duration of sunshine (on average 265.3 in July to 152.7 hours in October) and a drop in air temperature (from 22.4°C in July to 11.3°C in October). During all three years of the study, average annual air temperatures increased compared to the 70-year reference period (years 2019, 2020 and 2021; respectively by 1.64°C, 1.87°C, and 0.95°C) with

Table 2. The average monthly air temperature (°C), precipitation (mm) and sunshine duration (hours) in Bilogora region during the observed period (2019–2021) and compared with the long-term monthly average data obtained for the 70-year period (1949–2019) obtained by the CMHS

Parameter	Year	January	February	March	April	May	June	July	August	September	October	November	December
Air temperature (°C)	*1949-2019	-0.2	1.9	6.4	11.3	16.0	19.6	21.2	20.5	16.0	10.8	5.8	1.2
	2019	0.9	4.9	9.3	12.1	12.8	23.7	22.1	22.9	17.0	12.8	9.3	2.4
	2020	1.9	10.3	7.7	13.0	14.7	20.0	21.6	22.5	17.8	12.5	6.3	4.7
	2021	2.8	5.3	6.4	9.2	14.1	23.1	23.6	20.8	17.3	9.6	6.4	3.3
	Average	1.9	6.8	7.8	11.4	13.9	22.3	22.4	22.1	17.4	11.6	7.3	3.5
Precipitation amount (mm)	*1949-2019	48.0	47.7	48.8	58.1	78.7	88.3	76.9	77.0	80.1	65.2	79.8	62.5
	2019	32.0	22.5	18.1	84.6	170.1	69.5	91.3	14.4	115.3	45.3	154.7	77.5
	2020	24.9	31.8	43.6	9.3	71.3	60.5	147.3	82.3	77.1	149.1	14.2	82.7
	2021	58.9	44.0	46.8	49.7	86.8	8.4	57.7	65.5	28.4	91.7	74.4	81.9
	Average	38.6	32.8	36.2	47.9	109.4	46.1	98.8	54.1	73.6	95.4	81.1	80.7
Sunshine duration (hours)	*1949-2019	60.7	91.3	148.2	187.9	230.2	246.3	274.1	260.2	190.8	138.3	69.8	46.2
	2019	56	136	176	178	133	272	265	259	188	168	49	63
	2020	98	141	178	285	197	195	277	233	209	142	55	24
	2021	52	145	200	161	173	311	254	242	205	148	41	44
	Average	68.7	140.7	184.7	208.0	167.7	259.3	265.3	244.7	200.7	152.7	48.3	43.7

the assumption that is a consequence of global warming. Besides temperature and sunlight, other factors, such as relative humidity and rainfall, can directly or indirectly prolong the period of reduced sexual activity and significantly affect fertility. The lambing rate was positively correlated with the amount of annual precipitation (Arrébola et al. 2015) during mating, particularly during autumn 2020, so the next lambing season (winter and early spring 2021) brought a significantly larger litter size. The litter size at birth in

the Romanov breed in Turkey was 2.01 (Kutluca Korkmaz and Emsen, 2016) similar to Casas et al. (2005) 2.05–2.12, which was higher than that reported here. The reason for this difference was the method of farming, which was intensive in the previous studies, while in this study, it was semi-intensive.

Therefore, air temperature, precipitation and sunlight duration during different months or seasons could affect the reproductive traits of Romanov sheep in Bilogora region, Croatia.

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Utjecaj nekih klimatskih elemenata na reprodukcijiska svojstva romanovske ovce na području Bilogore

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Cilj je istraživanja bio utvrditi utjecaj temperature zraka, količine dnevnih oborina i trajanja sunčeve svjetlosti na reprodukcijiska svojstva romanovske ovce u području Bilogore, Hrvatska. Životinje su držane na ograđenom rotirajućem pašnjaku s pristupom stajama tijekom noći. Ovce su bile prirodno pripuštane. Tijekom 3 uzastopne godine (2019.-2021.) prikupljeni su podaci o reproduktivnoj učinkovitosti četiri stada ovaca ($n=26-57$). Temperaturu zraka, trajanje sunčeve svjetlosti i dnevne količine oborina prikupio je Hrvatski meteorološki i hidrološki zavod (CMHS), Zagreb, Hrvatska, u najbližoj meteorološkoj postaji za mjerenje, koja je udaljena nalazi unutar 5-15 km od farmi. Pripušteno je ukupno 425 ovaca, od kojih je 399 uspješno koncipiralo i ojanjilo 851 janje. Prosječna veličina legla bila je 1,63; prosječna plodnost tijekom istraživanja bila je 93,88 %. Rasprostranjenost janjenja nije bila tijekom cijele godine ravnomjerno raspoređena, jer je 73 % svih ovaca ojanjeno tijekom zime i proljeća (zimi 51,88 %, u proljeće 21,31 %, u ljeto 13,53 % i u jesen 13,28 %). Spolna aktivnost bila je najniža od kraja ožujka do svibnja, dok je vrhunac

spolne aktivnosti bio od kraja kolovoza do listopada. Postojala je pozitivna ili negativna korelacija ($P<0,0001$ (Kruskall Wallis)) između temperature zraka, trajanja sunčeve svjetlosti i količine oborina s određenim reproduktivnim svojstvima (brojem gravidnih i negravidnih ovaca). Prosječne dnevne temperature najviše su ljeti, no početkom jeseni i početkom sezone razmnožavanja temperature zraka naglo padaju. Isto tako, dan postaje kraći, a noć postaje duža što je ključno za rasplodnu vrstu tzv. short day breeder kao što su ovce i koze. Osim temperature i sunčeve svjetlosti, drugi čimbenici, poput relativne vlažnosti i padalina, mogu izravno ili neizravno utjecati na spolnu aktivnost i znatno utjecati na plodnost. Možemo pretpostaviti da temperatura zraka, količina oborina i trajanje sunčeve svjetlosti tijekom različitih mjeseci ili godišnjih doba mogu utjecati na reproduktivne osobine romanovske ovce na Bilogori u Hrvatskoj.

Ključne riječi: temperatura zraka, količina oborine, reproduktivna svojstva, romanovska ovca, trajanje sunčeve svjetlosti