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THE EFFECT OF CLIMATE CHANGE ON THE REPRODUCTION SEASON OF THE KARAKUL OF BOTOȘANI BREED

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Abstract

Although climate change is a certainty in the current era, very few people are aware of the medium and long-term effects it may cause. Therefore, the purpose of this research was to assess the impact of climate change on the breeding season of Karakul of Botoșani ewes. The research relied on the analysis and interpretation of data concerning the time interval when the first ewes exhibited sexual heat and when over 50% of the total number of ewes assigned for mating were mounted, spanning each season between 2000 and 2022. The biological material studied consisted of a representative population of adult ewes belonging to the Botoșani Karakul sheep breed, located at the Research Station for Sheep and Goats Breeding, in Popăuți-Botoșani. The obtained data highlight that between 2000 and 2011, the first ewes were mounted at the end of August (when the temperature was around 15°C). For the reproduction seasons between 2011 and 2022, it is observed that the period in which the first ewes exhibit sexual cycles shifted towards the middle of September (when the temperature at 8 AM remained around 15°C). Moreover, the period when over 50% of ewes exhibited sexual cycles and accepted mating also shifted towards the latter part of September and the first half of October. Under these conditions, it can be said that the third heat cycle, in which the proportion of mounted ewes exceeded 95%, shifted towards the first half of November.

Key words*: climate change, Karakul, reproduction, sheep.*

INTRODUCTION

The current period is witnessing climate change as one of the most significant threats to the environment, social framework, and economy. Global warming is already a recognized phenomenon and will likely lead to major imbalances in the environment. It will also affect the production and reproduction performance of animals.

According to the sixth assessment report on climate change by the experts of the Intergovernmental Panel on Climate Change (IPCC), human-produced greenhouse gas emissions are responsible not only for the rise in global temperatures but also for substantial and rapid changes in the atmosphere, oceans, cryosphere, and biosphere. The range of global temperature increase caused by humans, starting from 1850, ranges regionally between 0.8°C-1.3°C. What is more concerning is that according to the IPCC report (AR6), it is anticipated that in the coming decades, climate change will affect all regions of the world. As the global temperature rises, extreme changes continue to intensify. Some studies indicate that with every additional 0.5°C increase in temperature, there are noticeable rises in the intensity and frequency of extremes with extremely high temperatures, including heatwaves, heavy rainfall, variations in air current intensity, and intensified meteorological droughts in some regions of the world (IPCC, 2023). In the case of a 2°C temperature increase compared to pre-industrial levels, extreme temperatures would more frequently surpass critical thresholds for agriculture and health.

Despite animals being an important resource for humans, it is observed that people pay too little attention to climate change and the negative effects that can occur in this domain. In animal husbandry, climate change represents an area that is very poorly researched. This is why very little is known about the interactions between the increasing variability of climate

and other factors that can affect animal husbandry systems and development under future pedoclimatic conditions (Thornton et al., 2009).
The effects of global warming will not be negative everywhere in the world and in all agricultural sectors. According to an analysis by Thornton et al. (2007), a slight increase in crop productivity is forecasted for agriculture in medium to high latitudes for a local average temperature increase of 1-3°C. However, in these areas, frost, heatwaves, or heavy rainfall can negate the advantages of increased temperatures. It is believed that a temperature increment of 1-2°C would severely affect crop production, especially cereals, in lower altitude regions. The most affected areas will be those in the northern hemisphere, especially North America, Northern Europe, Northern Asia, and to a lesser latitude, regions such as Mediterranean basin countries, Central and Western Asia (Easterling et al., 2007).
To guide the evolution of animal production systems under the influence of temperature increase and extreme climatological events, better information regarding biophysical and social vulnerability is needed. This information should be integrated with future agricultural and animal husbandry components.

MATERIALS AND METHODS

The area where the research was conducted is situated in the northeastern part of Romania, at 47°44′55 north latitude and 26°40′10 east longitude. This specific area is significantly affected by climate change, particularly the extension of periods with higher temperatures and extremely reduced precipitation.
The research began by observing that in recent times, with atmospheric temperatures frequently exceeding the thermal comfort limit, there has been a considerable change in the onset and execution of mating in Botoșani Karakul sheep breed ewes.
Presumably, these changes in climate are at the root of this situation, generating negative effects on the animals' bodies, affecting their reproductive activity and ovine performances.
To gather accurate information about the impact caused by climate changes on the breeding season, data were collected over a longer period, specifically spanning 20 years. Based on this data, the onset of the breeding season was determined, as well as the calendar interval in each season when the highest proportion of mounted ewes occurred.
All the data used in this study originate from farm records located at the Research and Development Station for Sheep and Goats Breeding, in Popăuți-Botoșani. Specific temperature data for each mating season were obtained from local meteorological stations.

RESULTS AND DISCUSSIONS

Climate change is an undeniable aspect, yet its effects are often controversial. Therefore, the aim of this research was to evaluate the effects caused by climate change on the reproductive activity within a population of sheep belonging to a breed that holds significant importance in the breed structure within the Northeast Region of Romania.
In the unit where the research was conducted, the breeding season traditionally started in the third decade of August and ended in the first half of October. However, in recent seasons, it has been observed that the breeding season's onset has shifted to late September and concluded in the second half of October.
To analyze the data and the conditions under which the reproductive activity occurred, all information regarding the day when the breeding season commenced was extracted from farm records over a representative time interval from 2000 to 2022. Based on these records, the timeframe in which at least 50% of the total allocated females were mated each season was also determined (Table 1 and Table 2).
Additionally, for this timeframe, data on the average values of daytime temperatures recorded at 8 AM on each day of the initial pairings were extracted. The obtained data highlight both consistency in the thermal regime and certain seasonal differences, for the day when the first ewes exhibited the sexual cycle and for the interval in which over 50% of the total ewes assigned for mating were mounted each year (Figure 1).

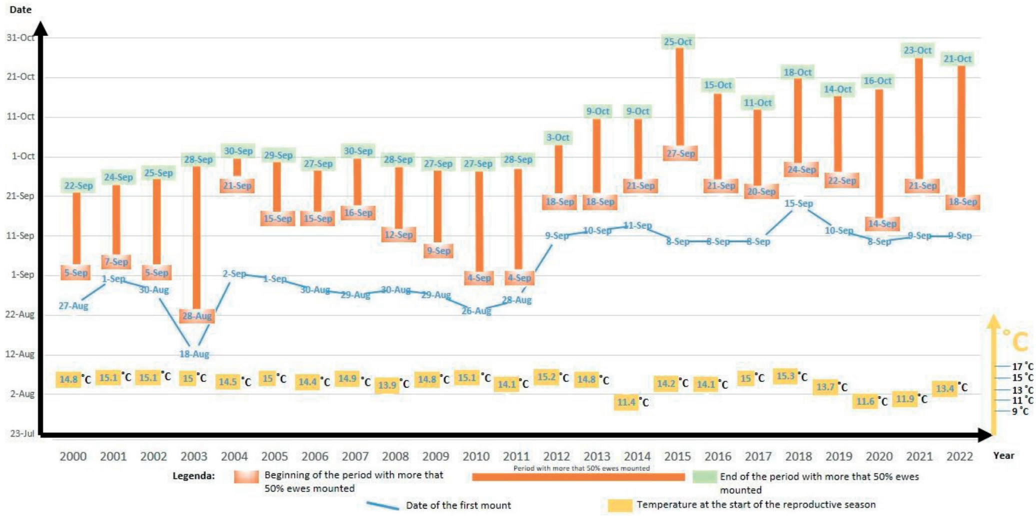

Figure 1. Graphical distribution of temperatures and the onset and end range of ewes' mating season

For the interval between 2000 and 2011, it was observed that the first pairings occurred at the end of August; an exception was noted in the seasons of 2004 and 2005 when the first females exhibited sexual cycles at the beginning of September (under similar thermal conditions to the analyzed time frame).
The analysis of the thermal regime corresponding to the periods of each year when the first females were inseminated highlights that the recorded values at 8 AM fluctuate within a relatively narrow thermal range, between 13.9°C and 15.1°C (Figure 2).

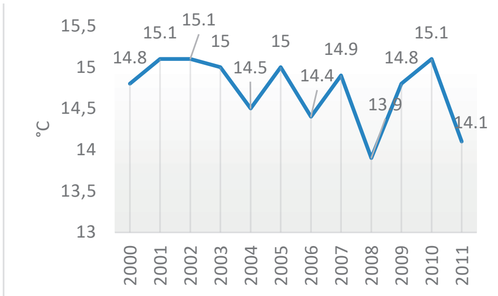

Figure 2. The distribution of the thermal regime when the reproductive activity started in Botoșani Karakul sheep breed

Table 1. The debut of breeding season and the time interval in which >50% of the ewes allocated for mating were inseminated between 2000-2011

Year	The debut of breeding season		The calendar interval during which >50% of the ewes were mated
	The date of first breeding	The temperature at 8 AM (˚C)	
2000	27.08	14.8	05.09 - 22.09
2001	01.09	15.1	07.09 - 24.09
2002	30.08	15.1	05.09 - 25.09
2003	28.08	15.0	18.08 - 28.09
2004	02.09	14.5	21.09 - 30.09
2005	01.09	15.0	15.09 - 29.09
2006	30.08	14.4	15.09 - 27.09
2007	29.08	14.9	16.09 - 30.09
2008	30.08	13.9	12.09 - 28.09
2009	29.08	14.8	09.09 - 27.09
2010	26.08	15.1	04.09 - 27.09
2011	28.08	14.1	04.09 - 28.09

For the time interval between 2000 and 2011, it is also observed that the time boundaries within which mating occurred with a proportion greater than 50% of the number of females allocated for mating, fall in the second half of September each year. In practice, each year, this interval corresponds to the second heat cycle, meaning that the last pairings occurred during the third cycle and concluded in the first half of October.
For the analysis period between 2012-2022, a shift is noticed in the time interval when the first pairings occurred (Table 2). Examining the data related to this aspect reveals that after 2011, there is a shift towards the middle of September regarding the first day when the first adult ewes showing clear signs of entering heat were identified.

Table 2. The debut of breeding season and the time interval in which >50% of the ewes allocated for mating were inseminated between 2012-2022

Year	The debut of breeding season		The calendar interval during which >50% of the ewes were mated
	The date of first breeding	The temperature at 8 AM (˚C)	
2012	09.09	15.2	18.09 - 03.10
2013	10.09	14.8	18.09 - 09.10
2014	11.09	14.1	21.09 - 09.10
2015	08.09	14.2	27.09 - 25.10
2016	08.09	14.1	21.09 - 15.10
2017	08.09	15.0	20.09 -11.10
2018	15.09	15.3	24.09 - 18.10
2019	10.09	13.7	22.09 - 14.10
2020	08.09	13.6	14.09 - 16.10
2021	09.09	13.9	21.09 - 23.10
2022	09.09	13.4	18.09 - 21.10

Throughout the analyzed interval, it is observed that the first pairings occurred between September 8th and 15th. After 2011, there is a tendency noticed for a shift of approximately 14 days in the date when the mating season begins (Table 2).

The data regarding the temperature levels recorded at 8 AM for each day when the first ewes were mated indicate that the average values fall within the same range, ranging between 13.4˚C and 15.3˚C (Figure 3). This aspect was possible because the period when optimal temperatures for triggering heat in sheep shifted towards the second half of September.

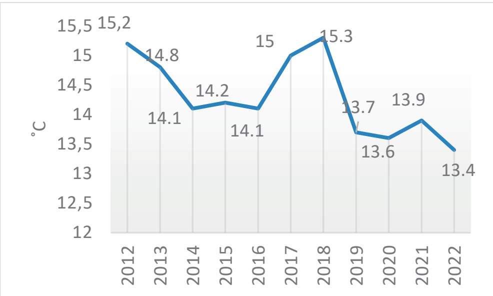

Figure 3. The distribution of the thermal regime when the reproductive activity started in the Botoșani Karakul sheep breed

Furthermore, it is observed that the period during which over 50% of ewes exhibit heat and accept mating has shifted towards the second part of September and the first half of October. Under these circumstances, it can be said that the third heat cycle, during which the proportion of sheep mated in that season exceeds 95%, has shifted towards the first half of November.

Climate change refers to a modification in the climate state that can be identified and persists for an extended period, usually for several decades or more (UNFCCC 2011). Some studies indicate that between 1901 and 2007, the average annual air temperature in Romania increased by 0.5°C (Climate Regions, 2011).

Similarly, data obtained from 94 meteorological stations show significant changes in seasonal average temperatures between 1961-2007. Specifically, during this interval, there was an approximately 2°C increase in average temperatures during summer, winter, and spring, with a slight tendency for a decrease in average temperatures during autumn (MEF, 2010). Other sources present similar findings concerning various temperature extremes, such as daily maximum and minimum temperatures (Busuioc et al., 2015), the number of summer days with temperatures outside comfort limits (Dobrinescu et al., 2015).

Climate change is expected to intensify in the coming years, continuing the trend observed in recent decades. According to the National Meteorological Administration of Romania, in 2021, the average annual temperature was recorded at 10.90°C, with a thermal deviation of 0.69°C compared to the 1981-2020 average, confirming the evident trend of rising air temperatures in recent decades.

According to NMA Romania, positive thermal anomalies for the 2012-2021 period ranged between 0.69°C (2021) and 1.92°C (2019), marking the hottest period of ten consecutive years in the history of meteorological measurements, attributed to climate warming. In descending order, the warmest years in the 2012-2021 period were: 2019, 2020, 2015, 2007, 2018, 2014, 1994, 2009, 2013, 2012, and 2021 (NMA Romania).

Consistent with these values, there is a trend of significant temperature increase for all seasons in recent times, except for autumn, with the highest rate of increase in summer and the lowest in spring (Busuioc et al., 2015).

The increase in average temperatures beyond certain thresholds has been relatively constant in the last 40 years across Europe.

Climatological data analysis for Romania shows a trend of increasing multiannual average temperatures over the past century (Figure 4). Additionally, the research area not only shows a tendency of rising average temperatures but also a reduction in atmospheric precipitation (Figure 5).

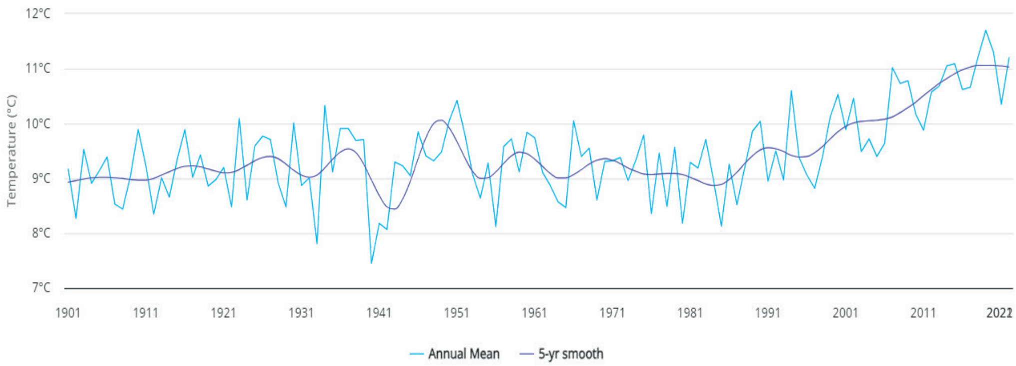

Figure 4. The evolution of multiannual average temperatures in Romania (1901-2022)

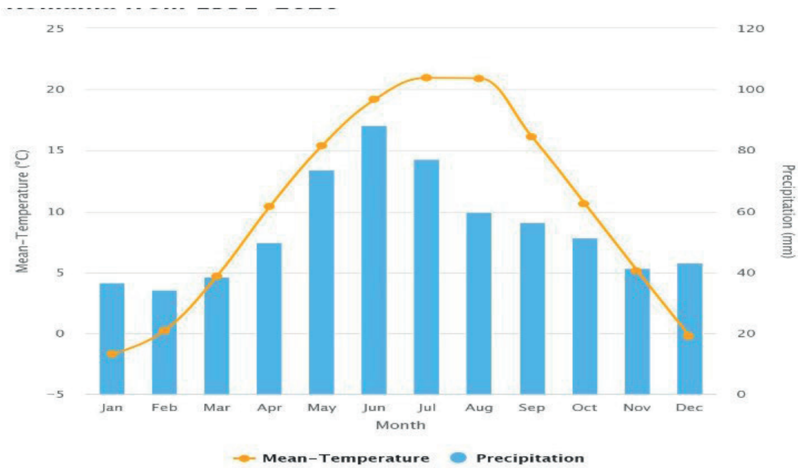

Figure 5. The average monthly temperatures and precipitation patterns in Romania (1991-2020)

Climatological diagrams based on data collected from six weather stations in the North-Eastern Region of Romania indicate a significant reduction in the period when both daytime and nighttime temperatures drop below 0°C, and dry periods have extended in the last 30 years due to climate change.

Air temperature in Botoşani has experienced a remarkable increase statistically significant from 1961 to 2017. The average annual temperature increased by 0.31°C per decade or 1.8°C throughout the period, with the maximum statistical significance ($p < 0.001$). Warm and cold seasons, summers, springs, winters, and the months of January to August notably show a statistically significant increase in air temperature (Strătilă et al., 2021).

Since animal reproduction, including sheep, is a complex process involving various physiological and psychological aspects governed by hormones, metabolites, and environmental factors, it's clear that climate change can lead to certain modifications. Ewes and rams are highly sensitive to high temperatures and undernutrition (Nechifor et al., 2022; Simeanu et al., 2023; Staykova et al., 2023; Pascal et al., 2023).

Continuous exposure of animals to thermal stress compromises growth, milk and meat production, and reproduction. An animal's capacity to mitigate the effects of rising environmental temperatures without progressing towards acquiring stress resistance differs within and between species (Joy et al., 2020).

All reproductive processes, such as gametogenesis, puberty, gamete migration, fertilization, early embryonic development, maternal recognition of pregnancy, gestation, birth, and postpartum recovery, can be indirectly influenced by environmentally-induced stress and directly affected by impairing the functions of reproductive organs or by blocking hormone-mediated cellular functions of the hypothalamic-pituitary-gonadal axis (Florea et al., 2017; Florea et al., 2021; Kumar et al., 2017; Pascal et al., 2008).

Increasing air temperatures cause animals to experience longer periods of heat stress, affecting both rams and ewes. For rams, the increment of body temperature during breeding period stress leads to testicular degeneration, a decrease in the percentage of normal and fertile sperm, reduced ejaculate volume, higher sperm pH, decreased sperm motility, and reduced sperm quality (Hamilton et al., 2016; Rahman et al., 2016). For ewes, exceeding specific thermal comfort limits increases the risk of mammary gland infections in lactating ewes (Koyuncu et al., 2018), as well as reducing lamb birth weights and viability during both colder and hotter months (Luo et al., 2020).

To mitigate the impact of stress factors, farmers need to adapt to current circumstances and adopt technologies and management practices that limit the negative effects of climate change; otherwise, substantial losses may occur.

Losses will arise because the animal environment is affected by key climatic factors (temperature, humidity, radiation, and wind). In any of these situations, extreme climatic values induce a change in energy transfer between the animal and its environment, potentially affecting reproductive activity. Seasonal variations in the environment, alongside nutrition and management, can also lead to changes in estrous activity and its duration. Moreover, it's known that conception rates are reduced under heat and cold stress, and endocrine functions are altered by climatic extremes (Gwazdauskas, 1985).

Regarding sheep, Narayan et al. (2018) specify that heat stress reduces embryo production during artificial insemination or embryo transfer due to disruptions in essential physiological elements, affecting not only reproductive function but also early embryo development in pregnant ewes.

Climate change and the increase in days when temperatures exceed normal limits can diminish the reproductive capacity of ewes because physiological adaptations struggle to cope with heat stress (Hansen, 2007a; Hansen, 2007b).

Extreme climatic conditions are undesirable as they can trigger physiological, biochemical, hematological, and hormonal changes that can affect the active maintenance of homeothermy and the productivity of sheep. Knowing the comfort limits and ensuring constant optimal values are challenging to manage during the warm season. Under these conditions, heat stress occurs, leading to disturbances in mechanisms responsible for heat stress tolerance in animals (McManus et al., 2020).

Apart from the effects of climate change on ecosystems, it's evident that prolonged periods of high temperatures will significantly alter the natural resources essential for animal production. Climate features such as temperature and precipitation levels have a significant impact on pasture productivity and other resources, affecting the ruminants' growth process (Tüfekci et al., 2021).

Several studies demonstrate that climate change and its disruptive factors can affect sheep in two ways: directly by reducing lamb survival rates and indirectly by influencing the vegetation season, endangering net primary productivity of pastures and forage availability (Castillo et al., 2021).

CONCLUSIONS

Climate change, mainly due to rising temperatures, affects the reproductive activity of Botoșani Karakul sheep breed.

Since 2011, the period when over 50% of ewes exhibit heat and accept mating has shifted towards the latter part of September and the first half of October.

This alteration of the period of sexual cycles manifestation also leads to a shift towards early November when over 95% of ewes forming the livestock exhibit sexual cycles and become pregnant.

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