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The Link Between Ixodid Tick Populations and Climate Change in the Stavropol Region

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ABSTRACT

The parasitism of livestock by ixodid ticks, which transmit blood-borne parasitic diseases, is a major challenge in animal husbandry. This research focuses on how climate change affects the diversity of ixodid tick species. Data from the Kislovodsk meteorological station, including average winter temperature, wind speed, and the variability and trends of the Bodman index (which indicates climate severity), were analyzed. The distribution of ixodid ticks is closely tied to the climatic zones. In the Stavropol region, 16 species of ixodid ticks across 6 genera have been recorded. Monitoring from 1999 onwards reveals a growing number of ixodid tick species. As the region experiences warming temperatures, milder winter conditions have led to an expansion of suitable habitats for ixodid ticks and a corresponding increase in their numbers.

Keywords: Stavropol, Insects, Climate change, Parasites

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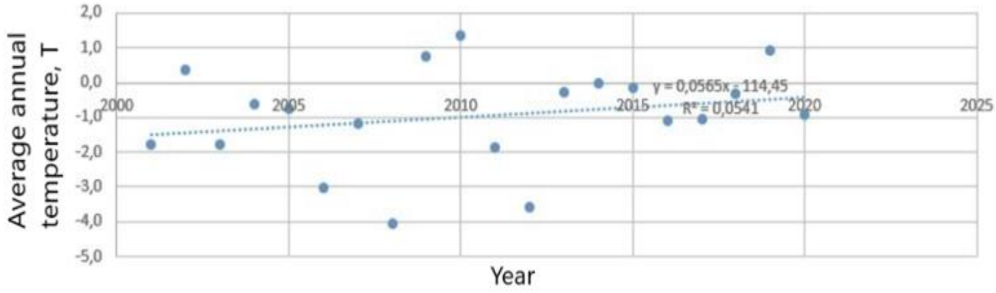
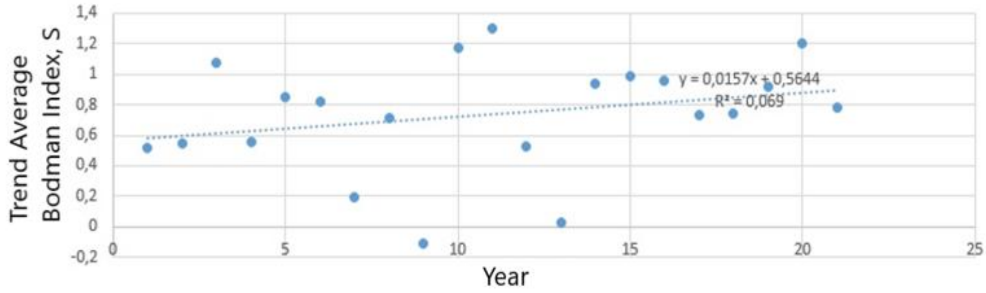
Introduction

The Stavropol region is situated in the southern part of Russia, between 43°45' and 46°15' north latitude and 40°50' and 45°40' east longitude. It includes the central section of the Pre-Caucasus, the western Caspian lowlands, and part of the northern slopes of the Greater Caucasus near the Caucasian Mineral Waters [1, 2]. The terrain is characterized by flatlands and foothills, with much of the flat area consisting of the Stavropol upland, parts of the Azov-Kuban lowland, the Kumo-Manych depression (at 20 meters above sea level), and the Caspian lowland [3]. These geographical features and climate create ideal conditions for the development of livestock farming, particularly dairy and beef cattle, and fine-wool sheep. However, one of the major challenges impacting animal husbandry in the region is the infestation of livestock by ixodid ticks, which serve as vectors for various blood parasitic diseases such as piroplasmosis, teileriosis, and anaplasmosis [4].

Temperature and precipitation at the Earth's surface are key climatic factors used to characterize landscapes and serve as indicators of climate change [5]. Experts have noted that the global surface temperature has risen by 0.6 ± 0.2 °C over the past century [6]. This shift in climate has been linked to changes in both ecological and human-driven systems, such as agriculture [7]. Rising temperatures may lead to shifts in climatic zones and an overall increase in average temperature [8]. Additionally, the Stavropol region has experienced a significant warming trend during the winter months **(Figure 1)**.



a)



b)

Figure 1. Fourier analysis (2001-2020): a) trend of the mean annual temperature, and b) average trend of the Bodman index.

Research has indicated that from 2001 to 2016, the average winter temperature rose by 0.9 degrees Celsius in the northern part of the region, 0.7 °C in Kislovodsk, and 1.1 °C in Stavropol compared to the 1961-2000 period. This upward trend continued through 2017-2020 [9]. Additionally, a significant increase in temperature was observed during the warm season, leading to the necessity for the agricultural sector to implement strategies to adjust crop production to the evolving climate conditions [10].

Some researchers suggest that warming is evident across the entire region, and certain landscapes may now fit into different climate zones based on the moisture conditions, which depend on the ratio of heat and moisture supply [11]. This hypothesis has been supported by subsequent investigations of the Stavropol climate. As the climate continues to change, with both temperature and precipitation rising simultaneously, these shifts are particularly important for dry-steppe ecosystems [12].

In the 21st century, the average start of spring in the Central Caucasus region occurs on February 16, ranging from February 11 in Novoaleksandrovsk to February 25 in Kislovodsk. Throughout the 2000s, the first consistent transition of the daily average temperature above 0 °C happened four times in January, seven times in February, and nine times in March. The earliest spring onset was recorded in 2013 on January 19, and the latest on March 16, 2012, a phenomenon that aligns with global warming trends. While the warming effect is most noticeable in the northern regions, many scientists argue that the primary contributor to the rise in average yearly temperatures in both middle and southern latitudes is the increase in winter temperatures [13].

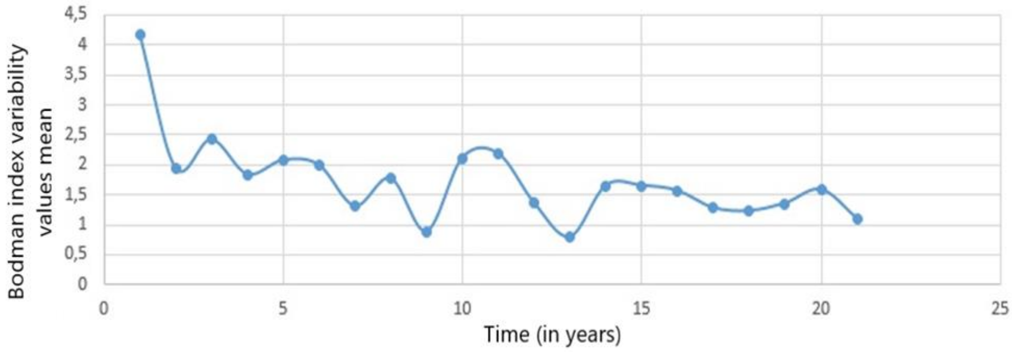


Figure 2. Variability spectrum of the Bodman index.

The evaluation of bioclimatic conditions using the Bodman index, moisture coefficient, and other indices derived from standard climatic parameters will help to identify the connection between climate, landscape characteristics, and the distribution of ixodid ticks **(Figure 2)** [14]. This study examines the impact of climate change on the diversity of ixodid tick species.

Materials and Methods

Since 1999, ongoing monitoring of ixodid ticks in the Stavropol region has revealed a trend of expanding species diversity, which correlates with conditions that are becoming more conducive to the spread of blood parasitic diseases [15, 16].

The foundation of the research consists of meteorological data collected over the last two decades by the ground network of the Stavropol Center for Hydrometeorology and Environmental Monitoring. Supplementary reference data on temperature patterns and wind speeds at the station's location during two extended periods of the 20th century were also incorporated.

For the research conducted at the Kislovodsk weather station, the following factors were assessed:

- The average temperature during the winter months
- The typical wind speed in winter
- The changes and overall trend of the Bodman index in the Kislovodsk resort reflects the climate's harshness.

To study the ixodofauna, four regions in the zone of sufficient moisture were surveyed: Mineralovodsk, Predgornyy, Georgievsk, and Kirovsk districts, as well as the species composition of ixodid ticks in Kislovodsk. Tick samples were gathered using a standard flag, a light-colored flannel cloth measuring 1 meter in length and 0.6–0.7 meters in width, as well as through direct collection from animals. The tick sampling took place between March and May, July, and August to October from 2016 to 2022. The identification of ixodid ticks was conducted in the veterinary laboratory of the All-Russian Research Institute of Sheep and Goat Breeding, a division of the North Caucasus Federal Scientific Agrarian Center, using a binocular microscope (MBS-2) and following the guidelines for monitoring ixodid ticks in the Stavropol region [17].

Results and Discussion

In the Stavropol region, sixteen species of ixodid ticks from 6 genera have been found to parasitize [18]. These ticks are highly specialized parasites of terrestrial vertebrates, particularly birds and mammals [19, 20]. The epidemiological and epizootological importance of ixodid ticks lies in their role in transmitting pathogens responsible for a variety of serious vector-borne diseases to both humans and animals, including bacteria, rickettsiae, viruses, protozoa, and spirochaetes [21].

The spread of ixodid tick species is primarily determined by the climatic zones. The region includes four agricultural zones: extremely arid, arid, a zone of unstable moisture, and a zone with adequate moisture [9, 22]. The adequate moisture zone, encompassing the Mineralovodsk, Predgornyy, Georgievsk, and Kirovsk districts, lies across the foothill plains of the Caucasus. The climatic conditions in this zone resemble those of the forest steppe, where the evaporation rate is almost equal to the precipitation, allowing for the evaporation of 500-700

mm of water. The humidity coefficient in this area ranges from 0.7 to 1.0. Winter in the sufficient moisture zone generally starts in late November or December and concludes in early March.
The ixodofauna of this region from 2016 to 2022 is detailed in **Table 1**. An upward trend in the number of ixodid species is evident. In the period from 1999 to 2006, the ixodofauna in these areas consisted of 6 species from 5 genera, whereas by 2016-2022, 12 species from 6 genera were identified. In 2022, Kislovodsk itself saw the presence of 9 species from 5 genera (*Hyalomma*, *Dermacentor*, *Rhipicephalus*, *Ixodes ricinus*, and *Haemaphysalis*) within its biotope.

Table 1. Comparison of Ixodofauna in the zone of sufficient humidification of the Stavropol Territory for the periods 1999-2006 and 2016-2022

DISTRICTS	**TYPE OF TICKS**	
	1999 -2006	**2016-2022**
Mineralovodsk district	*Boophilus calcaratus (annulatus)* *Hyalomma marginatum* *Dermacentor marginatus* *Dermacentor pictus* *Rhipicephalus sanguineus* *Ixodes ricinus*	*Boophilus calcaratus (annulatus)* *Hyalomma marginatum* *Dermacentor marginatus* *Dermacentor pictus* *Rhipicephalus sanguineus* *Ixodes ricinus*
Predgornyy district	*Hyalomma marginatum* *Dermacentor marginatus*	*Hyalomma marginatum* *Hyalomma anatolicum* *Dermacentor marginatus* *Dermacentor pictus* *Dermacentor daghestanicus*
Georgievsk district	*Boophilus calcaratus (annulatus)* *Hyalomma marginatum* *Dermacentor marginatus*	*Boophilus calcaratus (annulatus)* *Hyalomma marginatum* *Hyalomma scupense* *Hyalomma anatolicum* *Hyalomma detritum* *Dermacentor marginatus* *Dermacentor pictus* *Dermacentor daghestanicus* *Rhipicephalus sanguineus* *Rhipicephalus turanicus* *Ixodes ricinus*
Kirovsk district	*Boophilus calcaratus (annulatus)* *Hyalomma marginatum* *Dermacentor marginatus* *Ixodes ricinus*	*Boophilus calcaratus (annulatus)* *Hyalomma marginatum* *Hyalomma anatolicum* *Dermacentor marginatus* *Dermacentor pictus* *Ixodes ricinus*
Kislovodsk city	*Hyalomma marginatum* *Dermacentor marginatus* *Dermacentor pictus* *Ixodes ricinus*	*Hyalomma marginatum* *Hyalomma scupense* *Hyalomma anatolicum* *Dermacentor marginatus* *Dermacentor pictus* *Dermacentor daghestanicus* *Rhipicephalus sanguineus* *Ixodes ricinus* *Haemaphisalis punctate*

One possible factor behind the widespread distribution of ixodid ticks is the rise in average winter temperatures, which supports the expansion and proliferation of biotopes conducive to ixodid hatching.

Conclusion

The data analysis indicated that frosts are common in both the autumn and spring seasons in Kislovodsk and throughout the region. A frosty day is defined as one where the minimum air temperature falls below 0 °C on at least one occasion, but the average daily temperature stays positive. The last frost in spring marks the beginning of the frost-free period, while the first frost in autumn marks its end. Despite the general trend of warming temperatures, the frost-free period in the region is expected to lengthen. However, due to increasing climate instability, there could still be late spring frosts and early autumn frosts, which might reduce the overall frost-free period.

Over the past five decades, the growing season for natural vegetation and crops in the northern hemisphere has lengthened by approximately 1 to 4 days per decade, particularly in higher latitudes. The range of plant growth and animal habitats has shifted poleward and to higher elevations. There has been an earlier onset of flowering, bird arrivals, and insect appearances. Additionally, average annual temperatures in the region have risen, primarily due to warming during the colder months. Despite this overall warming trend, some months during the warmer period show a tendency for cooling across most landscape zones.

Research indicates that the ongoing climate warming in the region has led to a reduction in the intensity of bioclimatic conditions, particularly during the winter. This change has contributed to the expansion and growth of biotopes favorable for ixodid ticks.

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Conflict of Interest: None

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Ethics Statement: None

References

1. Saaty AH. Grapefruit seed extracts’ antibacterial and antiviral activity: anti-severe acute respiratory syndrome coronavirus 2 impact. Arch Pharm Pract. 2022;3(1):68-73.
2. Ahmed F. Hypoglycemic potential of Basella Alba Linn.-an in vitro study. Arch Pharm Pract. 2022;13(1):18-23.
3. Belozerov V, Alexander P, Prikhodko R, Chihichin V, Cherkasov A. Gis ‘ethnic atlas of Stavropol territory. InterCarto. InterGIS. 2015;1:13-8. doi:10.24057/2414-9179-2015-1-21-13-18
4. Fedonyuk LY, Pryvrotska IB, Podobivskyi SS, Rujytska OY, Stravskyy YS, Zhyhalyuk SV. Ticks of genus Ixodidae: bioecological mechanisms of adaptation to environmental conditions, medical and epidemiological significance. Ukr J Ecol. 2020;10(6):236-42. doi:10.15421/2020_288
5. Haylock MR, Hofstra N, Klein Tank AM, Klok EJ, Jones PD, New M. A European daily high-resolution gridded data set of surface temperature and precipitation for 1950–2006. J Geophys Res Atmos. 2008;113(D20). doi:10.1029/2008JD010201
6. Jones PD, New M, Parker DE, Martin S, Rigor IG. Surface air temperature and its changes over the past 150 years. Rev Geophys. 1999;37(2):173-99. doi:10.1029/1999RG900002
7. Aydinalp C, Cresser MS. The effects of global climate change on agriculture. Am-Eurasian J Agric Environ Sci. 2008;3(5):672-6.
8. Sivaramanan S. Global warming and climate change, causes, impacts and mitigation. Cent Environ Auth. 2015;2(4). doi:10.13140/RG.2.1.4889.7128
9. Antonov S, Katorgin I. Mapping the characteristics of climate change in Stavropol region. InterCarto. InterGIS. 2021;27:171-82. doi:10.35595/2414-9179-2021-3-27-171-182

10. Vadez V, Kholova J, Choudhary S, Zindy P, Terrier M, Krishnamurthy L, et al. Responses to increased moisture stress and extremes: whole plant response to drought under climate change. Crop Adapt Clim Change. 2011:186-97. doi:10.1002/9780470960929.ch14
11. Kulichenko AN, Prislegina DA. Climatic prerequisites for changing activity in the natural crimean-congo hemorrhagic fever focus in the South of the Russian federation. Russ J Infect Immun. 2019;9(1):162-72. doi:10.15789/2220-7619-2019-1-162-172
12. Pismennaya EV, Stukalo VA, Volters IA, Azarova MY, Perederieva VM, Faizova VI. Optimization of agriculture land use development basing on natural-resource potential (On the example of the Stavropol territory). KnE Life Sci. 2019:448-57. doi:10.18502/kls.v4i14.5632
13. Savinova SV, Loshakov AV, Bratkov VV, Lomakin GV, Ivanova NA. Current climate conditions and their impact on agricultural production in Stavropol Krai. InIOP conference series: earth and environmental science 2020 Oct 1 (Vol. 579, No. 1, p. 012010). IOP Publishing. doi:10.1088/1755-1315/579/1/012010
14. Olga V, Ilyinskikh E, Rudikov A, Poltoratskaya T, Irina E, Lukashova L. Clinical and epidemiological manifestations of Ixodic tick-borne borreliosis foci in the Tomsk region. Epidemiol Vaccinal Prev. 2022;21(4):70-9. doi:10.31631/2073-3046-2022-21-4-70-79
15. Almalki G, Rabah S, Al-Faifi Z, Alharbi A, Sharma M. Phytochemistry screening, antioxidant and antimicrobial activities of euphorbia inarticulata schweinf plant extract. Pharmacophore. 2022;13(1):91-9.
16. Kale BS, Bhale MS, Bhagat AB, Khairnar SA. Pharmacognostic evaluation of osyris quadripartita salz. Ex decne. Pharmacophore. 2022;13(3):50-6.
17. Pushkin SV, Tsymbal BM, Nagdalian AA, Nuzhnaya KV, Sutaeva AN, Ramazanova SZ. The use of model groups of necrobiont beetles (Coleoptera) for the diagnosis of time and place of death. Entomol Appl Sci Lett. 2019;6(2):46-56.
18. Nurcahyo H, Sumiwi SA, Halimah E, Wilar G. Secondary metabolitm determination from Brebes shallot’s ethanol extract and its ethyl acetate fraction “Allium ascalonicum L.”. J Pharm Educ Res. 2022;12(1):70-3.
19. Sándor AD, Milchev B, Takács N, Kontschán J, Szekeres S, Hornok S. Five ixodid tick species including two morphotypes of Rhipicephalus turanicus on nestlings of Eurasian eagle owl (Bubo bubo) from south-eastern Bulgaria. Parasit Vectors. 2021;14(1):334. doi:10.1186/s13071-021-04832-0
20. Peñalver E, Arillo A, Delclòs X, Peris D, Grimaldi DA, Anderson SR, et al. Ticks parasitised feathered dinosaurs as revealed by Cretaceous amber assemblages. Nat Commun. 2017;8(1):1924. doi:10.1038/s41467-017-01550-z
21. Sándor AD, Mihalca AD, Domşa C, Péter Á, Hornok S. Argasid ticks of Palearctic bats: distribution, host selection, and zoonotic importance. Front Vet Sci. 2021;8:684737. doi:10.3389/fvets.2021.684737
22. Lubova V, Leonova G, Shutikova A. Role of ixodic ticks in circulation of tick--borne infections in the south of the Far East. Hum Ecol. 2020;27:58-64. doi:10.33396/1728-0869-2020-2-58-64