Entomology and Applied Science Letters
Volume 10, Issue 1, Page No: 106-111

Available Online at: www.easletters.com

ISSN No: 2349-2864

The Relationship between the Population of Ixodid Ticks and Climate Change in Stavropol Region

Robert Gurgenovich Zakinyan[1], Galina Khamzatovna Badakhova[1], Maria Sergeevna Lopteva[2], Natalya Anatolyevna Koshkina[2], Vasiliy Petrovich Tolokonnikov[3], Sergey Nikolaevich Povetkin[4*]

[1]Department of Theoretical and Mathematical Physics, Faculty of Physics and Technology, North Caucasus Federal University, Stavropol, Russia.
[2]Laboratory of Veterinary Medicine, Department of Animal Husbandry and Veterinary Medicine, Federal State Budgetary Scientific Institution "North Caucasus Federal Scientific Agrarian Center", Mikhaylovsk, Russia.
[3]Department of Parasitology and Veterinary Examination, Anatomy, and Pathanatomy named after Professor S.N.Nikolsky, Faculty of Veterinary, Stavropol State Agrarian University, Stavropol, Russia.
[4]Laboratory of Food and Industrial Biotechnology, Faculty of Food Engineering and Biotechnology, North Caucasus Federal University, Stavropol, Russia.

ABSTRACT

One of the main factors hindering the development and causing damage to animal husbandry is the parasitism of animals of ixodid ticks - carriers of pathogens of blood parasitic diseases. In the course of this scientific work, a study was made of the influence of changes in climatic conditions on the species composition of ixoid ticks. In the course of the work, for the meteorological station in Kislovodsk, the average winter temperature was calculated, as the average winter wind speed, and the variability, and trend of the Bodman index, characterizing the severity of the climate. The distribution of ixodid tick species largely depends on climatic zones. On the territory of the Stavropol Region, parasitism of 16 species of ixodid ticks belonging to 6 genera was established. Monitoring of ixodid ticks on the territory of the Stavropol Region since 1999 has shown a trend toward an increase in the species composition of ixodid. During the period of climate warming in the territory of the region, there is a weakening of the severity of bioclimatic conditions, especially in winter, which entails the spread and increase in the number of biotopes of ixodid ticks.

Keywords: Insects, Parasites, Climate change, Stavropol.

HOW TO CITE THIS ARTICLE: Zakinyan RG, Badakhova GK, Lopteva MS, Koshkina NA, Tolokonnikov VP, Povetkin SN. The Relationship between the Population of Ixodid Ticks and Climate Change in Stavropol Region. Entomol Appl Sci Lett. 2023;10(1):106-11. https://doi.org/10.51847/P1wGJHRvQE

***Corresponding author:** Sergey Nikolaevich Povetkin
E-mail ✉ serenkiy7@yandex.ru
Received: 27/10/2022
Accepted: 07/03/2023

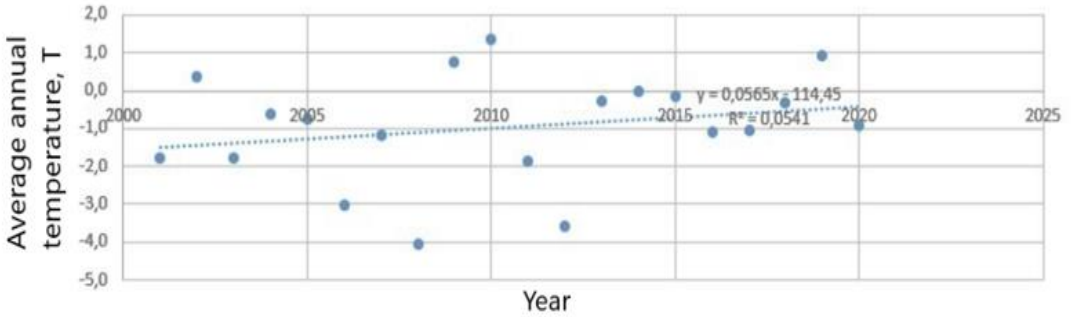
INTRODUCTION

Stavropol Region is located in the southern part of the Russian Federation, between 43’45” and 46’15” north latitude and 40’50” and 45’40” east longitude. It occupies the central part of the Pre-Caucasus, the western part of the Caspian lowland, and partly the northern slopes of the Greater Caucasus in the area of the Caucasian Mineral Waters [1, 2]. According to the relief, the Region is divided into a flat part and a foothill strip. Most of the flat territory is occupied by the Stavropol upland and adjacent parts of the Azov-Kuban lowland, the Kumo-Manych depression (20 m above sea level), and the Caspian lowland [3]. These territorial and climatic conditions contribute to the favorable development of the livestock industry: dairy and beef cattle breeding, and fine-wool sheep breeding. One of the main

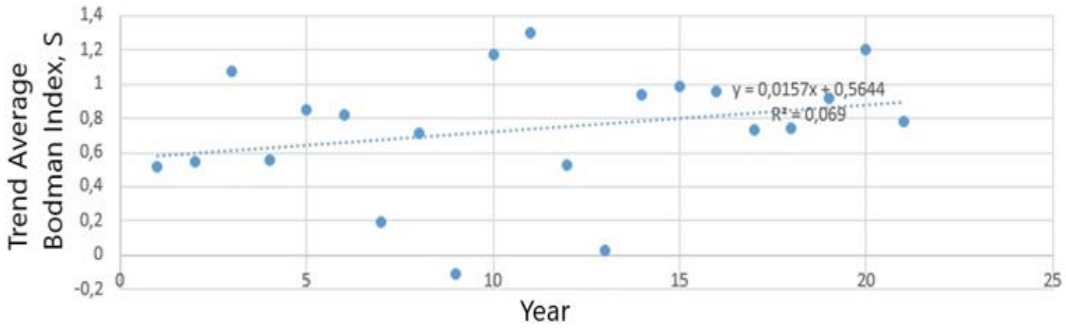
factors constraining the development and causing damage to animal husbandry is the parasitization of ixodid ticks on animals – carriers of pathogens of blood-parasitic diseases (piroplasmidosis, teileriosis, anaplasmosis, etc.) [4].

In the vast majority of cases, the most important climatic parameters used both for the identification and classification of landscapes and as indicators of climate change are the air temperature at the earth's surface and precipitation [5]. According to experts, over the past 100 years, the global air temperature at the earth's surface has increased by 0.6±0.2°C [6]. The influence of Regional climate changes on ecological and anthropogenic (including agriculture) systems has been established [7]. A change in climatic conditions towards warming can lead to a shift in climatic zones, as well as to an increase in average temperature [8].

There was also a noticeable increase in the temperature regime of the winter period in the Stavropol Region **(Figures 1a and 1b)**.



a)



b)

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

Several studies have shown that from 2001-2016 the average winter temperature increased by 0.9°C in the north of the Region, by 0.7°C in Kislovodsk, and by 1.1°C in Stavropol compared to 1961-2000. In 2017-2020, the noted trend continued [9]. However, it was also noted that an increase in temperature takes place during the warm season. Moreover, this increase is so noticeable that in the agricultural sector of the economy, there is a need to take measures to adapt crop production to new climatic conditions [10].

Some authors believe that the warming is significant throughout the territory of the Region and some landscapes can already be attributed to another landscape zone according to the conditions of humidification (by the ratio of heat and moisture supply) [11]. These conclusions were confirmed by further studies of the Stavropol climate. Since the ongoing climate changes are expressed in the fact that both temperatures and precipitation are increasing at the same time, the overall result of these changes is of particular interest for dry-steppe landscapes [12].

In the XXI century, the average date of the onset of spring in the Central Caucasus Region is February 16, from February 11 in Novoaleksandrovsk to February 25 in Kislovodsk. In the new century, four times the average date for the Region of a steady transition of the average daily temperature through 0 0C

fell in January, 7 times - in February, and 9 times - on March. The earliest onset of spring was noted in 2013 - on January 19, and the latest - on March 16 - in 2012, which is inclusive of the concept of global warming. The warming is most noticeable in the northern latitudes. However, many researchers believe that in both middle and southern latitudes, the main contribution to the increase in average annual temperatures is made by the increase in winter temperature [13].

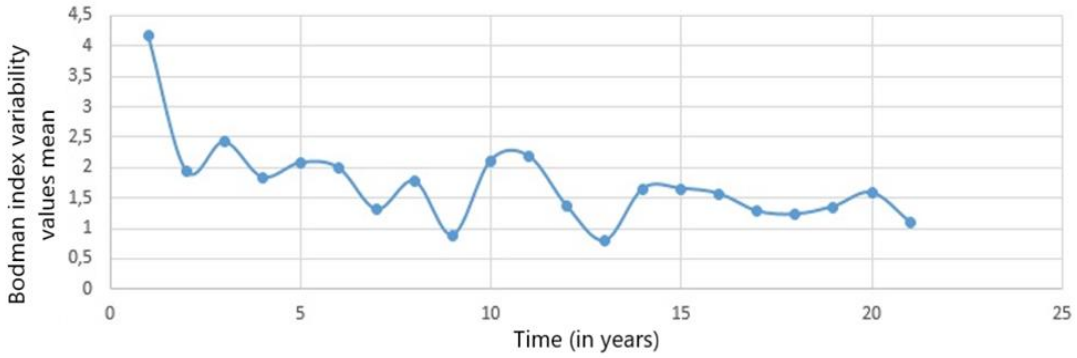


Figure 2. Spectrum variability of the Bodman index

Assessment of bioclimatic conditions based on the Bodman index, moisture coefficient, and other coefficients and indices based on typical climatic parameters will trace the relationship between climatic conditions, landscape appearance, and the spread of ixodid ticks **(Figure 2)** [14].

MATERIALS AND METHODS

Having been engaged in the monitoring of ixodid ticks on the territory of the Stavropol Region since 1999, we found a tendency to increase the species composition of ixodids and unfavorable points for the spread of blood parasitic diseases [15, 16].

The information base for the research work was the materials of meteorological observations of the ground network of the Stavropol Center for Hydrometeorology and Environmental Monitoring over the past 20 years, as well as reference data on the temperature regime and wind speed in the area of the station location for two long-term periods of the year of the twentieth century.

During the research work for the Kislovodsk weather station, the following indicators were calculated:

- average winter temperature;
- average winter wind speed;
- variability and trend of the Bodman index in the resort of Kislovodsk, characterizing the severity of the climate.

To monitor the ixodofauna, we investigated four areas of the zone of sufficient moisture: Mineralovodsk, Predgornyy, Georgievsk, and Kirovsk districts, as well as the species composition of the ixodids ticks of the city of Kislovodsk. The collection of ticks was carried out using a standard flag – a piece of light-colored flannel with a length of 1 m and a width of 0.6–0.7 m, as well as by collecting directly from animals. The collection of ticks was carried out in March–May, July, and August - October 2016 - 2022.

Typing of ixodid ticks was carried out in the laboratory of veterinary medicine of the All-Russian Research Institute of Sheep and Goat Breeding - Branch of the Federal State Budgetary Scientific Institution North Caucasus Federal Scientific Agrarian Center under a binocular magnifying glass (MBS-2 binocular microscope) using the Methodological guide for accounting and distribution of ixodid ticks in Stavropol Region [17].

RESULTS AND DISCUSSION

On the territory of the Stavropol Region, parasitization of 16 species of ixodid ticks belonging to 6 genera has been established [18]. All ixodids are highly specialized parasites of terrestrial vertebrates, especially mammals and birds [19, 20]. The epizootological and epidemiological significance of ixodid ticks is determined by their participation in the transmission of pathogens of many dangerous

vector-borne infections to humans and animals (bacteria, rickettsias, viruses, protozoa, spirochaetes) [21].

The distribution of ixodid ticks species depends more on climatic zones. There are four agricultural zones in the Region: extremely arid, arid, unstable humidification zone, and a zone of sufficient humidification [22, 23]. The zone of sufficient moisture, which includes the Mineralovodsk, Predgornyy, Georgievsk, and Kirovsk districts, covers the sloping plains of the foothills of the Caucasus. The humidification conditions in this zone correspond to the forest steppe, i.e. the evaporation rate is not much higher than the amount of precipitation, and 500-700 mm can evaporate. The humidification coefficient ranges from 0.7–1.0. In the zone of sufficient moisture, winter usually begins in late November-early December and ends in the first decade of March.

The ixodofauna of the zone of sufficient moisture for the period 2016-2022 is presented in **Table 1**.

The dynamics towards an increase in the species composition of ixodids is traced. If in the period 1999 – 2006, the ixodofauna of the areas of the zone of sufficient moisture was represented by 6 species belonging to 5 genera, then already in the period 2016-2022 12 species of ixodid ticks belonging to 6 genera parasitize in these territories.

In the city of Kislovodsk itself in 2022 appeared in the biotope of 9 species belonging to 5 genera (Hyalomma, Dermacento, Rhipicephalus, Ixodes ricinus, Haemaphisalis).

Table 1. Ixodofauna of the zone of sufficient humidification of the Stavropol Territory in the period from 1999 – 2006 to the period 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 of the factors of such a spread of ixodid ticks is certainly an increase in the average winter temperature, which contributes to the spread and increase in the number of biotopes favorable for the hatch of ixodids.

CONCLUSION

Analysis of the data obtained showed that both for Kislovodsk and for the entire territory of the Region, frosts are a characteristic feature of the spring and autumn periods.

For a day with frost, a day is taken on which at least one of the dates the minimum air temperature was below 0 °C, while the average daily temperature is positive. The date of the last spring frost marks the beginning of the frost–free period, and the date of the first autumn frost marks its end. In accordance with the general trend of climate warming, the duration of the frost-free period in the territory of the Region should increase. However, due to increased climate instability, both late frosts in spring and early frosts in autumn can be expected, which may lead to a reduction in the frost-free period.

The growing season of crops and natural vegetation has been lengthened by about one to four days per decade over the past 50 years in the northern hemisphere, especially in high

latitudes. The boundaries of plant growth and animal habitat have shifted towards the pole and up in absolute height. There is an earlier flowering, an earlier arrival of birds, and an earlier time of the appearance of insects in the northern hemisphere. There is also an increase in average annual temperatures in the Region, largely due to the warming of the cold period of the year. During the warm period, despite the general increase in the temperature background, in some months there is a tendency for cooling in almost all landscape zones.

These studies show that during the period of climate warming in the territory of the Region, there is a weakening of the severity of bioclimatic conditions, especially in winter, which entails the spread and increase in the number of biotopes of ixodid ticks.

ACKNOWLEDGMENTS: The authors are thankful to Dr. Sergey Pushkin for assistance in conceptualization and methodology.

CONFLICT OF INTEREST: None

FINANCIAL SUPPORT: The study was funded by a grant from the Ministry of Science and Higher Education of the Russian Federation "Study of the mechanisms of interaction of lactic acid microorganisms, lactose-fermenting yeast and biologically active substances during micro capsulation of various fractions of microbiota" by Decree of the Government of the Russian Federation No. 220 in the form of a subsidy from the federal budget for state support of scientific research conducted under the leadership of leading scientists of Russian educational institutions of higher education, scientific institutions and state scientific centers of the Russian Federation (IX stage), Agreement No. 075-15-2022-1129 01.07.2022.

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;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;21:70-9. 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
23. Antonov SA, Katorgin IY. 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