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ВЛИЯНИЕ АГРОКЛИМАТИЧЕСКИХ УСЛОВИЙ НА ЗАБОЛЕВАЕМОСТЬ БРУЦЕЛЛЕЗОМ СЕВЕРНЫХ ОЛЕНЕЙ В АРКТИЧЕСКИХ РАЙОНАХ ЯКУТИИ

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Изучено распространение бруцеллеза среди северных оленей в зависимости от агроклиматических условий их содержания. Эксперимент проведен в Момском, Нижнеколымском и Эвено-Бытантайском районах Якутии в 2012–2019 гг. Показано, что за исследуемый период по всем районам годовая температура воздуха была выше нормы на 1,1…1,9 °С за счет более значительного ее повышения в холодный период (на 1,5…2,8 °С) по сравнению с теплым (на 0,5…0,6 °С). Наибольшее повышение температуры отмечено в апреле (на 2,8…4,4 °С) и ноябре (на 2,2…4,1 °С), в весенне-летний период – в мае (на 0,9…1,7 °С), в июле она была ниже нормы на 0,2…1,0 °С. Годовое количество осадков на территории Эвено-Бытантайского района изменялось незначительно, на территории Момского и Нижнеколымского районов увеличилось на 40 и 70 мм соответственно. Заболеваемость бруцеллезом северных оленей в зависимости от места (района) их содержания и погодных условий составляла от 0 до 3,86% (коэффициент вариации 131%), меньше заболевших животных было на территории Нижнеколымского района (0,20%), больше – Эвено-Бытантайского (1,15%). Между заболеваемостью северных оленей бруцеллезом и температурой за холодные месяцы и годовой температурой установлена отрицательная связь (r = –0,19…–0,42), с температурой весенне-летних месяцев – средняя положительная (r = 0,30…0,53) с достоверным уровнем в июле. В целом, на заболеваемость температура оказывала большее влияние (r^2 = 0,115), чем осадки (r^2 = 0,092), однако между суммой осадков за год и заболеваемостью животных выявлена существенная обратная связь (r = –0,48; r^2 = 0,23). За все месяцы между этими показателями также наблюдалась отрицательная корреляция (r = –0,13…–0,41), за исключением апреля и августа (r = 0,10 и 0,11 соответственно). В зимние месяцы данная зависимость была более значимой (r = –0,30…–0,40), чем в летние (r = –0,13…–0,27).

Ключевые слова: арктические районы Якутии, агроклиматические условия, потепление климата, бруцеллез северных оленей, заболеваемость животных, корреляция

EFFECT OF AGRO-CLIMATIC CONDITIONS ON THE INCIDENCE OF BRUCELLOSIS OF REINDEER IN THE ARCTIC REGIONS OF YAKUTIA

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The spread of brucellosis in reindeer depending on agroclimatic conditions of their housing was studied. The experiment was conducted in Momsky, Nizhnekolymsky and Eveno-Bytantaysky districts of Yakutia in 2012–2019. It was shown that the annual air temperature for the studied period in all districts was higher than the norm by 1.1 ... 1.9 °C due to its more significant increase in the cold period (by 1.5 ... 2.8 °C) compared to the warm period (by 0.5 ... 0.6 °C). The highest temperature increase was registered in April (by 2.8 ... 4.4 °C) and November (by 2.2 ... 4.1 °C), in spring-summer period - in May (by 0.9 ... 1.7 °C), in July it was 0.2 ... 1.0 °C below the norm. The annual precipitation on the territory of the Eveno-Bytantaysky district changed slightly, and on the

territory of the Momsky and Nizhnekolymsky districts increased by 40 and 70 mm, respectively. The incidence of brucellosis of reindeer, depending on the place (area) where reindeer are kept and weather conditions, ranged from 0 to 3.86% (coefficient of variation of 131%), fewer sick animals were in the Nizhnekolymsky district (0.20%), more – in Eveno-Bytantaysky (1.15%). There was a negative correlation (r = –0,19...–0,42) between the incidence of brucellosis in reindeer and the temperature during the cold months and the annual temperature, with the temperature of the spring-summer months - medium positive (r = 0,30...0,53) with a reliable level in July. In general, temperature had a greater effect on morbidity (r^2 = 0.115) than precipitation (r^2 = 0.092), but a significant inverse relationship (r = –0.48; r^2 = 0.23) was found between annual precipitation sum and animal morbidity. In all months there was also a negative correlation between these indicators (r = –0.13...–0.41), except for April and August (r = 0.10 and 0.11, respectively). In winter months, this dependence was more significant (r = –0.30...–0.40) than in summer (r = –0.13...–0.27).

Keywords: Arctic regions of Yakutia, agro-climatic conditions, climate warming, reindeer brucellosis, animal morbidity, correlation

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INTRODUCTION

Important conditions for the sustainable development of the agro-industrial complex of the Republic of Sakha (Yakutia) are control of the livestock production and study of the factors affecting animal morbidity. Periodic veterinary analysis of multi-year data makes it possible to assess the epizootic situation more quickly and effectively plan and carry out measures to prevent and eliminate dangerous diseases.

Brucellosis is a chronic disease of animals caused by the bacteria, united under the common name Brucella. Arthritis, bursitis, tendovaginitis, orchitis, mastitis, abortions in breeding stock are observed in sick reindeer, which negatively affects reproduction, complicates breeding work and leads to a decrease in animal productivity. The main sources of brucellosis are sick domestic and wild reindeer, and the factors of transmission are infected pastures and calving places [1]. Particularly dangerous are individuals that release large amounts of brucellosis into the external environment during abortion and even during normal childbirth [2]. Animal brucellosis is registered everywhere in the world, but is predominantly found in the Mediterranean basin, the Persian Gulf, the Indian subcontinent, Mexico, Central and South America, Southeast Asia, Africa, as well as in all areas of the Asian North, including Yakutia [3-5]. The presence of brucellosis infection in the Taimyr, Yakut and Chukchi populations of wild reindeer has been revealed[1]. In domestic reindeer, it was diagnosed by the serological method in 1942, by the bacteriological method in 1955, and in wild reindeer - in 1960. [6].

Control of brucellosis by culling positive animals is effective only when animal husbandry is highly cultured [7]. In the Russian Federation, the brucellosis control system, including its diagnosis, prevention, implementation of restrictive veterinary and sanitary, and organizational and economic measures, developed in the second half of the 20th century [8].

One of the factors influencing the epizootic situation for this disease is natural and climatic conditions. The Earth's climate has changed over the century, both globally and regionally,

[1]Vinokurov N.V. Features of the diagnostic value of the indirect hemagglutination reaction in brucellosis of reindeer: Ph.D. in veterinary sciences. Yakutsk, 2010. 18 p.

and the process of change has accelerated significantly in recent decades [9]. Since the mid-1970s, the average surface air temperature in Russia has been rising at an average rate of 0.43 °C per decade, which significantly exceeds the rate of global warming. Particularly significant climate changes are observed in the Arctic and subarctic permafrost zone [10]. The increase in annual temperatures is mainly due to its increase in winter. At the same time, lengthening of the warm period of the year is registered: spring comes 10-15 days earlier and autumn ends 15-20 days later compared to the middle of the last century [11].

Studying the influence of environmental conditions on the epizootic situation of reindeer brucellosis in different natural and climatic conditions is of scientific and practical interest. It is especially relevant for the Arctic zone of Yakutia, where this issue is poorly studied under the conditions of the changing climate.

The purpose of the study is to identify changes in agroclimatic conditions and assess their impact on the incidence of brucellosis in reindeer in different Arctic regions of Yakutia.

MATERIAL AND METHODS

The Arctic zone of Yakutia is characterized by a sharply continental climate, no shortage of heat, a long period with no sun in summer and no sunlight in winter. The duration of the period with snow cover is about 220 days, the absolute minimum temperature reaches -67 ° C, the absolute maximum reaches 35 ° C. The region occupies more than 50% of the total area of Yakutia, it includes 13 uluses (districts), in which traditional trades of peoples of the North, including reindeer breeding prevail. About 74% of all herds of reindeer of the republic are situated there, the considerable part of them (over 51 thousand animals, or more than 28% of the total herd of the Republic) is kept in three districts different by natural and climatic conditions: Momsky, Nizhnekolymsky and Evено-Byantaysky. In these districts there is often an unfavorable epizootic situation with brucellosis of reindeer[2].

The initial data on animal disease incidence for 2012-2019 were obtained from statistical reports of the Department of Veterinary Affairs of the Republic of Sakha (Yakutia) and its subordinate organizations - District Veterinary Offices with veterinary testing laboratories. The reports on detection of positive reindeer herds for brucellosis by the Yakutsk Republican Veterinary Testing Laboratory were used.

Reindeer positive to the simultaneous application of 3-4 serological methods of research (complex serodiagnosis) were considered as brucellosis patients. In our studies, the following serological diagnostic methods were used: Rose Bengal test reaction (RBT), in vitro hemagglutination reaction (HR), complement-fixation test (CFT), immunodiffusion reaction (IDR) with 0-polysaccharide antigen[3] [12, 13].

Analysis of agroclimatic conditions for 2012-2019 was carried out on the basis of archival data of meteorological stations Honu (Momsky district), Chersky (Nizhnekolymsky district) and Batagai-Alyta (Eveno-Bytantaisky district). Average monthly and annual values of air temperature and the amount of precipitation were the studied indicators. Statistical processing of the obtained data was performed by the method of variation and correlation according to B.A. Dospekhov[4] using the Snedecor[5] and Microsoft Office Excel 2007 software packages.

RESULTS AND DISCUSSION

According to the Veterinary Department of the Republic of Sakha (Yakutia), in 2012-2019,

[2]System of agriculture in the Republic of Sakha (Yakutia) for the period of 2021-2025: methodological handbook. Ministry of Agriculture of the Republic of Sakha (Yakutia). FSBIS FRC Yakut scientific center of the Siberian Branch of the Russian Academy of Sciences. Yakut scientific-research institute of agriculture named after M.G. Safronov. Belgorod: Publishing house of Sangalov K.Y. 2021. 592 p.

[3]Vashkevich R.B. Plate agglutination reaction in brucellosis of reindeer. Epizootology and immunoprophylaxis of diseases: collection of scientific papers Novosibirsk, 1983. pp. 16-20.

[4]Dospekhov B.A. Methodology of field experience (with the basics of statistical processing of research findings). Moscow: Agropromizdat, 1985. 416 p.

[5]Sorokin O.D. Applied statistics on the computer. Novosibirsk, 2004. 162 p.

the region annually registered from 35 to 47 points unfavorable for reindeer brucellosis. During this period, 14 such unfavorable locations were registered in the Momsky District, 8 in the Nizhnekolymsky District, and 8 in the Eveno-Bytantaisky District.

Analysis of statistical data on the incidence of reindeer in the studied areas of the Arctic zone of Yakutia for 2012-2019 showed that the number of animals positive for brucellosis infection varied from 0.08 to 3.68% of the total number of examined animals. The variability of this indicator was very significant, the coefficient of variation was 131%. No positive reindeer were detected in the Momsky district in 2016 and 2018, and in the Nizhnekolymsky district in 2018 and 2019, (see Table 1).

During the analyzed years, the lowest number of brucellosis diseased animals was registered in the territory of the Nizhnekolymsky District (0.20%), the highest - in the Eveno-Bytantaysky District (1.15%). On average by districts higher incidence of brucellosis of reindeer was registered in 2012 and 2015 (respectively 1.03 and 1.66%), and lower - in 2016 and 2017 (0.38 and 0.29%). The highest number of diseased animals in the territory of the Momsky (0.88%) and Nizhnekolymsky (0.43%) districts was detected in 2012, Eveno-Bytantaisky (3.68%) - in 2015.

Табл. 1. Динамика эпизоотии по бруцеллезу северных оленей в арктических районах Якутии за 2012–2019 гг.

Table 1. Epizootic dynamics of reindeer brucellosis in the Arctic regions of Yakutia for 2012–2019

Indicator	Momsky district	Nizhnekolymsky district	Eveno-Bytantaisky district	Total
2012				
The total number of researched, heads	10060	16127	16335	42522
Of those responding positively: heads	89	69	281	439
%	0,88	0,43	1,72	1,03
2013				
The total number of researched, heads	15114	18450	15600	49164
Of those responding positively: heads	115	40	69	224
%	0,76	0,22	0,44	0,46
2015				
The total number of researched, heads	3325	13003	10718	27046
Of those responding positively: heads	8	46	394	448
%	0,24	0,35	3,68	1,66
2016				
The total number of researched, heads	2200	8897	14103	25200
Of those responding positively: heads	0	14	83	97
	0,0	0,16	0,59	0,38
2017				
The total number of researched, heads	6415	14267	17039	37721
Of those responding positively: heads	32	12	65	109
%	0,50	0,08	0,38	0,29
2018				
The total number of researched, heads	7207	12500	12850	32557
Of those responding positively: heads	0	0	164	164
%	0,0	0,0	1,28	0,50
2019				
The total number of researched, heads	4716	8432	14709	27857
Of those responding positively: heads	32	0	114	146
%	0,68	0,0	0,78	0,52
2012–2019				
The total number of researched, heads	49037	91676	101354	242067
Of those responding positively: heads	276	181	1170	1627
%	0,56	0,20	1,15	0,67

To provide safety of reindeer and their epizootic well-being only veterinary help is not enough, timely prevention and elimination of brucellosis is possible with taking a complex of measures. For planning and operative realization of sanitation works accurate and objective information is necessary not only about the level of epizootic situation and state of the herd, but also about the conditions of animals' keeping.

Analysis of weather conditions showed that agrometeorological indicators in the studied areas differed significantly: the average annual air temperature for the years under study in Nizhnekolymsky District was -8.7 °C, in Eveno-Bytantaisky District -13.4, in Momsky District -14.0 °C.

An increase of average annual air temperature by 1,1 ... 1,9 °C (on average by 1,5 °C) in the period from 2012 to 2019 in comparison with the norm - the mean annual value for the last 50 years (see Table 2) was observed on the territory of these regions.

More considerable warming was observed in April (by 2.8 ... 4.4 °C) and November (2.2 ... 4.1 °C), in spring-summer period - in May (by 0.9 ... 1.7 °C) and August (by 1.0 ... 1.1 °C). In all the regions only in July a decrease in air temperature by 0.2 ... 1.0 °C was noted in comparison with the mean annual value.

The analysis of distribution of the atmospheric precipitation on the territory of the studied areas in 2012-2019 allowed to identify some features of their distribution. The least amount and insignificant variability of precipitation for the year (181 mm with the norm of 179 mm) were recorded at the meteorological station Batagai-Alyta (Eveno-Bytantaisky district). In the territory of the Momsky (meteostation Honu) and Nizhnekolymsky (meteostation Chersky) districts the annual amount of precipitation was 263 and 294 mm, which was more than the mean annual value by 41 and 70 mm respectively (see Table 3).

Табл. 2. Температура воздуха в арктических районах Якутии за 2012–2019 гг., °С
Table 2. Air temperature in the arctic regions of Yakutia for 2012–2019, °C

Indicator	January	February	March	April	May	June	July	August	September	October	November	December	Total for the year
Momsky district (Honu weather station)													
Average	–44,1	–41,6	–29,1	–10,4	4,7	12,4	14,6	11,5	2,6	–12,3	–32,8	–43,7	–14,0
Norm	–46,0	–42,4	–31,1	–13,2	3,0	12,2	14,8	10,5	2,1	–14,7	–35,5	–45,1	–15,4
Deviation from the norm	1,9	0,8	2,0	2,8	1,7	0,2	–0,2	1,0	0,5	2,4	2,7	1,4	1,4
Eveno-Bytantaisky district (Batagai-Alyta weather station)													
Average	–44,6	–42,4	–27,4	–8,1	4,7	14,5	15,2	12,7	3,1	–12,8	–32,8	–43,0	–13,4
Norm	–45,5	–42,3	–29,3	–11,7	3,8	13,5	16,2	11,6	2,6	–14,3	–35,0	–43,3	–14,5
Deviation from the norm	0,9	–0,1	1,9	3,6	0,9	1,0	–1,0	1,1	0,5	1,5	2,2	0,3	1,1
Nizhnekolymsky district (Chersky weather station)													
Average	–30,3	–29,6	–21,1	–9,2	0,7	10,8	12,5	10,7	4,1	–6,7	–18,6	–27,5	–8,7
Norm	–32,4	–30,9	–23,7	–13,6	–0,2	10,1	12,9	9,6	3,2	–9,2	–22,7	–30,4	–10,6
Deviation from the norm	2,1	1,3	2,6	4,4	0,9	0,7	–0,4	1,1	0,9	2,5	4,1	2,9	1,9
Average for the districts													
Deviation from the norm	1,6	0,7	2,2	3,6	1,2	0,6	–0,5	1,1	0,6	2,1	3,0	1,5	1,5

Табл. 3. Сумма осадков в арктических районах Якутии за 2012–2019 гг., мм
Table 3. Precipitation sum in the Arctic regions of Yakutia for 2012–2019, mm

Indicator	January	February	March	April	May	June	July	August	September	October	November	December	Total for the year
Momsky district (Honu weather station)													
Average	7,4	8,6	4,4	5,3	14,1	42,1	77,1	45,2	22,2	15,2	14,0	7,1	263
Norm	7,0	7,2	4,9	5,4	12,6	37,1	49,8	40,1	23,4	14,7	12,1	7,8	222
Deviation from the norm	0,4	1,4	–0,5	–0,1	1,5	5,0	27,3	5,1	–1,2	0,5	1,9	–0,7	41
Eveno-Bytantaisky district (Batagai-Alyta weather station)													
Average	6,1	5,2	2,7	4,2	17,3	33,3	29,5	29,9	19,9	14,3	12,6	5,5	181
Norm	6,3	5,7	4,6	5,1	14,0	29,6	34,2	30,8	18,0	13,0	10,3	7,8	179
Deviation from the norm	–0,2	–0,5	–1,9	–0,9	3,3	3,7	–4,7	–0,9	1,9	1,3	2,3	–2,3	2
Nizhnekolymsky district (Chersky weather station)													
Average	19,8	13,2	11,9	5,4	10,7	29,0	47,0	33,7	36,3	32,8	33,6	21,0	294
Norm	14,2	11,3	9,7	7,8	9,5	18,6	32,2	29,1	29,1	27,1	20,5	15,0	224
Deviation from the norm	5,6	1,9	2,2	–2,4	1,2	10,4	14,8	4,6	7,2	5,7	13,1	6,0	70
Average for the districts													
Deviation from the norm	1,9	0,9	–0,1	–1,1	2,0	6,4	12,5	2,9	2,6	2,5	5,8	1,0	37

The greatest increase in atmospheric precipitation in the Nizhnekolymsky and Momsky districts over the years of research was observed in July (14.8 and 27.3 mm, respectively) and June (10.4 and 5.0 mm), in the winter months the changes were insignificant.

Analysis of the temperature regime for warm (May - September) and cold (October - April) periods of the year showed that climate warming in these areas from 2012 to 2019 was due to a more significant temperature increase in the cold period of the year (by 1.5 ... 2.8 °C) compared to the warm period (by 0.5 ... 0.6 °C) (see Table 4).

According to data from the meteorological station Honu (Momsky District), an increase in the amount of precipitation during the years of the study from 222 (normal) to 263 mm was mainly due to precipitation of the warm period. In the Nizhnekolymsky district (weather station Chersky), the contribution of precipitation of warm and cold periods to the annual increase of 70 mm was almost equal - 32 and 38 mm, respectively. In the territory of the Eveno-Bytantaisky district (meteorological station Batagai-Alyta) significant changes in the amount of precipitation for warm and cold periods were not observed. On average, the ratio of precipitation for cold and warm periods in the studied years was 1: 1.5.

Statistical processing of the received data shows that amount of precipitation for month

Табл. 4. Отклонение агроклиматических показателей за теплый и холодный периоды от нормы в арктических районах Якутии. Среднее за 2012–2019 гг.
Table 4. Deviation of agro-climatic indicators for warm and cold periods from the norm in the Arctic regions of Yakutia. Average for 2012–2019

District	Air temperature during the warm period, °C	Air temperature during the cold period, °C	Precipitation amount for the warm period, mm	Precipitation amount for the cold period, mm
Momsky	0,6	2,0	37,7	2,9
Eveno-Bytantaisky	0,5	1,5	–2,2	3,3
Nizhnekolymsky	0,6	2,8	32,1	38,2
Average	0,6	2,3	22,5	14,8

and year is characterized by more significant variability (coefficient of variation 28-96%, average 69%), than air temperature (13-69%, average 27%) on the territory of the studied areas. The greatest variability of air temperature is noted in May (69%) and September (47%), i.e. in transitional periods from spring to summer and from autumn to winter, and the amount of precipitation - in March (96%) and November (91%) (see Table 5).

Significant climate changes currently occurring in the Arctic regions of Yakutia and periodically emerging unfavorable epizootic situations on reindeer brucellosis in the region cause the need to study the relationship between these factors. Correlation analysis showed that between reindeer brucellosis morbidity and cold period air temperature (September - April) and annual temperature there is a negative weak or medium relationship (r = -0.19...-0.42), and the temperature of warm months (May - August) is medium positive (r = 0.30...0.53) with a reliable level in July (see Table 6).

The coefficient of determination ($r2$) shows that 4-28% of animal morbidity was determined by fluctuations in air temperature by months and 13% by annual temperature.

Precipitation by months had less influence on variability of the studied indicator (on average $r2$ = 0,092) than temperature ($r2$ = 0,115), but there was a significant (r = -0,48) inverse relation between the annual sum of precipitation and reindeer brucellosis incidence with a determination coefficient of 0,23. A weak to medium negative correlation (r = -0.13...-0.41) was also observed between these indicators in all months except April and August (r = 0.10 and 0.11, respectively). In winter months this correlation was more significant (r = -0,30...-0,40) than in the warm period (r = -0,13...-0,27). The revealed correlations logically explain the high level of reindeer morbidity (3.68% of those surveyed) in 2015 in the Eveno-Bytantaisky district compared to the Momsky (0.24%) and Nizhnekolymsky (0.35%) districts, as in this year. In the territory of the Eveno-Bytantaisky district during the spring-summer period (May-August) the average daily air temperature was by 1.2...3.5 °C higher and the amount of precipitation by 44-71 mm less than in the Momsky and Nizhnekolymsky districts.

Табл. 5. Изменчивость агроклиматических показателей по трем районам арктической зоны Якутии за 2012–2019 гг.

Table 5. Variability of agro-climatic indicators in three regions of the Arctic zone of Yakutia for 2012–2019

Month	Air temperature, ℃				Precipitation amount, mm			
	average	minimum	maximum	Coefficient of variation, %	average	minimum	maximum	Coefficient of variation, %
January	–39,4	–47,4	–27,7	19	11,0	1,7	37,7	86
February	–38,4	–48,3	–21,7	19	8,2	0,8	25,6	86
Mart	–26,0	–33,4	–14,5	19	6,2	0,2	23,7	96
April	–9,2	–14,1	–5,3	30	4,5	0,6	16,0	73
May	3,5	–1,4	7,1	69	14,0	1,8	40,0	71
June	12,7	8,7	17,9	17	31,3	5,1	64,9	58
July	14,0	10,8	16,7	13	52,2	9,6	122,0	55
August	11,2	8,3	14,6	15	36,6	8,8	103,0	58
September	3,2	1,4	7,4	47	26,9	3,2	56,9	52
October	–10,7	–16,8	–2,3	34	20,3	5,7	53,7	66
November	–27,5	–35,6	–13,0	26	20,1	4,2	78,5	91
December	–37,7	–46,9	–21,4	24	12,2	2,4	38,9	80
Year	–12,0	–14,5	–7,4	21	243,5	107	391,2	28
Average				27				69

Табл. 6. Влияние агроклиматических показателей на заболеваемость бруцеллезом северных оленей в арктических районах Якутии за 2012–2019 гг.

Table 6. Influence of agro-climatic indicators on the incidence of brucellosis in reindeer in the Arctic regions of Yakutia for 2012–2019

Month	Air temperature		Precipitation amount	
	Correlation coefficient (r)	Determination coefficient (r^2)	Correlation coefficient (r)	Determination coefficient (r^2)
January	–0,40	0,160	–0,41	0,168
February	–0,25	0,063	–0,34	0,116
March	–0,21	0,044	–0,39	0,152
April	–0,21	0,044	0,10	0,010
May	0,32	0,102	–0,13	0,017
June	0,35	0,123	–0,27	0,073
July	0,53*	0,281	–0,16	0,026
August	0,30	0,090	0,11	0,012
September	–0,19	0,036	–0,19	0,036
October	–0,42	0,176	–0,33	0,109
November	–0,32	0,102	–0,30	0,090
December	–0,38	0,144	–0,40	0,160
Year	–0,36	0,130	–0,48*	0,230
Average		0,115		0,092

*Significant at 5% significance level

CONCLUSION

Analysis of the obtained data indicates that in the Arctic regions of Yakutia there are processes aimed at warming the climate. There is an increase in annual air temperature compared to the norm by 1.1 ... 1.9 °C due to its more significant increase in the cold period. Annual precipitation in the territory of some Arctic regions during the study period exceeded the mean annual value by 41-70 mm.

It has been revealed that agroclimatic conditions can have a certain influence on brucellosis morbidity in reindeer in the region. It is shown that a decrease in the amount of precipitation for the year and in winter months, as well as a decrease in air temperature during the cold period of the year (September - April) and an increase in the warm period (May - August) causes an increase in the incidence of brucellosis in animals.

СПИСОК ЛИТЕРАТУРЫ

1. *Хоч А.А., Слепцов Е.С.* Бруцеллез северных оленей в Якутии. Якутск, 2001. 216 с.
2. *Федоров А.И., Искандаров М.И., Искандарова С.С.* Свойства культур бруцелл, выделенных от северных оленей // Ветеринария. 2022. № 5. С. 20–27.
3. *Pappas G., Akritidis N., Bosilkovski M., Tsianos E.* Brucellosis // The New Ingland Journal of Medicine. 2005. № 352. P. 2325–2336.
4. *Hurtado R.* Brucellosis – new and old issues regarding diagnosis and management // Harvard education online (31 октября 2001 г.): http:/ www. mgh.harvard.edu / id / images / brucellosis.pdf.
5. *Слепцов Е.С., Винокуров Н.В., Федоров В.И., Григорьев И.И., Захарова О.И.* Эпизоотическое состояние по бруцеллезу северных оленей в Республике Саха (Якутия) // Аграрный вестник Урала. 2018. № 8 (175). С. 57–61.
6. *Забродин В.А., Лайшев К.А., Гулюкин М.И., Гулюкин А.М., Искандаров М.И., Слепцов Е.С., Винокуров Н.В., Федоров В.И., Бочкарев И.И., Захарова О.И.* Бруцеллез оленей и некоторых диких животных на Енисейском Севере: монография. Новосибирск: Издательство АНС «СибАК», 2018. 290 с.
7. *Слепцов Е.С., Искандаров М.И., Винокуров Н.В., Племяшов К.В., Павлова А.И.* Анализ материалов эффективности применения вакцинных штаммов и систем профилактики и ликвидации бруцеллеза животных на территории РФ // Ветеринария и кормление. 2020. № 5. С. 45–48. DOI: 10.30917/ATT–VK–1814–9588–2020.
8. *Красиков А.П., Зуев А.В., Ермакова Т.В.* Эпизоотологический анализ основных бактериальных и вирусных инфекционных болезней крупного рогатого скота на территории Омской области // Ветеринарно–санитарные мероприятия по предупреждению антропозоонозов и незаразных болезней животных. 2018. С. 39–47.

9. *Панин Г.Н., Выручалкина Т.Ю., Соломонова В.И.* Региональные климатические изменения в Северном полушарии и их взаимосвязь с циркуляционными индексами // Проблемы экологического мониторинга и моделирования экосистем. 2010. Т. 23. С. 92–108.
10. *Кириллина К.С.* Тенденции изменения климата Республики Саха (Якутия) // Вопросы географии Якутии. 2013. Вып. 11. С.115–121.
11. Глобальные изменения климата и прогноз рисков в сельском хозяйстве России / под ред. акад. А.Л. Иванова, В.И. Кирюшина. М.: Россельхозакадемия. 2009. С. 331–342.
12. *Абиджанов М.С., Гринько В.К., Назарова С.А.* Розбенгал проба в диагностике бруцеллеза животных // Труды УзбНИВИ. 1980. Вып. 30. С. 8–12.
13. *Винокуров Н.В.* Изучение диагностической эффективности реакции непрямой гемагглютинации при бруцеллезе // Якутский медицинский журнал. 2008. № 4. С. 72–73.

REFERENCES

1. Khoch A.A., Sleptsov E.S. *Brucellosis of reindeer in Yakutia.* Yakutsk, 2001, 216 p. (In Russian).
2. Fedorov A.I., Iskandarov M.I., Iskandarova S.S. Properties of brucella cultures isolated from reindeer. *Veterinariya = Veterinary medicine*, 2022, no. 5, pp. 20–27. (In Russian).
3. Pappas G., Akritidis N., Bosilkovski M., Tsianos E. Brucellosis. *The New Ingland Journal of Medicine*, 2005, no. 352, pp. 2325–2336.
4. Hurtado R. Brucellosis – new and old issues regarding diagnosis and management. *Harvard education online* (31 октября 2001 г.): http:/ www. mgh.harvard.edu / id / images / brucellosis.pdf.
5. Sleptsov E.S., Vinokurov N.V., Fedorov V.I., Grigoriev I.I., Zakharova O.I. Epizootic state of brucellosis of reindeer in the Republic of Sakha (Yakutia). *Agrarnyi vestnik Urala = Agrarian Bulletin of the Urals*, 2018, no. 8 (175), pp. 57–61. (In Russian).
6. Zabrodin V.A., Laishev K.A., Gulyukin M.I., Gulyukin A.M., Iskandarov M.I., Sleptsov E.S., Vinokurov N.V., Fedorov V.I., Bochkarev I.I., Zakharova O.I. *Brucellosis of deer and some wild animals in the Yenisei North.* Novosibirsk: Publishing house of ANS "SibAK", 2018, 290 p. (In Russian).
7. Sleptsov E.S., Iskandarov M.I., Vinokurov N.V., Plemyashov K.V., Pavlova A.I. Analysis of materials on the effectiveness of the use of vaccine strains and systems for the prevention and elimination of brucellosis of animals in the territory of the Russian Federation. *Veterinariya i kormlenie = Veterinaria i kormlenie*, 2020, no. 5, pp. 45–48. (In Russian). DOI: 10.30917/ATT-VK-1814-9588-2020.
8. Krasikov A.P., Zuev A.V., Ermakova T.V. Epizootological analysis of the main bacterial and viral infectious diseases of cattle in the Omsk region. *Veterinarno–sanitarnye meropriyatiya po preduprezhdeniyu antropozoonozov i nezaraznykh boleznei zhivotnykh = Veterinary and sanitary measures to prevent anthropozoonosis and non–infectious animal diseases*, 2018, pp. 39–47. (In Russian).
9. Panin G.N., Vyruchalkina T.Yu., Solomonova V.I. Regional klimatic change in the Northern Hemisphere and their relationship with circulation indices. *Problemy ekologicheskogo monitoringa i modelirovaniya ekosistem = Problems of ecological monitoring and modeling of ecosystem,* 2010, Vol. 23, pp. 92–108. (In Russian).
10. Kirillina K.S. Trends in climate change in the Republic of Sakha (Yakutia). *Voprosy geografii Yakutii = Questions of the geography of Yakutia*. Yakutsk, 2013, is. 11, pp. 115–121. (In Russian).
11. *Global climate change and risk forecast in Russian agriculture* / edited by acad. A.L. Ivanova, V.I. Kiryushina M.: Rosselkhozakademiya, 2009, pp. 331–342. (In Russian).
12. Abidzhanov M.S., Grinko V.K., Nazarova S.A. Rozbengal test in the diagnosis of animal brucelleosis. *Trudy UzbNIVI = Proceedings of UzbNIVI*, 1980. is. 30. pp. 8–12. (In Russian).
13. Vinokurov N.V. Study of the diagnostic efficiency of the reaction of indirect hemagglutination in brucellosis. *Yakutskii meditsinskii zhurnal = Yakut Medical Journal*, 2008, no. 4, pp. 72–73. (In Russian).

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