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INFLUENCE OF CLIMATIC FACTOR ON NATURALLY DETERMINED DISEASES IN A REGIONAL CONTEXT

ABSTRACT. The spread of almost all diseases caused by living pathogens is determined primarily by environmental conditions. These pathogens like any other biological objects are the components of the certain natural ecosystems. An essential part of any medico-geographical assessment is the search for links between the spread of diseases and factors of the geographical environment. The role of factors that affect the spread of the natural diseases is unequal. The climatic factor is deemed one of the main determinants for the spread of naturally-determined diseases. This factor manifests itself at all levels of territorial differentiation. The goal of these studies was to identify the natural and climatic suitability of the certain territory for spread of diseases in order to assess the possible influence of the climatic factor on the medico-geographical situation in the context of the regional environment. The objectives are to estimate the role of climatic and weather parameters in the functioning of natural foci in Russia; to assess the natural and climatic suitability of the territory for spread of diseases; and to identify the climatic preconditions of spread of particular climate-dependent infections. In this study, on the example of several climate-depended diseases different approaches to medico-geographical assessment have been implemented and number of new methodological solutions have been proposed.

KEY WORDS: Medical geography, naturally-determined diseases, climatic factor

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INTRODUCTION

The spread of almost all diseases caused by living pathogens is determined primarily by environmental conditions. Their parasitic systems like any other biological objects are integral components of ecosystems, thus their spatial distribution and dynamics are influenced by various natural factors (Malkhazova 2001).

An essential part of any medico-geographical assessment is search for links between spread of diseases and factors of the geographical environment. These factors are considered as preconditions of infectious diseases as postulated by a concept developed and substantiated by the Russian scholars in the middle of 20th century. Although existence of a disease in reality is determined by a nature and a structure of a geosystem as a whole, only one of the natural components usually turns to be the direct cause of the spread of certain disease. Therefore, depending on the research tasks, it is possible to consider both the landscapes and their individual components as disease preconditions.

The role of factors affecting spread of natural diseases is different. The climatic factor is deemed one of the main determinants for spread of naturally-determined diseases. This factor manifests itself at all levels of territorial differentiation. At its highest (national) level it determines the latitudinal zoning which, in turn, defines the conditions for the existence of disease hosts and vectors and, ultimately, the foci of diseases. At the regional level the effect of climate conditions manifests itself in parameters of weather such as average monthly temperature, precipitation levels, snow cover height, duration of the frost-free period, etc. Climate characteristics are especially crucial for poikilothermic animals like arthropods and for the pathogens that spend part of their life cycles inside them.

Atmospheric temperature defines the heat supply of a region which has a significant influence on pathogen hosts and vectors affecting the pathogen's survival in vectors and in the environment. It also determines existence of disease vector populations that have a thermal optimum and threshold temperatures above and below which they cannot survive. Important parameters are also the sum of active temperatures (i.e. the sum of temperatures during a period with the annual daily temperatures above 10°C) (Isaev 2001) and the sum of effective temperatures, or growing degree days (GDDs) (i.e. the number of temperature degrees above a certain threshold temperature below which an organism cannot survive). The sum of active temperatures characterizes the heat supply of an ecosystem, whereas GDDs reflect warmth needs of a particular biological species. These parameters are mostly used in relation to plants, but, in fact, they characterize warmth necessities of any poikilothermic organisms, including pathogens and vectors (Podolsky 1967). Other meteorological indices (minimum temperature, maximum temperature, etc.) can play a significant role, especially on the local level.

Precipitation determine availability and characteristics of water bodies where vectors breed (primarily mosquitoes, horseflies, etc.). Water bodies also serve as habitats for hydrophilic species that carry natural focal infections like tularemia or leptospirosis.

Over the recent years, the team at the Department of Biogeography of the Faculty of Geography of the Lomonosov Moscow State University conducted the research with the aim to assess the changes in distribution of naturally-determined diseases and the role of climatic factor in their development. The goal of these studies was to identify the natural and climatic suitability of the certain territory for spread of diseases in order to assess the possible influence of the climatic factor on the medico-geographical situation in the context of the regional environment. The objectives are to estimate the role of climatic and weather parameters in the functioning of natural foci in Russia; to assess the natural and climatic suitability of the territory for spread of diseases; and to identify the climatic preconditions of spread of particular climate-dependent infections.

Below we consider the results of a study of the climatic factor effect on spread of certain important naturally-determined diseases in Russia with different transmission mechanisms.

MATERIALS AND METHODS

To identify the natural and climatic suitability of the territory for the spread of diseases, three model infections were chosen: tularemia (as of the most important widespread natural focal disease), West Nile fever (as one of the most important emergent vector-borne disease with expanding nosoareal), and vivax malaria (as one of the most important natural endemic anthroponosis).

Statistical data on population morbidity rates in 1997-2015 was provided by The Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing (Rospotrebnadzor) and Moscow branch of the federal anti-plague agency "Rospotrebnadzor Anti-Plague Center". The data on the tularemia pathogen culture isolation from environmental sources was considered for the period 1941- 2015, climatic data for assessment of favorability of climatic conditions for malaria reintroduction was considered for the period of 51 years (1965-2015). A numerous literature sources (Lvov and Lebedev 1974; Lvov and Ilyichev 1979; Lvov 1989; Tran et al. 2014, etc.), cartographic materials (Geographical Atlas, 1982; Atlas of the USSR, 1983; National Atlas of Russia, 2007; Medico-geographical Atlas… 2017), Department of Biogeography's archive data served as information sources throughout our research. Data processing was carried out using Microsoft Excel, MapInfo Professional 11.0. and ArcGIS 10.1 software. To calculate meteorological characteristics, mean daily air temperature and precipitation data obtained from open online databases (http://www.worldclim.org; www.meteo.ru) was used.

The overall algorithm implemented in the study consisted in, with the use of morbidity rates data, evaluating spread of considered infections, and then, with the use of meteorological parameters, assessing the effect of climate on the naturally determined diseases distribution (Fig. 1). Specific approaches and methodologies were chosen based on the disease peculiarities, territorial level of research and data availability.

RESULTS AND DISCUSSION

Tularemia

Tularemia (rabbit disease) is a highly infectious bacterial disease caused by a hazard class A pathogen, Francisella tularensis. Tularemia can spread through arthropod bites, infected water or dust, or by handling sick animals. The impact

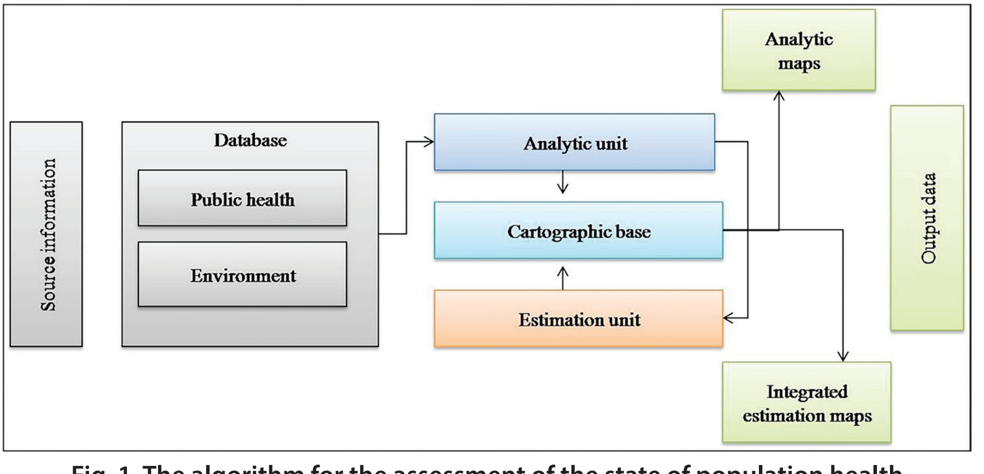

Fig. 1. The algorithm for the assessment of the state of population health Results and discussion

of climate change is likely to have an effect on tularemia transmission patterns in highly endemic areas because a large majority of cases transmitted to humans by blood-feeding arthropods occur during the summer season and is linked to increased temperatures (Rydén et al. 2009; Meshcheryakova et al. 2014). Therefore, high temperature for a long period accompanied by low rainfall and low humidity may affect the vector's biology and initiate a tularemia outbreak.

In recent years, on an average of 100 to 500 tularemia cases were reported annually in the Russian Federation. There are active natural foci of tularemia on endemic areas as evidenced by the results of isolation of the pathogen cultures from rodents, arthropods, environmental objects, including water samples from open reservoirs. Tularemia manifests itself primarily as a sporadic disease in Russia. At the same time, there were vector-borne outbreaks that occurred in 2005 in the Central Federal District with more than 800 people affected and in the Khanty-Mansiysk Autonomous Okrug in 2013 with more than 1,000 individuals involved. Over the past decade, about 2,000 tularemia cases have been reported in the Russian Federation, the most of them occurred in the European territory of Russia. The spread of tularemia is uneven due to variations in natural (primarily climatic) conditions in focal area.

To identify peculiarities of tularemia distribution on areas with various climatic conditions, three key regions with different climate types were selected: Murmansk Oblast, Moscow Oblast, Krasnodar Krai (including the Republic of Adygea), and a series of maps was created. Using the GIS package MapInfo Professional 11.0, we marked on the raster regional climatic maps the sites of cases of human infection with tularemia (red dots) and sites of cases of isolating of the tularemia pathogens (blue dots). Climate types were considered in accordance with B.P.Alisov's classification (Atlas... 1983).

Tularemia morbidity rate in Murmansk Oblast is very low and occurs only as sporadic cases. From 1997 to 2015 only eight cases of tularemia were reported. Pathogen cultures from environment objects were also quite rarely isolated. All locations of human infection and pathogen culture isolation were confined to the northern and central regions of the Oblast with varied mean annual air temperatures but with the same amount of precipitation from 500 to 600 mm per year.

According to climatic zoning of Russia (National Atlas.. 2007) tularemia foci are dispersed over the territories of both Atlantic province of the subarctic climatic belt (moderately cold, wet, the total solar radiation is 2,700 MJ/m2 per year, the sum of air temperatures above 10°C is 200°C, the average annual precipitation and evaporation sum is more than 200 mm) and in the Atlantic-Arctic province of the temperate belt (moderately warm, excessively wet, the total solar radiation is 3150-3350 MJ/m2 per year, the sum of air temperatures above 10°C is 800–1400°C, the average annual precipitation and evaporation sum is more than 200 mm). In general, Murmansk Oblast can be attributed as the area unfavorable for the existence of tularemia foci. Rare cases of human disease and isolated pathogen cultures were associated with unusual weather conditions (for example, extremely high summer temperatures).

Tularemia morbidity in Moscow Oblast has been registered since 1941 and to date, the presence of tularemia natural foci of three types has been reliably confirmed in 36 administrative districts within the said region: floodplain and swamp, field and meadow and forest foci. Tularemia foci activity is confirmed by registered autochthonous morbidity, isolation of the pathogen cultures from rodents, bloodsucking arthropods, snow-covered nests and from the natural water bodies. From 1965 through 2013, 226 cultures of tularemia microbe were isolated, 96 of them from small mammals. The highest number of cultures (25%) was isolated in the field and meadow stations from common voles. The number of water voles in recent decades has decreased significantly, most likely due to the ongoing changes in biocenoses (Demidova et al. 2015). One of the factors that determine the circulation of the tularemia pathogen in the natural foci of Moscow Oblast are ixodid ticks that are considered vectors and long-term natural reservoirs of this infection, both in epizootic and interepizootic periods.

The locations where cases of human tularemia infection were recorded are evenly distributed throughout the territory of the region (Fig.2).

On the basis of the data obtained, the regionalization of Moscow Oblast according to the degree of epidemic danger was carried out (Fig. 3). Points were assigned to each administrative district with the following indicators: the number of tularemia cases (1-3 points); the number of years of disease cases registration (1-3 points); the number of isolated tularemia pathogen cultures from environmental sources (1-3 points); the number of years with pathogen reporting (1-3 points); presence of settlements with infected humans near the pathogen isolation sites (1-3 points). On the basis of this scoring, all districts of the Moscow Oblast were divided into three groups: areas with high epidemic hazard (11-15 points), areas with moderate epidemic hazard (6-10 points), and areas with low epidemic hazard (0-5 points).

In Krasnodar Krai and the Republic of Adygea (Fig. 4), epizootics among rodents and disease cases among humans were periodically reported. Natural foci of tularemia were found within 35 districts of Krasnodar Krai and 7 districts of the Republic of Adygea. The most epizootologically important are two landscapes: the plain-steppe and piedmont in which human

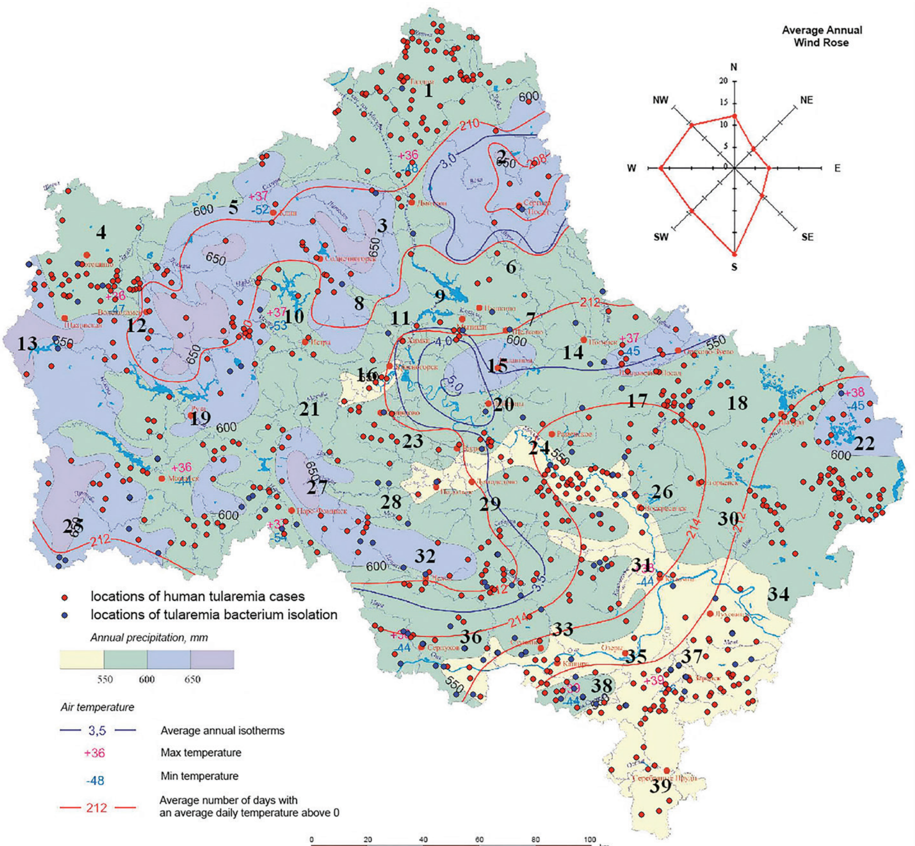

Fig. 2. Climatic characteristics of Moscow region and tularemia cases distribution

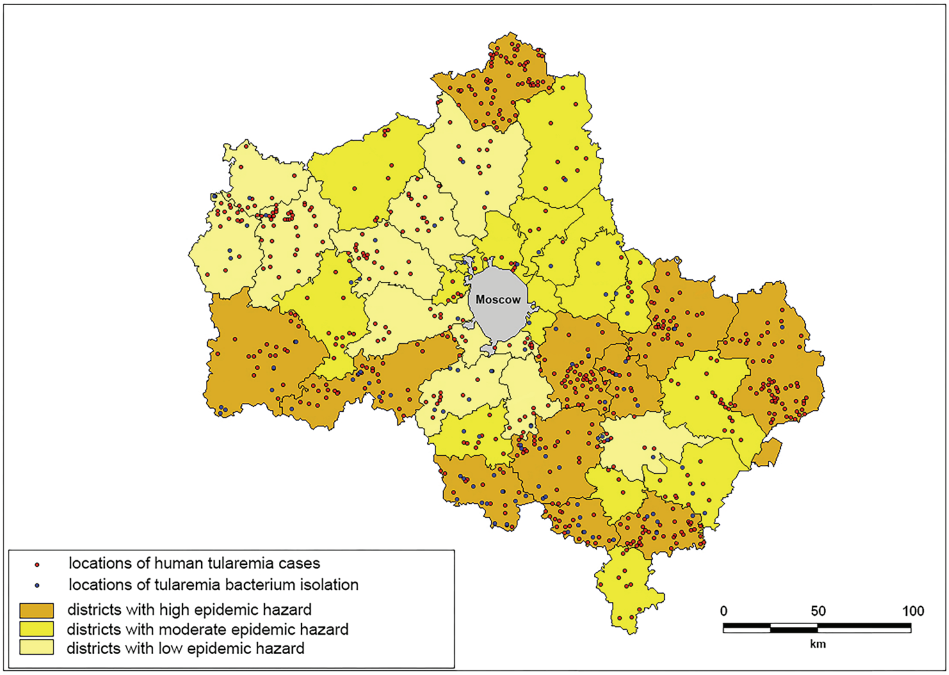

Fig. 3. Regionalization of Moscow Oblast according to the degree of tularemia epidemic risk

disease cases were reported for decades and pathogens were isolated from rodents and ticks. There are 28 species of rodents which are the main nutrient sources of ixodid ticks in this region. This factor plays a leading role in the maintaining of tularemia natural foci. Sporadic human cases and the isolation of the pathogen cultures have been reported from 1997 to 2015. All cases were unevenly distributed throughout the region concentrating in the plain-steppe and piedmont regions of the Atlantic-continental Southern European climatic province of the temperate belt with average annual precipitation of 500-800 mm (very warm, not sufficiently moist, the total solar radiation is 4600-5050 MJ/m2 per year, the sum of air temperatures above 10°C is 2600-3200°C, the average annual precipitation and evaporation sum is -200 – -400 mm). In the south of Krasnodar Krai, tularemia was not reported in areas with an average annual precipitation of 800 mm or more.

Thus, natural foci of tularemia are common in different climatic zones of Russia and are confined to various landscapes. The conditions of human infection, seasonality, magnitude of morbidity and other epidemiological features of tularemia infection vary significantly in areas with natural foci of one type or another. Apparently, the areas with a moderate climate are the optimal for this infection. In the arctic, subarctic, subtropical belts, tularemia occurs within intrazonal landscapes.

West Nile fever

West Nile fever (WNF) is a natural focal arboviral emergent infectious disease caused by West Nile virus (WNV). WNV was first isolated in 1937 from a feverish patient in the West Nile province in northern Uganda, which gave its name. After 60 years, the disease was revealed on 5 continents, so the virus became the most common arbovirus in the world. The main components of WNF natural focus are hosts (predominantly birds), vectors (predominantly blood-sucking mosquitoes) and the pathogen itself (WNV). The two most significant natural factors in WNF's epidemiology are climatic and biotic (availability of suitable vectors and hosts). WNV transmission on

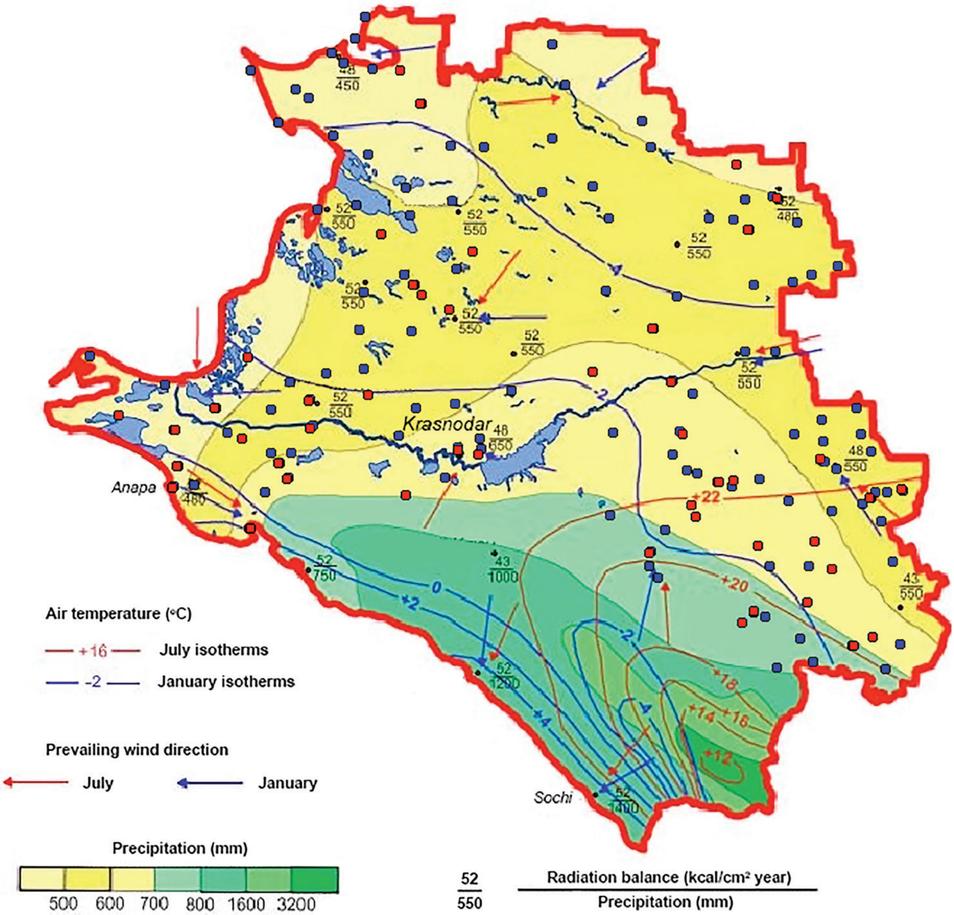

Fig. 4. Climatic characteristics of Krasnodar Krai and the Republic of Adygea and tularemia cases distribution

its own depends on a complex interaction of different factors, related to virus, birds, mosquitoes, humans, and weather, that contribute to epidemic/epizootic spread of the infection. The reproduction of WNV in infected mosquitoes increases along with temperature rise (Kilpatrick et al. 2008). An increase in temperature in the 18–30°C range shortens the gonotrophic period of mosquitoes encouraging mosquito activity (increasing the frequency of mosquito's bloodmeals) (Paz et al. 2008). It was shown that extrinsic incubation period (EIP) of the virus in an American mosquito species Cx. tarsalis decreased from 30 days at 18°C to 10 days at 26°C (Reisen et al. 2006). Supposedly, this results in intensifying WNV transmission which may accelerate at high temperatures. It was estimated for American strains of WNV that that the temperature threshold for virus developing in a mosquito is 14.3°C, and the EIP required for its transmission is 109°C/day (Reisen et al. 2006; Hartley et al. 2012).

It was long believed that the northern border of WNF's nosogenic territory in Russia more or less coincides with the 16ÅãC July isotherm, meaning that the majority of Russia's territory is at risk (Lvov et al. 1989). Unfortunately, an accurate data on EIP duration and the threshold temperatures for WNV strains occurring in Russia and its populations of Culex mosquitoes is not available but juxtaposition of results of several Russian studies with estimation of Reisen et al. (2006) confirms acceptability of these figures for Russian strains (Platonov et al. 2014; Safronov et al. 2014). Cold winter months lower the likelihood of an outbreak during the following summer (Platonov et al. 2014).

The first case of human disease with the WNV in Russia was detected in the Astrakhan Oblast in 1997. By 2017, 20 regions (mainly located in the south of the European part of Russia, the Southern Urals and the south of Western Siberia) are already affected by the arbovirus. Currently, WNV cases are registered in most years in the Astrakhan, Volgograd and Rostov oblasts. In this area, the most suitable climatic and biotic conditions for the pathogen occur (continuously high temperatures and the presence of a large number of birds in the aquatic complexes and wetlands). More than 2400 cases of the disease were registered during 20 years. The biggest amount of cases (more than 100 yearly) occurred in 1999, 2007, 2010, 2012 and 2016.

For the purpose to determine the northern limit of the possible spread of WNV in regions with continental climate we relied on the results of the study in other globe regions and on the estimates for the territory of Russia (Lvov et al. 1989; Reisen et al. 2006; Kilpatrick et al. 2008; Adishcheva et al. 2016) and took as the border the July isotherm at 14°C, and the duration of the period with temperatures above 10°C for 135 days. In more humid, maritime climate, the nosoareal is limited by the sum of the effective temperatures above 10°C, which must be at least 2000°C. The potential nosoareal of the WNV was ascertained by imposing these indicators on the administrative map of Russia chosen as a basis for the convenience for counting the number of regions in which the natural and climatic conditions allow the transmission of the virus.

The analysis shows (Fig. 5) that about 60 regions of the Russian Federation are located on the area of WNF potential outbreak risk. The main WNF natural foci in Russia saturated in the lowlands of the Volga and Don rivers but, since its introduction in Russia, WNF has moved significantly eastward and northward in just two decades. Overall, the disease was reported in 21 Russian regions from 1997 to 2015. Most WNF cases in Russia occur in the summer beginning in mid-July. Outbreaks in Russia's southern regions are first of all linked with favourable climate conditions (average July temperatures far exceed 16°C, which allows for the rapid accumulation of virus in mosquitoes' salivary glands) and the presence of hosts and vectors. Therefore, with the climate warming, the

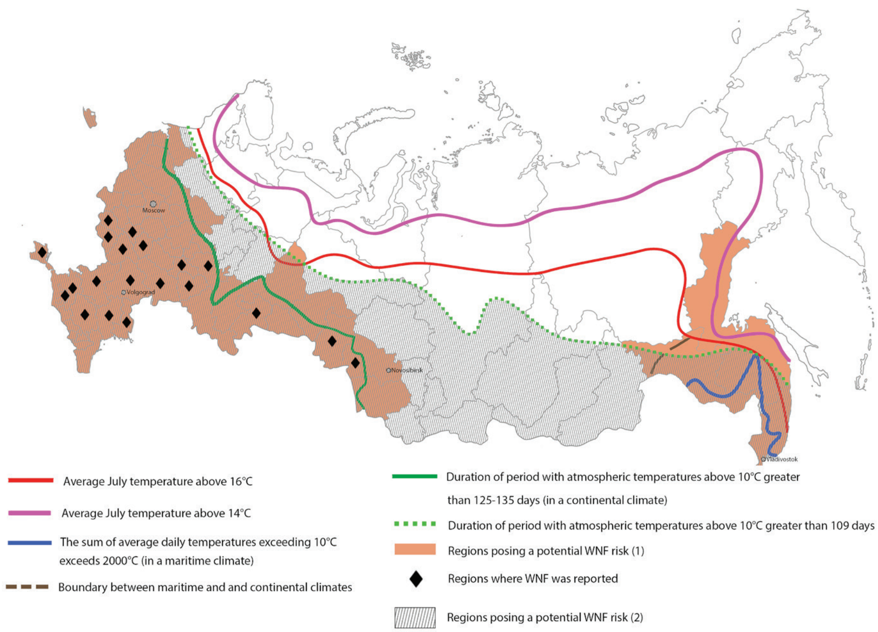

Fig. 5. WNF potential risk areas

range of suitable climatic conditions is possible to expand which may increase the geographical range of mosquitoes and, correspondingly, the range of WNF in Russia.

Vivax malaria

There are four species of malaria that infect humans. Each of them induce one of four different diseases, each with specific clinical features and epidemiology. In the pre-elimination era malaria was endemic in most of Europe. In the middle of 20th century all species of malaria were eliminated on the territory of the USSR, and since then, short-living episodes of autochthonous transmission following importation of P. vivax have been documented in a number of European countries, but Russia was the most affected. More than 500 autochthonous cases were recorded in European Russia from 1997 to 2010. Autochtonous malaria cases were reported in 24 of 50 regions of European Russia. After 2004 local malaria transmission dramatically decreased due to less favorable weather conditions after 2002 and interruption of the importation of malaria from Tajikistan and Azerbaijan due to improvement of malariological situation in these countries.

From the point of view of possible transmission re-introduction, vivax malaria represents a reliable model because it was highly endemic in European Russia in the past and, unlike other malaria species, could easily re-introduce itself in previously endemic areas after elimination (Mironova 2006; WHO 2010).

During the last half of the 20th century the suitability of climatic conditions for vivax malaria transmission improved on the entire territory of European Russia but this trend manifested itself differently in various parts of the potential nosoareal. We estimated the changes in favorability of climatic conditions for vivax malaria transmission in different parts of European Russia.

To assess the role of climate change trends in reemergence of vivax malaria in European Russia we investigated the variations in favorability of weather conditions in different parts of European Russia in order to assess their role in malaria reintroduction. Summer temperatures have been analyzed for 5 geographical points of various climatic zones in European Russia for 51 years up to 2015 (Fig.6). The analysis was based on Moshkovsky's method (Moshkovsky and Rashina 1950), that allows to assess elements of malaria season.

Required sum of temperatures above the base temperature for Plasmodium vivax is 105 degree-days

The formula for calculating of daily effective temperature for P. vivax parasite is

$$E=T_a-T_b, \text{ at } T_a>T_t, \text{ where:}$$

E – effective temperature (a sum of temperatures gained by a parasite during one day)

T_a – daily average temperature

T_b – base temperature (14,5°C)

T_t – Lower threshold of development (+16°C)

The effective temperatures are summarized for the whole season starting from the date of beginning of the period of effective infectivity (e.g. the date of a stable transition of daily average temperatures through the threshold of +16°C) till the date of the last effective infection of mosquito.

Each summer season was classified upon its favorability to vivax malaria transmission into several groups, from "absolutely unfavorable" to "particularly favorable", according to the previously elaborated methodology (Mironova 2006). The structure of malaria epidemic season and the correspondence of its parts is discussed in details in our work dedicated to the method of prognosis of vivax malaria potential spread using climate modeling data (Malkhazova et al. 2018).

The territory of European Russia was tentatively divided into three latitudinal parts. The trends in the evolution of the malariological situation were examined in each of them.

Northern part of possible malaria nosogenic territory.

During the period under review, the occurrence of secondary malaria cases (that

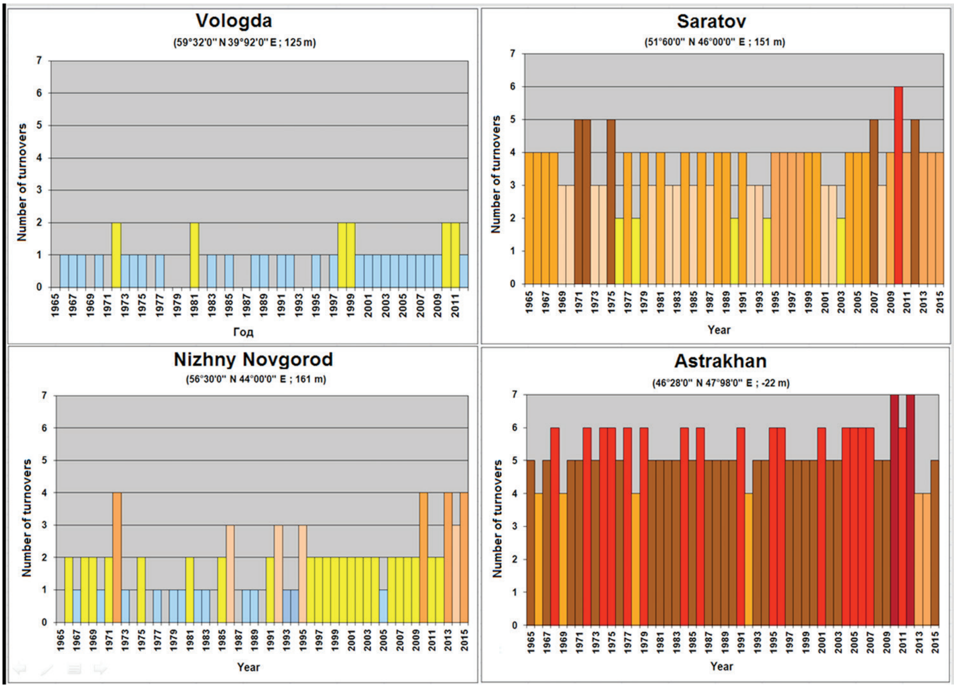

Fig. 6. Vivax malaria epidemic seasons in different parts of European Russia

is, ephemeral transmission) in Arkhangelsk was possible in less than half of the seasons and only three times – (in 1972, 1974 and 2010) third generation cases could occur from secondary cases. The remaining seasons were absolutely unfavorable, meaning that maturation of sporozoites in mosquitoes was impossible. From 1991 to 1997, the amount of warmth needed to transmit malaria by mosquitoes was not reached. The situation has changed slightly since 1998 and the main distinguishing feature of this period was a significantly smaller number of absolutely unfavorable seasons.

Mean annual sum of air temperatures above 10°C in Arkhangelsk is about 1200°C. In the years when the transmission of vivax malaria was possible, the average annual sum of the effective temperatures (above the threshold value of +16° C) was only 182.8°/days. Given that the minimum amount of effective temperatures for a vivax is 105°/days, we can say that in general this region is unfavorable for the spread of malaria and the climatic changes of the past few decades have affected only by a slight increase in the number of seasons when an ephemeral transmission is possible.

The meteorological situation in Vologda (see Fig. 6) is similar to the situation described above in Arkhangelsk. It differs only in a larger number of seasons during which only ephemeral transmission from imported cases is possible (i.e. the unfavorable seasons). It is noteworthy that absolutely unfavorable seasons have not been noted after 1997 which fact, it may be supposed, is due to the increase in the heat supply in this region. However, the number of days with an average daily air temperature above + 16°C is negligible.

Despite the fact that, according to our calculations, the probability of local transmission of vivax malaria in Arkhangelsk and Vologda is estimated as extremely low, we can state the presence of a tendency to a certain increase in favorability of climatic conditions in the northern periphery of the potential nosoareal of malaria. If these trends persist in these territories, it is possible to talk about the probable occurrence of authochtonous cases under appropriate conditions, at least in certain years.

Central part of possible malaria nosogenic territory.

The considered period of 1965-2015 in Nizhny Novgorod (see Fig. 6) can be quite clearly divided into two intervals, before and after 1995. During the first period, the number of favorable epidemic seasons was insignificant and unfavorable and absolutely unfavorable seasons prevailed. After 1995, the transmission of vivax malaria became possible annually in this region. There were conditions favorable for occurrence of cases of the second and third generation and after 2010 there were three very favorable seasons (2010, 2013 and 2015) during which cases of the fourth generation could occur, i.e. there were opportunities for epidemic outbreaks in presence of infected individuals. We previously observed the similar situation in Moscow region (Mironova 2006).

Southern part of possible malaria nosogenic territory.

The climatic conditions of Saratov (see Fig. 6) have always been very favorable for malaria transmission. However, there is a trend to an increase in the number of infection turnovers during the season, starting from mid-1990s. If before 1995, the seasons with four possible turnovers alternated with seasons with only three or even two, then after 1995 there were almost no seasons with less than four turnovers of the infection.

In Astrakhan (see Fig. 6), considering the region's fair heat supply, absolutely all seasons were very favorable for the transmission of vivax malaria differing only in the number of infection turnovers. Since the mid-1990s, however, the trend towards an increase in the number of turnovers during one epidemic season is fairly evident (despite two relatively unfavorable seasons of 2013 and 2014 when only four infections were possible).

As demonstrated by the calculations, throughout the European territory of Russia (ETR), one can note an increase in the degree of favorability of the climate conditions for the transmission of malaria. There is a trend in the north of the ETR towards an increase in number of seasons favorable for malaria transmission. At the same time there is an increase in the number of possible turnovers during one season in the southern regions. This conclusion corresponds to our previous estimations made for Moscow region (Mironova 2006) and to modeling implemented for European Russia as a whole (Malkhazova et al. 2018).

Besides the favorable climatic conditions, the presence of infection (infected persons) and an effective vector is crucial for spread of malaria. Therefore, the favorable climate conditions themselves do not certainly produce autochtonous malaria cases. We can speak only about the existence of climatic preconditions which can be realized in local transmission in the presence of necessary members of malaria parasitic system.

CONCLUSIONS

The climatic factor is deemed one of the main determinants for the spread of naturally determined diseases.

An essential part of any medico-geographical assessment is the search for links between the spread of diseases and factors of the geographical environment. A medico-geographical analysis allows for establishing the relationships between diseases and natural factors and differentiate territories upon epidemiological hazard levels.

The analysis showed that natural foci of tularemia are common in different climatic zones of Russia and are confined to various landscapes but the conditions of human infection (seasonality, morbidity rates and other epidemiological features) of tularemia infection vary significantly. The conditions of different climatic zones are not equal for existence of tularemia natural foci. In European Russia, the most favorable for tularemia infection are the areas with a moderate type of climate – (temperate belt), Atlantic-continental European region (total solar radiation - 3350-4200 MJ/m^2 per year, the sum of air temperatures above

10°C - 1600-2400°C, average annual the sum of precipitation and evaporation - 200 - -100 mm). In the Arctic, subarctic, subtropical climatic belts, tularemia occurs mainly within the intrazonal landscapes, such as floodplains and deltas of rivers, coasts of lakes and swamps.

Outbreaks of West Nile fever in Russia are primarily linked with favorable climate conditions (average July temperatures far exceed 16ÅãC which allows for the rapid accumulation of virus in mosquitoes' salivary glands) and the presence of viral hosts and vectors. The analysis shows that about 60 constituent entities of the Russian Federation are located on WNF outbreak risk area. The main WNF natural focal area in Russia have been evolved in the lowlands of the Volga and Don rivers but, since its introduction in Russia, WNF has moved significantly eastward and northward in just two decades.

During the recent decades, the suitability of climatic conditions for vivax malaria transmission improved on the entire territory of European Russia but this trend manifested itself differently in various parts of the potential nosoareal. In general, the possibility of autochtonous malaria transmission is estimated as extremely low at its northern periphery but it can be noted that there is a tendency towards a rising number of favorable malaria transmission seasons. If this trend remains stable on these territories, we can talk about the possibility of local cases occurrence in the presence of an infection source. In the central and southern parts of the potential nosoareal, the climate suitability improved due to a more favorable combination of temperatures during summers. The changes are more apparent in central parts of European Russia. With regard to southern part of European Russia, the climatic changes evidence in that in some seasons the number of possible transmission turnovers exceeded 7 for the first time in the past 50 years.

Regional and global environmental changes, first and foremost, the global warming, may complicate the modern medico-geographical situation. With the climate warming, the range of suitable climatic conditions is possible to expand, which may increase the geographical ranges of naturally-determined diseases in Russia. All this called for a focused research in order to assess possible alterations.

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