

**CHARACTERISTICS OF NATURAL FOCI OF TULAREMIA IN THE CRIMEA, THEIR POTENTIAL DANGER IN EPIDEMIC PROCESS DEVELOPMENT AND THE MAIN DIRECTIONS OF ITS PREVENTION**

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Geographical and climatic conditions of the Crimean peninsula, mammals of a particular ecosystem together with pathogens of the infection and a complex of their ectoparasites, contribute to preservation of natural foci of tularemia and other natural focal infectious diseases on its territory. Epizootic activity of natural foci of tularemia has a well-defined periodicity and seasonality. Currently, natural foci of tularemia of the steppe type in the flat Crimea and forest type on the territory of the mountain-forest Crimea function. Three types of enzootic tularemia were identified. The epidemiological analysis of people with tularemia in the Crimea showed that its dynamics, level and distribution of cases in the administrative regions are determined primarily by activity and duration of epizootics in natural foci located in the territories where tularemia is diagnosed. Prevention of diseases of people with tularemia in the Crimea requires constant monitoring these infections natural foci activity, rodent epizootics' timely detection, their ectoparasites study, and the of preventive measures implementation basing on their results

**Key words:** marine medicine, natural foci, natural focal infections, epizootics, reservoir, carriers, tularemia.

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**Introduction.** The Crimean peninsula covers 26.1 thousand km<sup>2</sup>, and three main areas can be distinguished in its territory: the mountain Crimea, the flat Crimea, and the Kerch Peninsula. The northern and the central parts of the Crimean peninsula are the flat Crimea. The peninsula is located on the border between temperate and subtropical climatic zones. Depending on the peculiarities of the relief, climate and vegetation, five landscape groups of animals are distinguished: steppe, forest-steppe, mountain-forest, mountain and southern coast — and each of them more or less affects the preservation of various natural foci and development of epizootic processes .

The vast majority of species of the Crimean fauna is a natural reservoir of pathogens of many natural focal infections. Mammals of a specific ecosystem, along with pathogens and a complex of their ectoparasites, which are often carriers, constitute a single natural focal ecosystem [1, 2].

By now, natural foci of tularemia, leptospirosis, tick-borne viral encephalitis, the Lyme disease, intestinal yersiniosis, pseudotuberculosis, hemorrhagic fever with renal syndrome, the Crimean hemorrhagic fever, Marseilles fever, Q fever, rabies, etc. have been formed, and they are functioning in the territory of Crimea [3, 4]. There are environmental factors that can be favorable for preserving foci of anthrax and brucellosis and for spreading cholera.

Millions of tourists come to the Crimea annually; the number of tourist routes is steadily increasing; the number of contacts of the local population is increasing due to growth and expansion of the local recreational areas and agricultural land. All this contributes to an increase in the risk of infecting some people when they get on the territory of natural foci of tularemia.

Planned systematic work to clarify the boundaries of natural foci of tularemia in the Crimea, determining the degree of their activity, the number of main carriers and custodians of this infection, and the influence of various environmental factors on them are the basis for creating a system of preventive measures aimed at preventing infection of people temporarily or permanently enzootic for tularemia territories [5, 6].

**The Materials and Methods.** The work was based on some materials of perennial (since 1978) epizootiological, bacteriological and serological surveys of natural foci of tularemia in the Crimea, conducted by the 637<sup>th</sup> Center for State Sanitary and Epidemiological Surveillance of the Black Sea Fleet independently or jointly with the Federal State Budget Educational Institution “Plague Control Station in the Republic of Crimea” of the Federal Service on Customers’ Rights Protection and Human Well-being Surveillance (the Rospotrebnadzor) and a Federal Budget Health Institution “Center for Hygiene and Epidemiology in the Republic of Crimea and the city of federal importance Sevastopol”, as well as data on natural focal infections in the Crimean peninsula, published in the press over the past 40 years.

During the period from 1978 to 2017, about 57 thousand traps per night were set, more than 3,175 rodents and insectivores were caught, and 57,550 Lyme's ticks (ixodic ones) were collected at natural biotopes as well as from dogs and livestock. More than 2350 ectoparasites (fleas, lice, gamasid, red-shelled and ixodic ticks) were combed from captured small mammals; about 370 pellets of the birds of prey were collected. More than 95% of the collected zoo-entomological material has been disassembled, determined and investigated for tularemia antigen and antile for tularemia, as well as for other pathogens of natural focal infections. When trapping gray and black rats, small gophers, and common hamsters, common traps and live traps were used; when trapping the mouse-like rodents, Gero's break-back traps were applied. Registration of holes and settlements of rodents and other animals was carried out. To estimate the number of fox, brown hare and other species of vertebrate animals, various methods of visual and other types of accounting were used.

**The Results and Discussion.** In the Crimea, the group incidence of people with tularemia has been registered since 1951, when during five years (1951–1955), 352 cases of this infection, clinically confirmed, were recorded in the Dzhankoysky, Sovetsky and Leninsky districts, of which 334, (94.9%) were identified on the Kerch Peninsula. In the future, the incidence of tularemia among people, the distribution of cases among populated areas and administrative districts of Crimea was determined by the state of activity and the duration of epizootics in natural foci in these territories. So, for the analyzed period from 1981 to 2017, 22 cases of tularemia were recorded. The dynamics of the incidence of tularemia is as follows: in 1981–1983 – 4 cases, in 1989 – twice, in 1997 – twice, in 2000–2004 – 6 times, in 2015–2017 – 8 cases.

During these years, the activation of natural foci of tularemia was recorded.

- In 1981 on the Kerch Peninsula in the Kamenka settlement there were 3 cases of tularemia among the local population. According to the results of the epizootological survey of this outbreak, 20 cultures of the tularemia pathogen and 2 cultures from the water of open reservoirs were isolated from rodents, which confirmed the high intensity of the pathogen circulation and characterized the intensity of the epizootic process in the area. People living in this territory were vaccinated against tularemia.

- 1989–1990 active epizootics of tularemia were recorded in most of the territory of the Kerch Peninsula. 2 people got tularemia. During this period, in the southern part of the Kerch Peninsula, tularemia epizootics were found in 18.7% of the surveyed sites of natural biotopes with an average infestation of small mammals of 6-7.0%. In 20.0% of water samples from natural water bodies, the causative agent of tularemia was detected, and the microbe antigen was detected in 8.8% of the investigated birds of prey. The causative agent of tularemia, antigen and antibodies to it in the winter of 1989-1990, found in the studied objects in vicinities of the Ptashkino, Maryevka, Vyaznikovo, Yakovenkovo, Vuklkanovka, and Bright settlements. People living in these settlements were vaccinated against tularemia

- In 1991, an epizootological survey of the southern coastal region of the Kerch Peninsula was carried out. Among the 5 species of small mammals captured in the surveyed area, a rodent typical for the steppe Crimea, the public vole (*Microtus socialis*), dominated – 57.8% of all animals of all species. Less common was a steppe mouse (*Sicista subtilis*) – 27.5%. The share of other species of the mouse-like rodents did not exceed 3–7%. 82 ectoparasites were collected from 183 captured mammals: 10 fleas, 18 ixodic, and 54 gamasid mites. A serological study of the mouse-like rodents in 11 (6.0%) revealed a tularemia antigen.

- In 2003, an epizootological survey of territories enzootic with tularemia was carried out, with environmental sampling and testing for antigen and antibodies to tularemia. At bacteriological research of 2200 rodents and ticks, from a common vole and a mouse-steppe, caught in the Leninsky district, two cultures of the causative agent of tularemia were identified.

- In 2004–2016, the epizootic situation on tularemia in the southern coastal region of the Kerch Peninsula has not changed and remained challenging. The annual epizootological surveys of the territories adjacent to the Opuksky Nature Reserve, conducted by the experts from the 637<sup>th</sup> Center for State Sanitary and Epidemiological Surveillance of the Black Sea Fleet, confirm this situation. Over the entire period, 574 specimens of small mouse-like rodents were captured and investigated for the antigen and antibodies to tularemia, of which: 372 voles (*Microtus socialis*) – 64.8%, 116 steppe mice (*Sicista subtilis*) – 20.2%, 52 small white shrews (*Crocidura suaveolens*) – 9.1% and 34 kurganchikovyyh mice (*Mus spicilegus*) – 5.9%. 134 pieces of the birds of prey were collected and investigated, 75 water samples were taken from natural reservoirs. 7321 copies of the ixodic ticks, 187 mosquitoes and 31 mosquitoes were collected. During serological examination of rodents for tularemia in 37 (6.4%) cases (all voles are public), specific antibodies were detected in titers of 1:20 and 1:40 in the indirect hemagglutination reaction (IHGR). In the study of smears-prints from the organs of small mouse-like rodents using the fluorescent antibodies

method (FAM) in 75 (13.1%) cases, a tularemia microbe antigen was detected (a vole, a common kurganchikovy mouse and a small white-toothed tooth). When examining the pellets of birds of prey in 77 (57.5%) cases, the remains of the public vole skeleton were found, in 34 cases the gray hamster (25.3%), and in 23 cases the rat gray (17.2%). A serological study of predatory bird pellets using the dot enzyme immunoassay method (dot EIA method) revealed a tularemia antigen in 16 samples (11.9%). In the study of 287 samples of ticks (5875 copies), captured on the Kerch Peninsula, the dot-EIA and FAM methods in 43 samples (15.0%) detected an antigen tularemia.

The results of the long-term monitoring of the southern coastal region of the Kerch Peninsula confirm the presence of potentially dangerous natural foci of tularemia that are potentially dangerous for human infection and the development of the epidemic process.

In the areas adjacent to the city of Sevastopol, natural foci of tularemia have been registered for more than 30 years in the Balaklavsky district (the Reserve, Goncharnoye, Tylovoe, Orlinoe, and Shirokoye settlements) and in the Nakhimov district (the Verkhnyaya Sadovoe and Front settlements.) In 2002–2017, the cases of tularemia among the population of the city of Sevastopol were not registered. During this period, a zoentomological survey of natural biotopes located on the territory of the city of Sevastopol (the Revyakina street, cape Fiolent, park Maksimova Dacha, the Karantinnaya bay, the Yukharev's balka, the Karakoba mountain area) and in its suburbs (the Baidarskaya valley, the Shirokoe, Ozernoe, and Rodnikovoe settlements), the experts from the 637<sup>th</sup> Center for State Sanitary and Epidemiological Surveillance of the Black Sea Fleet captured and investigated 360 small mouse-like rodents and mammals, 12,947 copies of ixodic ticks, conducted 5859 serological tests for tularemia. Positive findings of tularemia antigen were detected in 302 cases (5.2%), of which in 210 cases (3.6%) in tick samples and in 92 cases (1.6%) from the mouse-like rodents. The positive findings of antibodies to the causative agent of tularemia in diagnostic titers of 1/20–1/40 were found in the mouse-like rodents in 39 cases (10.8%). Research results confirm the presence of low-activity natural foci of tularemia in these areas of the city of Sevastopol (human diseases and isolation of cultures of the pathogen are not recorded, but there are irregular findings of tularemia antigen in environmental objects), which requires further observation of natural foci and a set of preventive measures, including immunization of at-risk populations.

Epizootological surveys of natural foci of tularemia in the northwestern and central regions of the Crimea in 2015–2016 showed that, out of 441 specimens of wild rodents and shrews in 9 points of 4 administrative districts of the Steppe Crimea and the Forest Crimea. some were caught in natural biotopes (one of them is caught in the Sovetsky district; two – in the Dzhankoysky district; eight – in the Simferopol district; three – in the Krasnogvardeysky district); for 14 (3.4%) cases, antibodies to the tularemia pathogen were detected in diagnostic titers of 1/40–1/80. In addition, an antigen was detected in the ixodic ticks on the territory of the Dzhankoi district (the city of Dzhankoy.) Among synanthropic rodents, in 4 cases, antibodies to the causative agent of tularemia were detected: in the city of Kerch in the titers 1/40 (1 house mouse) and 1/80 (1 gray rat), in the Krasnogvardeysky district (1 house mouse, titer 1/80; the Yantarnoe settlement), in the town of Feodosiya in credits 1/40 (1 house mouse.)

According to some literature data and the results of long-term observations of natural foci of tularemia in the Crimea, it can be concluded that natural foci of steppe-type tularemia are functioning in the plain Crimea and forest type in the territory of the mountain-forest Crimea. The territories enzootic for tularemia of the free types specified below were identified.

The first type is such an enzootic area, where natural foci of tularemia are confirmed by releasing the pathogen and human disease — this is the entire territory of the Kerch Peninsula and 6 nuclear foci occupying minor areas: 3 foci in the forest (the Kherskovka region, the Ternivka, Pochtovoe, Maryino, Perevalnoe, Vasilyevka and Pavlovka settlements) and 3 centers in the steppe zone of the Crimea (east of the city of Dzhankoy, the Tabachnoe, Pervomayskoye and Krasnoyarskoye settlements.)

The second type is for conditionally enzootic foci of forest type tularemia with release of antigen and antibodies to tularemia and sporadic human morbidity (territories adjacent to the South Coast of the Crimea along the line: Sevastopol, Bakhchisarai, Simferopol, Belogorsk and Old Crimea cities and Planerskoye urban-type settlement.)

The third type is conditionally enzootic foci of steppe-type tularemia with release of antigen and antibodies to tularemia and sporadic morbidity of people in this territory – the central, northern and western parts of the steppe Crimea.

Among mammals, the public vole (*Microtus socialis*), the small white-toothed (*Crocidura suaveolens*) and the crocodile mouse (*Mus spicilegus*) play a leading role in maintaining the epizootic process in foci of steppe-type tularemia. In forest-type foci, the common vole (*Microtus obscurus*) plays the leading role of the intermediate host, and the ectoparasite complex and ixodic ticks play the role of carriers. They also

play the role of the main keepers of the infection. The main carriers of the pathogen are ixodic ticks (*Haemophysalis runctata*, *Dermacentor marginatus*), gamasid ticks (*Androlaelaps glasgovi*, *Haemogamasus nidi*) and fleas (*Ceratophyllus consimilis*, *C. Mokrzecky*, *Amphipsylla rossica*.)

The leading role in the epidemiology of morbidity in people in all foci of the steppe type in the territory of Crimea is played by hares. It should be noted numerous facts of detection of the tularemia microbe antigen in the pellets of birds of prey in various regions of the peninsula, confined to the natural foci of tularemia.

The epizootic activity of natural foci of tularemia has a well-defined periodicity and seasonality. Thus, acute spilled epizootics on the Kerch Peninsula are recorded every 7–8 years, they are preceded by increased circulation of the pathogen among the main carriers of this infection and the complex of ectoparasites, lasting for 1–2 years, then after the maximum rise, extinction occurs and the sluggish epizootic process can last 4–5 years old. The activity of natural foci of steppe-type tularemia occurs in November-February, and the natural foci of forest-type tularemia occur in the spring, when ixodic ticks are activated.

Epidemic situation on tularemia in the Crimea during 2015–2017 remained unstable. In 2015, 2 cases of tularemia were reported among the civilian population, and ticks could be a likely source of infection. In 2016, 3 cases of tularemia were registered (2 cases of tularemia in Yevpatoria), in 2017, 3 cases were also recorded (2 cases in the Kerch Peninsula and 1 case in Simferopol); that is making carcasses of a hare what propagated the infection.

**Conclusion.** The Crimean peninsula is a potentially dangerous territory with natural foci of tularemia of steppe and forest types. Analysis of research results and literature data suggests that the state of populations and the dynamics of the number of small mammals and other vertebrate animals, their ectoparasites and ixodic ticks in the Crimea, which are the reservoir and source of infection of humans by the tularemia pathogen, in different landscape areas of the peninsula contribute to maintaining epizootic stress situation that leads to annual (2015–2017) cases of human tularemia in all territories of natural foci, and in the enzootic territory of the first type (the Kerchensky Peninsula) may cause disease in humans group this infection.

Epizootological examination of natural foci of tularemia is the most important direction of epidemiological surveillance of the disease and is necessary for the timely detecting epizootics among small mouse-like rodents, determining their intensity, studying the pathogen circulation mechanisms, assessing the threat of epidemic complications, and justifying specific preventive measures.

Preventive measures are being held in the Crimea, including: routine vaccination and revaccination of the population at risk, systematic, annual disinsection (mites, fleas, etc.) and deratization activities in recreational areas, as well as areas adjacent to tourism and recreation centers.

For people traveling by tourist routes in the mountain forest of Crimea, it is necessary to provide for using them any repellents, and in the years of high activity of the ticks – impregnation of clothing to prevent bites from ticks and other blood-sucking insects.

An important direction in the prevention of tularemia infection of people is to strengthen the quality control of decentralized water supply and the improvement of territories adjacent to small towns and recreation areas. Prevention of diseases of people with tularemia in the Crimea requires constant monitoring of the activity of natural foci of this infection, timely detection of epizootics of rodents and other animals, researching their ectoparasites complex and their results of preventive measures that will ensure the sanitary and epidemiological well-being not only the residents, but also the revelers of the peninsular.

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