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TRANSMISSIBLE ARBOVIRUSES OF THE UKRAINIAN BLACK SEA REGION

Kucherenko M.P.[1]*; Kovalchuk L.I.[1]; Strus O.Ye.[2]; Romanenko I.Y.[3]; Nishkumay O.I.[4]; Glushchenko V.Y.[1]; Bobro E.V.[1]; Shelest T.D.[1]

[1]State Institution "South Ukrainian National Pedagogical University named after K. D. Ushynsky", Odesa, Ukraine;
[2]Danylo Halytsky Lviv National Medical University, Lviv, Ukraine;
[3]Ukrainian Scientific and Practical Center for Endocrine Surgery, Transplantation of Endocrine Organs and Tissues of the Ministry of Health of Ukraine, Kyiv, Ukraine;
[4]Bogomolets National medical University.

*docnickolask@gmail.com.

Abstract

The article presents a retrospective analysis of epidemiological and ecological-virological studies of authors' teams in the field of landscape-faunistic features and noso-geography of biocenoses. The endemicity of arboviruses in the south of Ukraine was established for the first time. The spread of transmissible forms such as West Nile fever and tick-borne encephalitis on models of blood-sucking arthropods (carriers), warm-blooded animals and birds - migratory / local birds (carriers) in the zones of their concentration (reserves, "bird colonies") in natural biocenoses of Odessa, Kherson, Nikolaev regions and Crimea.

Among the population of the southern regions, an immunological background has been established regarding their transmissible nature. So, from the cerebrospinal fluid of a patient with neuroinfection, a strain of arbovirus was isolated on transplanted cells. Genetic features, epidemic risks are determined, biotic and abiotic factors of their natural circulation are reflected in nature [49, 50].

According to the theory of the dynamics of averages, taking into account the influence of environmental factors and infection of biological objects, a mathematical model of the intensity of the epidemic process in West Nile fever has been created.

Keywords: *biocenoses, arthropods, warm-blooded animals, arboviruses, mathematical model.*

Introduction

At the present stage of landscape evolution, forest cover of the southern Ukrainian region is approximately 10%. With a change in floristic complexes, qualitative and quantitative rearrangements also occur in the fauna of this region.

Therefore, the study of arboviruses, like other pathogens of any natural focal infection, is not possible without knowledge and understanding the conditions caused and associated with the natural climatic-geographical and faunistic features of the region [1-6, 39].

Natural focal diseases are an interacting group of species populations and are characterized by biological and functional patterns [7, 48, 52, 54].

As a prerequisite for endemic diseases, we used data on climatic, landscape and faunistic characteristics of the territories of Odessa, Nikolaev, Kherson regions and Crimea, which make up the southern Ukrainian Black Sea region and occupy an area between 44°11'' and 47°14'' north latitude and between 28°46'' and 36°16'' east longitude [8-13, 45].

Due to the significant remoteness from the Arctic Ocean, these territories are less affected by the Arctic air masses, and direct access to the Black Sea favors transport links with ports of states located in equatorial latitudes, where foci of mosquito fevers and neuro-viral infections remain active throughout the year [14-15, 39].

Scientific evidence for the involvement of wild animals is known to be to outbreaks of epidemics of diseases that are fatal to humans was obtained only in the 19th century, when a lot of evidence accumulated about the links of the causative agents of these diseases with vertebrates and arthropods [16, 17, 20]. Many discoveries that proved that wild animals can be sources and carriers of pathogenic (pathogenic) microorganisms were included in the golden fund of the world biomedical science [29, 30]. However, it was only in 1939 that E. N. Pavlovsky first formulated the main provisions of the theory of natural focus of diseases, the fundamental essence of which is that the causative agents of a number of infectious diseases, like many biological species, arose independently of humans and exist in nature as natural joints of the ecosystem [5, 7, 14, 15, 28, 41, 45].

Among the natural focal transmissible infections specific to Ukraine, diseases caused by arboviruses have the shortest history. This group of infections attracted the attention of researchers only after the end of World War II, when foci of tick-borne encephalitis, as well as the circulation of equine encephalomyelitis viruses, were identified in the regions of Ukrainian Polesie [31, 32].

Since the discovery of arboviruses, the scientific interest in infections caused by this virus has not diminished. However, the south of Ukraine turned out to be unexplored - the territory occupying 180,000 km² (Odessa, Nikolaev, Kherson regions, Crimea). Territorial factors and connections with the outside world were not taken into account: the neighborhood with the western regions of Polesie and adjacent territories endemic for arboviruses, the specifics of the economic and the tourist interaction of the Black Sea seaports with the ports of hot and tropical countries, where the foci of mosquito arboviruses with a transmissible transmission mechanism, their potential for introduction into Ukraine, and now retain their relevance [41, 43, 48, 49].

Methods

The identification and study of the spread of arboviruses in the southern Ukrainian Black Sea region was carried out using epidemiological, parasitological, immunological, virological and laboratory diagnostic methods of research, followed by mathematical modeling.

Results

In the process of analytical study of the materials, specific landscape-faunistic features of the region were established. In the southern regions of the Ukrainian Black Sea region, the average monthly temperature of the coldest month is - 9.7 °C, the hottest + 25.5 °C. The absolute minimum temperature is 22.3 °C. The average precipitation is 399 mm. The snow cover is thin and unstable. The average annual sum of effective temperatures

(April-September) is 254.3-403.5-525.0-506.0-500.9-281.9, respectively.

According to physical and geographical features, steppe, forest-steppe and mountain associations are distinguished, as well as intrazonal inclusions, which include the floodplains of the Dniester, Danube and Dnieper rivers. The most common type of soil is podzolic (in the forest) and deep medium-humus chernozems (arable land).

The mammalian fauna of the region is quite diverse and includes about 50 species [16]. The average incidence of murine rodents in this zone was 8% (catches were carried out mainly near forests and forest plantations). At the same time, about 50% of the catch was house mouse, 30-35% wood mouse, about 15% common vole.

The fauna of ixodid ticks of the forest-steppe zone is represented by the following species: Ixodes ricinus (mainly forest biotopes), Ixodes laguri, Dermacentor marginatus, Rhipicephalus rossicus, Rhipicephalus sanguineus, Haemaphysalis punctata [17-19].

The most numerous of them are Ixodes ricinus. Ticks overwinter at all stages of development (mature forms dominate). In spring, the larvae of farm animals - hosts, are affected.

In treeless areas, the mite Hyalomma plumbeum dominates.

In addition to farm animals, tick hosts are birds (forest pipit, rook, thrush, pheasant) - (5.7 ± 1.8%), rodents (field mouse, common vole, wood mouse) (4.5 ± 1.9%), lagomorphs (28.5 ± 18.0%), insectivores (hedgehog) - (100 ± 20.0%) in the lymph and larval stages.

The seasonal variation in the abundance of Ixodes ricinus was characterized: the first peak was observed in mid-May - early June, the second peak was noted in mid-August. The first ticks of this species were observed in the second half of April [2-4].

The fauna of blood-sucking mosquitoes is diverse. The most common species are Anopheles maculipennis, Aedes caspius dorsalis, and Culex pipiens [20]. There were also Anopheles bifurcatus. Aedes vexans, Mansonia Richardi, and others. Mass emergence of Anopheles maculipennis was noted in the floodplain area of the Kodyma, Savranka, and the upper reaches of the Tiligul estuary [21-23].

The mammalian fauna of the steppe zone consisted of more than 60 species (of which 25 species are rodents). House and wood mice, common (Right Bank) and public (Left Bank) voles were dominant.

Average incidence of all rodent species was 4.6%, that is, almost 2 times less than in the forest-steppe. The proportion of certain species of rodents was almost the same as in the forest-steppe: house mouse - 48%, common vole - 15%, other species (gray hamster, yellow-throated mouse) - 3%.

The fauna of mites of the steppe zone is represented by: Ixodes laguri (in virgin areas), Ixodes ricinus (in forest areas and shrubs), Haemaphysalis punctata (Crimean steppes), Rhipicephalus sanquineus, Rhipicephalus rossicus, Hyalomma plumacentus, Hyalomma plumbeum dominate, etc. rossicus [24].

The fauna of blood-sucking mosquitoes is marked by background species: Anopheles hyrcanus, Rhododendrons bifurcatus; Aedes caspius dorsalis and Aedes vexans are also found [21, 22, 25 - 28, 42].

Long-term observations with the collection and study of biological material were mainly carried out on the territory of the Black Sea Biosphere Reserve.

The epidemic situation of natural focal diseases is currently based on modern data of the proposed concept of the origin and existence of biological interspecific relationships, depending both on the pathogenicity and virulence of the pathogen genome, and symbiotic relationships between donors, vectors and recipients in natural landscapes and aquatic environments. At stages pre-adaptive processes, the emergence of individual antigenic variants is allowed - the population of microorganisms and numerous interactions with susceptible warm-blooded animals and birds that live mainly in water or near-water basins, as a result of which autonomous foci of arboviruses are formed independently of humans on the territory of steppe, forest-steppe, coastal zones and intrazonal

inclusions in the floodplains of large rivers [46, 47, 55].

According to the reported data, in the isolation of viruses from biomaterial, continuous cell lines were used [30 - 32, 35, 36]. The results were evaluated in the neutralization reaction (RN) with poly- and mono-valent specific sera according to the account of cell degeneration (Table 1).

Immunological tests established the incidence of West Nile fever (15.3 ± 1.9) and tick-borne encephalitis (1.6 ± 0.6). The largest number of cases of West Nile fever were detected during examination of inpatients in the Odessa and Kherson regions; this infection also spread in the Nikolaev region and in the Crimea.

Clinically, the disease was characterized by polymorphism of signs: temperature reaction, intoxication, hemorrhagic phenomena, exanthema and neurological disorders.

According to modern views, under natural conditions, populations of arboviruses are characterized by many selective processes [35, 36]. However, they cannot be regarded as independent, independent events, since selection acts on the organism as a whole, and not on its individual trait. Since the selection factors could be very diverse, pathogenic for humans, the properties of microorganisms, apparently, did not appear purposefully in separate groups or in different species.

Each system of pathogenic microorganisms has a characteristic for its totality, features, including the type of parasitism (molecular, intracellular, extracellular), the localization of reproduction (nucleus, cytoplasm, outside the cells), the mode of replication (chemo-transformation, double division, life cycle), as well as properties such as filterability, presence cell wall, growth in an artificial environment [48, 52]. Pathogenic (virulent and toxigenic) signs of microorganisms are controlled by genes of chromosomal or plasma DNA. However, the functions of many of them are still not clear [13]. Perhaps they not only determine various states and processes of the existence of the pathogen in natural conditions, but they also represent a reserve for the possible manifestation of various pre-adaptive traits, including pathogenicity [40, 51, 53].

An epidemic situation has developed in the natural landscapes of the Ukrainian Black Sea region, in which the arbovirus disease is considered as the result of a meeting unnecessary for the pathogen with a specific person who has penetrated (or is connected) into the ecosystem where the pathogen lives (circulates).

The analysis of the typological division of the revealed pathology in the territory of the South Ukrainian region showed that the endemicity is made up of autonomous foci of arboviruses. The first group of foci of tick-borne encephalitis occupies the territory of predominantly forest and forest-steppe zones and constitutes a 3-membered parasitic system - the pathogen is carriers (ticks), carriers are rodents, sedentary birds, and agricultural animals. The second group of foci of West Nile fever is concentrated in intrazonal inclusions and forms the basis of a 3-membered parasitic system: the causative agent is vectors (mosquitoes), sedentary birds, and agricultural animals. The third group - ephemeral pseudo-foci of arboviruses. It is formed as a result of the transfer of vectors with micro-populations of the pathogen from the territory of autonomous foci by birds during their migration and local migrations.

The identified biocenoses of transmissible tick-borne and mosquito arboviruses, we believe, arise due to various biotic and abiotic factors that ensure the natural functioning of the infectious (infection - biological hosts) and regulatory systems (susceptible organisms).

In the studied region, taking into account the endemicity of predominantly West Nile fever, for the purpose of prompt detection, a mathematical model was created based on the theory of the dynamics of averages, which is based on the elements involved in etiological processes, delimited into separate classes. With a plurality of elements in the classes, it was allowed to operate with concepts of mean values [33 – 35]. Using the appropriate equations and formulas, the incidence of West Nile fever was calculated.

All this makes it possible to identify, taking into account the influence of environmental factors and infection of various biological objects, a seasonal epidemic rise in M1 / Hmax, with an established incidence of transmissible arboviruses in the south of Ukraine [49, 50, 52.53].

Further study of natural focal transmissible arbovirus infections in the southern Ukrainian region, we believe, should be carried out along the line of expanding work and the nature of the scale of the influence of anthropogenic factors on natural focal complexes.

The issues of interaction of arboviruses with arthropods (primarily with common species), as well as "migrants" - mosquitoes of sea vessels staying in the roadstead in ports, adapting in local biocenoses, remain topical.

It seems important to study the conditions of coexistence of pathogens of several infections in combined foci, for example, West Nile fever and psittacosis. Further monitoring of the immunological structure of both the local population and visitors should be carried out.

Discussion

The results of the analysis of retrospective epidemiological and ecological-virological studies are confirmed by the concept of the existence of natural focal infections of West Nile fever and tick-borne encephalitis in the southern Ukrainian Black Sea region.

Elements of biotic and abiotic factors have been identified. Virologically, strains of West Nile fever (29-29-0) and tick-borne encephalitis (54-0) IN log 3.1 were isolated from the biomaterial from patients.

On immunological examination, specific antibodies of West Nile fever were 44.0 ± 8% and tick-borne encephalitis 27.01 ± 7.0%.

The obtained results were confirmed by the laboratory of arboviruses of the Odessa Institute of Epidemiology and Virology, and the laboratory of arboviruses of the Institute of Poliomyelitis and Viral Encephalitis (now the Institute of Poliomyelitis and Viral Encephalitis named after M.P. Chumakov of the Academy of Medical Sciences of the Russian Federation).

The nature of epidemic risks by spreading and circulation of arboviruses due to climatic-geographical, flora-faunistic, zoological and entomological features and the nature of biocenoses in the south of Ukraine.

Further biomonitoring is regulated in order to identify the features of the circulation and conditions of persistence of the pathogen during the periods most unfavorable for their circulation in the southern Ukrainian Black Sea region.

One of the most important issues in the implementation of epidemiological surveillance over the territory of Ukraine is the study of the consequences of the introduction of blood-sucking arthropods by migratory birds and bats during spring migrations with the survey of birds. It is important to use integrated means to improve the natural environment and methods for controlling vectors and carriers of dangerous vector-borne arboviruses.

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The authors declare that there are no conflicts of interest.

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Table 1. Influence of isolated strains of arboviruses on cell cultures

Cell names	*Total number of samples studied*	*Degree of degeneration*				*% affected cells*
		3,4 +	*2+*	*1+*	*-*	
RH	19	10	6	-	-	84
HEP	27	13	7	2	3	74
Total	46	23	13	-	3	78