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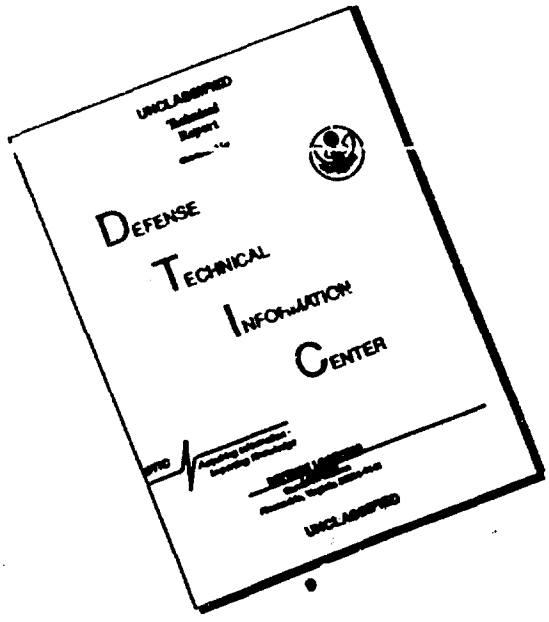

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PROBLEMS OF EPIDEMIOLOGICAL GEOGRAPHY VII. THE SIGNIFICANCE OF THE ANTHROPOSPHERE IN THE GEOGRAPHY OF ZOONOSES CAUSATIVE AGENTS

[Following is the translation of an article by I. I. Yelkin and V. K. Yashkul, Ist Moscow Medical Institute imeni I. M. Sechenova, published in the Russian-language periodical Zhurnal Mikrobiologii, Epidemiologii i Immunobiologii (Journal of Microbiology, Epidemiology and Immunobiology) No. 11, 1966, pages 101-109. It was submitted on 22 April 1966. Translation performed by Sp/7 Charles T. Ostertag, Jr.]

At the end of the last century the concept was substantiated that the earth had specific covers (geospheres): Solid (lithosphere), liquid (hydrosphere), and gaseous (atmosphere). Besides this, sectors of these geospheres, inhabited by living organisms, were separated out into a specific earth cover - the biosphere, which is not homologous to the remaining covers. The concept of the biosphere as a medium of life was first developed by V. I. Vernadskiy (1926, 1934, 1940, 1942).

The biosphere is an association of living organisms (biomass of the earth) together with the inorganic base, which is the abiotic medium of life for these organisms. Its entire population makes up a single complex of an organic nature. The energetic resources and plastic substances of this complex depend on solar energy and the inorganic substances of the geosphere. As V. I. Vernadskiy pointed out, in the biosphere the flow of chemical elements and energies from living to inert matter and back is continuous.

In different sectors the biosphere, which is surrounding the earth in the form of a concentric cover with a thickness reaching 20 km and more in places, is non-uniform both in the physical-chemical properties of its inorganic base and in the species composition and population density of living organisms. Therefore, in the biosphere itself it is possible to separate out sectors with sharply differing conditions of life. These sectors are usually defined as the habitats for living organisms: Water (hydrosphere), terrestrial-air (troposphere) and within the ground (lithosphere).

The distribution of organisms in habitats is characterized by a great deal of diversity. Some of these live constantly in one particular habitat and are not capable of a more or less prolonged existence in other habitats. Therefore, we have hydrobionts (for example, the majority of fish), aerobionts (many species of quadrupeds) and pedobionts (a number of soil microorganisms, certain worms, moles, mole-voles). There are organisms which, during the process of development (metamorphosis), change their habitat. For example, blood-sucking mosquitoes and black flies, with

rare exceptions, spend their pre-imago phases in the water, but in the adult stage they are aerobionts. Finally, a number of organisms are capable of existing, during the same stage of development, in two or more habitats. Thus, fossorial rodents are aero-pedobionts, diving birds - aero-hydrobionts, and the water vole - an aero-pedo-hydrobiont.

It is necessary to say that within the confines of specific habitats no single organic species makes up a solid cover. As a result of the evolution of inorganic and organic nature, specific landscape-sectors developed on the surface of the earth in complete conformity with the distribution of certain properties and qualities of the biosphere (see Report IV). These were characterized by the irreversible association of their geographical properties. Each organic species, existing in primeval nature, is distributed in a strictly specific landscape or combination of landscapes.

At the same time the overwhelming majority of organisms inhabiting our planet not only live in habitats which are inherent to them, but they themselves are the habitat for parasitic organisms. Ye. N. Pavlovskiy (1934, 1940, 1948, 1961) substantiated the stand, according to which living creatures themselves represent a habitat, which he called "the organism as a habitat" or "ontosphere". Primarily parasitic species are adapted to and live in this habitat. However, parasites are not adapted to the ontosphere alone, which is their habitat of the first order, but also to the completely specific features of a biotic and abiotic habitat of the second order (see Report V). As a result of this the distribution of parasites, as a rule, does not coincide with the distribution of their hosts. However, the bond with specific geographical landscapes is preserved on the part of the causative agents of naturally focal zoonoses.

The bond between the distribution of the order of helminths and landscapes was established by K. I. Skryabin in 1924. K. I. Skryabin considers that the life of parasitic worms is continuously connected with natural historical conditions, characterizing a given geographical region, therefore in each locality there is a more or less specific fauna of helminths. From this point of view it is possible to speak of helminthiases of the steppes, deserts, tundra, tayga, etc. (see K. I. Skryabin et al., 1962). The dependency of the distribution of infectious diseases on the natural features of a territory and their bond with specific landscapes was also established by V. N. Beklemishev, who developed these ideas relative to malaria already in 1925 (V. N. Beklemishev, 1939, 1940, 1947; V. N. Beklemishev, P. G. Sergiyev, 1940). The bond of natural foci with the landscape, often right up to their complete conformity with units of landscape regionalization, was also noted by N. A. Gayskiy (1930). However the detailed development of the problem of landscape parasitology (landscape epizootology) belongs to Ye. N. Pavlovskiy (1944, 1964) and his numerous students and followers (P. A. Petrishcheva, 1954, 1955, 1959, 1965; N. G. Olsufyev, 1947; N. G. Olsufyev and V. P. Dobrokhotov, 1965;

A. A. Maksimov, 1947, 1957, 1960; V. V. Kucheruk, 1959, 1960, 1965, and others).

The proposal of landscape confinement of natural foci of disease can be considered as proven at the present time. In general features it amounts to the fact that a parasitic system, entering into a concrete biocenosis, and along with it the natural focus of a disease are an inherent part of a specific geographical landscape.

However, landscape confinement in the distribution of naturally focal infections by no means signifies that within the limits of one landscape the natural foci inherent to it should be encountered everywhere. On more than one occassion, P. A. Petrishcheva (1958, 1965) pointed out that when analyzing any locality it is necessary to consider the natural heterogeneity of the landscape, and to expose all elements, its components, and the results of studying the natural biocenoses in which the circulation and prolonged retention of the causative agents of disease take place, and to tie up with specific habitats, having some distinct features from the dominant landscape. Birulya, also in analyzing the territorial distribution of natural foci, noted that it did not follow to search for regular relationships on the part of foci directly with the landscape in general. Each enzootic focus has the corresponding spatial structure, inherent only to it. Therefore, it is necessary to analytically establish separately the bonds of the natural focus with the factors of the geographical habitat and only after this to expose the coincidence of the limits of a given taxonomical unit of physical geography with natural foci. Subsequently Kucheruk (1965) demonstrated conclusively the absence of a coincidence between the geographical distribution of natural foci of plague and units of physico-geographical regionalization. The author detected a complex dependency in the distribution of the infection in landscape zones, having noted that its distribution is determined by a complex of abiotic and biotic factors, and only a study of these factors can produce a basis for explaining the distribution of natural foci.

It is necessary to note, however, that the distribution of many zoonoses is not subordinated to the law of landscape confinement. The distribution of many of these is influenced by the economic activity of man. Actually, with the appearance of man on the earth and the development of economic activity, a combination of completely new, anthropogenic conditions of existence appeared. V. I. Vernadskiy (1934) points out that man, in the process of his work, is remaking the biosphere, converting it into a nosophere. In the biosphere man is creating new biochemical processes which did not exist previously. Under his influence the plant and animal world is changing and the face of the planet is deeply changed. It is apparent that all these tremendous transformations of the biosphere, which are connected with the practical activity of man, took place mainly toward the end of the Quaternary period, which evidently covers no more than 10-15

millenia (the period of civilization), though these changes were prepared by the entire course of man's development in anthropogenesis.

As a result of the work and practical activity of man in the biosphere anthropogenic factors of environment appeared which for many organisms, adapted to life in a certain degree of proximity to man or domesticated by man, became the conditions for their existence. Thus, on the earth it is also possible to separate out a completely unique anthropogenic habitat (anthroposphere), which in our time is being developed intensively and is exerting a very particular influence on organic life. This habitat is basically concentrated within the limits of the territories of the earth, however it has penetrated to some degree or other into the aquatorium and the lithosphere, and also beyond the biosphere - into the upper layers of the atmosphere and space.

The anthropogenic habitat is characterized by a high degree of polymorphism and sharply expressed gradations of development. It is undergoing rapid and intensive processes of evolution, which often bear an irreversible nature. The anthroposphere is formed as a result of the transforming nature of man's activity and is in essence the modified or completely transformed sectors of the geosphere, which in the event of cessation of economic activity may again revert back to a primitive condition; this can be clearly followed in examples of the formation of natural biocenoses within sectors that have been abandoned by man (example, fallow land).

Special importance in the formation of an anthropogenic habitat belongs to the practical activity of man, connected with the appearance of new landscape features, the construction of populated points, the creation of artificial reservoirs, the plowing of ground and utilization of farm land, and also the taming and breeding of domestic (primarily agricultural) animals and cultivation of plants. As a result of such practical activity by man new forms of organisms are being created, and also conditions are springing up for the evolution of a particular group of synanthropic animals. The principle difference between these groups of animals and wild animals is mainly that their habitat is becoming an anthroposphere with particular conditions of life.

In exerting an unique influence on living organisms and undergoing relatively rapid changes, the anthroposphere may oppose the association of other habitats - the "natural habitat", which are sectors of the biosphere, not transformed as a result of the practical activity of man.

The anthroposphere reaches its greatest degree of development at the sites of artificial structures and on the territories of populated points and intensive industrial activity. At these sites an "industrial landscape" is formed, with very unique conditions of existence for organisms. In the rural areas beyond the limits of populated points the transformation of the landscape usually does not reach such a level. However, even at these places the activity of man, which is directed at the transformation

of nature for the sake of using its natural forces in the economy, leaves a quite sufficient trace. In our time for all practical purposes there are hardly any landscapes left on the earth which have not been touched by the economic activity of man. Depending on the degree and nature of the influence of human activity on the whole, landscape may be subdivided into 3 main groups: Primeval (original), transformed (cultivated) and artificial.

Apparently, in the very short period of existence of anthropospheres (in comparison with the periods of geological history of the earth and the evolution of life), synanthropic organisms could not acquire sufficiently profound adaptation mechanisms, equalizing them with the factor of the anthropogenic habitat. Therefore, in our time the equilibration of these animals with the factors of the anthroposphere is being carried out primarily on the basis of the available general type adaptations which they have (see Report VI). These emerged earlier in the process of adaptation to factors of primeval nature and subsequently turned out to be useful for existence in the anthroposphere. One of the most important mechanisms, ensuring the adaptation of synanthropic organisms to the factors of an anthropogenic environment, was a change in their behavior, at the same time that the organization of these animals did not undergo any noticeable transformations.

Along with the numerous, very diverse, elements in the anthropogenic habitat, man is also creating conditions which are close to the optimum demand of his biological organization. These conditions are the more or less constancy of certain physico-chemical properties (temperature, humidity, organic substances) which has been created primarily in dwellings. Here as a rule there is observed a considerable lowering in the range of fluctuations of these factors in comparison with the change in the surrounding natural-geographical environment as a result of a sharp lowering, and in some cases a discontinuance of the influence of the primary-periodic factors on them. The parameters of the factors of the anthroposphere turn out to be very close to the conditions of the tropical countries, where the formation and development of the ancestors of man from anthropomorphous monkeys took place. Therefore, among synanthropic animals we encounter mainly descendents of the southern, tropical species (house fly, synanthropic rats, cockroach, water bugs, etc.). It is very noteworthy that all these synanthropic forms in indiginous areas are capable of existing in primeval nature.

The anthroposphere is also the habitat of domesticated animals, which originated as a result of artificial selection and which at the present time in the majority of cases are sharply different from their wild parents based on their organization. This is their basic qualitative difference from synanthropic animals, which during their evolution were subordinated to the laws of natural selection.

The absence of clear ideas on the conditions of existence for organisms in converted and artificial landscapes, if the anthroposphere is disregarded as a particular habitat, hampers the classification of organisms based on the nature and peculiarities of their existence in connection with man and his practical activity. The separation of the anthroposphere as an independent habitat, which it is, makes it possible to create clear criteria for the classification of an organism. Indeed the identification of the affiliation of a certain group of organisms to a habitat should be based on an investigation of the importance of the elements of the concrete habitat in the life activity of the organisms, and an investigation of the presence of conditions of existence for the organisms in the habitat without which and regardless of which they can maintain the continuity of life. Establishing ourselves on this criterium, among the freely living organisms it is possible to separate out several groups with various forms of bonds with the anthroposphere.

1. Wild living species, residing under the conditions of natural biocenoses and not finding the conditions of existence in the anthroposphere. And among these it is possible to distinguish species-misanthropes, for which the anthroposphere is a hostile environment. Even the relatively mild conversion of the landscape by man leads to the dislodgement of these organisms or their death in the given territory (for example, susliks, gerbils). The preservation of these organisms is possible only within the limits of an unoccupied territory (primeval nature). At the same time a considerable number of wild species can exist in moderately converted landscapes and close to cultivated areas. These species are not capable of taking root in extensively cultivated areas and in populated points, where they do not find the necessary conditions of existence (for example, pasturing ticks).

2. Semisynanthropic species, capable of existing both in wild nature and in the anthroposphere (for example, the house mouse under the conditions of a warm climate, and apparently also the water vole, common vole, etc.).

3. Synanthropic species, capable of existing in an anthroposphere and, with the exception of certain territories with a hot climate where they may carry out a semisynanthropic mode of life, are not encountered in wild nature (for example, synanthropic rats, water bugs, etc.).

4. Domesticated (including agricultural) animals - organisms created by the practical activity of man and existing thanks to this activity.

In the first phases of evolution of human society there were no clearly expressed differences between wild species and domesticated organisms. There biology was very close and the domesticated animals maintained to a considerable degree the form of life of their wild parents. And zoonoses of domesticated animals were at the same time naturally focal, rooted among their wild parents.

However, along with the development of human society, and in particular agricultural activity, the picture changed substantially. As a result of selection agricultural animals were changed strongly and their wild predecesors were destroyed by man on a large scale. A significant biological break appeared between agricultural animals and the other living members of natural biocenoses. In addition to this the conditions of maintenance and breeding of agricultural animals turned out to be so unique that in essence their behavior became unlike that of their wild parents; in our time this has become particularly clearly expressed in huge territories of economically developed agricultural production.

Apparently under these conditions there was also a change in the nature of the epizootic processes developing among agricultural animals, infections appeared which were inherent only to them (brucellosis, glanders), and mainly, the most significant changes were undergone by the population structure of the various species of causative agents. Parasitic species which had taken root in agricultural animals in the majority of cases turned out to be considerably more polymorphous and their populations were considerably less insulated in a territorial respect than the populations of parasites on the inhabitants of natural biocenoses. The functional individualization of such populations was considerably reduced in connection with the intensive migration of farm animals.

The development of the anthroposphere exerted a serious influence on the population structure of parasites of synanthropic animals, in certain respects occupying an intermediate position between zoonoses of domestic and wild animals. Nevertheless, synanthropic animals, developing according to the laws of primeval nature, form populations in the anthroposphere and enter into the composition of its biocenoses (community of species of synanthropic and semisynanthropic animals). In connection with this also, true parasites of such animals are fellow members of the biocenoses of the anthroposphere. At the same time the formation of enzootic foci among synanthropic animals comes under the influence of the practical activity of man, which brings them together with enzootic foci of zoonoses of farm animals.

Certain authors (A.G. Voronov, 1965) consider that infections of synanthropic animals should be combined with infections of animals of primeval nature into one group of naturally focal zoonoses. Of course an enzootic focus of zoonoses of synanthropic animals represents a population of the causative agent together with the populations of animal-hosts supporting its existence (carriers and vectors). However, the conditions for the existence of these populations are created under the influence of the practical activity of man and their formation is essentially different from the formation of populations in natural biocenoses, as a result of which it is more expedient to consider infections of synanthropic animals as an independent group of zoonoses.

It is necessary to take into consideration that by no means can every zoonosis be positively related to one of the three groups mentioned. For example, as G. I. Netskiy (1965) points out, depending on the adaptability of the causative agents to a more or less wide circle of vertebrates, it is possible to distinguish obligate and facultative infections with a natural focalness. Here, in contrast to obligatory infections, taking root only in natural biocenoses, facultative infections with a natural focalness are characterized by the fact that along with natural foci it is possible that anthropurgic (intrapopulation and intraherd) foci may be formed among them. An example of such a type of zoonoses are Q-fever, leptospirosis and certain others.

It should be noted that the name "facultative naturally focal infections" can be applied only to those naturally focal zoonoses, during which the formation of stable enzootic foci in the anthroposphere (anthropurgic foci) is impossible, however, there is the possibility of the migration of the causative agent into an anthropogenic habitat and the development of an enzootic process among aynanthropic and farm animals. Zoonoses, taking root in natural biocenoses and among synanthropic and farm animals, that is, forming stable natural and anthropurgic enzootic foci, are apparently more correctly defined as "naturally-anthropurgic".

Finally, there are those zoonoses which are capable of taking root only in an anthropogenic habitat, in some cases forming temporary natural foci (facultative anthropurgic zoonoses), or in other cases not capable of migrating into natural biocenoses even for a short time (obligatory anthropurgic zoonoses).

Thus, zoonoses, depending on their relationship to an anthropogenic habitat, may be subdivided into naturally focal, obligatory and facultative, naturally-anthropurgic ("seminaturally-focal"), and anthropurgic, obligatory and facultative (see table).

It is necessary to take into consideration, however, that in various natural geographical conditions the relationships of many zoonoses to the anthropogenic habitat may be essentially changed. Thus, within the limits of a large portion of the areal of the causative agent, brucellosis is a typical facultative anthropurgic zoonosis. However, in polar countries, where natural foci of this infection are formed, the causative agent may also exist among wild deer. Probably natural foci of brucellosis are also formed among antelopes on the African continent. Zoonoses of synanthropic animals in the temperate and higher latitudes are related to the group of anthropurgic zoonoses, while in the tropical countries they may turn out to be naturally-anthropurgic in connection with the fact that under the conditions of a hot climate their hosts may exist in primeval nature (for example, rat rickettsiosis). As a result of this the arrangement presented above for the main groups of zoonoses will be correct only within a specific geographical territory.

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Main groups of zoonoses, broken down on the basis of the relationship of their causative agent to the anthroposphere

Group of diseases	Main habitats		Nosological form
	First order	Second order	
Naturally-focal zoonoses			
Obligatory	Exclusively animal-hosts--comembers of natural biocenoses	Ecology of hosts is terrestrial-aerial	Tsutsugamushi, North Asian tick-borne rickettsiosis, Crimean hemorrhagic fever, Rocky Mountain spotted fever, loaiasis, hemosporidiosis of wild animals
Facultative	Mainly the same	Mainly the same	Plague, tularemia, farm type of cutaneous leishmaniasis, tick-borne encephalitis
Naturally anthropurgic zoonoses	Animal-hosts of natural biocenoses, synanthropic and farm animals	Ecology of wild animals, form of life and behavior of domestic animals - terrestrial, aerial, water, abiotic factors of anthropogenic medium	Leptospirosis, Q-fever, trichinosis, opistorchosis, fascioliasis, dicrocoeliosis, pseudotuberculosis
Anthropurgic			
Obligatory	Exclusively synanthropic and farm animals	Exclusively form of life and behavior of farm animals, ecology of synanthropic animals, abiotic factors of anthropogenic environment	Glanders, salmonellosis, hemosporidiosis of domestic and synanthropic animals, rat rickettsiosis
Facultative	Mainly the same	Mainly the same	Brucellosis, foot and mouth disease (?)