

ARTHROPODS IN ENVIRONMENT AT VARIOUS STAGES OF ANTHROPOGENIZATION

GENERAL CONSIDERATIONS

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The comparative biology of ectoparasites, results of which are obtained from studies of various environments arranged according to the stage of anthropogenization, makes possible a prognosis about the occurrence of ectoparasites as vectors of diseases and as pests, and analyzes the reasons of their existence and often abundance in the regions cultivated by man. Epidemiological and epizootological evaluations of the role of arthropods studied are based on precise data on the natural focality of diseases (Pavlovskij, 1939; 1964; Rosický, 1967). The knowledge of ecology and behaviour of arthropod vectors supplies answers to the questions as to why various natural foci have been maintained in cultivated landscape, why some foci of transmissible diseases are progressive in character, why culturocenoses and devastated areas are not free from ticks, mosquitoes, black flies, sand flies, rodent ectoparasites and also from natural foci of diseases.

The anthropogenization influences not only the existing and developing ectoparasite — host — environment system, but also the system: ectoparasite (parasitic arthropod) — pathoergont* (arthropod-borne) — host — environment.

The following activities of man influence the incidence, distribution and frequency of the arthropod groups studied and the natural foci in general: domestication of animals, cattle breeding (pasturing), agriculture, forestry, hunting and game-keeping, water management, transport, tourism, industry, various pollutions of the environment etc.

* After Pavlovsky (1965) it may be more convenient to call the causative agent (from arboviruses to parasitic worms) by one word with a general meaning "pathoergont" instead of the term "pathogen" which may suggest some genetic relationship not necessarily included in studies of the theory of natural focus diseases.

Cattle breeding connected with pasturing is one of the oldest influences of man on the environment. After degradation of the forest and steppe forest natural pasturelands develop. These ancient pasturelands exerted a considerable influence upon the formation of a number of very stable places for ticks but also for mosquitoes, black flies, ceratopogonids and natural foci. Other domestic animals are also involved now.

The long-lasting ploughing by man results in the formation of highly developed anthropogenic relief in various parts of continents. Many anthropogenic forms of the relief are connected with many species of ectoparasites and their hosts. Various types of ridges in fields may be mentioned. E. g. in ancient Greece the division of land as described by several authors gave rise to the first historically known ecotons, the places where original remnants of fauna were preserved. Terraces of several kinds, including rice field terraces, various agricultural practices using water are suitable breeding places for parasitic arthropods, earth dams and ridges are survival places for ticks, trombiculid mites, other parasites of rodents etc.

Deforestation involves the origin and development of breeding places (*sensu lato*) for mosquitoes, ticks, trombiculid mites and with these places are connected the natural foci of diseases of man and animals (e. g. Audy, 1965; Garnham, 1965; Rosický, 1964; Pavlovsky, 1964; Mouchet, 1975).

We have clearly demonstrated (Rosický, 1962; 1956; 1959) that the artificial maintenance of a large number of game animals and birds for economic or recreational purposes in a region where there are natural foci of tick-borne infections, is one of the factors contributing to the preservation of these foci even in completely cultivated landscape.

The next activity of man, extremely important for the anthropogenization of the arthropods studied, is water management. The importance of irrigation canals, drainages, gullies, open ditches, various water reservoirs and streams is commonly and perfectly well-known from malariology. However, the role of dykes and earth dams must be mentioned, because of the existence of rodent colonies, tick infested places etc. The building of transport facilities creates many suitable man-made breeding places for ticks (railway fills, road embankment, bridges) and mosquitoes (open excavations along railways in lowland, open cuts along roads etc.).

The synanthropy is a process of the last period in the history of animals and is now in full development (Rosický, Kratochvíl, 1953; Kucheruk, 1965). Different species of rodents and their ectoparasites, ticks, mosquitoes and sand flies have advanced to different stages of synanthropy. Even in places devoided of human habitation, such as found in the Himalayas, voles of the genus *Alticola* readily settle in the tents

of mountaineers. The fully urbanized regions, the new modern houses are inhabited by various rodents, their ectoparasites and mosquitoes (so-called eusynanthropes) completely adapted to specific microclimatic and especially trophic conditions in houses in towns and cities.

From the point of view of biology and the epidemiological role of ectoparasites, 7 principal stages of anthropogenization of the environment may be distinguished: 1. the natural region, 2. the slightly cultivated region, 3. the moderately cultivated region, 4. the highly cultivated region, 5. the completely cultivated region, 6. the region devastated by agriculture or different industrial activities, 7. urbanized region. This grouping and the term "region" is used after Rosický and Hejný (1959).

"Region" is the term applied to genetically homogeneous country in which the following interdependent complexes are regularly and typically repeated: geological structure, the form of the relief, surface and ground water, microclimate, soil types, phytocenoses and zoocenoses. The main conditions for the formation of phytocenoses and zoocenoses in a region are: 1. the same geological structure, 2. the same historical geological development of all parts of the area and 3. the same climate in all parts of the region throughout the whole of its development. For instance this applies to the Elbe river valley, the middle of the Vltava river valley, the country at the foot of the Giant Mountains and the Šumava foothills, etc. as examples of genetically homogeneous country, i. e. regions. In their use of the term Rosický and Hejný (1959) do not have particular geographical or ecological zones in mind, such as taiga, steppe, semi-desert, etc., which is the sense in which some authors use the word.

The term "cultivated region" used by Rosický and Hejný (1959) applies to the influence of all human activities purposeful or random, which interfere with an undisturbed, uncultivated region. The term "disturbed or devastated region" is used with reference to the original, natural character of the region.

1. The natural region includes original area untouched by man's activities. Ecosystems (biogeocenoses) with a zonal arrangement (taiga, steppe, semi-desert, tropical forest etc.) have very characteristic phytocenoses and zoocenoses. In this stage the arthropods may be extremely numerous (e. g. mosquitoes in the Arctic tundra, gnus in the Siberian tajga, sandflies in semi-desert and desert areas) and maintain archaic (primary) natural foci of transmissible diseases of man and domestic animals. There is no need to explain in detail that biocenoses important for the circulation of transmissible pathoergonts developed and became stabilized in natural regions of various continents (Pavlovsky, 1964; Rall', 1958; Audy, 1965; Garnham, 1970 et al.).

This stage is no longer to be found in Central Europe today. The nearest approximation are the high mountain massifs, the primaevial forest of Białowieża, although even here some degree of cultivation can be seen along the periphery and in the valleys between the mountain ridges. Even reservations (national parks) cannot be regarded as absolutely natural regions. Today they are only a reflection of the original region and many of them in the past have undergone complex development under the influence of anthropogenic factors (old pastures, tree felling, etc.).

2. The slightly cultivated region. The original, natural arrangement of the ecosystems is broken up by elements of cultivation (chiefly pastures, fields and meadows). The border-line between the natural part of the region and areas altered by man is not yet completely defined phytocenologically.

This stage is found in most mountain ranges in Central Europe and the Balkan Peninsula (the Giant Mountains, Šumava, the High and Low Tatras, Stara Planina, Rhodope Mts. etc.). The main feature of this type of region are forest ecosystems forming clearly defined, relatively extensive areas; forest ecosystems are the dominant component of this region. In the subalpine and alpine zones the original vegetation is conserved, unless interrupted by pasture-land. Vertical vegetation zones are well developed and only slightly disturbed by cultivation.

In Central Europe, high elevations above 1.200 m do not provide suitable conditions for the development of natural foci. At lower altitudes, however, foci in the various ecosystems are differentiated under man's influence. This is especially evident on the border-line of these ecosystems (ecotons), where they come into contact with a more cultivated zone. In this region there are places on the dividing line between elements of cultivation (pastures, meadows, fields) and mountain forests, where the animal component of the ecosystem is enriched by new species of arthropod vector (ticks, mosquitoes, black flies, chiggers) and rodents (e. g. the field vole *Microtus arvalis* Pall.).

Such places are important from the epidemiological aspect. In Czechoslovakia tick-borne encephalitis natural foci have been found in the vicinity of Javořina in the High Tatras. There is no doubt that similar situations will be found in other regions at the same stage of cultivation.

3. The moderately cultivated region. Natural ecosystems are scattered due to cultivation measures into very irregularly distributed systems of natural, partly cultivated and totally cultivated parts of the region. They

are characterized by typical mosaic distribution of the different components of the region. The main feature of a moderately cultivated region is the marked breaking up of continuous forest ecosystems.

Conditions which affect the incidence of natural foci in this type include interference by the irrigation of the region (e. g. the draining of marshes), the formation of pastures, forestry, game preserves etc., all of which can play a part in the intensification or extinction of natural foci. Large numbers of game animals, for instance, help to maintain natural foci of tick-borne encephalitis, untended pastures with large numbers of ticks help to maintain foci of Q-fever, tick-borne rickettsioses etc.

4 The highly cultivated region. In this region, natural forest ecosystems in most instances have been replaced by cultivated or partly cultivated ecosystems. Human activities in this region (game-keeping, cattle grazing, irrigation, water reservoirs etc.) form conditions for mass occurrence of some species of ticks, mosquitoes, sandflies, black flies. For example at this stage of cultivation in Czechoslovakia, the forests have been tended since the 16th and 17th century and yet the number of ticks is very high. The main feature at this stage is the disappearance of continuous forest or steppe ecosystems, only isolated groups of which remain.

Sectors of original vegetation can also be formed on a small scale within artificial types of vegetation under conditions of complete cultivation of the region. These islands of vegetation, together with a concentration of animals, in this case chiefly small mammals, game and ticks, may be the only basis of scattered elementary foci of tick-borne diseases in the region. Their focal components attain considerable concentration and in some places the infection is maintained for long periods (Radvan et al., 1959).

5. The completely cultivated region. Culturocenoses and substitute cenoses completely predominate in such regions. The original ecosystems are either completely scattered or reduced to such negligible proportions that they can no longer give refuge to the original vegetation components. Impoverishment of plant and animal species also occurs in culturocenoses. Examples of such regions are to be found in some parts of the Central Bohemian lowlands, Haná and the South Moravian lowlands (apart from the marshy forests).

The breeding places of mosquitoes and the colonies of rodents are in open ditches, in large drainage canals and others water streams, ticks are living in the railway fills, road embankment, in dykes and in other anthropogenous types of the relief. In these conditions various pathergonts as arboviruses, rickettsiae, bacteriae etc. may also be present.

6. The devastated region by agriculture (mainly pasturing) or different industrial (mainly mining) activities consists of places with irreversible changes in natural cenoses or culturocenoses which have lost the possibility of being restored. The renovation of such places through natural succession of vegetation and animal life or through the common agricultural activities of man is impossible in a few years.

For instance on the Balkan Peninsula the intensive deforestation and pasturing result in devastated landscape gradually changing into completely devastated lands and give rise to a quite desolate territory of rocky desert type. In Europe this phenomenon is typical especially of some western parts of the Balkan Peninsula, where the activities of man (pasture, deforestation) have produced extensive devastation of the original forest landscape. Another human activity devastating large areas is the mining, mainly coal pit, quarrying and mining subsidence.

However, even in such devastated regions arthropods and rodents are adapted to the environment. For example in Albania, pasturing of sheep in sparsely inhabited regions and the difficult agricultural conditions in mountainous and hilly terrain have led to the formation of extensive tick-infested areas, with several tick-borne diseases involved.

In semi-desert and desert areas many species of sandflies, mosquitoes, parasites of rodents, *Ornithodoros* ticks etc. are adapted to their surroundings.

The incidence of rodents and their ectoparasites in areas of mining subsidence are associated (Ašmera et al., 1973) with depressions where water accumulates and with places where garbage is dumped. The water pools in areas of mining subsidence are breeding places for mosquitoes of the genera *Anopheles*, *Aedes* and *Culex* (the vectors of various diseases).

7. Urbanized region. Human settlements, not only villages but also cities, are inhabited by various rodents, their ectoparasites and mosquitoes. For instance *Culex pipiens molestus* is encountered in various accidental water reservoirs in houses. *Ornithonyssus bacoti*, *Allodermanyssus sanguineus* penetrate along with the genus *Argas* from bird nests to human flats etc. Dyk (1957) described a relatively high degree of infestation by ticks *Ixodes ricinus* among pet dogs in the gardens of suburbs of a large city. The presence of exoanthropic parasites and rodents in cities is not an exception (in city parks for instance).

The process of anthropogenization in a given region must be considered dynamically. The influence of man's activity results, on one hand, in increasing cultivation and devastation of landscape, while on the other hand the region may return to a more original or completely original

stages as a result of economic changes (thinning out of human population of the region, with a lower degree of cultivation of individual units as aftermath of wars etc.). This is also reflected in the epizootological situation in individual natural foci.

The present analysis shows that densely populated regions do not necessarily constitute a culturocenosis or devastated area devoid of all conditions for the existence and maintenance of blood sucking arthropods studied and of natural foci of diseases.

In conclusion it may be said that the anthropogenization influences the existing and developing ecological parasite-host environment system and changes it up to the formation of new relations. The anthropogenic factors may lead to mass occurrence of certain species of ectoparasites, as well as to suppression or complete disappearance of others. These phenomena and their causes should be the subject of a comprehensive investigation in the near future, since they may shed light upon many important questions of epidemiology and epizootology and contribute to effective arthropod control and to the suitable formation of a healthy environment for man.

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