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The Natural Focality of Leishmaniasis in the USSR

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The paper contains up-to-date information on the occurrence of cutaneous leishmaniasis in natural foci in the USSR. Data are given on the vertebrates that are the main carriers and reservoirs of leishmaniae, the phlebotomines that are the vectors of the parasite, and the conditions required for the independent existence of foci of infection unlinked with any human economic activity.

The main achievements of Soviet investigators in research on natural foci are described, a preliminary schema is given for typing foci by the nature of the terrain, and there is also an account of biocoenoses in the wild animal burrows that constitute the primary natural unit foci. The biology and ecology of the main hosts of leishmaniae, the interrelationships between leishmaniae, vertebrate animals, and phlebotomines, and the conditions required for infection of human beings with leishmaniae are also discussed.

The leishmaniases are diseases of wild animals that can exist quite independently of man. All the basic propositions in E. N. Pavlovskij's theory of the natural focality of disease are fully applicable to the leishmaniases. The nature of the natural focality of cutaneous and visceral leishmaniasis was established for the first time in the USSR.

During extensive exploitation of the deserts and semi-deserts of Central Asia, large groups of construction workers were sent from areas where the leishmaniases were not endemic: the large number of cases that occurred among human beings in formerly unpopulated regions at once attracted attention. Earlier there had been regular findings of Phlebotominae in the burrows and lairs of wild animals in uncultivated areas (Vlasov, 1932, 1941; Petriščeva, 1932, 1936).

Natural foci of cutaneous leishmaniasis were discovered simultaneously by N. I. Latyšev and his colleagues and by I. V. Gusev, working in the sandy deserts of the Turkmenian SSR. Cutaneous leishmaniasis involving lesions of the ears, eyelids, and nose was found in the burrow-dwelling rodents, the large gerbil (*Rhombomys opimus*), the red-tailed jird (*Meriones erythrourus*), and the midday gerbil (*Meriones meridianus*) and also in the long-clawed ground squirrel (*Spermophilopsis leptodactylus*) (Latyšev & Krjukova, 1941). Gusev (1939), working in another focus, also found leishmaniasis in gerbils; at the same time, Phlebotominae infested with promastigotes were also found in the burrows of the sick animals.

This important discovery determined the whole future direction of study of cutaneous leishmaniasis and of its prophylaxis, when deserts and semi-deserts were being brought into economic use.

In the USSR, natural foci of leishmaniasis are encountered mainly in the plains at low altitudes (100–450 m above sea level) and somewhat less commonly at medium altitudes. The distribution of cutaneous leishmaniasis is closely linked with the valleys and with large rivers, streams, brooks, and old river beds.

In the mountains and foothills above 1000–1300 m foci of leishmaniasis are encountered relatively rarely. Human morbidity in such instances usually takes the form of sporadic cases, despite the great abundance and diversity of the sandfly fauna, the fauna of wild vertebrates, and the appropriate climatic conditions. It seems to us that in these regions the reasons why infection does not persist require further study. It may be that in some vertebrates the causal agent does not develop or else undergoes only feeble development. Possibly the carriers are birds that are encountered in great numbers in such places. It is still a puzzle why natural foci of cutaneous leishmaniasis are not present or are very rare on the slopes and in the narrow valleys of lower

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mountains, which are sometime quite thickly populated with gerbils and sandflies.

DESERT RODENTS THAT CARRY THE CAUSAL AGENT OF CUTANEOUS LEISHMANIASIS

The large gerbil (*Rhombomys opimus*) is the main reservoir of the causal agent of cutaneous leishmaniasis in the deserts and semi-deserts. This gerbil is a social and colonial animal. Its colonies are situated in the depressions between barkhans, along the slopes of the barkhans, and in the desert thickets of saksaul.[1] The large gerbil prefers to settle along the borders between fixed sands and shifting sands, where the earth is fairly soft and can be dug easily. In the clay deserts the burrows of this gerbil are more frequently encountered at the junction between the foothills and the mountains. Quite often it digs burrows in the banks along irrigation canals, railways, and roads, choosing irregularities in the ground.

Cutaneous leishmaniasis affects areas that are easily accessible to phlebotomines for their blood meals: the lobes of the ears, the eyelids, and the nose. The over-all prevalence of infection of the ear among gerbils is 75%, of the nose about 15%, and of the eyelids about 10% (Latyšev & Krjukova, 1941; Krjukova, 1941). According to Gusev, Eliseev & Sidorova over 90% of all gerbils have infection on the ears in some desert areas. In some closed habitats, where there is extensive contact between the gerbils, the morbidity rate reaches almost 100%. Quite often, in the Kara-Kum, colonies of gerbils are encountered with no morbidity or with only isolated cases.

The large gerbil plays a leading part in the epizootiology and epidemiology of cutaneous leishmaniasis. When new localities are being brought into economic use, it remains for a long time near the centres of population until driven away by cultivation of the land. The presence of colonies of gerbils near villages and towns, and the constant presence of phlebotomines, explain the occurrence of cases of the disease among inhabitants living on the edges of villages and towns.

The red-tailed jird (*Meriones erythrourus*) is quite often encountered in the same habitat as the large gerbil. It is more widespread along river valleys and irrigation canals and has a great liking for newly cultivated land. In some areas this species can more easily be found near cultivated land and even on waste ground in new settlements, near the edges of towns or in cemeteries. It also lives in the semi-deserts of the foothills, along the slopes of the first range of hills, where it is often the dominant species.

The tendency of this animal to settle near human habitations may be of great epidemiological importance. Sometimes its colonies form a continuous ring around small villages, occupying waste ground unsuitable for cultivation.

The natural prevalence of leishmaniasis among red-tailed jirds is lower than among the large gerbils. In foci in the upper reaches of the Amu-Darya the prevalence in some areas ranged from 9% to 26% (Latyšev et al., 1947).

In some places the red-tailed jird, like the large gerbil, may maintain natural foci over a long period by itself. Under experimental conditions it is extremely susceptible to infection with cutaneous leishmaniasis.

In some natural foci of cutaneous leishmaniasis, other sources of human infection may be the midday gerbil (*Meriones meridianus*), the tamarisk gerbil (*Meriones tamariscinus*), the long-clawed ground squirrel (*Spermophilopsis leptodactylus*), the long-eared hedgehog (*Hemiechinus albulus major*), and other animals. These animals have more than once been found to have cutaneous leishmaniasis under natural conditions. However, they are not so widely distributed as the large gerbil and their burrows are less favourable for phlebotomine reproduction.

Only in exceptional circumstances, and when they are in particularly close contact with human beings, do these animals have any appreciable significance in the causation of human cases of cutaneous leishmaniasis. It is not impossible that other animals also play a part in the epizootiology of cutaneous leishmaniasis—for example, bandicoot rats (*Nesokia indica*), foxes, jackals, wildcats, badgers, and wolves, whose lairs often contain large numbers of sandflies.

Not long ago the jerboas (*Allactaga servertzovi*) (Ipatov & Zvjaginceva, 1947) and marbled polecats (*Vormela peregusna*) (Fajzulin, 1967) were found to be infected with cutaneous leishmaniasis in natural foci in Uzbekistan, while in Turkmenia the common polecat (*Mustela* spp.) was also found to have the disease (Dubrovskij & Kellina, 1966). The marbled polecat and the common polecat are predators that hunt gerbils and often use their burrows as living quarters.

With the great variety in landscapes it is always possible to find natural foci where certain animals—

[1] "Saksaul" is any plant of the genus *Haloxylos* [Translator].

large and the red-tailed gerbils, jerboas, etc.—are the main reservoir and where the vectors are particular species of sandfly (*Phlebotomus papatasi*, *P. grimmi*, *P. sergenti*, etc.). In more widely ranging foci of the large gerbil, the vectors may be several species of sandfly (sometimes there are 12 or more species of sandfly in one colony) but they differ in importance as vectors of the causal agent among the animals. According to numerous pieces of evidence, the large gerbil is the most important reservoir species for cutaneous leishmaniasis.

The origin of the gerbils (family Gerbillidae) goes back to the lower Pliocene, i.e., 11 or 12 million years (Gromov, 1952). At the present time, over 160 species of gerbil are known in the world fauna (Rall', 1965). There are now 135 species in Africa, 14 species in Iran and in Afghanistan, 5 or 6 in India, in Ceylon, and in China, and 13 or 14 species in the USSR and it is possible that natural foci of the leishmaniases could exist in all these countries.

REPTILES AND BIRDS ENCOUNTERED IN RODENT BURROWS

The deserts of Central Asia are rich in reptiles. Numerous lizards and snakes, as well as Horsfield's terrapin, are often found living in gerbil burrows. Among them are commonly found small lizards such as geckos, the common sheltopusik (*Ophiosaurus apus*), and members of the genus *Phrynocephalus*, particularly *P. mystaceus*, *P. helioscopus*, and *P. interscapularis*; the largest representative of modern reptiles in the USSR, the desert monitor (*Varanus griseus*), which hunts gerbils and frequently destroys their burrows; the steppe agama (*Agama aralensis*); the sand snake (*Eryx miliaris*); the common viper (*Vipera berus*); the arrow snake (*Taphrometopon lineolatum*); Horsfield's terrapin (*Testudo horsfieldi*); and many other reptilian species.

Sandflies, particularly some species of *Sergentomyia*, often bite lizards and in that group of cold-blooded animals " reptilian " strains of leishmaniae are found. However, when the flies feed on more than one type of host, the reptilian strains may enter a mammal host and *vice versa*. At present, there is inadequate evidence of the pathogenicity for mammals of reptilian strains of leishmaniae but those strains often produce a clearly marked allergic reaction in human beings who have had cutaneous leishmaniasis. So far, there have been few instances of the susceptibility of lizards to strains of leishmaniae from mammals. However, the findings of Belova (1966, 1967) are disturbing. Five species of lizard were successfully infected with strains pathogenic for man. *Agama aralensis*, *Gymnodactylus caspius*, *Eremias intermedia*, and *Phrynocephalus interscapularis* were successfully infected with *Leishmania donovani*. *G. caspius*, *Eremias intermedia*, and *Eremias lineolata* were successfully infected with *Leishmania tropica*. All these species of lizard were successfully infected with reptilian strains.

Without going into a detailed discussion of these data it is clear that the question of the relation of reptiles to the leishmaniasis problem has still not been adequately investigated. Independently of this, we believe that mammalian and reptilian leishmaniae are antigenically similar. They are closer to the genus *Leishmania* and stand farther apart from the genus *Leptomonas* (Hodukin & Sofiev, 1940).

SANDFLIES IN WILD ANIMAL BURROWS

Sandflies are rightly considered to be indigenous inhabitants of the burrows and lairs of wild animals, where they are provided with everything they need for life: the vertebrate animals harbour the adult sandflies, and the excrement, remains of food, and litter in the vertebrates' burrows are a source of food for the larvae. The biotope of the vertebrate animal is at the same time the biotope of the sandflies, where they can shelter from the heat of the day, breed, and overwinter.

All sandfly species in the fauna of the USSR are encountered in uncultivated or little cultivated areas in deserts, semi-deserts, upland steppes, wooded mountain gorges, and river valleys. Each of these types of habitat has many special features that determine the composition of the sandfly population and the numbers of different species. In the monotonous landscape of the plains with its poor vegetation the phlebotomine fauna is represented by only a few species, whereas a rich plebotomine fauna has been found in mountain areas with a wider range of vegetation. Here, as a result of the extremely rugged topography and the variations in the exposure of different localities to the sun, a large variety of natural biotopes and microclimates is found.

The greatest numbers of sandflies develop into adults and begin their winged existence in the burrows of large animals, such as those of wolves (*Canis lupus*), jackals (*Canis aureus aureus*), foxes (*Vulpes vulpes*), badgers (*Meles meles*), and the porcupine (*Hystrix leucura*).

In sandy deserts, sandflies reach the adult state

mainly in the burrows of the large gerbil, and to a somewhat lesser extent in those of the red-tailed jird and the midday and tamarisk gerbils. In the deserts and semi-deserts of the foothills, sandflies are encountered in the burrows of the Afghan pika (*Ochotona rufescens*), and quite often large numbers of sandflies breed in bandicoot-rat burrows.

The phlebotomines settle in various natural and artificial caves, on large cliff overhangs, and in grottoes. In these resting places there are sometimes large numbers of bats and reptiles, particularly small geckos, and they are often visited by large animals and are constantly inhabited by some rodent species. Many birds nest or roost in or near these caves.

In the first half of the season of mass sandfly emergence, large numbers of the insects accumulate in places where birds such as rollers (*Coracias garrulus*), bee-eaters (*Merops apiaster* and *Merops superciliosus*), and the rock dove (*Columba livia neglecta*), nest in great numbers.

The main vectors of zoonotic cutaneous leishmaniasis in desert regions of various types include *Phlebotomus papatasi*, *P. sergenti*, *P. mongolensis*, *P. grimmi*, *P. alexandri*, *Sergentomyia arpaklensis*, and *S. clydei*.

In some small isolated colonies of the large gerbil, promastigotes occur spontaneously in 65% of *P. caucasicus* and *P. papatasi*.

Usually, when the prevalence rate of leishmaniasis among gerbils is high, the rate among sandflies increases also and *vice versa*, but the two indices do not always coincide. Thus, when investigating the south-eastern Kara-Kum, Latyšev et al. (1955) found a total prevalence of 48% in gerbils, whereas promastigotes occurred in about 20% of sandflies. This can be ascribed to the fact that when large numbers of reptiles are present in the gerbil colonies, particularly young sand-snakes and geckos, some species of sandfly feed on them. Many of the species of sandfly listed above show a quite high degree of susceptibility to infection with leishmaniae under experimental conditions.

The relative importance of individual species of sandfly in the epidemiology of cutaneous leishmaniasis depends not only on their susceptibility to leishmaniae but also on the frequency with which they come in contact with man. All the above-mentioned species of sandfly are usually co-members of natural foci of cutaneous leishmaniasis. They breed in gerbil burrows and feed on gerbil blood. In relation to gerbils, all these species may be important in transmitting the leishmaniae from an infected gerbil to a healthy one. When centres of population are built in the desert, all these species quickly leave the gerbil burrows and migrate on to the newly developed land. However, not all species feed regularly on human blood. When they move into settled areas, *S. arpaklensis* and *S. sumbarica* are more inclined to feed on the blood of domestic poultry. These species therefore attack smaller prey. On farmlands they are more capable of maintaining the circulation of leishmaniae among synanthropic small animals, such as rodents and hedgehogs. These same species also transmit promastigotes among lizards. Geckos often settle in human habitations and various farm buildings, particularly in rural localities and on the edges of towns.

The most troublesome parasites of man are *P. papatasi*, *P. sergenti*, *P. caucasicus*, *P. mongolensis*, and *P. alexandri*—the usual carriers of promastigote forms of leishmaniae in natural foci. These species are all equally dangerous to man, both under natural conditions and in settled areas. Some species of sandfly (*P. papatasi*, *P. sergenti*, and others) feed on a hundred or more different species of wild and domestic vertebrate (Petriščeva, 1953, 1954). Studies on the sources of sandfly nutrition, based on precipitation tests with blood from their stomachs and on blood-feeding experiments on various types of animal in the laboratory, have shown that in economically exploited areas not a single species can be considered strictly specific in its choice of host, except for some species in the *Sergentomyia* group, which feed more frequently on birds. References to the lack of strict host selection in sandflies are also found in the non-Soviet literature (for example, Kostich, 1951). For that reason, under certain environmental conditions many species of sandfly can be of epizootiological and epidemiological importance in the transmission of leishmaniae.

RODENT BURROWS—NATURAL FOCI OF LEISHMANIASIS

In the deserts of Central Asia, rodent burrows are the most widespread natural biocoenoses in which the epizootiological process of the transmission of the causal agent of leishmaniasis from sick to healthy animals occurs. The leading role in the epizootiology of cutaneous leishmaniasis is played by the large gerbil (*Rhombomys opimus*). The colonial burrows of the large gerbil are typical natural foci of leishmaniasis, in which sandflies live all year round,

using the burrows to the full, as day-resting places, overwintering places, and breeding grounds.

The vertebrate inhabitants of the burrow act as sandfly hosts. The burrows of a colony of gerbils constitute a complex labyrinth of subterranean runways, with numerous branches and various sections such as nesting chambers, toilet areas, and food stores. The length of all the runs in a medium-sized colony may reach many tens of metres. Quite often separate colonies join up and occupy hectares of sand that has been stabilized by vegetation. In a gerbil township two or three layers of underground runways can be distinguished, situated at depths ranging from 45–60 cm to 2 m. Sometimes the third layer and the nesting chamber are situated at a depth of 2.5–3 m.

A characteristic feature of the microclimate in the burrows is its relative constancy. At the hottest time of day, when the ground surface temperature reaches 65–80°C, the temperature at a depth of 1.2–1.5 m in the gerbil burrows does not exceed 24–25°C. While there is a marked humidity deficit at the surface, the relative humidity in the depths of the burrows is 75–90% (because of a perched moisture table in the sand).

The great extent of the burrows and the varying depths of their underground runways enable the gerbils and the sandflies to find the most favourable microclimate at any time of day. In some years sandflies breed on a massive scale in large gerbil colonies. When colonies have been dug up, from 100 to 500 larvae and pupae have been found in a single nesting chamber.

Gerbil burrows are particularly numerous at points of junction between different types of soil, relief, or plant community, e.g., at places where sandy desert gives way to *takyr* or to loess and clay desert, or round isolated hillocks, or on the borders between irrigated land and river terraces and uncultivated, sandy terrain, or where mountains and foothills give way to the deserts of the plains.

The burrows are found in places where there is a perched water table in the sands, where humidity is always at a certain level, a feature connected with the physical properties of sandy soils. The stable microclimate in the burrows is also an important factor in controlling the body temperature of the gerbils, the evaporation from various excretions, and the enzymatic processes in the large masses of stored food, etc. Over 300 different species of insect and arachnid inhabit gerbil burrows. There are about 200 species of blood-sucking insect and tick alone, among which are the original inhabitants of gerbil burrows, the sandfly vectors of leishmaniasis.

A gerbil burrow with its constant population of sandflies represents a potential or an active focus of cutaneous leishmaniasis. Even if at a given time there are no infected gerbils in the colony, this can only be considered a temporary phenomenon, which may last as long as several years. Several instances have been noted in recent years in which a focus began to show activity after many years of complete quiescence, with no change in the conditions of contact between man and gerbil-inhabited territory.

Sometimes when the sandflies are emerging on a large scale from the pupal state, fly-papers suspended near large gerbil burrows have caught thousands of sandflies of different ages and sexes. On the other hand, in other colonies at the same times only tens or even single specimens have been caught. Consequently, it is by no means every colony of gerbils that presents microclimatic conditions suitable for sandflies.

In the Kara-Kum, particularly extensive epizootics of cutaneous leishmaniasis may occur among gerbils where a sandy landscape gives way to *takyrs* or to sectors of cultivated land, or where the sands give way to sectors of desert where water infiltrates from large rivers, such as the Amu-Darya, the Murghab, etc. In all these cases probably the most important factor is the humid layer of sand that is maintained by constant infiltration of water from irrigated land and from natural watercourses.

The capacity of the soil to maintain a more or less constant humidity is of decisive importance for establishing the correct microclimate in the depths of the burrows for their successful habitation not only by the sandflies but also by their vertebrate hosts. It has often been noted that excessive infiltration of water into sandy soils has resulted in the gerbil colonies moving to a great distance from the irrigated agricultural land, and this quickly results in a reduction of human morbidity without the application of any prophylactic measures. Obviously the microclimate in the burrows of wild animals determines the extent to which they are infested with sandflies and the differences in the intensity of the epizootiological process, even though animals highly susceptible to leishmaniasis are present.

In almost all the landscape types found in the Central Asian and Transcaucasian parts of the USSR, natural foci of visceral leishmaniasis are encountered. Human infection, however, is not on

a large scale. Usually single sporadic cases are found, with infection in places sometimes hundreds of kilometres apart. Foci of cutaneous and visceral leishmaniasis may be encountered simultaneously in the same areas. However, the area of distribution of visceral leishmaniasis exceeds that of cutaneous leishmaniasis, while the number of the foci of cutaneous leishmaniasis is considerably greater than those of the visceral disease and they are more active.

At the present time in the USSR the known natural reservoirs of visceral leishmaniasis are jackals (Latyšev et al., 1947; Dursunova, 1966), foxes (Maruašvili, 1966), and porcupines (Petriščeva, 1954).

The epizootic process in any natural biocoenosis is a complex phenomenon and often changes under the influence of environmental conditions. The intensity of the focus is affected by closely interconnected and interacting relationships:

(1) between vertebrates and sandflies;

(2) between vertebrates and leishmaniae; and

(3) between sandflies and leishmaniae.

All these interrelationships can be expressed as host–parasite links that have become established in the course of evolution. Such interrelationships, particularly between leishmaniae and their hosts, have not yet been thoroughly studied. As a result of various types of encounter of the causal agent with various species of sandfly and a wide range of vertebrate animals, some strains of leishmaniae may be present concurrently with others and leishmaniae may also be present concurrently with the causal agents of other infections and infestations. All this may affect the viability of the leishmaniae and change their virulence and their antigenic properties, and may possibly completely inhibit their activity, thus determining the state of the epizootiological process in the different natural foci.

CLASSIFICATION OF LEISHMANIASIS FOCI BY TYPE

The question of classifying leishmaniasis foci by type has recently attracted the attention of many investigators. The first division into man-made and natural foci was suggested by E. N. Pavlovskij soon after his discovery of the natural focality of cutaneous leishmaniasis. Petriščeva (1954, 1961) summarized the available information on all the areas known to her in Turkmenia and in parts of Uzbekistan and Kirghizia and made the first attempt to type foci on the basis of landscape, taking into account the most widespread features of landscape, including mountain areas. Remjannikova (1964) devoted particular attention to the non-uniformity of the landscape in the Turkmenian deserts and classified foci according to the degree of their epidemiological significance. Lysenko et al. (1965), using their findings on the immunological status of the population, classified foci into three types: active–stable foci, active–unstable foci, and inactive (quiescent) foci. Saf'janova et al. (1965), working in south-east Turkmenia, classified foci into two types on the basis of the species composition and numbers of sandflies. Leaving aside any attempt to evaluate the various approaches to the typing of foci, the most complete scheme at the moment seems to be that of Petriščeva, since it covers the basic landscape areas of Central Asia (see accompanying table).

In sandy deserts, intense epizootics occur in colonies of the large gerbil, the basic source of large-scale human infection. Other types of gerbil, the long-clawed ground squirrel, and hedgehogs are additional reservoirs of leishmaniae. In this landscape, natural foci of visceral leishmaniasis may exist, particularly in the valleys of former or present rivers. The reservoirs of this disease are the jackal, the fox, and, less frequently, the wolf. The foci of visceral leishmaniasis are of limited distribution and human cases are sporadic.

In clay and loess deserts and semi-deserts, foci are of epidemiological significance only in limited areas. It is possible for foci to exist in small areas unsuitable for cultivation (such as abandoned irrigation canals and the ruins of the ancient buildings in towns that are no longer inhabited). Here the broken relief and the presence of vegetation make it possible for rodents, insectivores, and predatory animals to settle. Sporadic cases of cutaneous and visceral leishmaniasis are possible. Hedgehogs, foxes, wolves, and jackals are possible sources of infection in addition to rodents.

In river valleys, in the plains, or in only slightly broken terrain, foci of cutaneous and visceral leishmaniasis may occur. The steep banks of rivers with numerous holes of different kinds and any kind of uneven ground overgrown with bushes and thick forest are settled by predators, insectivores, and other animals. Here, jackals are of particularly great importance, and, to a lesser extent, foxes, while among smaller animals there are hedgehogs and short-tailed bandicoot rats. Leading a stealthy mode of life, the jackals visit villages and the edges of

Natural foci of the leishmaniases in the USSR

Type of focus	Type of leishmaniasis	Main reservoirs	Main vectors	Comments
Foci in sandy deserts	Cutaneous	Gerbils (the large gerbil and the red-tailed jird)	*P. papatasi, P. sergenti, P. mongolensis*	The presence of foci of visceral leishmaniasis is not ruled out, particularly where the sandy desert landscape gives way to various other landscape elements
Foci in clay and loess deserts	Cutaneous and, in places, visceral	The red-tailed jird and, more rarely, other gerbils, foxes, the corsac fox, and hedgehogs	*P. papatasi, P. sergenti, P. mongolensis, P. grimmi*	The cutaneous type is predominant
Foci in river valleys	Cutaneous and visceral	Gerbils, jackals, foxes, porcupines, and possibly hedgehogs	*P. papatasi, P. sergenti, P. mongolensis, P. alexandri*	The cutaneous type is predominant
Foci in foothill and mountain areas	Cutaneous and visceral	Gerbils (predominantly the red-tailed jird), jackals, wolves, foxes, porcupines, and possibly the Afghan pika (*Ochotona rufescens*)	All the above species	Foci of both nfections are limited and nowhere do they cause large numbers of cases among human beings

towns at night. Quite often they settle in cemeteries and in the ruins of abandoned buildings. Sandflies live in these same habitats. Cutaneous leishmaniasis is predominant in human infections, while visceral leishmaniasis occurs only in sporadic form.

Considerable epizootics of cutaneous leishmaniasis may occur where river terraces and forests give way to sandy landscapes, where for 40 or more kilometres from the main bed of a river the infiltration water is still active. Gerbils and other rodents are of prime importance here.

Foci are not possible everywhere on the lower slopes of mountains (700–800 m above sea level) and in gorges in the valleys of rivers, streams, and brooks. Owing to the broken terrain they are unevenly distributed. Foci of cutaneous leishmaniasis are associated with settlements of the red-tailed jird and, less frequently, with the large gerbil, the short-tailed bandicoot rat, and other similar animals. There are no extensive epidemic outbreaks. Occasional cases of visceral leishmaniasis are possible.

These foci are characterized by biocoenoses of vertebrates and sandflies that are rich in species and contain large numbers of insects of some of those species. However, the small sporadic epizootic outbreaks of cutaneous leishmaniasis follow a sluggish course. Atypical manifestations of the disease occur that sometimes do not lead to ulceration. The abundant variety of food sources for sandflies, including the numerous birds found here as sandfly hosts, is perhaps responsible for the low intensity of leishmaniases of this type in natural foci. In this type of focus it is clear that natural " dead-ends " (i.e., unsusceptible groups of animals) can neutralize the causal agent and hinder the development of natural epizootics.

FOCI WHERE DIFFERENT TYPES OF LANDSCAPE MEET

(1) Places where sandy desert gives way to clay desert, particularly in the foothills;

(2) places where *tugai* forest in the river valleys gives way to various types of desert;

(3) places where sandy or clay desert gives way to *takyrs*;

(4) isolated hillocks in the deserts and semi-deserts.

The intensity of cutaneous leishmaniasis epizootics depends on the species composition of the co-members of the biocoenoses. In places, isolated mass

outbreaks among gerbils and a high rate of epidemiological risk through prolonged contact of human beings with the foci are possible.

Many species of sandfly and small mammal apparently play a part in the circulation of the causal agent of leishmaniasis in natural foci. However, further work needs to be done to discover the comparative significance of different species.

At present a great deal of work is being undertaken on methods of typing foci more accurately; such work is needed if control measures and the tactics used in their application are to be given a scientific foundation.

THE OCCURRENCE OF MAN-MADE FOCI OF CUTANEOUS LEISHMANIASIS

The leishmaniases as human diseases represent a secondary, later phenomenon. Extensive studies in the USSR have shown that the leishmaniases may quickly become human diseases even at the present time. These conclusions are based on numerous observations made while carrying out extensive plans for bringing new land in the deserts and semi-deserts of the USSR into cultivation.

Even in the first stage of farming activity in formerly unpopulated areas, the temporary dwellings of the settlers are visited by sandflies from the nearest natural biotopes. The close presence of large prey attracts these irritating blood-sucking insects and with the appearance of permanent dwellings and various farm buildings the sandflies are quite often converted to a synanthropic mode of life. In areas inhabited by man they often find better conditions for existence than in their natural habitats. Man and domestic animals are always a more acceptable prey. The surrounding structures, particularly those for keeping domestic animals, turn out to be suitable biotopes for adult sandflies, where they can find just the microclimate necessary for the development of their progeny.

Quite often, in addition to sandflies, small wild animals migrate on to farmland or its immediate vicinity and quickly become synanthropic or semi-synanthropic.

Both among the sandflies and among wild animals that migrate on to cultivated territory, carriers of pathogenic leishmaniae may exist. This completes the establishment of this disease of wild animals as a human disease.

In order to exclude the occurrence of man-made foci of leishmaniasis when new lands are being brought into cultivation it is essential first to act on the natural biocoenoses—the foci of the leishmaniases.

A natural focus can be eliminated by the eradication of both rodents and sandflies and by taking precautions to prevent the reestablishment of the former biocoenoses. If surveillance is not exercised over cleared localities, it is possible for the causal agent to be introduced from outside by infected sandflies, but if there are no animals susceptible to leishmaniasis in the area, the focus will obviously not be reestablished. It is possible for the causal agent to be imported by sick animals, which sometimes make long migratory journeys, but if there are no sandflies on the cleared area capable of transmitting the causal agent, its circulation cannot be reestablished.

The most effective way of clearing foci is by making radical changes in the natural landscape around villages and towns: with the establishment of a wide belt of cultivated crops, constant supervision will ensure that they cannot be invaded by wild animals.

RÉSUMÉ

LA DISTRIBUTION DES FOYERS NATURELS DE LEISHMANIOSE EN URSS

C'est en URSS que l'on a, pour la première fois, constaté l'existence de la leishmaniose cutanée dans des foyers naturels, cette forme de la maladie ayant été étudiée dans ce pays plus que partout ailleurs parce qu'elle y est plus répandue que la forme viscérale.

On trouve des foyers naturels de leishmaniose cutanée dans les sables stabilisés du désert de Kara-Kum, dans la partie méridionale du désert de Kyzyl-Kum et dans certaines zones désertiques ou semi-désertiques des contreforts montagneux. Le rôle de la grande gerbille *(Rhombomys opimus)*, le plus répandu des rongeurs des déserts sableux, est d'une extrême importance dans l'épizootiologie et dans l'épidémiologie de la forme cutanée; on trouve des secteurs où presque toutes les grandes gerbilles sont atteintes. Les terriers des colonies de ce petit animal sont des foyers naturels caractéristiques et anciens de la maladie cutanée.

En certains endroits, le mérione à queue rousse

(*Meriones erythrourus*) joue un rôle tout aussi important comme réservoir de l'agent causal. *Meriones meridianus* et *Spermophilopsis leptodactylus* ainsi que plusieurs autres espèces de rongeurs sont des vecteurs bien moins fréquents de la leishmaniose (réservoirs supplémentaires).

Chaque année, en URSS, des dizaines de milliers d'hectares de zones désertiques ou semi-désertiques, autrefois évitées par l'homme et où la leishmaniose est endémique, sont maintenant mises en valeur. Le danger d'infection est particulièrement élevé durant les quelques premières années d'exploitation économique d'un nouveau territoire où d'importants groupes humains vivent temporairement sous la tente ou dans de légères constructions provisiores.

Les vecteurs de la leishmaniose — les phlébotomes — peuplent les terriers des rongeurs et des prédateurs comme le renard, le chacal et le blaireau. Ils s'y reproduisent et y hibernent. Dans l'accul de la grande gerbille peuvent gîter de 100 à 500 phlébotomes. Ces insectes se gorgent du sang des gerbilles dont elles piquent les parties exposées de la peau (le lobe de l'oreille et le nez) qui sont généralement touchées par la leishmaniose et transmettent ensuite l'agent infectieux à un autre animal ou à l'homme.

Les connaissances sur la biologie et l'écologie des animaux sauvages qui vivent dans des terriers et sont les principaux hôtes de *Leishmania* et des phlébotomes, vecteurs majeurs de ce parasite, fournissent une base scientifique permettant d'établir un système de mesures prophylactiques et de supprimer le danger dans de vastes zones désertiques ou semi-désertiques.

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