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Natural Foci of Infection Of Some Helminthiases

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ACCORDING to the data in the literature, human trichinellosis is encountered in all countries, and it has a focal distribution. Large foci of trichinellosis exist in the United States where, according to the material of American workers, it was estimated about 21 million persons were infested with trichinellae. Trichinellosis was also quite widespread in Germany, particularly until the thirties of the present century (according to Kalu's summary, 16,541 cases of trichinellosis were recorded from 1866 through 1921), as well as in certain other countries. In the U.S.S.R., Byelorussia is a stabilized focus of trichinellosis (according to data of official statistics, 709 cases of trichinellosis were recorded in the Byelorussian S.S.R. in 1955); various regions of the Ukrainian S.S.R. and certain other republics are also stabilized foci of trichinellosis.

In analyzing the data in the literature on the spread of human trichinellosis, it may be ascertained that along with foci of this disease which have been stable for many years there not uncommonly occur brief outbreaks of it, which occur sporadically in various corners of the globe. The occurrence of these outbreaks has remained unclear from the epidemiological point of view until recently, since the majority of research workers thought of trichinellosis as a "synanthropic" disease the transmission of which is carried out mainly by domestic animals such as hogs, cats, dogs, and also rats. From the standpoint of the theory it was difficult to explain the cause of the sudden occurrence of the infestation in man in a locality previously favorable with respect to trichinellosis.

Numerous investigations which have been conducted in recent years both in the Soviet Union and abroad, however, have shown clearly that trichinellosis is considerably more widespread among wild animals than among domestic animals. Of the wild animals, wolves, foxes, polar foxes, raccoons, badgers, minks, bears, wild boars, lynxes, coypus, hedgehogs, moles, field mice, skunks, martens, squirrels, ermines, beavers, muskrats, weasels, lemmings, seals, walruses, lions, and tigers have now been recorded as hosts of trichinellae. It is entirely possible that as a result of further investigations this list will be lengthened considerably.

As observations of a number of authors have shown, in the U.S.S.R. trichinellosis is most often found in wolves. Thus, A. V. Merkushev (1953) found trichinella larvae in all 10 wolves which he examined in Voronezhskaya Oblast. A. N. Kadenatsii (1953) recorded trichinellosis in 9 wolves dissected by him in Omskaya Oblast; B. F. Bobrov (1955) found trichinella larvae in 148 out of 152 (97 percent) of the wolves in Saratovskaya Oblast; E. M. Geller (verbal report) notes 100 percent involvement of wolves in Kurskaya Oblast with trichinellae.

The second most frequently involved carnivore is the fox, in which trichinellosis has been recorded in 30 to 60 percent of the cases. In the north, trichinellosis is most often found in bears and in polar foxes. In the rest of the animals enumerated, trichinellosis has been recorded in a smaller percentage of cases but quite often. M. Ya. Belyayeva (1954, 1955), for example, in a dense Belovezhskaya forest found trichinella larvae in three species of carnivores (wolf, fox, and lynx) and also in insectivores and rodents (the yellow-throated mouse, shrew, and mole). Here, according to the author's data, the shrews and moles played the main part in the transmission of the infestation among the wild animals. Ye. G. Mashirov (1955), investigating wild animals in Tatarskaya A.S.S.R., demonstrated trichinella larvae in 23 out of 187 foxes, 4 out of 101 minks, 3 out of 15 martens, 1 out of 5 raccoons, 1 out of 13 polecats, and 1 out of 7 ermines. The author notes that the infection of wild animals occurs chiefly during the period from May through October and is accomplished through the eating of infested rodents. Yu. A. Berezantsev (1956), examining wild animals in Leningradskaya and Novgorodskaya Oblasts, found trichinellae in 10 out of 11 wolves, in 1 out of 7 foxes, in 3 out of 31 raccoons, and in 3 out of 5 lynxes. All these data undoubtedly show the existence of natural foci of trichinellosis, and make evident the fact that in wild animals trichinellosis is much more widespread and more intense than in domestic animals.

According to the data of V. P. Koryazhnova (1938, 1950), A. V. Merkusheva (1951–55), M. Ya. Belyayeva (1954, 1955), Yu. A. Berezantsev (1955, 1956), and a number of other research workers, the main primary foci of trichinellosis is in nature; secondary foci, in biocoenoses associated with man.

A. V. Merkushev, analyzing his own data and those in the literature on the spread of trichinellosis among wild and domestic animals, worked out a scheme of the main routes of transmission of the infestation in "forest biocoenoses" and "biocoenoses associated with man." According to this scheme, the spread of trichinellosis among wild animals is accomplished as the result of predacity, the eating of carrion as well as the swallowing of insects and bird excrement. The last mentioned route of infection is possible because certain carcass-eating insects such as ground beetles, carrion beetles, fly larvae, and birds are, according to the author's data, reservoir hosts of trichinellae. From natural foci the infestation may be transmitted to domestic animals, and here the catch of the hunt, carrion, insects, and bird excrement serve as the transmission factors. From domestic animals, mainly hogs, the infestation is transmitted to man. Therefore, trichinellosis of man is associated with trichinellosis of wild animals.

It seems to us that in the light of the data presented, the cause of occurrence of various outbreaks of this disease becomes clear among the population in localities previously favorable with respect to human trichinellosis and trichinellosis of domestic animals. Apparently, such outbreaks are possible where trichinellosis is widespread among the wild animals and where, thanks to the occurrence of some kind of specific conditions, the transition of infestation is effected from a natural focus into a biocoenosis associated with man. These conditions may be of a chance nature, and then the spread of trichinellosis among people is limited to a single outbreak, but it can also be reinforced, and in this case the disease becomes epidemic. We believe that the character of chance epidemics and endemic cases of trichinellosis are so different that they can be separated into independent types of foci.

We call localities with an endemic spread of trichinellosis permanent stabilized foci of this disease. It may be supposed that in the first stages of formation of such foci they were associated with natural foci. In time, thanks to the presence of favorable epidemiological con-

ditions the spread of the infestation began to be realized within the human biocoenosis and the connection of these foci with the primary natural focus was lost. It is possible that in certain cases a synanthropic focus becomes associated with a natural focus but can exist independently also. Therefore, although permanent foci arose from natural foci of trichinellosis, at the present time they exist independently of them. The infestation cycle in such foci is accomplished through domestic animals, from which trichinellosis is transmitted to man. Among such stabilized foci are the United States, Germany, Byelorussian S.S.R., and certain regions of the Ukrainian S.S.R.

We call various brief outbreaks of trichinellosis temporary foci. The infestation cycle in them is accomplished with the participation of both domestic and wild animals. The domestic animals, particularly hogs, are infected from wild animals directly (by eating their carcasses, the catch of the hunt, insects) or through the medium of other domestic animals, for example, rats. In foci of the temporary type man is infested from domestic animals, chiefly from hogs. In various cases the infection may occur also from wild animals; however, this is less characteristic than infection from domestic animals. Thus, cases of brief outbreaks of human trichinellosis are known which have occurred as the result of the consumption of badger meat (M. Ye. Semenova, 1947); wild boar meat (G. M. Maruashvili, N. G. Sakvarelidze, and I. G. Matiashvili, 1955); bear meat (M. R. Zak, 1955), and others as food. Foci of the temporary type are recorded everywhere now, including various regions of the Soviet Union. However, these two types of foci do not exhaust the list of the entire variety of epidemiological characteristics of trichinellosis in various localities. An analysis of the data in the literature permits us to distinguish a third type of trichinellosis focus characteristic of regions with extensively developed hunting, thanks to which the population has a permanent direct contact with wild animals.

An example of this type of focus is the Arctic region. While previously the problem of the spread of trichinellosis in the Arctic was mainly of interest from the point of view of studying regional pathology, at the present time it is assuming much greater importance because of the opening up of these regions and is attracting the attention of numerous research workers.

Study of this problem was begun in 1947, when word was received in the Copenhagen Institute of Sera of a large trichinellosis outbreak among the Eskimos of the eastern part of Greenland. The expedition which went to the site of the outbreak found more than 300 cases of trichinellosis among the native population, 33 of which terminated in death (Thorborg, Tulinius, and Roth, 1948). According to the data of the authors mentioned, similar outbreaks had occurred in Greenland in 1933 and in 1944 (the last outbreak included 63 persons, of whom 20 died), but had been diagnosed as ptomaine poisoning first and typhoid fever second. Both outbreaks are at the present time considered to have been trichinellosis. At the same time as this disease was found in Greenland, its presence was also suspected on the island of Southampton, and in 1948 Brown and co-authors made an immunological examination of the population of the island for trichinellosis and obtained a positive skin reaction in 91 out of 195 and a positive microprecipitation reaction in 39 out of 98 persons (Brown and others, 1949). On an island next to Southampton, Igloolik, positive immunological tests for trichinellosis were recorded in 22 (skin test) and 28 (microprecipitation test) of 100 persons examined (Brown and others, 1950).

In Canada, through the use of trichinelloscopy of the muscles of the diaphragms of cadavers from Ottawa and British Columbia, trichinellosis was found in 1.5 to 4 percent (Poole, 1953). Approximately the same percentage of involvement was shown in other regions of Canada: 1.5 percent in the population of Montreal; 1.75 percent in the population of Toronto; 4 percent in the population of Vancouver (Coffey and Wigglesworth, 1956). These authors found two cases of trichinellosis in Eskimos who had come from the Labrador Peninsula. In Alaska, trichinellosis was found among the Eskimos and Indians in 6.6 percent of the cases in Bethel and 1.6 percent in Kotzebue (Hitchcock, 1950, 1951).

After having studied the routes of entrance of the infestation into man in the Arctic, all the authors have come to the unanimous con-

clusion that hog meat does not play any part as a factor in the transmission of trichinellosis in these regions, because the native population uses it rarely as food. Various research workers have expressed the idea of the possibility of transmission of the infestation to man through the meat of sled dogs, which have a very high incidence of trichinellosis (Kuitunen-Ekbaum and Eleming, 1949; Masterton and Lewis, 1955). However, such a suggestion does not have adequate basis, because the dogs are used as food only in exceptional cases. This is explained by the fact that the meat of old dogs is too hard and tasteless; the young animals are kept for traveling and for hunting and are killed for food only during years of famine (Thorborg, Tulinius, and Roth, 1948). In the opinion of the majority of research workers engaged in the study of trichinellosis outbreaks among the Arctic population, human infection in this region is accomplished basically through wild animals.

The examination of various species of wild Arctic animals has shown that many of them are actively involved with trichinellosis. Thus, Roth (1949) found trichinella larvae in 6 out of 19 polar bears, in 6 of 101 polar foxes, and, which is particularly interesting, in 1 out of 17 seals, *Erignathus barbatus*. Rausch and co-authors (1956) found trichinellae in 22 out of 42 species of Arctic animals examined. According to the data of these authors, the greatest involvement is among grizzly, black, and polar bears, and among wolves, foxes, polar foxes, and shrews. Coffey and Wigglesworth (1956) also mention the great degree of trichinellosis infestation among polar and black bears. Kuitunen (1954) found trichinella larvae in 17 of 394 walruses caught near the island of Southampton. This author presents an unpublished report of Danish workers who found trichinella larvae in two walruses caught on the western coast of Greenland. In the opinion of the authors, all the species enumerated can transmit trichinellosis to man, since the native population of the Arctic uses all the wild animals possible as food. In a number of cases the meat of these animals is eaten raw or very slightly cooked. Recently, many research workers have been emphasizing the role of sea mammals in the transmission of the infestation to man (Roth, 1949; Rausch and others, 1949, 1950; Hitchcock, 1950). The authors mentioned come to a similar conclusion on the basis that study of the various outbreaks of trichinellosis has permitted them to establish the coincidence of the onset of epidemics with the season of starting the hunts for sea mammals.

In addition, it has been shown in a number of cases that infection occurred after the use of walrus or seal meat as food. Thus, according to Roth's data (1949), in the cases observed by him the trichinellosis infection of two men in the region of Sukkertopen, Greenland, occurred as the result of eating raw walrus meat which had been sent from Holsteinborg—the center of an epidemic outbreak of trichinellosis. Hitchcock (1950), in his turn, notes that of the 10 patients with trichinellosis found by him, 2 persons had been infected following the consumption of raw seal meat, and 1, of whale meat. The possibility of occurrence of large epidemics of human trichinellosis from sea mammals is also confirmed by the observations of Rausch and co-authors (1949), according to whose data several persons were infected simultaneously from one walrus carcass, the meat of which had been distributed among all the inhabitants of the small village. In another inhabited place the inhabitants were infected after eating whale meat.

As far as the routes of spread of trichinellosis among the wild Arctic animals is concerned, the infestation cycle may be accomplished differently in them. The eating of dead animal carcasses is of great importance, particularly in connection with the fact that in the north they can be preserved for a long time in the environment. Predacity also plays a definite part. Certain authors indicate the possibility of transmission of the infestation through the eating of bird meat, such as crows and polar owls, which, according to their observations, are reservoir hosts of trichinellae (Abs and Schmidt, 1954). The trichinella larvae swallowed by birds after eating animal carcasses preserve their viability for a certain time in the birds' digestive tract and can then be disseminated in the environment along with host excrement. Polar foxes, bears, Eskimo dogs, and other terrestrial mammals are infected with trichinellosis by eating the birds which have

the viable trichinella larvae in their intestines as well as by eating plants or eggs from the bird nest contaminated by bird excrement. The problem of infection of sea mammals has not as yet been solved and requires further study. As one of the possible routes of infection, mention is made of the swallowing of larvae which have fallen into the water together with bird excrement.

Existing ideas concerning the role of lemmings in the transmission of infestation deserve great attention. According to Faliatarek's data (1943), lemmings periodically make great migrations, in the process of which they have to cross rivers. If the river has a rapid flow they may be brought out to sea, where they serve as the source of nutrition for mammals. A high percentage of trichinellosis of lemmings has been established by a number of authors.

The material presented shows the distinctness of the epidemiological conditions of regions in which hunting is well developed. The third type of trichinellosis focus distinguished by us on this basis is characterized, on the one hand, by its stability, similar to the focus of the first type, but, on the other hand, markedly different from it in the routes of spread of the infestation. In the focus of the third type the invasion cycle occurs among wild rather than domestic animals and specifically the wild animals serve as the transmission factors in giving man trichinellosis.

Therefore, we are proposing the distinguishing of three types of human trichinellosis foci: (*a*) permanent foci, in which the invasion cycle is accomplished in domestic animals and infection of man occurs from domestic animals (mainly from hogs); (*b*) temporary foci, in which the transmission of the infestation to man is accomplished mainly through domestic animals, less often through wild animals; (*c*) permanent foci, the invasion cycle in which the transmission to man is brought about through wild animals.

If these foci are analyzed in the historical aspect, the first existing type should be considered a focus in which the invasion cycle and transmission to man are accomplished through wild animals (third type of focus). Afterward, when domestic animals are included in the epidemiological chain of trichinellosis, thanks to the agricultural activity of man, the remaining two types of foci occur. Of these, the second type is the earlier and characterized by the sporadic occurrence of cases, since in the first stages of the transition of the infestation from natural foci into a biocoenosis associated with man the connection between them is of a temporary nature. Gradually, an increase in infestation occurs in these biocoenoses, as a result of which its cycle is accomplished now without the participation of wild animals, and therefore a stabilized focus of human trichinellosis develops (first type of focus).

At the present time, as seen from the data in the literature presented here, all three types of human trichinellosis foci can exist in parallel, independently of one another.

It is quite obvious that the measures for combating trichinellosis cannot be the same for foci of different types. In the foci of the first type, measures for disinfecting hog meat, the main transmission factor, and the prevention of infection of hogs should be the principal ones taken. In the temporary foci the main attention should be given to eliminating the possibilities of transmission of the infestation from a natural focus to a biocoenosis associated with man. Recommendation of any kind of measures for foci of the third type is still difficult, because the spread of the infestation in them is associated directly with wild animals and depends on the characteristics of the life and occupational activity of the population.

Echinococcosis

Echinococcosis is one of the helminthozoonoses which is widespread on the territory of the Soviet Union and in many foreign countries. The economic significance of echinococcosis and also the proportion of it in human pathology causes us very pointedly to ask the question of the need for fighting decisively against this disease. Success in this work is to a considerable degree determined by the completeness of the knowledge of the epidemiology and epizootology of echinococcosis. At the same time, a number of problems in this field have not as yet been adequately studied. Among them, first of all, is the problem of the

natural foci of echinococcosis and its part in the epidemiology of human echinococcosis.

One of the first to direct attention to the natural focalization of echinococcosis was Riley (1933, 1939), who showed the transmission of the infestation from wolves to caribous in the State of Minnesota in the United States. Rausch and Schiller (1951) in Alaska and Sweatman (1952) and Miller (1953) in Canada established the fact that wolves, coyotes, and foxes serve as the definitive hosts of echinococci, while American and Canadian deer, moose, caribous, and bisons serve as the intermediate hosts. The infection of wild carnivores is accomplished as the result of predacity; herbivora are infected by swallowing the eggs of the echinococcus which are widely disseminated in the environment by wolves and other definitive hosts. The authors emphasize the fact that domestic herbivora and dogs do not participate in this cycle. According to the observations of Wolfgang and Poole (1956), the main definitive host of echinococcus in Canada is the wolf. From wolves the disease is transmitted to wild herbivora, chiefly by the caribou, the percentage of infection of which ranges from 5 to 20 percent. Similar data were obtained for Canada by Meltzer (1956) and for Canada, Alaska, and the United States by Magath (1954). According to the material of the latter author, the invasion cycle in these countries may be accomplished along three main routes: (*a*) wolf—elk—wolf; (*b*) fox (less often, wolf or dog)—long-horned cattle, hogs—fox, wolf, dog; (*c*) polar fox—field mice—polar fox. Of the three possible routes mentioned by the author, the first and third characterize natural foci. Therefore, all the data presented in the literature undoubtedly show that, in addition to the usual invasion cycle carried out among domestic animals (dog—domestic herbivora—dog) and characteristic of synanthropic foci of echinococcosis, there also exist cycles among wild animals; that is, natural foci of invasion.

In a whole series of cases the natural foci may exist for a long time, without inflicting any particular economic damage and without going into a biocoenosis associated with man. Miller, for example, asserts that in a number of places of British Columbia and northern Canada, natural foci (wolf-American and Canadian deer-wolf) have been existing for centuries without spreading to involve domestic animals and man.

For the transition of the invasion from the natural focus into a synanthropic one and for the purpose of reinforcing the latter, the existence of definite epidemiological conditions is needed for providing contact of man or dogs with wild animals. In a number of places, particularly in the Arctic, such conditions are of a permanent nature, because they depend on the characteristics of the life and work activity of the population. It is therefore completely natural that in the Arctic a considerable degree of human involvement is observed along with the extensive distribution of echinococcosis among wild animals. Thus, among the native population of Canada and Alaska, echinococcosis was found, by means of the intracutaneous Cazzoni test, in a large percentage of cases. According to Miller's data, in Indians from reservations in British Columbia positive reactions were found in 15 and doubtful reactions in 12 out of 842 persons examined. Wolfgang examined 293 Indians in 1954 in the Yukon region and found 38 percent positive reactions. In his examination of 1,145 Indians living along the Mackenzie River, he obtained a positive result in 41.5 percent of the cases. Poole in 1955 examined 584 Indians from settlements situated near Great Slave Lake and found 13.5 percent involvement (Wolfgang and Poole, 1956); Hitchcock in 1950 examined 366 Indians from Kotzebue, Alaska, and obtained a positive intracutaneous test in 3.2 percent of cases. On St. Lawrence Island a positive reaction with echinococcus antigen was obtained in 66 of 232 Eskimos examined in 1950, and in 78 of 260 examined in 1954 (Rausch and Schiller, 1956).

It should be noted that in many of the regions listed above a considerable degree of involvement of dogs was also observed. Thus, dogs from Indian settlements of British Columbia, Alberta, and the northeastern territory of Canada were infected in 28 percent of cases, according to the authors' data; dogs from settlements situated along the Mackenzie River, in 25 percent; and dogs from St. Lawrence Island, in 12 percent of cases.

The data presented graphically demonstrate

the extensive distribution of echinococcosis among the Arctic peoples and also the complete coincidence of areas of the natural foci of this disease with foci of human echinococcosis. In a whole series of cases the synanthropic foci of echinococcosis have already lost their connection with natural foci and at the present time exist entirely independently. The parallel existence of natural and synanthropic foci is also possible, whereby the invasion cycle is accomplished within each of them and by means of the passage from the natural focus into the synanthropic one, and vice versa.

An analysis of the data in the literature shows that the passage of the infestation from natural foci to man can be accomplished by three routes: directly from wild animals, through the medium of dogs, and through elements of living and nonliving nature.

The first route is observed in regions in which hunting is well developed. It is found among Indians and Eskimos of Alaska, Canada, and the St. Lawrence, Bering, and Komandorskie Islands as well as in a number of other Arctic localities. Man is infected by swallowing eggs located in the pelts of wild carnivores killed in hunting. In the removal of the hide, the eggs which stick to the fur remain on the hands of the hunter or person cutting up the carcass (among the Indians and Eskimos this work is most often done by women, which explains the greater percentage of involvement of them with echinococcus than of men), and can then enter the mouth. In addition, in shaking out the hides, which are usually tanned in the house, the eggs fall onto household objects and food products, where they may maintain their viability for a long time (Magath, 1954; Rausch and Schiller, 1956).

In the second route of passage of the infestation to man, dogs are infected directly from wild animals and then serve as the source of infection of the population. The dogs are infected when they are fed products of the hunt (for example, the entrails of deer infected with echinococcus), in the process of hunting wild rodents and other small animals (particularly often in the summer, when the dogs are not used so much for work and are fed less), and also through the eating of carcasses of wild animals which have died. In certain regions, dogs may play the part of mechanical vectors of the infestation, since sometimes eggs from infected dogs, which was established by A. F. Nosik (1952, 1954), or from wild carnivores fall onto their fur. The latter occurs in Canada, where according to the data in the literature (Wolfgang and Poole, 1956), the population not uncommonly raise young wolves together with the dogs in order to train them. Certain authors mention the fly, *Phormia regina*, in the intestine of which the eggs maintain their viability (Schiller, 1954), as the second mechanical vector of the echinococcus eggs.

Infection of man through elements of living and nonliving nature (third route of passage of the infestation) is accomplished as the result of the eating of various plants contaminated by the excrements of wild carnivores as well as the result of drinking water from natural bodies of water which serve as watering places for wild animals (Magath, 1954; Meltzer, 1956).

Echinococcus Species

The possibility of human infection through elements of nature is the more probable since observations of a number of authors have shown that the oncospheres of the genus *Echinococcus* (*E. granulosus* and particularly *E. sibiricensis*) are very resistant to environmental influences. For example, in water at a temperature of +2° C. the eggs maintain their viability for 2 years. Low temperatures act very weakly on the eggs. The eggs may maintain their viability even after a brief temperature effect equal to −51°. The eggs which are in frozen animal carcasses remain viable for a very long time (2 years or more). Lyell found live eggs in the body of a polar fox which had been lying in the tundra under the snow for several years. The eggs can also pass the winter in ground covered with snow, despite the fact that the air temperature at this time reaches −37° to −40° (A. F. Nosik, 1951, 1952; Schiller, 1954; Lyell, 1956). The problem of the natural focalization of echinococcosis cannot be considered in isolation from the question of the species composition of the genus *Echinococcus* which has for a long time been debated in the literature.

As is known, two points of view existed among investigators on this question until re-

cently. According to one of them, which was supported by Virchow, Leuckart, Klemm, Dew, K. I. Skryabin, A. F. Nosik, and certain other authors, the unilocular and multilocular echinococci are the same zoological entity—*E. granulosus*. The proponents of the unitarian theory explain the difference in the structure of the larval forms of the echinococcus by the capacity of the maternal vesicle of budding off exogenous daughter vesicles very early under the influence of certain environmental conditions, which leads to the formation of an alveolar (multilocular) echinococcus. According to the views of the adherents of the dualistic theory, Mangold, Posselt, Romanov, N. F. Mel'nikov-Razvedenkov, Deve, the alveolar echinococcus represents an independent species—*E. alveolaris* (multilocularis), which is distinguished from *E. granulosus* not only through the character of the structure of the larva but also through certain details of the structure of the sexually mature forms. In 1950–56, Rausch and Schiller, in studying the distribution of echinococcus on the St. Lawrence, Bering, and Komandorskie Islands, isolated and described a new species of echinococcus—*E. sibiricensis* (Rausch and Schiller, 1954), characterized by an alveolar larval structure similar to the multiloculated echinococcus. The definitive hosts of this species proved to be polar foxes, foxes, and dogs; the intermediate hosts, Microtinae rodents and, facultatively, man. According to the authors' data the percentage of involvement of the polar foxes varied within limits of from 40 to 100 percent. Dogs were affected to a much smaller degree (about 12 percent). Development to sexually mature forms in the polar foxes was completed in 32–33 days, and oviposition lasted about 3 to 3½ months. The larval forms of *E. sibiricensis* parasitized rodents in the liver, producing metastases in the mesenteric lymph nodes.

The authors were able to produce an experimental infection of rodents through feeding them with echinococci obtained from spontaneously infected polar foxes. As early as the 150–170th day of infection, the liver was markedly enlarged and constituted two-thirds of the body weight. The rapid growth and alveolar forms of the parasite were brought about, in the authors' opinion, by the exogenous growth of secondary vesicles, which is not characteristic of *E. granulosus*. According to Mankau's (1956) data, a characteristic feature of the pathological process which developed in the rodents was perivascular mononuclear infiltration of all organs.

Simultaneously with the demonstration of the alveolar echinococcus in rodents, the considerable distribution of this parasite was shown also among the inhabitants of the St. Lawrence and Bering Islands. Hereby, the authors established the fact that the number of cases of human echinococcosis increased particularly during a period of an increase in the number of polar foxes and rodents.

It is assumed that *E. sibiricensis* has an Arctic origin and has spread mainly from the center of Europe to the East, whereby the St. Lawrence Island represents the extreme northeastern boundary of it (Rausch and Schiller, 1951, 1954, 1956; Rausch, 1954; Schiller, 1955; Lyell, 1956; Thomas and others, 1954). In summarizing the results of their 6 years of research, Rausch and Schiller have come to the conclusion that alveolar echinococcosis, which is widespread among the population of the Arctic regions of Eurasia, is produced by *E. sibiricensis* parasitization and that the previous conception of *E. granulosus* as the etiological factor of this disease is erroneous. Therefore, they consider the newly described species an independent zoological entity and recognize the existence of two echinococcus species: *E. granulosus* and *E. sibiricensis*. They identify the multiloculated echinococcus with *E. sibiricensis*.

A detailed study of the new species was carried out by Vogel (1954) in Germany. After investigating wild animals in the areas of distribution of alveolar echinococcus in man, the author found sexually mature echinococci, morphologically distinct from *E. granulosus*, in the intestines of 4 out of 11 dissected polar foxes. By feeding these parasites to 19 species of mammals, he showed the development of larvae of the alveolar type in the liver of wild rodents (*Microtus oeconomus ratticeps*, *Microtus arvalis*, *Sigmodon hispidus*). In the histological changes and the pathogenic effect, the picture resembled alveolar echinococcus of man. Infection of dogs by means of feeding them with the liver of spontaneously infected field

voles *M. arvalis* led to the development of sexually mature forms of echinococcus identical with the parasites found in the polar foxes and different from *E. granulosus* in their smaller size, different arrangement of the sexual opening, a smaller number of testes, and the absence of lateral uterine appendages. Similar specimens were isolated from dogs infested with alveolar vesicles which had been taken from man. Vogel comes to the conclusion that *E. sibiricensis* is a synonym for *E. multilocularis* (Leuckart, 1863) and should be called this according to the law of priority.

Subsequent authors engaged in the study of *E. sibiricensis* confirmed the existence of a number of morphological characteristics of the sexually mature forms of this helminth. Therefore, at the present time it has been established that *E. sibiricensis* is different from *E. granulosus* not only in the structure of the larva but also in that of the mature parasites. In addition, according to the material of all the authors, it is distinguished also by certain biological-ecological features, particularly the lack of coincidence of areas of distribution and by the parasitization of different host species. The definitive hosts of *E. granulosus* are wolves, jackals, and dogs; the intermediate hosts, domestic and wild herbivores (mainly); the definitive hosts of *E. sibiricensis* are polar foxes, foxes, dogs; the intermediate hosts, wild rodents. Therefore, there is every basis for considering *E. granulosus* and *E. sibiricensis* independent zoological species.

In the Soviet Union, no special work has been done yet in the matter of demonstrating *E. sibiricensis*. However, in 1941 V. P. Afanas'yev published a work in which he reported finding multilocular echinococcus vesicles in the livers of wild rodents on the Komandorskie Islands. At the same time, he found sexually mature echinococci in one of the dissected polar foxes. It is characteristic that the echinococci were absent from domestic animals. At the present time, certain authors report their finding of sexually mature forms of echinococcus, different from *E. granulosus* morphologically, in polar foxes and foxes. Thus, A. N. Kadenatsii found such parasites in foxes in Omskaya Oblast (verbal report). A. M. Petrov found *E. sibiricensis* in an Azerbaijan fox and in polar foxes in material collected by I. M. Isaychikov on Kil'din Island (verbal report). The larval stages of *E. sibiricensis* have been reported in rodents only by Yu. F. Morozov (1956) in a red mouse in Vilyuskiy Rayon of Yakutskaya A.S.S.R. and in one field vole—*M. oeconomus* in Barabinskiy Rayon of Novosibirskaya Oblast. As far as the spread of this species among the population is concerned, in the present state of our knowledge it is possible to say only that foci of alveolar echinococcus of man have been found in western Siberia, in certain regions of eastern Siberia, particularly in Yakutskaya A.S.S.R., in Tartarskaya and Bashkirskaya A.S.S.R., and in various rayons of Kazakhstan, that is, in the northeastern part of the Soviet Union.

It must be supposed that further investigations will aid in establishing more exactly the species classification of the causal organism of this infestation and will aid in deciding whether, as Rausch and Schiller suppose, the etiology of human alveolar echinococcosis is actually associated with *E. sibiricensis*. At present, this may be only assumed, based on a number of facts and primarily on the similarity of the clinical and histopathological picture of the disease in man and rodents as well as on the morphological similarity of the parasites. Thus, according to Vogel's data, the sexually mature echinococci found in dogs artificially infected with multilocular vesicles which had been taken from man were identical with *E. sibiricensis* from spontaneously infected polar foxes. Proof of the role of *E. sibiricensis* as a causal agent of alveolar echinococcosis of people is the distribution of this disease in the northeastern regions, which, as has already been noted above, is characteristic of the given species of parasite.

Acknowledging, therefore, the correctness of the Rausch and Schiller hypothesis concerning the etiological role of *E. sibiricensis* in the development of alveolar echinococcosis of man, we consider it premature as yet to identify *E. sibiricensis* completely with *E. alveolaris* as Vogel suggests. Certain data which speak against such an identification motivate us.

Among these data is the problem of the intermediate hosts of these parasites. According to material obtained by all authors, a character-

istic feature of *E. sibiricensis* is the parasitization by the larval stages only of rodents and facultatively of man. At the same time, a number of authors (K. I. Skryabin and R. S. Shul'ts, 1949; A. F. Nosik, 1953) note the possibility of the existence of the multilocular echinococcus in long-horned cattle and hogs. It is interesting that the vesicles found in the liver of the animals mentioned had a somewhat unusual structure. In connection with this, it might be supposed that the multilocular echinococcus found in domestic animals is not identical with *E. sibiricensis*, being an independent third species or else a variety of *E. granulosus*. It is certainly possible that such an assumption will not be confirmed in the future; however, for a final answer to the question of the identity of the multilocular echinococcus and *E. sibiricensis*, further observations and experimental research are needed.

Regardless of the results of this research, it is already quite obvious that in connection with the demonstration of *E. sibiricensis*, the role of natural foci of echinococcosis in the epidemiology of this disease is increasing still further, since the given species is much more widespread among wild animals than *E. granulosus*. The epidemiological importance of natural foci of *E. sibiricensis* in regions where hunting for wild carnivores and herbivorous animals is of great importance in the economy of the population and also in regions where the population is constantly in contact with dogs is particularly great. Among such regions, North America and the Arctic should be mentioned first. Apparently, similar epidemiological conditions occur also in a number of the northern regions of the Soviet Union. The data of V. S. Semënov (1950) concerning the considerable distribution of echinococcosis and particularly of the alveolar echinococcus among the population of Yakutskaya A.S.S.R. is very symptomatic in this respect.

It is quite evident that the attention of Soviet investigators should be directed to the problem of echinococcosis devastation, whereby in developing a plan for fighting against this disease, measures directed both at the sanitization of dogs and at cutting the connections with natural foci of echinococcosis should be provided.

EDITORIAL NOTE: The author's figure for trichinellosis in the United States is an estimate of about 30 years ago projected from examinations of the diaphragms of a small part of the population. Rather than a record of this disease, the estimate was based on the presence of a few worms. There have been no satisfactory national estimates of the prevalence of subclinical infection, but it is probable that the incidence has declined since the enforcement in recent years of regulations requiring heat treatment to destroy trichina in garbage fed to hogs. All States except Alaska and Hawaii now have such regulations.

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