

THE OCCURRENCE OF BABESIASIS AFFECTING SMALL TERRESTRIAL MAMMALS AND THE IMPORTANCE OF THIS ZOONOSIS IN EUROPE

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Abstract. A short survey is given of the occurrence of babesiasis affecting small terrestrial mammals in some parts of Europe. Results obtained in studies of 7,038 small terrestrial mammals (42 species) from Czechoslovakia, Austria, Hungary, Yugoslavia and Bulgaria, show the distribution of *Babesia microti* in these countries. The authors found babesias in the following host species: *Neomys anomalus*, *Clethrionomys glareolus*, *Microtus arvalis*, *M. agrestis*, *Apodemus agrarius*, *A. flavicollis*, *A. sylvaticus* and *Mus musculus*. The average incidence was very low—0.2 % and varied in individual countries from negative to 0.7 %. Problems of the natural foci of *B. microti* in Central Europe are discussed and hitherto recorded cases of *Babesia* infections in man are summarised. The epidemiological importance of the unspecific mammal hosts of *B. microti* is emphasised and the necessity of surveillance of this zoonosis in Europe is pointed out.

Babesiasis (=piroplasmosis), caused by various species of *Babesia*, has been described in a number of animal species, mainly in mammals, particularly in ruminants. Taxonomically babesias are placed in the class Telosporica (Riek 1968), order Eucoccida, suborder Haemosporina, superfamily Babesiioidea, family Babesiidae and genus *Babesia*. A detailed list of all existing *Babesia* findings is given in a monograph by Krylov (1974).

Babesia microti, which has been found in various small terrestrial mammals in different countries (Doflein and Reichenow 1953, Zasukhin 1956, Shortt and Blackie 1965, Van Peenen and Duncan 1968), is apparently distributed all over the world. This species was described by Franca (1912) in Portugal as *Smithia microti* from the vole *Microtus incertus* (*Microtus arvalis incertus*). Later the genus *Smithia* became synonymous with the genus *Babesia* (Neitz 1956, Riek 1968).*) Most probably the several species of *Babesia* described from various small terrestrial mammals are identical with *B. microti*. Shortt and Blackie in England (1965) found this *Babesia* species not only in rodents, but also in insectivores and Van Peenen and Duncan (1968) in California, USA reported it from rodents as well as from a rabbit species.

Of special importance is the fact that in the USA in recent years two human cases have been described in which *B. microti* was considered to be the causative agent (Benson et al. 1969, Western et al. 1970, Anderson et al. 1974).

MATERIAL AND METHODS

Between 1958 and 1975 a total of 7,038 small terrestrial mammals were investigated microscopically for the presence of parasitic protozoa in their blood; 5,104 animals came from Czechoslovakia (mostly from Bohemia and Moravia), 15 from Austria, 291 from western Hungary, 1,274 from Yugo-

*) The correct name of this species of *Babesia* is somewhat problematic. Most authors (Van Peenen and Duncan 1968, Fay and Rausch 1969, Benson et al. 1969, Western et al. 1970, Anderson et al. 1974) write *Babesia microti*, while others (Shortt and Blackie 1965, Šebek 1970, 1975, Šebek et al. 1975) write *Babesia microtia*. In Franca's (1912) paper this new species of *Babesia* was cited as *S. microtia* as well as *S. microti*.

slavia (464 from Bosnia-Herzegovina, 476 from Montenegro and 334 from Macedonia) 354 from East Bulgaria. (Table 1). The animals were mostly caught in standard mousetraps during expeditions organized for the research of natural foci of human diseases. Typical biotopes were chosen for trapping in the areas under study, so that an objective picture of the small mammal fauna could be obtained. Larger animals such as muskrats, polecats and others were shot or they were made available to us by our co-workers who were hunters. In the laboratory the animals were first examined for ectoparasites, then processed mammalogically and dissected under sterile conditions. To obtain blood smears the blood was collected by puncturing the heart with a Pasteur pipette. After drying the blood smears were fixed with methyl alcohol by current method and stained after Giemsa-Romanowski

Table 1. Small terrestrial mammals investigated in Czechoslovakia, Austria, Hungary, Yugoslavia and Bulgaria and positive findings of *Babesia microti*

Species	Country							Total	
	Czechoslovakia	Austria **)	Hungary	Bosnia-Herzegovina	Montenegro	Macedonia	Bulgaria	Investigated	Positive
<i>Erinaceus concolor</i>	50/0	0/0	0/0	0/0	6/0	3/0	0/0	59	0
<i>Talpa europaea</i>	494/0	2/0	0/0	1/0	3/0	0/0	0/0	500	0
<i>Sorex araneus</i>	219/0	2/0	4/0	0/0	1/0	2/0	12/0	240	0
<i>Neomys fodiens</i>	55/0	0/0	0/0	0/0	5/0	0/0	0/0	60	0
<i>Neomys anomalus</i>	11/0	0/0	0/0	24/0	0/0	11/1	32/0	78	1
<i>Putorius putorius</i>	87/0	0/0	0/0	0/0	0/0	0/0	0/0	87	0
<i>Cricetus cricetus</i>	57/0	0/0	0/0	0/0	0/0	0/0	0/0	57	0
<i>Clethrionomys glareolus</i>	591/2	1/0	71/0	10/0	0/0	2/0	0/0	675	2
<i>Arvicola terrestris</i>	55/0	0/0	0/0	1/0	1/0	11/0	0/0	68	0
<i>Pitymys subterraneus</i>	92/0	0/0	1/0	3/0	0/0	2/0	0/0	98	0
<i>Microtus arvalis</i>	947/6	3/0	6/0	61/0	1/0	52/0	6/0	1076	6
<i>Microtus agrestis</i>	218/1	0/0	0/0	0/0	0/0	0/0	0/0	218	1
<i>Microtus oeconomus</i>	53/0	5/0	0/0	0/0	0/0	0/0	0/0	58	0
<i>Apodemus agrarius</i>	30/0	0/0	0/0	95/2	41/0	2/0	7/0	175	2
<i>Apodemus flavicollis</i>	447/0	2/0	124/0	140/1	103/0	150/0	55/0	1021	1
<i>Apodemus sylvaticus</i>	508/0	0/0	65/0	102/0	196/0	35/0	150/1	1056	1
<i>Apodemus microps</i>	76/0	0/0	0/0	0/0	0/0	2/0	1/0	79	0
<i>Rattus norvegicus</i>	391/0	0/0	0/0	3/0	4/0	0/0	3/0	401	0
<i>Mus musculus</i>	351/0	0/0	2/0	12/0	53/0	28/1	41/0	487	1
<i>Lepus europaeus</i>	122/0	0/0	0/0	0/0	1/0	11/0	15/0	149	0
Further 22 species*)	250/0	0/0	18/0	12/0	61/0	23/0	32/0	396	0
Total	5104/9	15/0	291/0	464/3	476/0	334/2	354/1	7038	15

*) Czechoslovakia: *Erinaceus europaeus* 2, *Sorex minutus* 20, *Sorex alpinus* 18, *Crocidura leucodon* 1, *Crocidura suaveolens* 14, *Mustela erminea* 13, *Mustela nivalis* 25, *Putorius eversmanni* 5, *Martes martes* 7, *Martes foina* 9, *Felis silvestris* 2, *Sciurus vulgaris* 41, *Citellus citellus* 3, *Ondatra zibethica* 37, *Micromys minutus* 47, *Rattus rattus* 3, *Muscardinus avellanarius* 3. Hungary: *Sorex minutus* 1, *Crocidura leucodon* 6, *Crocidura suaveolens* 7, *Microtus nivalis* 1, *Glis glis* 3. Yugoslavia: Bosnia-Herzegovina: *Crocidura suaveolens* 7, *Rattus rattus* 4, *Muscardinus avellanarius* 1. Montenegro: *Crocidura leucodon* 4, *Crocidura russula* 3, *Crocidura suaveolens* 9, *Crocidura* sp. 1, *Dolomys bogdanovi* 1, *Apodemus mystacinus* 40, *Rattus rattus* 1, *Glis glis* 1, *Dryomys nitedula* 1. Macedonia: *Crocidura suaveolens* 7, *Citellus citellus* 8, *Rattus rattus* 1, *Dryomys nitedula* 7. Bulgaria: *Sorex minutus* 4, *Crocidura leucodon* 11, *Crocidura suaveolens* 5, *Citellus citellus* 1, *Rattus rattus* 4, *Dryomys nitedula* 7.

**) These investigations have been only relatively recently started and will be a high priority project for 1977.

RESULTS

A. SURVEY OF THE WORLD DISTRIBUTION OF BABESIASIS IN SMALL TERRESTRIAL MAMMALS

Since the question of taxonomy of babesias affecting small terrestrial mammals is not yet clear, particularly in older findings, in this survey we shall also mention, besides *B. microti*, the other names describing *Babesia* species in small mammals. It should be pointed out that Wenyon (1926) has already emphasised that the small piroplasms from wild mammals are not morphologically distinguishable one from another.

A comprehensive survey of the world distribution of babesias in small mammals is difficult to achieve because of unsatisfactory description. In many countries these parasites in wild small mammals are unknown or insufficiently studied. In Europe the first description of babesias in small terrestrial mammals, namely laboratory white rats, was probably given by Fantham (1906—ex. Rodhain 1950) in London. Particularly interesting is the question of the vector, because the presence of ticks on laboratory white rats is highly improbable. In our opinion the identity of these babesias with *B. microti* cannot be excluded. *B. microti* was detected in England in many other hosts; the data from various authors were summarised by Cox (1970), mentioning the following species: *Sorex araneus*, *S. minutus*, *Talpa europaea*, *Clethrionomys glareolus*, *Microtus agrestis*, *Arvicola amphibius*, *Apodemus sylvaticus* and *Micromys minutus*. Franca (1912) in Portugal reported *Smithia microti* from the vole *Microtus incertus* and *Nuttallia herpestidis* from the mongoose *Herpestes ichneumon*. In southern Russia near Saratov Yakimoff (1909—ex. Zasukhin 1930) recorded *Nuttallia ninensis* from the hedgehog *Erinaceus europaeus*, and in Switzerland Galli-Valerio (1914) found *Smithia talpae* in the mole *Talpa europaea*. In Italy Franchini (1924—ex. Zasukhin 1930 and Rodhain 1950) recorded *Nuttallia myoxi* in the dormouse (*Myoxus* (= *Muscardinus*) *avellanarius*), and Baldelli (1960) reported *B. leporina* from the hare *Lepus europaeus*. In Belgium Rodhain (1931—ex. Carini 1941) found *Nuttallia talpae*, and in the USSR near Pyatigorsk Malakhov (1940—ex. Zasukhin 1956) recorded babesias from *Rattus norvegicus*. In Central Europe *B. microti* was first found by Šebek (1970) in *Clethrionomys glareolus*, *Microtus arvalis* and *M. agrestis*. In North Tyrol Mahnert (1972) demonstrated it in small alpine mammals—*Sorex araneus*, *Clethrionomys glareolus*, *Microtus agrestis*, *M. nivalis* and *Pitymys subterraneus*.

In Asia the babesias *Nuttallia danii* were described by Tsur et al. (1960) in Israel and *N. adleri* in the rodent *Meriones tristrami* by Feldman-Muhsam (1962) as new species of babesias. In the southern Caucasus in the outskirts of the town of Kars (Turkey) Yakimoff and Sapronovitch (1915—ex. Zasukhin 1930) recorded *Theileria rossica* in the field mouse *Apodemus agrarius*. Yakimoff later wrote to Zasukhin (1930) that these parasites belonged to the genus *Gonderia*. In Transcaucasia Dschunkovsky and Luss (1909—ex. Zasukhin 1930) demonstrated *Piroplasma leporis* in hares. In the southern part of the USSR *Piroplasma kolzovi* and *Francaella epsteini* were reported by Zasukhin (1930, 1956) in the suslik *Citellus pygmaeus*. Krylov and Zanina (1963) described *Smithia tadzhikistanica* in the rodent *Meriones erythrorus* in the Tadzhik SSR, and Muratov (1966) discovered *Nuttallia musculi* in *Mus musculus*. In the Kazakh SSR Tselishchev (1950—ex. Zasukhin 1956) recorded *Nuttallia rhombomys* in the gerbil *Rhombomys opimus* and in the Far East *Babesia yakimovi* was found by Springholz-Schmidt (1937—ex. Doflein and Reichenow 1953 and Zasukhin 1956) in the chipmunk *Eutamias asiaticus*. The aforesaid species of *Babesia* seems to be identical to that found by Nauck (1938—ex. Doflein and Reichenow 1953) in *Sciurotamias davidianus*. In Central Vietnam Capponi et al. (1955) recorded babesias of the genus *Nuttallia* in *Rattus norvegicus*, and in Taiwan Manwell and Kuntz (1964) observed babesias in *Bandicota indica*. In Indonesia Van Peenen (1975) found in two specimens of *Rattus exulans* piroplasms which were similar to *B. microti*. Babesias in small mammals in that area is apparently rare, because only those two animals with a positive incidence have been mentioned from more than 4,000 rodents investigated in Vietnam and Indonesia. From Asia *Nuttallia cricetuli* was mentioned by Springholz-Schmidt (1937—ex. Doflein and Reichenow 1953 and Capponi et al. 1955) in the hamster *Cricetus furunculus*.

In Africa Nicolle (1907—ex. Capponi et al. 1955) demonstrated *Nicollia quadrigemina* in the *Ctenodactylus gondi* in Tunisia, and Galli-Valerio (1911) found piroplasms in the hedgehog *Erinaceus algirus* in Algeria. In Accra Scott-Macfie (1915) demonstrated *Nuttallia decumani* in *Rattus norvegicus*. In Senegal Leger and Bedier (1923) reported *Nuttallia golundae* from *Golunda campanae*, Schwetz and Collart (1930—ex. Rodhain 1950) *Babesia ratti* from various rodents—*Mastomys uganda*, *Arvicanthis abyssinicus* and *Pelomys frater*—in the territory of Zaire, Hoare (1930) *Babesia crocidurae* in the shrew *Crocidura bicolor* in Uganda, Wenyon (1909—ex. Zasukhin 1930) *Piroplasma avicularis* from *Arvicanthis zebra* in the Sudan and Van Den Berghe et al. (1950—ex. Rodhain 1950) described *Babesia rodhaini* from *Thomomys surdaster* in Katanga. In South Africa

Noitz (1938) recorded *Nuttallia cynicti* in the civet cat *Cynictis penicillata*. Also in Africa Garnham (1951) described a new *Babesia*-like species *Echinozoon hoogstraali* from the rock hyrax *Heterohyrax syriacus*.

In North America Tyzzer (1938) in Massachusetts described from *Microtus pennsylvanicus* the species *Cytoecetes microti*, which Van Peenen and Duncan (1968) and also Western et al. (1970) consider to be identical to *B. microti*. Kirner et al. (1958) observed *B. microti* in the same vole species in New York. Possibly the babesias described by Tomlinson et al. (1948) from *Citellus variegatus* in Texas as *B. wrighti* also belong to the species *B. microti*; the same applies to *B. citelli* reported by Becker and Roudabusch (1933) from the suslik *Citellus tridecemlineatus* in Iowa. This fact was already pointed out by Van Peenen and Duncan (1968). Van Peenen (1965—ex. Van Peenen and Duncan 1968) reported *B. microti* from rodents in California. In southern California Van Peenen and Duncan (1968) found this *Babesia* species in the rodents *Neotoma lepida*, *Peromyscus californicus*, *Microtus californicus*, *Spermophilus beecheyi* and in the North American rabbit *Sylvilagus audubonii*. In the Los Angeles area Wood (1952—ex. Van Peenen and Duncan 1968) demonstrated babesias also in raccoons. In Alaska Fay and Rausch (1969) reported babesias from the voles *Microtus oeconomus* and *Clethrionomys rutilus* without species identification. It is very possible that the parasites belonged to the species *B. microti*. In South America Carini (1941) described *Babesia tucotucui* from the rodent *Ctenomys* sp.

Also in Australia babesias were found in small mammals. Backhouse and Bollinger (1959—ex. Tsur et al. 1960) described *Babesia tachyglossi* from the marsupial *Tachyglossus aculeatus*. This incomplete survey of *Babesia* findings in small terrestrial mammals in various countries of the world shows that babesias may be anticipated in this animal group practically wherever suitable reservoirs and vectors are present. It is very likely that several of the *Babesia* species mentioned are identical with *B. microti*.

B. DISTRIBUTION OF *B. MICROTI* IN SOME EUROPEAN COUNTRIES

a) Our findings of *B. microti* in Central and South-eastern Europe. We consider all our *Babesia* finds in small terrestrial mammals in Czechoslovakia, Yugoslavia (Bosnia-Herzegovina, Macedonia) and East Bulgaria to be *B. microti*. The following 8 host species proved to be positive: the bank vole (*Clethrionomys glareolus*), the common vole (*Microtus arvalis*), the field vole (*Microtus agrestis*), the striped field mouse (*Apodemus agrarius*), the yellow-necked mouse (*Apodemus flavicollis*), the Mediterranean water shrew (*Neomys anomalus*), the house mouse (*Mus musculus*) and the long-tailed field mouse (*Apodemus sylvaticus*) as shown in Table 1. Of particular interest are our findings in the shrew *Neomys anomalus* and in the mice *Apodemus agrarius*, *Apodemus flavicollis* and *Mus musculus*, because, so far as can be ascertained, it is the first time that *B. microti* was demonstrated in these species of hosts. Although *Nuttallia musculi* was described by Muratov (1966) as a new *Babesia* species in the house mouse (*Mus musculus*) in Tadzhikistan, we consider the authenticity of this new species to be questionable and the identity with *B. microti* possible. Experimentally *N. musculi* could be transmitted to the suslik (Muratov 1966). Of these positive hosts the incidence of *B. microti* was highest in *Neomys anomalus*—1.3 %, followed by *Apodemus agrarius*—1.1 %, *Microtus arvalis*—0.6 %, *M. agrestis*—0.5 %, *Clethrionomys glareolus*—0.3 %, *Mus musculus*—0.2 %, *Apodemus flavicollis*—0.1 % and *Apodemus sylvaticus*—0.1 %.

As for this average incidence, we would like to point out that the sequence of the individual host species does not necessarily represent the true situation because the number of investigations per host species is very variable, particularly in individual countries. Our finds in Austria, West Hungary and Montenegro were negative; in the first mentioned country we only investigated 15 animals. The fact that the incidence of *B. microti* in wild small terrestrial mammals in some areas in Central Europe may be quite high, is shown by our results from a locality in Southwest Moravia in Czechoslovakia, where 6.0 % of *Microtus arvalis* were positive (Fig. 1). It must be emphasised that the common voles were caught in early autumn and that in this particular area there was a relatively high population density of small mammals, and of the tick

Ixodes ricinus as well. The incidence of *B. microti* in small mammals in a locality may vary considerably according to the season and from year to year and particularly according to the population density of small mammals and ticks.

b) **Problems concerning the distribution of *B. microti* in Europe.** The results obtained so far suggest that the incidence of these parasites in different areas may be different. For example, *B. microti* is apparently much more common in England than in Central or Southeast Europe. Baker et al. (1963) reported an incidence of 26 % in field voles and 15 % in bank voles. In the same host species Cox (1970) had positive results of

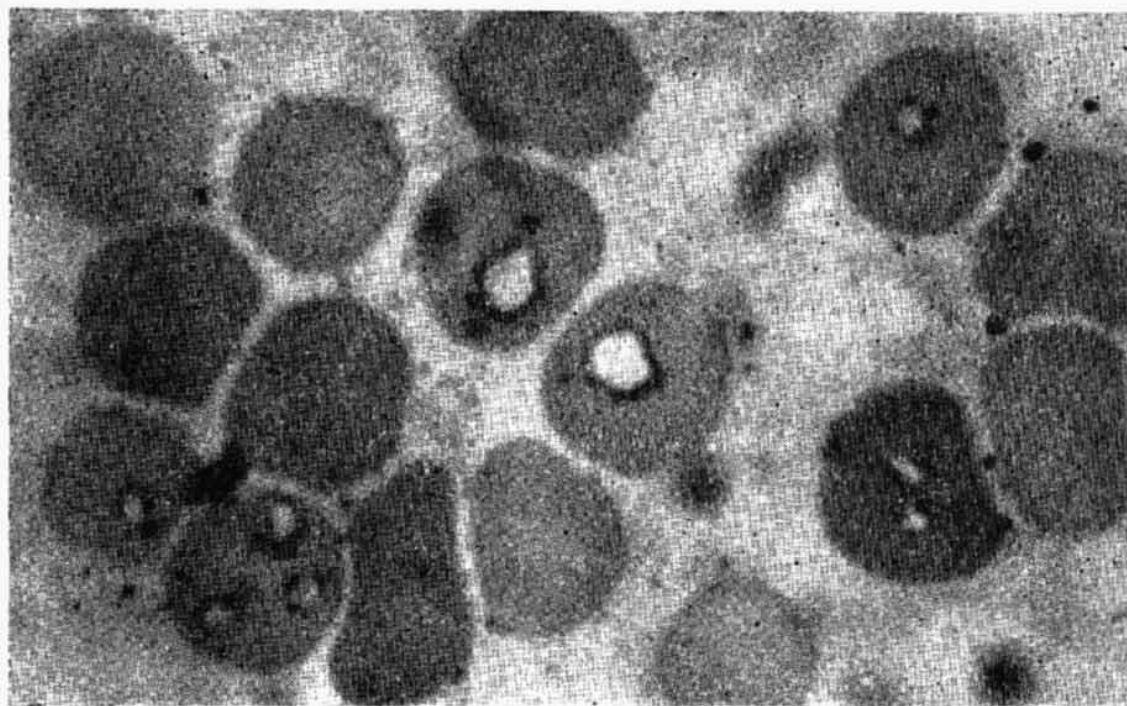


Fig. 1. *Babesia microti* in erythrocytes of the common vole *Microtus arvalis*.

25.2 % and 16.3 % respectively, and also positive results 1.6 % of long-tailed field mice, 6.8 % of common shrews (*Sorex araneus*) and 5.5 % of pigmy shrews (*Sorex minutus*). Shortt and Blackie (1965) in England demonstrated *B. microti* in the mole, bank vole, long-tailed field mouse, field vole and common shrew. They do not give the incidence in each species, but point out that the number of positive animals varies from year to year ranging from 2 to 10 % in the same locality. Mahnert (1972) in North Tyrol had positive findings in small alpine mammals: 1.9 % of common shrews, 1.0 % of bank voles, 6.5 % of field voles and 2.3 % of snow voles (*Microtus nivalis*), and in addition 2 out of 11 pine voles (*Pitymys subterraneus*). In these areas the tick *Ixodes trianguliceps* is the possible vector. The findings from Czechoslovakia (Šebek 1975) are mentioned above.

A comparison of the above results shows that *B. microti* in small terrestrial mammals is much more common in England than in North Tyrol and especially in Czechoslovakia. One could object that the difference might primarily be due to the different methods of investigation, but in our opinion that is not the case because we have years of experience with *B. microti*, besides using the same methods as the English authors. However, differences might be considerable if animals are often captured in the same localities where they have already been found positive; in our material this was not the case. The composition and number of host species investigated could be also important. We presume that the incidence of *B. microti* in small mammals in England and North Tyrol is really higher than in the countries and areas investigated by us.

From the epizootological and epidemiological viewpoints the most important is the type of babesiasis natural foci (Šebek et al. 1975) which depends upon the ecological zone of small terrestrial mammals. In this type only one species of *Babesia* is likely to be represented, namely *B. microti*. Shortt and Blackie (1965) demonstrated experimentally that the *Babesia* strains isolated by them from different species of small terrestrial mammals in England, were identical. On the other hand Fay and Rausch (1969) claim that the *Babesia* strains isolated by them from the voles *Clethrionomys rutilus* and *Microtus oeconomus* in Alaska were biologically different. It is known that *B. microti* can be transmitted experimentally not only to various rodents, but also to insectivores (Shortt and Blackie 1965) and to primates (the monkey *Macaca mulatta*) (Western et al. 1970). Moreover, several spontaneous cases of babesiasis in man are already known, as mentioned below, in which the patients had their spleen in situ. This is evidence that *B. microti* has no specific host, a feature by which it differs from species of *Babesia* present in domestic animals, mostly typical of one species or genus. Besides, we would like to point out that in our opinion, infection of domestic animals with *B. microti* is not excluded, a possibility already suggested by Soviet authors (Zasukhin 1956). The question of the main reservoir of *B. microti* is quite open. We suppose that the main reservoirs are different species of the genus *Microtus*, and in Europe, mainly *M. agrestis* and *M. arvalis*, while spontaneous infections of *M. pennsylvanicus* and *M. oeconomus* were also found in North America (Van Peenen and Duncan 1968, Fay and Rausch 1969).

In natural foci of babesiasis of this type in Central Europe, the tick *Ixodes ricinus* might be taken into consideration as vector. Also *Ixodes trianguliceps* might be the most likely vector in the natural foci, as it is a typical tick infesting small mammals.

D. BABESIASIS IN MAN

a) **Due to *Babesia* species from domestic animals.** Twenty years ago babesias were considered harmless to man but in 1957 Škrabalo and Deanović recorded a fatal case of human babesiasis in Yugoslavia. The patient, a 33-year-old farmer from the suburbs of Zagreb (Croatia), was admitted to hospital with fever, anaemia, jaundice and haemoglobinuria. With malaria suspected, blood smears were examined and, in the erythrocytes, numerous ring-shaped structures found, which were taken for malarial rings. Three days after hospitalization the patient died. Since the clinical course of this disease was not typical of malaria, the blood smears were sent to three prominent protozoologists who identified the parasites in the erythrocytes as *B. bovis*. The dead man's case history said that 11 years earlier he was splenectomised and that the cattle on his farm were infected with *B. bovis* and that this species of *Babesia* was also present in ticks collected from the cattle pastures.

The second case was recorded in 1966 in California in the USA (Scholtens et al. 1968) in a 46-year-old man who had become infected during his holiday near San Francisco. He was hospitalized with a febrile illness which was assumed to be malaria, and treated with Chloroquin, after which he recovered. Only later revised blood smears showed that he had babesiasis probably of the species *B. equi* or *B. caballi*, and also that the patient had been splenectomised 3 years earlier.

The third case was observed in 1957 in Northern Ireland (Fitzpatrick et al. 1968, 1969, Garnham et al. 1969). A 48-year-old sailor after spending his holiday in Northern Ireland, returned home ill with fever, jaundice and anaemia and died a week later. Shortly before his death malaria-like rings were found in his blood smears, which were later identified by a protozoologist as *B. divergens*. The case history said that 4 months before his illness he had been splenectomised. In the area in which the dead man had been infected *B. bigemina* was detected in cattle (Garnham et al. 1969).

The fourth case of human babesiasis was again reported from Zagreb (Škrabalo 1971) and the patient was a 27-year-old factory worker who had been splenectomised 3 years earlier. The babesias found in his blood were identified as *B. divergens*. The patient died after 5 days.

We would like to make a short comment regarding the host specificity of the most important species of *Babesia* present in domestic and wild animals. Curasson (1943) considered the cattle babesiasis to be specific for „all cattle“, and Huttyra et al. (1959) suggested that *B. divergens* was present only in cattle and that other mammals were unsusceptible. Garnham and Bray (1959)

succeeded in infecting splenectomized chimpanzees and Rhesus monkeys with *B. divergens*, but were unsuccessful with similarly treated rabbits. Enigk and Friedhoff (1962a) reported the susceptibility to *B. divergens* of moufflon, fallow deer, red deer and roe deer, while goats and sheep were not susceptible. The same authors (1962b) reported that *B. capreoli* was not transmissible to cattle, sheep and goats with their spleen removed. We feel that the study of Latif and Adam (1973) is both most interesting and important: by allowing *B. divergens* infected ticks to feed on sheep, they brought about a normal babesiosis disease in the lambs. Infection of man with species from wild game animals (roe-deer, red-deer) cannot be excluded (Šebek et al. 1975).

b) Due to *Babesia microti*. The following two cases are particularly interesting. They were reported from Massachusetts, USA; the first in 1969 (Benson et al. 1969, Western et al. 1970), and the second in 1973 (Anderson et al. 1974). Both concerned women (of 59 and 48 years respectively) who had not undergone splenectomies, i.e. had their spleen in situ. They were admitted to hospital with fever, the first case with suspected malaria, the second with Rocky Mountain spotted fever. Both had a history of tick bite and by laboratory tests babesias were isolated and as *B. microti* identified.

An asymptomatic human infection with *Babesia* sp. in a 51-year-old man with the spleen in situ was diagnosed by Healy et al. (1976) in Georgia in the USA. In this case, in our opinion, *B. microti* was the most probable species.

Benenson (1975) mistakenly reported that 5 cases of human babesiosis were known, 3 of which originated in the USA and that all were caused by *B. microti*. In a personal communication Dr. G. R. Healy*) from the Center of Disease Control, Atlanta, Georgia, USA, informed one of us (Sixl) that 21 human cases had been recorded in the USA to February 1977. All patients had the spleen in situ and the disease had a mild clinical course. This information is of great importance for Europe where babesiosis of rodents is widespread. Indeed, the human infections with *B. microti* are most probably also present there as Šebek et al. (1973, 1975) have already pointed out.

DISCUSSION AND CONCLUSIONS

From the above mentioned *Babesia* infections in man and the problems of babesiosis in animals discussed the following theoretical and practical considerations may be concluded:

a) Man may be infected with various species of *Babesia*. Apparently only splenectomized people are in danger of infection with the *Babesia* species from domestic animals. The clinical course of human infection with babesiosis acquired from domestic animals in splenectomized persons is grave, with a high mortality rate.

b) The existence of natural foci of *B. microti* should be anticipated everywhere in Europe where ticks — particularly *Ixodes ricinus* — and small mammals are abundant, especially in leaf and mixed forests up to 600–1000 m above sea level. *B. microti* depends practically on the same biotopes as the European tick-borne encephalitis. It displays no distinct host specificity and therefore healthy man with his spleen in situ may become infected. Since babesiosis in man caused by *B. microti* has so far not been detected in Europe, it might not be taken into consideration by physicians and therefore easily be incorrectly diagnosed. The clinical course of babesiosis in man caused by *B. microti* is mild and may be even asymptomatic. The people especially at risk from babesiosis caused by *B. microti* are those who often come into contact with ticks due to their profession such as cutters, foresters and hunters, or due to other activities (pickers of mushrooms, berries). Babesiosis caused by *B. microti* will only occur during the period in which ticks are active, namely in the warmer seasons.

In our opinion, human infection with *B. microti* is indeed occurring in Europe and perhaps is not even rare. It is only a question of time before its existence will be con-

*) We would like to thank Dr. G. R. Healy for this important information

firmed. All general practitioners, people concerned with infectious diseases and epidemiologists should be kept informed of the possible occurrence of this new disease. The correct diagnosis depends on the joint cooperation between physicians and experienced protozoologists. We consider the preparation of a careful surveillance in Europe as being not only useful but also extremely necessary.

РАСПРОСТРАНЕНИЕ БАБЕЗИОЗА МЕЛКИХ МЛЕКОПИТАЮЩИХ И ЗНАЧЕНИЕ ЭТОГО ЗООНОЗА В ЕВРОПЕ

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Резюме. Дан краткий обзор распространения бабезиоза мелких земных млекопитающих в некоторых частях Европы. Исследовано 7 038 мелких земных млекопитающих (42 вида) из Чехословакии, Австрии, Венгрии, Югославии и Болгарии и полученные результаты показывают распространение *Babesia microti* в этих странах. Бабезиоз обнаружен авторами у следующих видов хозяев: *Neomys anomalus*, *Clethrionomys glareolus*, *Microtus arvalis*, *M. agrestis*, *Apodemus agrarius*, *A. flavicollis*, *A. sylvaticus* и *Mus musculus*. Среднее поражение у них оказалось очень низким—0,2 % и колебалось в отдельных странах от нуля до 0,7 %. В работе обсуждены природные очаги *B. microti* в Средней Европе и кратко изложены до сих пор зарегистрированные случаи заболеваний бабезиозом людей. Подчеркнуто эпидемиологическое значение млекопитающих—неспецифических хозяев *B. microti* и указана необходимость надзора за этим зоонозом в Европе.

REFERENCES

- ANDERSON A. E., CASSADAY P. B., HEALY G. R., Babesiosis in man. Sixth documented case. Amer. J. Clin. Path. 62: 612—618, 1974.
- BALDELLI B., Un caso di piroplasmosi della lepre (*Lepus europaeus*) de *Babesia leporina* n. sp. Parassitologia 2: 15—20, 1960.
- BAKER J. R., CHITTY D., PHIPPS E., Blood parasites of wild voles, *Microtus agrestis*, in England. Parasitology 53: 297—301, 1963.
- BECKER E. R., ROUDABUSH R. L., *Trypanosoma iowensis* n.sp. and *Babesia citelli* n. sp. from *Citellus tridecemlineatus*, and *Trypanosoma hirsioni* n. sp. from *Citellus franklini*. Iowa State Coll. J. Sci. 8: 527—531, 1933.
- BENENSON A. S., Control of communicable diseases in man. Twelfth Ed., The Amer. Publ. Health Ass., Washington. Interdisciplinary Books, Pamphlets & Periodicals For the Professional & the Layman, 196, 1975.
- BENSON G. D., GALDI V. A., ALTMAN R., FIUMARA N. J., Human babesiosis — Massachusetts. Morb. Mortal. Weekly Rep. (Atlanta/Ga) 18: 277—278, 1969.
- CAPPONI M., SUREAU P., DESCHIENS R., Presentation d'un hématozoaire observé dans le sang de *Mus norvegicus* au centre Vietnam. Bull. Soc. Path. Exot. 48: 649—651, 1955.
- CARINI A., Piroplasmideo do sangue de um roedor do Brasil. Arq. Biol. 25: 71—72, 1941.
- COX F. E. G., Parasitic protozoa of British wild mammals. Mamm. Rev. 1: 1—28, 1970.
- CURASSON G., Traité de protozoologie vétérinaire et comparée. Vol. 3, Paris, 1943.
- DÖFLEIN F., REICHENOW F., Lehrbuch der Protozoenkunde. II. 2: Sporozoa und Ciliophora. 6: Aufl., Jena, 1953.
- ENICK K., FRIEDHOFF K., Zur Wirtsspezifität von *Babesia divergens* (Piroplasmiden). Z. Parasitenkunde 21: 238—256, 1962a.
- , —, *Babesia capreoli* n. sp. beim Reh (*Capreolus capreolus* L.). Z. Tropenmed. Parasit. 13: 8—20, 1962b.
- FAY H. F., RAUSCH R. L., Parasitic organisms in the blood of arvicoline rodents in Alaska. J. Parasitol. 55: 1258—1265, 1969.
- FELDMAN-MUHSAM B., On *Nuttallia adleri* of *Meriones tristrami*. XI. Internat. Congr. Ent. Wien 1960, Bd. 3, 91—94, 1962.
- FITZPATRICK J. E. P., KENNEDY C. C., McGEOWN M. G., OREOPOULOS D. G., ROBERTSON J. H., SOYANNWO M. A. O., Human case of piroplasmosis (babesiosis). Nature 217, 861—862, 1968.
- , —, —, —, —, Further details of third recorded case of redwater (babesiosis) in man. Brit. Med. J. 4: 770—772, 1969.
- FRANCA C., Sur la classification des piroplas-

- mes et description de deux formes de ces parasites. Arq. Inst. Bact. Camara Postana 3: 11—18, 1912.
- GALLI-VALERIO R., Sur un *Piroplasma* d'*Erinaceus algirus*. Zbl. Bakt. I. Orig. 58: 565—567, 1911.
- , *Smithia talpae* n. sp. (Piroplasmidae) chez *Talpa europaea* L. Zbl. Bakt. I. Orig. 73: 142—143, 1914.
- GARNHAM P. C. C., A new piroplasm from the rock hyrax. Parasitology 37: 528—532, 1951.
- , BRAY R. S., The susceptibility of the higher primates to piroplasms. J. Protozool. 6: 352—355, 1959.
- , DONNELLY J., HOOGSTRAAL H., KENNEDY C. C., WALTON G. A., Human babesiosis in Ireland: Further observations and the medical significance of this infection. Brit. Med. J. 4: 768—770, 1969.
- HEALY G. R., WALZER P. D., SULZER A. J., A case of asymptomatic babesiosis in Georgia. Amer. J. Trop. Med. Hyg. 25: 376—378, 1976.
- HOARE C. A., On a new piroplasm from an African shrew. Trans. Roy. Soc. Trop. Med. Hyg. 24: 245—250, 1930.
- HUTYRA F., MAREK J., MANNINGER R., MOCSY J., Spezielle Pathologie und Therapie der Haustiere. 11: Aufl., Vol. 1, Jena, 1959.
- KIRNER S. H., BARBEHENN K. R., TRAVIS B. V., A summer survey of the parasites of two *Microtus pennsylvanicus pennsylvanicus* (Ord) populations. J. Parasitol. 44: 103—105, 1958.
- KRYLOV M. V., Katalog Piroplasmida mirovoy fauny. (A catalogue of Piroplasmida of world fauna). Izd. Nauka Leningrad 1974. (In Russian).
- , ZANINA Z. L., *Smithia tadzhikistanica* n. sp. from the gerbil *Meriones erythrorus* Gray, 1842. Tr. inst. zool. i parazitol. AN TadzhSSR 24: 169—170, 1963. (In Russian).
- LATIF B. M. A., ADAM K. M. G., Antibody to *Babesia* in Scottish red deer (*Cervus elaphus*). Nature 241: 476—477, 1973.
- LEGER M., BÉDIER E., Piroplasmie d'un muridé, *Golunda campaneae*, du Senegal. Compt. Rend. Soc. Biol. (Paris) 88: 424—425, 1923.
- MAHNERT V., *Grahamella* und Sporozoa als Blutparasiten alpiner Kleinsäuger. Acta Trop. 29: 88—100, 1972.
- MANWELL R. D., KUNTZ R. E., A new *Babesia* from Indian bandicoot. J. Parasitol. 50: 390—393, 1964.
- MURATOV E. A., A blood parasite of the genus *Nuttallia* Franca from the house mouse (*Mus musculus* Lin.). Dokl. Tadzh.SSR 9: 34—47, 1966. (In Russian).
- NEITZ W. O., The occurrence of *Nuttallia cynictis* sp. nov. in the yellow mongoose *Cynictis penicillata* in South Africa. Onderstepoort J. Vet. Sci. Anim. Ind. 10: 37—40, 1938.
- , Classification, transmission, and biology of piroplasms of domestic animals. Ann. N. Y. Acad. Sci. 64: 56—111, 1956.
- RIEK R. F., Babesiosis, infectious blood disease in man and animals. Ed. D. Weinman, M. Ristic. New York Acad. Press, 220—268, 1968.
- RODHAIN J., Sur la pluralité des espèces de *Babesia* des rongeurs. À propos de la spécificité de *Babesia rodhaini* Van den Berghe. Ann. Inst. Past. 79: 777—785, 1950.
- SCHOLTENS R. G., BRAFF E. H., HEALY G. R., GLEASON N., A case of babesiosis in man in the United States. Amer. J. Trop. Med. Hyg. 17: 810—813, 1968.
- SCOTT-MACFIE J. W., Babesiosis and trypanosomiasis at Accra, Gold Coast, West Africa. Ann. Trop. Med. Paras. 9: 457—494, 1915.
- ŠEBEK Z., Krevní a tkáňové parazitičtí prvoci drobných savců Českomoravské vysočiny. Vlastivěd. sbor. Vysoč. (Jihlava), odd. věd. přír. 6: 111—116, 1970.
- , Blutparasiten der wildlebenden Kleinsäuger in der Tschechoslowakei. Folia parasit. (Praha) 22: 11—20, 1975.
- , ROSICKÝ B., VÁVRA, J. Někteří málo známá protozoární onemocnění člověka a možnost jejich výskytu v ČSSR. Čs. Epidem. Mikrob. Imunol. (Praha) 22: 186—193, 1973.
- , SIXL W., ROSICKÝ B., Ein Beitrag zur Charakteristik der Naturherde der Piroplasmose und zur Kenntnis der Wirtstiere mit Daten zur Rinderpiroplasmose in der Steiermark und Kleinsäugeruntersuchungen in der ČSSR (Sporozoa, Haemosporina). Mitt. Abt. Zool. Landesmuseum Joanneum (Graz) 4: 67—80, (355—368), 1975.
- SHORTT H. E., BLACKIE E. J., An account of the genus *Babesia* as found in certain small mammals in Britain. J. Trop. Med. Hyg. 68: 37—42, 1965.
- ŠKRABALO Z., Babesiosis. Pathology of protozoal and helminthic diseases. Ed. RA Marcial-Rojas. Williams and Wilkins, Baltimore, 232—233, 1971.
- , DEANOVIĆ Ž., Piroplasmosis in man. Report on a case. Docum. Med. geogr. Trop. (Amsterdam) 9: 11—16, 1957.
- TOMLINSON T. H. Jr., SMITH C. S., FOGG V. H., A piroplasm, *Babesia wrighti*, n. sp., from the rock squirrel (*Citellus variegatus buckleyi*). J. Nat. Malaria Soc. 7: 254—258, 1948.
- TSUR I., HADANI A., PIPANO E., *Nuttallia dani* n. sp. — a haemoprotozoon from the gorbil (*Meriones tristrami shawii*). Refuah Veterinarith (Israel) 17: 244—236, 1960.
- TYZZER E. E., *Cytoecetes microti*, n. g., n. sp., a parasite developing in granulocytes and

- infective for small rodents. *Parasitology* 30: 242 - 257, 1938.
- VAN PEENEN P. F. D., Piroplasmosis in rats from Indonesia. *Bull. Soc. Pathol. Exot.* 68: 303—306, 1975.
- , DUNCAN J. F., Piroplasms (Protozoa: Sarcodina) of wild mammals in California. *Bull. Wildlife Dis. Assoc.* 4: 3—8, 1968.
- WENYON C. M., Protozoology. Bellicre, Tindall and Cox, London, 1926.
- WESTERN K. A., BENSON G. D., GLEASON N. N., HEALY G. R., SCHULTZ M. G., Babesiosis in a Massachusetts resident. *New Engl. J. Med.* 283: 854 - 856, 1970.
- ZASUKHIN D. N., A contribution to the studies on blood parasites of rodents in the South-East RSFSR. II. Blood parasites of *Citellus pygmaeus*. *Vestn. Mikrob. Epid. Parazitol. (Moskva)* 9: 555—571, 1930. (In Russian).
- , Hemosporidiasis of wild animals and their importance in animal husbandry. *Trudy Inst. Zool. AN KazakhSSR* 5: 169—179, 1956. (In Russian).

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