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Zoonotic Reservoir of *Babesia microti* in Poland

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Abstract

Babesiosis is as one of the emerging human and animal diseases transmitted by ticks. It is caused intraerythrocytic parasites of the genus *Babesia*. Current evidence of human babesiosis suggests that the majority of cases are involved by *Babesia divergens* and *Babesia microti* piroplasms. As zoonotic reservoir of *B. microti* serve small mammals – insectivores and rodents. The occurrence of this parasite in natural environment in Poland is documented for various regions, in the wide range of mammal hosts. The most important role as *Babesia microti* reservoir play *Microtus* voles. The prevalence of infection in *Microtus arvalis* studied in Mazurian Lakeland is 9–33%; in *Microtus agrestis* in Katowice agglomeration reach almost 50%, *Microtus oeconomus* in Białowieża 7.7–50%. The lesser role as zoonotic reservoir play *Clethrionomys* voles, *Apodemus* mice and shrews; the prevalence of infections in these mammals don't exceed 2 %. The vectors for *B. microti* piroplasms in middle-European conditions are *Ixodes ricinus*, *I. trianguliceps* and *Dermacentor reticulatus*. There were recorded the infections of *Ixodes ricinus* ticks with *B. microti* in Szczecin and Tri-City, the rate was 6.2–13.3%. The variation in *B. microti* prevalence in rodents and ticks is very changeable and determined by season, the interaction with other hemoparasites, host's age and local conditions.

Key words: babesiosis, *Babesia* spp. reservoires in Poland

Piroplasmosis is the dangerous tick-borne disease of human and animals, caused by protozoans of the *Babesia* genus. Human babesiosis has been ascribed to cause animal babesias, but current evidence suggests that the majority of cases are caused by *Babesia divergens* and *Babesia microti*. Including the first case described by Skrabalo and Deanovic in 1957 in Former Yugoslavia, over 20 cases of human babesiosis have been reported in Europe. *B. divergens*, cattle pathogen, was involved in a majority of human babesiosis in Europe, the cases caused by *Babesia microti* are seldom (Homer *et al.*, 2000; Skotarczak and Cichocka, 2001a). Only recently, the case of imported babesiosis was reported in Poland (Humiczewska and Kuźna-Grygiel, 1997). Splenectomy is the main factor of risk which was found in 86% of the patients (Brasseur and Gorenflot, 1996).

As zoonotic reservoir of *Babesia microti* serves small mammals; there is documented ability of 16 European species of insectivores and rodents to be host of this piroplasm (Cox, 1970; Šebek, 1975; Šebek *et al.*, 1977; Šebek *et al.*, 1980; Siński, 1999). The occurrence of some *Babesia* in natural environment in Poland is documented from various regions in the wide range of mammal hosts. *Babesia microti* was found in rodents in Białowieża National Park, Katowice agglomeration and Mazurian Lakeland (Bajer *et al.*, 1998; Karbowiak *et al.*, 1999). Infections of ticks with *Babesia microti*, in many cases mixed with *B. divergens* and *Borrelia burgdorferi* spirochetes, are recognised in Szczecin (Skotarczak and Cichocka, 2001a) and Tri-City (Stańczak *et al.*, 2004).

Voles from the genus *Microtus* are still considered to be the main reservoir of *Babesia microti* in natural environment in Europe. The analysis of data collected from various research centres shows that the prevalence rate of infection in *Microtus* voles is much higher than in other rodents (Table I). Similar zoonotic situation is observed in Poland. The prevalence of infection are the highest in *Microtus* voles: in common vole *Microtus arvalis* studied in Mazurian Lakeland the prevalence is 9–33%; in field vole *Microtus agrestis* in Katowice agglomeration reach almost 50%, in root vole *Microtus oeconomus* in Białowieża 7.7–50%. The lesser role as zoonotic reservoir play *Clethrionomys* voles, *Apodemus* mice and shrews; the prevalence of infections in these mammals don't exceed 2% (Table II).

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Table I
The hosts recorded and prevalence (in %) of *Babesia microti* infections in Europe (apart Poland)

Host's species	Prevalence	Localisation	Authors
Microtus arvalis	8.3[a]	Austria, Steiermark	Šebek *et al.* (1980)
	0.7	Czech, s. Moravia	Šebek (1975)
	0.6	Czech	Šebek *et al.* (1977)
Microtus agrestis	25.5	southern England	Baker *et al.* 1963
	4.1–22.2	England	Healing (1981)
	25.2	England	Cox (1970)
	38.0	Germany, Bavaria	Kramptiz and Bäumler (1978)
	30.5	Austria, Steiermark	Šebek *et al.* (1980)
	6.5	Austria, North Tyrol	Mahnert (1972)
	0.5	Czech, s. Bohemia	Šebek (1975)
	0.5	Czech	Šebek *et al.* (1977)
Microtus nivalis	2.3	Austria, North Tyrol	Mahnert (1972)
Microtus socialis	50.0	Ukraine, Askania Nova	Karbowiak *et al.* (2002)
Clethrionomys glareolus	9.6–13.0	England	Healing (1981)
	21.3	England, Sussex	Turner (1986)
	16.3	England	Cox (1970)
	1.8	Austria, Steiermark	Šebek *et al.* (1980)
	1.0	Austria, North Tyrol	Mahnert (1972)
	0.4	Czech, s. Moravia	Šebek (1975)
	0.3	Czech	Šebek *et al.* (1977)
Pitymys subterraneus	11.1[a]	Austria, Steiermark	Šebek *et al.* (1980)
	18.1[a]	Austria, North Tyrol	Mahnert (1972)
Apodemus flavicollis	1.6	Austria, Steiermark	Šebek *et al.* (1980)
	0.1	Bosnia-Herzegovina	Šebek *et al.* (1977)
Apodemus sylvaticus	2.1–10.0	England	Healing (1981)
	8.8	England, Sussex	Turner (1986)
	1.6	England	Cox (1970)
	0.1	Bulgaria	Šebek *et al.* (1977)
Apodemus agrarius	1.1	Bosnia-Herzegovina	Šebek *et al.* (1977)
	0.8	Eastern Slovakia	Karbowiak et al. (2003)
Mus musculus	0.2	Macedonia	Šebek *et al.* (1977)
Sorex araneus	6.8	England	Cox (1970)
	1.9	Austria, North Tyrol	Mahnert (1972)
Sorex minutus	5.4	England	Cox (1970)
Neomys anomalus	1.3[a]	Macedonia	Šebek *et al.* (1977)

[a] statistically insignificant

The morphological features of *B. microti* strain found in Poland is identical to described by other authors. The parasites were mostly of the ring-like and pear-shaped form (Fig. 1.) and were 1.5−3.0 µm in diameter. Dividing stages were 2.5−3.5 mm in diameter. The mean intensity of the erythrocyte infection was 2.5%. Usually one parasite was seen in infected erythrocyte. The regular form of four cells – "maltese cross", characteristic for "small" *Babesia* species, was noticed very seldom.

The infection of *Microtus* voles with *Babesia microti* resulted in a dramatically enlarged spleen (Fig. 2). This phenomenon hasn't been observed with other common hemoparasite infections, as *Trypanosoma* or *Hepatozoon*. However, apart splenomegaly symptoms, natural *Babesia* infections haven't any visible signs, so it is evident that piroplasms cause chronic avirulent infections in its natural hosts (Baker *et al.*, 1963; Krampitz and Bäumler, 1978; Turner, 1986).

Table II
The hosts recorded and prevalence (in %) of *Babesia microti* infections in small mammals in Poland

Rodent species	Prevalence	Localisation	Authors
Microtus arvalis	13.8	Mazurian District[a]	Siński (1999)
	9.0	Mazurian District[a]	Bajer *et al.* (2001); Pawełczyk *et al.* (2004)
Microtus arvalis	33.3	Mazurian District[b]	Karbowiak (unpublished)
Microtus agrestis	50	Katowice	Karbowiak *et al.* (1999)
Microtus eoconomus	17.6	Białowieża	Karbowiak *et al.* (1999)
	7.7	Białowieża	Karbowiak *et al.* (2002)
	50[c]	Białowieża	Karbowiak (unpublished)
Microtus sp.	14.3	Mazurian District[a]	Bajer *et al.* (1998)
Clethrionomys glareolus	?	Mazurian District[b]	Karbowiak and Siński (1996)
	0.6	Mazurian District[a]	Siński (1999)
	1.0	Mazurian District[a]	Bajer *et al.* (2001)
Apodemus flavicollis	2.1	Mazurian District[a]	Bajer *et al.* (1998)
Apodemus sp.	0.7	Mazurian District[a]	Siński (1999)
Sorex minutus	20[c]	Białowieża	Karbowiak (unpublished)

Abbreviations: [a] Urwitałt near Mikołajki; [b] Kosewo Górne near Mrągowo; [c] statistically insignificant

The variation in *Babesia microti* prevalence in rodents and ticks is very changeable and determined by season, the interaction with other hemoparasites, host's age, sex and local conditions (Healing, 1981; Turner 1986, Pawelczyk *et al.*, 2004). The seasonal pattern of *B. microti* incidence correlates with seasonal changes in the abundance of the tick vector; the seasonal variation shows a characteristic rise in the early summer time and a minimum in January (Krampitz and Bäumler, 1978; Turner 1986). The differences of prevalence between some closely located hosts population were noted in *Microtus oeconomus* living in open habitats in Białowieża Primeval Forest (Karbowiak, unpublished). The differentiation of infections rate in some tick species are also showed by Skotarczak (Skotarczak and Cichocka 2001ab). However, several studies of

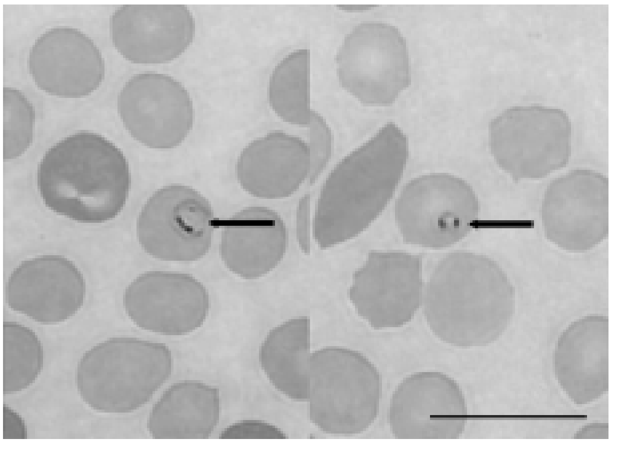

Fig. 1. Ring forms of *Babesia microti* in blood of naturally infected root-vole *Microtus oeconomus* in Białowieża. Scale bar 10 µm

Fig. 2. Splenomegaly induced by natural *Babesia microti* infection in root-vole *Microtus oeconomus*

rodent blood parasites have used a longitudinal survey format conducted in natural environment, and this requires further investigations.

The vectors for *Babesia* piroplasms in middle-European conditions are *Ixodes ricinus* and *I. trianguliceps*, as well as *Dermacentor reticulatus* (Randolph, 1995). In the case of *Babesia microti* the most important species is *Ixodes ricinus* – this is common in whole area of Poland, whereas *Dermacentor reticulatus* Eastern part only. *Ixodes trianguliceps* occurs in Eastern Europe seldom due to it has small significance. The role of *D. reticulatus* is not clear; there is demonstrated the ability of transfer *Babesia canis* piroplasms, but is nothing known about other babesias. Moreover, only *Ixodes ricinus* regularly attacks human, in every active developmental stages; for other tick species human isn't attractive host (Siuda, 1993; Homer *et al.*, 2000). Many authors accent the ability of *Rhipicephalus* in spreading of piroplasms, however this genus as not permanent component of polish fauna is able to play marginal role only (Siuda, 1993). Nevertheless, young stages of all these species are able to maintain the transmission cycle in population of rodents and the presence of zoonotic foci in environment.

The presence of two species of *Babesia* piroplasms in ticks *Ixodes ricinus* in Poland is documented using PCR method in Szczecin area and in the forests near the Tri-City agglomeration. There were found *B. microti* (infection rate 6.2−13.3%) and *B. divergens* (3.0%) in Szczecin (Skotarczak and Cichocka, 2001ab, Skotarczak *et al.*, 2003), and *B. microti* in Tri-City (infection rate of in ticks 2.3%) (Stańczak *et al.*, 2003). These demonstrations confirm recent findings that *I. ricinus* can be also involved in circulation of *B. microti* in Europe; tick infection rates with babesiae have been calculated at 7.4% in Slovenia (Duh *et al.*, 2001) and 3.5% in Hungary (Kálmán *et al.*, 2003). The most common infections were found in adult females – till 14.6%, other developmental forms were lighter infected – 11.1% of nymphs were infected (Skotarczak *et al.*, 2002). The percentage of infection is changeable, depending on the season (Skotarczak and Cichocka, 2001ab, Skotarczak *et al.*, 2002; 2003).

There are many potential reasons of differences in the epidemiology of human babesiosis between Europe and Northern America. Apart from the various virulence between European and American *Babesia microti* strains, there are some differences in the zoonotic foci structure. In Northern America the most competent reservoirs are white-footed mouse *Peromyscus leucopus* and meadow vole *Microtus pennsylvanicus*. Other reservoirs and vectors, as prairie vole *Microtus ochrogaster* (Burkot *et al.*, 2000) have local importance. *Peromyscus* is the most important reservoir host, with *Microtus pennsylvanicus* being a minor reservoir. Field surveys estimate that up to 40–60% of these mice are infected (Homer *et al.*, 2000; Burkot *et al.*, 2000). Both rodent species have large geographic range and are found in a progressively greater variety of habitats. The habitat of *Peromyscus leucopus* is chiefly wooded areas, they are most abundant in bottom lands, less so in post oak uplands and almost completely absent from prairie lands – but these open grassland are inhabited by *Microtus pennsylvanicus* (Hall and Kelson, 1959). The main competent vectors for transmitting *B. microti* are ticks *Dermacentor variabilis*, *Ixodes scapularis*, and *Ixodes dammini*. These species are widespread in the Eastern and Central United States as well as Western States, in various habitats (Kjemtrup and Conrad, 2000). Young stages fees on the rodents; however, man and many wild and domestic animals are also attacked (Furman and Loomis, 1984). Such structure maintains the easy ways to transmission of *B. microti* infections from animal reservoir to human.

In the European conditions the most competent reservoir are *Microtus* voles. These are the animals of the open country. Their preferred habitats are moist fields and meadows, forests edges and cropfield, rather than regular forests (Kowalski *et al.*, 1981). Such places are inhabited by *Dermacentor reticulatus* ticks, not *Ixodes ricinus*. *Ixodes ricinus* chooses bush and woodland, preferably old deciduous forests, well sheltered and moist. It avoids open places (Siuda, 1993). The field observations confirm that voles living in open areas are more often infested with young adult stages of *Dermacentor reticulatus* than with *Ixodes ricinus*, in comparison with these same species living in woodland (Karbowiak, unpublished). Moreover, young and adult *Dermacentor reticulatus* practically don't attack human and their significance as vector is slight. In such zoonotic foci structure there are few possibilities to transmit the *Babesia* piroplasms from rodent reservoir to human.

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