

Microparasites of three species of shrews from Finnish Lapland

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Forty-five common shrews, *Sorex araneus*, caught in 1997; and 48 *S. araneus*, 21 masked shrews, *Sorex caecutiens*, and 25 pygmy shrews *Sorex minutus* trapped in 1998 at Kilpisjärvi in northern Finland were examined for microparasites. *Bartonella* sp. was found in blood smears of *S. araneus* both in 1997 (prevalence 15%) and 1998 (10%) but no blood parasites were found in *S. caecutiens* or *S. minutus*. This is the first report of blood parasites of shrews from Finland. A fungal parasite, *Pneumocystis carinii*, was also observed in *S. araneus* both in 1997 (prevalence 31%) and in 1998 (58%). In contrast to previous reports, 20% of *S. minutus* had cyst forms of *P. carinii* in the lungs but none of the *S. caecutiens* were infected. Results of this study and related studies from elsewhere indicate that the blood parasite communities of *Sorex* shrews are less diverse than those found in small rodents. In this study the prevalence of *Bartonella* was highest in the most abundant host species in the shrew community.

1. Introduction

Shrews of the genus *Sorex* are widely distributed and abundant in many parts of the northern hemisphere including Finland, where five species occur. Although many aspects of the biology of these species have been investigated (Hanski & Pankakoski 1989), the overall parasite diversity of *Sorex* shrews in Finland remains poorly known. Occurrence of ectoparasites in shrews have been studied as part of ectoparasite surveys of small mammals (Ulmanen 1972) but only helminths (Erkinaro & Heikura 1977, Haukisalminen 1989, Haukisalminen & Henttonen 1998) and one microparasite spe-

cies (*Pneumocystis carinii*, Laakkonen 1995) of shrews have been studied in detail. As part of a larger study aiming to delineate which biological characteristics of soricid hosts contribute to the occurrence and diversity of parasites in species of *Sorex*, I examined three sympatric shrew species for parasite forms in the blood and tissues of major internal organs. Previous studies (Haukisalminen 1989, Laakkonen 1995) showed that the diversity and abundance of parasites in *Sorex araneus* are higher compared to *Sorex caecutiens* and *Sorex minutus*, suggesting that host body size and/or abundance are the key characters determining the occurrence of the parasites in these hosts.

2. Materials and methods

The material was collected at Kilpisjärvi (69°03'N, 20°49'E) in the subarctic birch forest zone in northern Finland in September 1997, and from June to September in 1998. All shrews examined for this study were found dead in traps (Ugglan special live-traps or large pitfalls) used for monitoring lemming and other rodent densities. Shrews caught in 1997 (*Sorex araneus*, $N = 45$) were dissected immediately after each trapping session. The shrews caught in 1998 (*Sorex araneus*, $N = 48$; *Sorex caecutiens*, $N = 21$; *Sorex minutus*, $N = 25$) were stored at $-20\text{ }^{\circ}\text{C}$ until examination in September 1998.

The shrews were classified as mature (usually over-wintered) and immature (born during the summer of the study) according to the tooth wear and condition of the pelage (Crawcroft 1957). In 1997, all but three female *S. araneus* were immature. Of these, two were over-wintered and one had matured during the summer it was born. All the shrews examined in 1998 were immature.

On necropsy, all major organs were examined macroscopically for parasites and anomalies. A drop of blood was obtained directly from the heart for preparation of thin blood smear (*see* Laakkonen *et al.* 1998). To get an estimate of the intensity (number of individuals of a particular parasite species in each infected host) of the blood parasite infections, 10 000 erythrocytes from each blood smear were examined (Godfrey *et al.* 1987). The number of blood samples analyzed (Table 1) was smaller than the total sample size because in some cases the amount of blood in the heart was too small to produce a proper blood smear. Pieces

of heart, lung, liver, spleen, kidney and brain were fixed in 10% buffered formalin to produce standard histological sections which were stained with hematoxylin-eosin (H&E), Grocott's modification of Gomori's methenamine silver (GMS) and Giemsa stains. Most fungi can be seen with GMS stain, and Giemsa's stain is useful for the demonstration of most protozoans. No samples of the gastrointestinal tract were obtained due to the often fast deterioration of helminths, particularly cestodes, after death of the shrews. Chi-square tests, or Fisher's exact test if the sample size was small, were used to analyze the interspecific differences in parasite occurrence, and differences between age and sex groups. Statistix® 4.0 statistical software package was used in all analyses.

3. Results

All shrews appeared to be healthy and in good condition. In both 1997 and 1998, rod-shaped *Bartonella* sp. were found in erythrocytes of *S. araneus* (Table 1). In 1997, in all five infected individuals less than 1% of the erythrocytes contained *Bartonella* organisms. The number of *Bartonella* organisms per cell was over 20 but in many cases it was impossible to distinguish individual rods. In 1998, in one infected *S. araneus* less than 1% of the erythrocytes contained *Bartonella* organisms. In the other two infected shrews captured in 1998, *Bartonella* organisms were observed in three percent of erythrocytes. The number of organisms per cell was similar to those found in 1997. The prevalence of *Bartonella* in *S. araneus* did not differ significantly between years (Table 1).

Table 1. *Bartonella* sp. in *Sorex araneus* from Kilpisjärvi in 1997 and 1998.

	Number infected	Number examined	Prevalence (%)	<i>P</i> (male:female)
1997				
Males	4	19	21	
Females	1	15	7	0.35
Total	5	34	15	
1998				
Males	2	18	11	
Females	1	13	8	1.00
Total	3	31	10	

1997:1998, $P = 0.71$

Blood parasites were not found in any of the 21 *S. caecutiens* or 22 *S. minutus* examined. In comparison with occurrence of *Bartonella* in *S. araneus*, the absence of *Bartonella* in the other shrew species was not statistically significant ($P = 0.26$ in both cases).

In both 1997 and 1998, cyst forms of *Pneumocystis carinii* were observed in the lungs of *S. araneus* (Table 2). The prevalence was significantly higher ($P = 0.008$) in 1998 than in 1997. No significant difference in prevalence between males or females was observed during either of the study years (Table 2). Cyst forms of *P. carinii* were also detected in the lungs of *S. minutus* but not in any of the *S. caecutiens* (Table 2). *Pneumocystis carinii* was significantly more common in *S. araneus* than in *S. minutus* and in *S. caecutiens*.

4. Discussion

Parasites were found only in blood and a lung tissue of the shrews. The blood parasite diversity found in shrews at Kilpisjärvi was low. Blood parasites of shrews have not been reported from

Finland before but reports from elsewhere (Sebek 1978, Walter & Liebisch 1980, and *see* Laakkonen *et al.* 1998) indicate that the blood parasite diversity in shrews is relatively low as compared with the blood parasite diversity in small rodents (Young 1970, Wiger 1979, Turner 1986). This may be due to the less abundant ectoparasite fauna (mites and fleas acting as vectors of blood parasites) often found in shrews as compared with that found in sympatric rodents (Ulmanen 1972, Nilsson 1974a, Lundqvist & Brinck-Lindroth 1990, *see* however Nilsson 1974b and Randolph 1995). The diversity and number of these ectoparasites, however, is usually considerable both in shrews and in rodents (*see* above). Further studies examining both the ectoparasite and the blood parasite fauna of shrews are clearly warranted.

Bartonella spp. (former *Grahamella*) are transmitted by fleas, and are gram-negative bacteria that are known to cause various diseases in humans and animals (Maurin *et al.* 1997). These emerging pathogens are now the subject of an intensive study in humans and animals. They have been found in *S. araneus* in Norway (Hoyte 1954), in Austria (Mahnert 1972), in Czechoslovakia (Se-

Table 2. *Pneumocystis carinii* in *Sorex araneus* (in 1997/in 1998), and in *Sorex caecutiens* and *Sorex minutus* (in 1998) from Kilpisjärvi.

	Number infected/Number examined	Prevalence (%)	<i>P</i> (male:female)
<i>S. araneus</i>			
1997			
Males	6/26	23	
Females	8/19	42	0.30
Total	14/45	31	
1998			
Males	15/27	56	
Females	13/21	62	0.66
Total	28/48	58	
<i>S. caecutiens</i>			
Males	0/12		
Females	0/9		
Total	0/21	–	
<i>S. minutus</i>			
Males	3/15	20	
Females	2/10	20	1.00
Total	5/25	20	

S. araneus, 1997:1998, $P = 0.008$;

S. araneus:*S. caecutiens*, $P = 0.001$;

S. araneus:*S. minutus*, $P = 0.004$;

S. caecutiens:*S. minutus*, $P = 0.07$.

bek 1975) and in Romania (Suciu *et al.* 1984), and in other shrew species in North America (Laakkonen *et al.* 1998). *Bartonella* spp. are not host specific, and all known species are morphologically indistinguishable from each other (Birtles *et al.* 1994). Comparisons based on molecular techniques are needed to investigate whether one or several species (strains) of *Bartonella* exists in shrews. Although the difference in the occurrence of *Bartonella* in *S. araneus* and the other shrew species was not statistically significant, it is of interest that *Bartonella* occurred only in the most common shrew species in the Kilpisjärvi area. This is similar to the findings for rodents from the southeastern United States, where the highest prevalence of *Bartonella* infection has typically occurred among the most common species in the rodent community (Kosoy *et al.* 1997). In contrast, in a shrew community in the eastern United States, *Bartonella* was found not to be most prevalent in the numerically dominant shrew species, *S. cinereus*, (Laakkonen *et al.* 1998). The sample sizes of some shrew species in Laakkonen *et al.* (1998) and the present study were, however, too small to draw any definitive conclusion on the increasing prevalence of bacteremia with increasing abundance of a species in a shrew community. Several species in the genus *Bartonella* have been associated with (human) disease (*see* Kosoy *et al.* 1997). The public health relevance of *Bartonella* infections in shrews and other wild animals remains to be determined.

As in previous studies of shrews from Finland (Laakkonen *et al.* 1993, Laakkonen 1995), the prevalence of the fungal pulmonary pathogen *Pneumocystis carinii* in *S. araneus* was high. The reason for the significantly higher prevalence in 1998 than in 1997 is not known. Similar variation in prevalence of *P. carinii* in *S. araneus* between years and individual studies have been detected before and they appear not to be related to population density of the host (Laakkonen *et al.* 1993, Laakkonen 1998). In contrast to previous results (Laakkonen *et al.* 1993, Laakkonen 1995) however, *P. carinii* was not found in *S. caecutiens* but was relatively commonly found in *S. minutus*. *Pneumocystis carinii* has not been found in *S. minutus* from Finland before, and findings of *P. carinii* in *S. minutus* from other areas are also rare (*see* Laakkonen 1998). The reason for the spo-

radic occurrence of *P. carinii* in *S. caecutiens* and *S. minutus* compared to the high prevalence consistently found in *S. araneus* is not known.

In some parasites (Frank 1977) infestation occurs only occasionally in the non-specific host as a spill-over from the specific host. In the case of *P. carinii* in shrews this is not likely, since *P. carinii* found in *S. araneus* appears to be genetically discrete from isolates found in other host species (Bishop *et al.* 1997).

As for other lung parasites, none were found in any of the three shrew species. In a previous study (Laakkonen *et al.* 1999) a fungal parasite, *Chrysosporium* sp., was observed in the lungs of one of 333 *S. araneus* from central Finland, and nematodes have occasionally been found in the lungs of *S. araneus* (Soveri *et al.* 1990, J. Laakkonen unpubl.). Histopathological changes are also known to be common in the lungs of *S. araneus* (Soveri *et al.* 1990).

Except for the *Bartonella* found in this study, we have no information on the bacteria or viruses occurring in shrews in Finland.

Similar to the results of previous studies on the occurrence of helminths in shrews (Haukisalminen 1989, Laakkonen *et al.* 1993), both parasite species found in this study were more common in *S. araneus* than in the other shrew species. It is of interest that organisms of three different parasite groups (helminths, blood parasites and fungal lung parasites) with different life-cycles and ways of transmission appear to be more prevalent in *S. araneus* than in *S. caecutiens* and in *S. minutus*. The fact that *S. araneus* is both the most abundant and the largest in body size of the three *Sorex* species examined, makes it difficult to separate the effect of these two factors in determining the parasite diversity and abundance in these host species. Large body size could be a factor increasing the helminth parasite burden of *S. araneus* through increased food intake compared to the smaller *Sorex* species. Abundance and a large distribution area of the host, on the other hand, are likely to favor transmission and co-evolution (with the host) of most parasites.

Sorex isodon is a habitat specialist with smaller distribution area but larger body size than *S. araneus*. Examination of the parasite abundance and diversity of these two species in areas where they co-occur are warranted to further investigate the

effect of host abundance and body size in determining the parasite community of *Sorex* shrews.

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