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 (Erkinarro & Heikura 1977, Haukisalmi 1989, Haukisalmi & Henttonen 1998) and one microparasite species (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 (Haukisalmi 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 °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>
<thead>
<tr>
<th>Year</th>
<th>Number infected</th>
<th>Number examined</th>
<th>Prevalence (%)</th>
<th>P (male:female)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>Males</td>
<td>4</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>1</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5</td>
<td>34</td>
<td>15</td>
</tr>
<tr>
<td>1998</td>
<td>Males</td>
<td>2</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>1</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3</td>
<td>31</td>
<td>10</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Number infected/Number examined</th>
<th>Prevalence (%)</th>
<th>$P$ (male:female)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S. araneus</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997 Males</td>
<td>6/26</td>
<td>23</td>
</tr>
<tr>
<td>Females</td>
<td>8/19</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>14/45</td>
<td>31</td>
</tr>
<tr>
<td>1998 Males</td>
<td>15/27</td>
<td>56</td>
</tr>
<tr>
<td>Females</td>
<td>13/21</td>
<td>62</td>
</tr>
<tr>
<td>Total</td>
<td>28/48</td>
<td>58</td>
</tr>
<tr>
<td><strong>S. caecutiens</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>0/12</td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>0/9</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0/21</td>
<td></td>
</tr>
<tr>
<td><strong>S. minutus</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>3/15</td>
<td>20</td>
</tr>
<tr>
<td>Females</td>
<td>2/10</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>5/25</td>
<td>20</td>
</tr>
</tbody>
</table>

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, $P = 0.07$. 

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Table 2. Pneumocystis carinii in Sorex araneus (in 1997/in 1998), and in Sorex caecutiens and Sorex minutus (in 1998) from Kilpisjärvi.
Pneumocystis carinii was relatively commonly found in ever, (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 exist 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 sporadic 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 (Haukisalmi 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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**References**


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