Smouldering Epidemic of *Yersinia pseudotuberculosis* in Barn Rats

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*Yersinia pseudotuberculosis* was isolated from 8 (8 *Rattus norvegicus*) of 270 (259 *R. norvegicus* and 11 *R. rattus*) rats examined. Seasonal variation was not found in the incidence of isolations. The isolation occurred almost equally in both young and old rats. The isolated strains were determined as serovar IB in one rat, and serovar IVA in seven rats. The strains were isolated from the contents of the intestinal tract (the duodenum, jejunum, ileum, cecum, colon, and rectum), the spleen, liver and mesenteric lymph nodes; they were not detected in the kidneys. Agglutinin titer in the eight rats was no more than 32.

*Yersinia pseudotuberculosis* has been recognized as a causative agent in acute human mesenteric lymphadenitis, enteritis, erythema nodosum, and septicemia (8, 9). Small rodents and wild birds have been recognized as its natural reservoirs (7, 8). Transmitters of the organism from the reservoirs to humans have been considered to be the contaminated foods and pets which carry the organism from the reservoirs. Although there are some reports (1-3, 10) on its isolation from house rats, which are possible communicators of human food, the role of rats in the ecology of *Y. pseudotuberculosis* is still unknown, due to insufficient research. This paper deals with *pseudotuberculosis* occurring in barn rats.

**MATERIALS AND METHODS**

Specimens examined. From July 1976 to May 1977, 270 rats (259 *Rattus norvegicus* and 11 *R. rattus*) were trapped alive in one barn, one slaughter house, and one zoo in Sapporo, Japan. The contents of the duodenum, jejunum, ileum, cecum, colon and rectum, and the mesenteric lymph nodes, liver, spleen and kidneys were sampled from each individual anesthetized with ethyl ether within 10 min after cardiac puncture to isolate *Y. pseudotuberculosis*.

Procedures. Age analysis of the rats, direct and enrichment culture methods, and identification of isolated strains were as described in the previous report (4).

Serological grouping of *Y. pseudotuberculosis* strains. O grouping of the isolates was done by using slide agglutination with the rabbit O antisera against serovars I through VI of *Y. pseudotuberculosis* reference strains prepared by us by the method of Tsukuba et al. (11).

Determination of agglutinin titers. Sera were obtained by cardiac puncture and stocked at -30°C. Of these sera, the sera obtained from the rats which yielded *Y. pseudotuberculosis* were tested with living suspensions of the isolated strains in accordance with the method of Tsukuba et al. (11), using the microtiter system. The sera were incubated at 56°C for 30 min before the test.

**RESULTS**

Seasonal incidence. Table 1 shows the incidence of *Y. pseudotuberculosis*-positive rats from three locations. The organism was isolated from 8 of 270 rats examined. It was isolated from neither the slaughter house nor the zoo rats. There was no significant difference in the prevalence of the organism among the three locations. In the barn, the incidence of isolations in summer (July and August) was 3:38 (7.9%); in autumn (September, October, and November), it was 1:76 (1.3%); in winter (December, January, and February), it was 2:43 (4.7%); and in spring (March, April, and May) it was 2:9 (22.2%). The spring incidence was significantly greater than that in autumn (*P < 0.05*). The incidence in spring and summer, however, was not significantly greater than that in autumn and winter (*P > 0.05*).

Age distribution of *Y. pseudotuberculosis*-positive rats. Table 2 shows the *Y. pseudotuberculosis*-positive rats divided into three age groups. Serovar IB strains were isolated from one rat, and serovar IVA strains were isolated from seven rats. Isolation of the IVA organism occurred almost equally in the three age groups.

Sex distribution of *Y. pseudotuberculosis*-positive rats. Of 122 male and 148 female rats examined, the organism was isolated in 4 males and 4 females.

Distribution of the organism in rats. Ta
organism was of embryo 32 any show rectal contents the direct nodes. The lymph found 3 shows the ble organism was to refer to black rats (R. rattus). Data were obtained between July 1976 and May 1977.

Values indicate the positive isolation rate in each location.

*IB organism-positive rat.

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**TABLE 1. Incidence of Y. pseudotuberculosis-positive rats (R. norvegicus and R. rattus) from three locations**

<table>
<thead>
<tr>
<th>Location</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>%b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barn</td>
<td>2/12</td>
<td>1/26</td>
<td>0/38</td>
<td>0/3</td>
<td>2/31</td>
<td>0/9</td>
<td>0/1</td>
<td>1*5</td>
<td>1/3</td>
<td>4.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slaughter house</td>
<td>1/6</td>
<td>0/7</td>
<td>0/16</td>
<td>0/1</td>
<td>0/47</td>
<td>0/27</td>
<td>0/6*</td>
<td>0/7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zoo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Each value indicates number of positive house rats/number of house rats examined. Values in parentheses refer to black rats (R. rattus). Data were obtained between July 1976 and May 1977.

b Values indicate the positive isolation rate in each location.

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**TABLE 2. Age distribution of Y. pseudotuberculosis-positive rats in a barn**

<table>
<thead>
<tr>
<th>Age (months)</th>
<th>Serovar</th>
<th>No. of rats examined</th>
<th>%e</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IB</td>
<td>IVA</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>35</td>
<td>5.7</td>
</tr>
<tr>
<td>3 to 6</td>
<td>1</td>
<td>64</td>
<td>3.1</td>
</tr>
<tr>
<td>≥6</td>
<td>3</td>
<td>39</td>
<td>2.6</td>
</tr>
<tr>
<td>Unknown</td>
<td>3</td>
<td>28</td>
<td>10.7</td>
</tr>
</tbody>
</table>

* Positive rate.

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Table 3 shows the isolation of the organism from various regions in the eight positive cases. The organism was not isolated from the kidneys. It was found to be most prevalent in the mesenteric lymph nodes. The organism was detected in the rectal contents of four rats (no. 1, 3, 7 and 8) by the direct culture method. The eight rats did not show any obvious signs of disease.

Agglutinin titer in eight rats was not more than 32 (Table 3). The entire body of each embryo of the nine females from which the organism was not isolated was prepared for bacterial culture. The organism was not detected by either the direct or the enrichment culture method.

**DISCUSSION**

Human infections with Y. pseudotuberculosis and its isolation from animals occurred most frequently during the cold season (6, 9, 12). Although we observed that the spring incidence was significantly greater than that in autumn, we conclude that the isolation of the organism from barn rats occurred almost equally in all seasons, because the number of rats examined in spring was less than that in the other seasons, and because there was no significant difference in incidence between spring and summer and between autumn and winter.

We detected Y. pseudotuberculosis in the liver and spleen from the same materials as mentioned in the previous report (4) on Y. enterocolitica. We conclude that Y. pseudotuberculosis may be more pathogenic in rats than Y. enterocolitica, because the latter was not iso-

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**TABLE 3. Isolation of Y. pseudotuberculosis and agglutinin titer in eight positive cases**

<table>
<thead>
<tr>
<th>Rat no.</th>
<th>Duodenum</th>
<th>Jejunum</th>
<th>Ileum</th>
<th>Cecum</th>
<th>Colon</th>
<th>Rectum</th>
<th>MLN</th>
<th>Liver</th>
<th>Spleen</th>
<th>Kidneys</th>
<th>Serovars of the isolates</th>
<th>Agglutinin titer against the isolate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>IVA</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>IVA</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>IVA</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>IVA</td>
<td>16</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>IVA</td>
<td>16</td>
</tr>
<tr>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>IVA</td>
<td>32</td>
</tr>
<tr>
<td>7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>IVA</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>IB</td>
<td>16</td>
</tr>
</tbody>
</table>

* +, Organism detected; -, no organism detected; MLN, mesenteric lymph nodes.

* Values indicate number of rats yielding the organism in each region.
lated from the organs. In both the present and previous investigations, it was noted that neither of the species was detected in the kidneys.

The relationship between animal species and serovars of the organism is not yet fully known. In European countries, the strains isolated from humans and animals have belonged mainly to serovar I or serovar II (5, 6, 9). Timofeeva et al. (10) reported that 90 of 129 Y. pseudotuberculosis strains isolated from rats (R. norvegicus) belonged to serovar I. In Japan, it is said that the serovar III organism is prevalent in pigs (12, 13).

Juščenko (3) reported that, in rats (R. norvegicus), the carrier rate of Y. pseudotuberculosis was 0.3% at most. In the present study, the organism was only isolated in the barn rats, for which the carrier rate was 4.8%. The fact that the organism was detected in the rectal contents of four rats by the direct culture method suggests that the rats might have played a role as spreaders in the barn. The seven animals yielding the organism in the mesenteric lymph nodes, the liver, or the spleen might be only recently infected, because the high agglutinin titer which is expected to occur did not develop in them. It was unknown whether the low agglutinin titer in rat no. 7, which yielded the organism only in intestinal contents, was on the latest stage of the infection, on the survivor carrier stage, or on the healthy-carrier stage. Isolation of the serovar IVA organism occurred almost equally in the barn over a period of about 1 year. These findings could indicate a smouldering epidemic of pseudotuberculosis in the barn rats. It is not known whether there were dead rats in the final stage of the infection because we had not been looking for them. It is necessary, therefore, to investigate in the future the relationship between rats and farm animals in the ecology of Y. pseudotuberculosis.

It is also important to clarify whether or not the serovar IVA organism was more frequent in rats than were the other serovars, because all but one positive rat yielded the serovar IVA strains. The serovar IVA organism occurred equally in all three age groups. This suggests that old rats might have the same susceptibilities to the organism as young rats. Because the serovar IB organism was detected in only one rat, the significance of its presence in rats was still obscure in the present study. Further studies are now in progress.

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LITERATURE CITED