Probable relation of increase in big buildings and road coverage to the rise and decline of *Rattus rattus* in Sapporo, Japan

Tatsuo Yabe

* Kanagawa Prefectural Public Health Laboratories, Asahi-ku, Yokohama, Kanagawa, 241 Japan

(Received: 24 February 1997; Accepted: 11 June 1997)

Key words: *Rattus rattus*, habitat fragmentation, road coverage, urban building, Sapporo

Abstract: Major cities such as Sapporo, Sendai, Shinjuku, Yokohama, and Nagoya, Japan, have experienced *Rattus rattus* infestations since the 1970s. The problem has disappeared in the 1980s in Sapporo where the *R. rattus* populations have decreased. The causes of the rise and decline were analyzed with aerial photographs of commercial districts in the five cities. In each city, the total basal area of buildings >10 m high increased from 5-10% in the mid-1960s to >15% in the 1970s. In 1988-1990, the mean road coverage per hectare for Sapporo was 0.424±0.133 ha, which was significantly larger at the 5% level than 0.334±0.156 ha, 0.374±0.195 ha, 0.351±0.136 ha, and 0.374±0.169 ha for Sendai, Shinjuku, Yokohama, and Nagoya, respectively. The coefficient of variation of 31.4% for Sapporo was apparently smaller than that for the other cities. Road coverage in Sapporo is generally large, but those in the other cities vary in size which explains Sapporo’s low value. The rapid increase of big buildings in the 1970s may have expanded the infestations in most cities. In Sapporo, however, the large road coverage may have fragmented habitats of the rats and it is possible that rat populations declined as a result.

In Japan, infestations of the roof rat *Rattus rattus* Linnaeus have been experienced since the 1970s in almost all big cities, although pest control operators multiplied rapidly at the same time (Japanese Committee on Commensal Rodent Control, 1985, 1988; Yabe, 1993; Inquiry Committee on Urban Rat Problems, 1995). For example, in the central area of Tokyo, *R. rattus* infested 66% of all types of buildings, with *R. norvegicus* or mixed species of commensal rodents infesting the rest (Watanabe, 1979). In the 1970s, *R. rattus* also became dominant in buildings in Sapporo, a northern city (S. Aoyama, in litt.). Niizeki (1977) reported that over 40% of 45 buildings in the center of Sapporo were occupied by *R. rattus*. In the 1980s, however, *R. rattus* population declined or was successfully controlled by pest control operators in Sapporo (Yabe, 1993; Takayasu, 1994). The causes of the infestations in big cities and the decline in Sapporo have yet to be determined.

I supposed the rapid increase of big buildings in the 1970s may have caused the expansion of *R. rattus* populations (Yabe, 1993). Big buildings provide suitable habitats for *R. rattus* because they usually have several catering establishments and these provide the food for the rats. Also, the structure of these buildings, such as a network of hidden pipes and ceilings provide ideal habitats and nesting places for the rats. Warmth from cooking in the catering establishments and from electri-
cal equipment being used in such buildings also probably supplies sufficient heat for all-season breeding (Tanikawa, 1993, 1994). Hence, the increase of big buildings helps probably infestations of the rats. The present study aims to prove the relation of the rapid increase of big buildings in the 1970s to R. rattus infestations in major cities. I have proposed that large coverage of roads in Sapporo made it easier to control R. rattus as a result of habitat fragmentation (Yabe, 1994). In the calculation of road coverage in the preliminary note, however, I counted elevated roads, which would less effectively isolate rats. It was necessary, therefore, to recalculate the coverage, omitting elevated roads.

Materials and Methods

Road coverage and big building density in commercial districts of Sapporo (43°03' N, 141°20' E), Sendai (38°16' N, 140°54' E), Shinjuku (35°41' N, 139°45' E), Yokohama (35°26' N, 139°39' E), and Nagoya (35°10' N, 136°58' E) were analyzed with aerial photographs. The photographs used were taken every 3 to 10 years from the mid-1960s to 1990 on scales from 1/27,000 to 1/8,000 by the Japan Map Center and local governments.

Roads and buildings in the photographs were examined with 3-power stereoscopic binoculars (Sokkia, MS-27), and building heights were estimated with a parallax device. One of the two photographs under the binoculars was covered with a sheet with a hole representing a 1.5 km square (225 ha) in the photographs. The hole surrounded a randomly sampled portion of a commercial area adjacent to a main railway station of each city. The hole was covered with a transparent plastic film, on which roads or basal areas of buildings were drawn with a red pen. The drawings were covered with another transparent plastic film on which 100 m square grids were drawn on a reduced scale, and were projected on a computer screen through an image scanner. The number of dots which formed the projected image was converted to an actual area.

Grids that encompassed open water were excluded from the building-space calculation. As a result, areas involved for Sapporo, Sendai, Shinjuku, Yokohama, and Nagoya were 225 ha, 202 ha, 132 ha, 211 ha, and 199 ha, respectively. Furthermore, the grids that encompassed railways or waterways also were removed from the road-coverage calculation. Passageways covered with roofs were not counted as roads because rats appeared to be able to move on the roofs independently of roads. Elevated roads were not counted as roads either.

Results

Figure 1 shows the yearly changes in the percentage of space occupied by buildings >10 m high from the mid-1960s through 1988, 1989, or 1990 for Sapporo, Sendai, Shinjuku, Yokohama, and Nagoya. These percentages doubled or tripled from 5–10% of the commercial districts in the mid-1960s to >15% in the 1970s in all the above cities.

Table 1 shows the average road coverage per hectare with S.D. and the coefficients of variation (C. V.) calculated from the photographs. In the year 1988–1990, the average road coverage 0.424 ± 0.133 ha for Sapporo was significantly larger.
Table 1. Average road coverage in 1 ha of commercial districts calculated from aerial photographs taken in the years 1964-1966 and 1988-1990.

<table>
<thead>
<tr>
<th>City</th>
<th>1964-66</th>
<th>1988-90</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\bar{x}$±S. D. (ha)</td>
<td>C. V.* (%)</td>
</tr>
<tr>
<td>Sapporo</td>
<td>0.424±0.158</td>
<td>37.3</td>
</tr>
<tr>
<td>Sendai</td>
<td>0.352±0.177</td>
<td>50.2</td>
</tr>
<tr>
<td>Shinjuku</td>
<td>0.253±0.176</td>
<td>69.7</td>
</tr>
<tr>
<td>Shinjuku S**</td>
<td>0.143±0.195</td>
<td>136.0</td>
</tr>
<tr>
<td>Shinjuku C***</td>
<td>0.274±0.163</td>
<td>59.5</td>
</tr>
<tr>
<td>Yokohama</td>
<td>0.357±0.121</td>
<td>34.0</td>
</tr>
<tr>
<td>Nagoya</td>
<td>0.358±0.175</td>
<td>49.0</td>
</tr>
</tbody>
</table>

* C. V. = S. D./$\bar{x}$
** Skyscraper zone.
*** Commercial district excluding skyscraper zone.

than that for Sendai ($t=4.630$, df = 219, $P<0.01$), Shinjuku ($t=2.053$, df = 178, $P<0.05$), Yokohama ($t=3.928$, df = 206, $P<0.01$), or Nagoya ($t=2.421$, df = 209, $P<0.05$). The coefficient of variation of 31.4% for Sapporo was apparently smaller than that for any other city. These results show that road coverage in Sapporo is generally large, but those in the other cities vary in size.

Table 1 also shows that average road coverages in the year 1988-1990 were not significantly different from those in the 1960s for all cities except Shinjuku (Sapporo, $t=0.006$, df = 228, $P>0.50$; Sendai, $t=0.800$, df = 213, $P>0.50$; Shinjuku, $t=3.749$, df = 130, $P<0.01$; Yokohama, $t=0.311$, df = 188, $P>0.50$; Nagoya, $t=0.626$, df = 191, $P>0.50$). In Shinjuku, the average road coverage for the skyscraper zone in the year 1988-1990 was significantly larger than that in the 1960s ($t=6.115$, df = 23, $P<0.01$). On the contrary, the averages for the commercial district excluding the skyscraper zone were not significantly different ($t=1.464$, df = 105, $P>0.10$) between those years. In Shinjuku, therefore, the road coverage was enlarged notably in the skyscraper zone only. These results show that road coverages had changed little during the period from the middle 1960s till the late 1980s or the early 1990s in all cities except Shinjuku where a skyscraper zone of about 59 ha had been developed.

**Discussion**

It is clear that big buildings increased rapidly in the 1970s. This increase of big buildings may have expanded *R. rattus* infestations, as was suggested by Yabe (1993). Differences in *R. rattus* problems between Sapporo and the other cities occurred under circumstances in which such buildings increased rapidly but road coverage was enlarged little: road coverage in Sapporo is generally large but those in the other cities are small. In other words, roads in Sapporo are generally wide, but narrow in the other cities.

Probably, *R. rattus* has easily dispersed across those narrow roads. The rat will cross roads walking on electric or telephone wires common along narrower roads, as well as on the ground. Meehan (1984) summarized from the literature available that, under normal circumstances, most roof rats can be recaptured within a distance from 16 to 50 m of the point from which they were originally trapped. However, probably he obtained this conclusion from the tests in the fields with vegetational covers or some other shelters. The extent of rat movement depends upon the distribution of food, habitation, and barriers (Davis, 1953). Wide roads are an obstruction to the Norway
rat *R. norvegicus* B. also. Davis (1953) observed in Baltimore, Maryland, that only one of 312 recaptured Norway rats went from one block to another and one block remained free of rats for 2.5 years even though Norway rats were present in adjacent blocks. However, Norway rats crossed narrow roads, and Davis (1953) estimated 10% of rats crossed alleys. Because of the open space and the obstacles such as vehicles in addition to the distance, rats will rarely cross wider roads.

Therefore, *R. rattus* populations in Sapporo were enclosed in each block which was functionally reduced to an island in a sea of asphalt. Because dispersal buffers population dynamics and promotes gene flow (Anderson, 1989), the prevention of dispersal in Sapporo must have made the rat populations ecologically and genetically unstable. Pest control operators in Sapporo, which multiplied in the 1970s, would have been able to control such unstable populations easily. I concluded that the large road coverage in Sapporo fragmented habitats of *R. rattus*, and as a result the rat populations declined. This hypothesis needs, however, further evidence that *R. rattus* populations in blocks surrounded by wide roads are ecologically and genetically unstable.

It is also known that *R. rattus* has become a rare species since the 1950s in northern and central Europe (Bentley, 1964; v. Bülow, 1981; Lund, 1988; Anonymous, 1991). Bentley (1964) and v. Bülow (1981) suggest that the reduction of the rats *R. rattus* was due to intensified control measures such as the use of anticoagulants and improvement of buildings. It will be interesting to examine the causes of the reduction from the viewpoint of habitat fragmentation.

**Acknowledgments**

I am deeply indebted to members of the Japanese Committee on Commensal Rodent Control, especially to Dr. M. Hasegawa, Dr. I. Tanaka, Mr. K. Miyamoto, Mr. M. Motoki, Dr. T. Tanikawa, and Mr. Y. Ito, for their helpful advice during the study.

**References**


**著 者**

大型ビルの増加と道路面積が札幌のクマネズミの盛衰に関与した可能性

矢部 辰男

神奈川県衛生研究所

〒241 横浜市旭区中尾1-1-1

わが国のビル街では、1970年代からクマネズミの横行が目立つようになったが、札幌では1980年代に至ってその駆除に成功した。その原因を、空中写真の解析によって考察した。解析対象は札幌、仙台、新宿、横浜、名古屋の商業・業務地域である。高さ10m以上のビルの占有面積割合を算定すると、いずれの都市でも1960年代半ばに5-10%であったものが、1970年代には15%以上に急増した。1988-1990年における1ha当たりの平均道路面積は、札幌で0.424±0.133haで、それは他のいずれの都市の値よりも有意に大きかった。また、その変動係数は31.4%で、他のいずれの都市よりも小さかった。これは、札幌では平均的に道路面積が広いのに対し、他の都市では道路面積が狭い上に、広い道路と狭い道路とが混在していることを示す。クマネズミの生息に適した大型ビルの急増がクマネズミの横行を促したが、道路面積の分布形態はその後のクマネズミ駆除の成否を分ける一因になった可能性もある。広い道路で街区を区切られた札幌では、すみ場の分散化によって容易に駆除されたが、狭い道路の混在する他の都市では分散化がなされず、駆除の困難な状態が続いてきたものと推測される。