Fauna and distribution of trombiculid mites in relation to the vegetational and geographical environment in northern Kyushu, Japan

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Abstract: A total of 33 species of trombiculid mites were identified in northern Kyushu, from 84,413 mites parasitic on captured host mammals at 123 sites, or collected by other methods. The vegetation types, based on the dominant plants or the physiognomies, were arranged into four groups by the trombiculid species structure, namely, the ordinary forest (Cryptomeria-Cypress forest, secondary forest, and evergreen broad-leaved forest), seaside pine forest, grassland, and montane deciduous forest. However, some differences in the structure were detected among sites in each vegetation type. A successive change in the trombiculid structure in accord with the succession of plants, beginning with pioneer species such as Gahriepia saduski, Leptotrombidium scutellare, and L. pallidum, is discussed. The possibilities of interspecific relationships, such as competition, between two pairs of morphologically related species were suggested in the vertical distribution of L. tanaka-ryot and L. fuji, and in the horizontal distribution of L. fukuoka and L. kitsatoto. The vector species of Tsutsugamushii disease, L. pallidum and L. scutellare, showed a somewhat restricted distribution. The small number of patients of Tsutsugamushii disease in this region, in comparison with that in southern Kyushu, was attributed to the lesser abundance of the vector trombiculid mites.

Introduction

Trombiculid mites have been studied actively for a long time in Japan, since some species are the vectors of Tsutsugamushii disease. Nationwide surveys on the trombiculid fauna had been performed previously (Sasa, 1956; Tamiya, 1962). However, there still remained room for detailed study in many localities, including northern Kyushu. Traub and Wisseman (1974) summarized that many trombiculids were habitat-specific. Recent papers on trombiculid mites have come to refer to the vegetational environment in detail (e.g., Uchikawa et al., 1983; Yamamoto et al., 1997). However, information on the relationships between the mites and the vegetation was still inadequate. Usually, studies on trombiculid mites tend to be restricted to the vectors of Tsutsugamushii disease. However, each trombiculid species was considered to live as a member of a trombiculid community, being related to other trombiculid species. Therefore, it seemed important to take notice of the relationships among species, including mites other than the vectors.

The contents of this paper may roughly be divided into the following four parts, which are arranged into sub-sections for convenience: the fauna of trombiculid mites besides the host mammals; the relat-
tionships between trombiculid mites and the vegetation; the horizontal and vertical distributions of trombiculid mites that showed the possibilities of interspecific relationships; and the distribution of vector mites of Tsutsugamushi disease in northern Kyushu.

**Study Sites and Methods**

From 1988 to 1998, excluding 1997, at a total of 123 study sites in northern Kyushu (Appendix, Fig. 1), small mammals were captured to examine trombiculid mites parasitic on them. Surveys were carried out in winter or spring, except some in November (mostly at grasslands) and May (mostly at highlands). Although incomplete, monthly surveys were attempted at Akaji (site number: B17) and UOEH Campus (a) (B04a). The sites were located in the area of latitude 33°18’N to 33°58’N, a spread of about 70 km; longitude 130°08’E to 131°11’E, a width of about 100 km; and at altitude from almost 0 m to 850 m above sea level (a.s.l.). Most sites were in Fukuoka Prefecture, and some were in Oita Prefecture.

Each study site was in a location showing the representative vegetation of the surroundings, and at the site, the dominant plant species were identified. The vegetation type (or physiognomy) was arranged into seven types (Appendix, Table 2), namely Cryptomeria-Cypress forest (CCF), consisting of Cryptomeria japonica (Cry: cryptomeria, sugi in Japanese) and/or Chamaecyparis obtusa (cypress, hinoki), secondary forest (SF), evergreen broad-leaved forest (EBF), seaside pine forest (SPF), montane deciduous forest (MDF), grassland (GL), and other forest (OF). Town areas and agricultural fields were mostly excluded from the study sites.

The entire study region was divided into the following five areas (Appendix, Fig. 1): the eastern area (area A) had outlets to the Sea of Suou; the middle area (area B) was the basin of the Ona River; the western area (area C) had outlets to the Sea of Genkai; the southern area (area D) was the Chikugo River Basin or the Yama-kuni River Basin; and the northern area (area E) faced the Sea of Genkai. Each site was numbered for the sake of convenience. Two neighboring places of different

![Map](image-url)

Fig. 1. Map of the study sites. The whole study site was divided into five areas A, B, C, D, and E. Site numbers (SN) correspond to those in Appendix.
vegetation were regarded as two sites, (a) and (b) (Appendix).

Larvae of trombiculid mites were taken from small mammals that had been captured mostly with Sherman's alive traps. Killing snap traps were used only in earlier surveys on riverside grasslands. At each study site, usually 20 traps were set for one to three nights to capture mammals. Following Teramura's method (Teramura, 1954), the killed mammals were hung over water with a surface active agent in petri dishes to make the mites detach and fall down. After two days' hanging, the bodies of hosts were examined in detail for mites. Moreover, the ears of the rodents and tails of shrew moles were cut off and examined for mites under a stereoscopic microscope. Sometimes, a chlortal solution (30 g chlortal hydrate, 2.5 g glycerin, 10 ml water) in a small dish was applied to separate mites from the sticky secretion of the rodent's ear. The collected mites were mounted in a gum-chlortal medium on slides, and then identified and counted. The following methods were additionally applied to collect more trombiculid mites, mostly at sites where no capture of hosts was made: the Tullgren funnel, the black plate (Sasa, 1956), Suzuki's black cloth, and the catching of mites that crawled up the boots.

To indicate the abundance of the trombiculid species, the percentage for a species was calculated for each site and for each host species, and then averaged in such categories as vegetation type, area, host species, etc.

Comparisons of the community structure of trombiculid mites were carried out using Pianka's $\alpha$ index ($\alpha$ in this paper, Pianka, 1973) as an index of similarity. $\alpha$ depends on the species composition and the number of individuals of each species, and takes the value from 1 (between identical communities) to 0 (between distinct communities). On the basis of $\alpha$, some dendrograms were drawn by the Mountford method (Mountford, 1962). The comparisons were made including the data of the formerly reported two forests (Kitazawa, 1993). The mites collected from shrew moles were excluded from the comparisons because of the peculiar species composition, but were included when the trombiculid communities on various host species were compared. Three sites of SPF and four sites of GL, where no mites were collected from the captured rodents (Appendix), were omitted from the whole calculation.

Results

General view of trombiculid fauna

A total of 84,413 individuals representing 24 species were collected from host mammals (Table 1). Zero to 12 species occurred at each study site (Appendix). On the basis of the mean percentage of the population number, Leptotrombidium fuji, L. fukuoka, L. pallidum, Gahrliepia saduski, and Miyatrombicula kochiensis were the dominant species. However, concerning the number of habitats, L. kuroshio occupied the third position, and L. pallidum fell to the ninth. Leptotrombidium miyajimai inhabited a wide region, despite its smaller population. Cheladonta ikaoensis was also distributed over a somewhat wide range, showing less abundance.

The rare species were Ascoschoengastia kitajimai, L. scutellare, L. owuense, L. pal-pale, L. tosa, Neotrombicula mitamurai (both forms hiroshima and kii, described by Sasa in 1956), and Chatia tarsalis.

The following species were collected by the Tullgren funnel from the soil: Eltonella ichikawai, L. himizu (identified by Dr. Hiroshi Suzuki; 10 dorsal setae in the second row; formerly reported as L. yasuokai by Kitazawa in 1993), Machiena todai, Neoschoengastia shirai, Walchia koshikienisis, W. masoni, and W. ogatai. Helenicula miyagawai was collected on grassland from my boots.

Consequently, adding Machiena smadeli collected by Kitazawa (1993), I identified 33 species of Trombiculidae and Leeuwenhoekiidae in this region.
Table 1. Total number of individuals, mean percentage, number of habitats of trombiculid mites, and mean number of mites per host mammal.

<table>
<thead>
<tr>
<th>Species</th>
<th>Total number</th>
<th>Mean percentage</th>
<th>No. of habitat</th>
<th>Mean number per host mammal</th>
</tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Asp (400)</td>
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<td>Chatia tarsalis</td>
<td>19</td>
<td>0.02</td>
<td>5</td>
<td>0.01</td>
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<td>Gahrieleia saduski</td>
<td>5,364</td>
<td>8.2</td>
<td>88</td>
<td>0.8</td>
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<tr>
<td>Leptotrombidium daisen</td>
<td>485</td>
<td>2.1</td>
<td>26</td>
<td>1.0</td>
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<tr>
<td>L. fusi</td>
<td>41,109</td>
<td>42.6</td>
<td>97</td>
<td>91.6</td>
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<td>L. fukuoka</td>
<td>8,413</td>
<td>10.8</td>
<td>67</td>
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<td>2,473</td>
<td>3.6</td>
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<td>8</td>
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<tr>
<td>L. miyajimai</td>
<td>586</td>
<td>1.1</td>
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<td>1,734</td>
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<td>1.0</td>
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<td>28</td>
<td>13.9</td>
</tr>
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<td>L. palpole</td>
<td>364</td>
<td>0.1</td>
<td>2</td>
<td>0.01</td>
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<tr>
<td>L. scutellare</td>
<td>4</td>
<td>0.003</td>
<td>1</td>
<td>1.0</td>
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<tr>
<td>L. tanaka-ryoi</td>
<td>1,647</td>
<td>3.9</td>
<td>21</td>
<td>1.3</td>
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<td>L. tosa</td>
<td>76</td>
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<td>1.0</td>
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<tr>
<td>L. kansai</td>
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<td>14</td>
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<td>9.7</td>
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<td>Neotrombicula japonica</td>
<td>81</td>
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<td>0.2</td>
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<td>N. mitamurai</td>
<td>33</td>
<td>0.2</td>
<td>4</td>
<td>0.1</td>
</tr>
<tr>
<td>Ascoschoengastia kitajimai</td>
<td>1</td>
<td>0.0004</td>
<td>1</td>
<td>0.003</td>
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<tr>
<td>Cheladonta tkaoensis</td>
<td>88</td>
<td>0.4</td>
<td>20</td>
<td>0.2</td>
</tr>
<tr>
<td>Doloisa okabei</td>
<td>20</td>
<td>0.1</td>
<td>7</td>
<td>0.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>84,413</td>
<td>100</td>
<td>116</td>
<td>163.5</td>
</tr>
</tbody>
</table>

Parentheses represent the number of individuals. The sites where no mite was collected from mammals were omitted from this table. Asp, *Apodemus speciosus*; Aar, *Apodemus argenteus*; Mmu, *Mus musculus*; Mmi, *Micromys minutus*; Esm, *Eothenomys smithii*; Mmo, *Microtus montebelli*; Uta, *Urotrichus talpoides*.

Host mammals and trombiculid mites

Six species of rodents and one shrew mole, composing a total of 765 individuals, including 32 that inhabited sites where no trombiculid mites were found, were captured (Appendix). Among the host mammals, *Apodemus argenteus* (the second most abundant species) and *Eothenomys smithii* were distributed only in the forests. *Microtus montebelli*, *Mus musculus*, and *Micromys minutus* inhabited only the grasslands. *Apodemus speciosus* (the most abundant species) and *Urotrichus talpoides* (a shrew mole; the third most abundant species) were inhabitants of both vegetation types.

Concerning the community structure of trombiculid mites on mammals, *A. speciosus* harbored a considerably large number of individuals of almost all trombiculid species (Table 1). The trombiculid structure on *A. argenteus* was similar to that of *A. speciosus* (*Pa* = 0.96), but had a small amount of mites, and lacked the rare species. In addition, this mouse yielded a smaller proportion of *L. pallidum*, *L. murotoense*, and *G. saduski*, but more of *L. speciosus*, *Eothenomys smithii* seemed to be a favorite host of trombiculid mites. Despite the small number of
captured individuals, this vole was parasitized by a variety of trombiculid mites, except for the rare species, and provided the maximal population density for many mite species. The community structure on *E. smithii* was somewhat similar to that on *A. speciosus* (*Pa*=0.85) and on *A. argenteus* (*Pa*=0.86). *Uroticus talpoide* showed a peculiar trombiculid fauna. *Doloisia okabei* was specific to this shrew mole, and most individuals of *C. tarsalis*, *L. miyairi*, and *L. kansai* were related to this host. *Uroticus talpoide* showed its maximum similarity in trombiculid structure to *E. smithii*, but the grade was quite low (*Pa*=0.05). From *M. montebelli*, *M. musculus*, and *M. minutus*, at most three trombiculid species, *L. pallidum*, *L. palpale*, and *G. saduski*, were collected. However, a large number of *L. pallidum* was observed on *M. montebelli*.

**Vegetation types and trombiculid mites**

The similarity of trombiculid community structure among six vegetation types (OF was eliminated) is presented in Fig. 2. The three forests, namely, CCF, SF, and EBF were closely related in the trombiculid structure. However, SPF was different from these three forests, and somewhat close to GL. MDF showed the most different trombiculid structure among all vegetation types. These differences were mostly attributed to the difference in the dominant trombiculid species (Table 2). The main species in CCF, SF, and EBF was *L. fuji*, while the successive species were varied; and the relatively small number of *G. saduski* in CCF, and of *L. kuroshio* in EBF, was noticeable. SPF and GL were characterized by *L. pallidum*. *Leptotrombidium tanaka-ryoi* and *L. daisen* were characteristic of MDF. *Leptotrombidium murotoense* was a somewhat common species, but restricted to the forests.

According to the dominant plant species, CCF was divided into five groups (Fig. 3, Table 2). Nevertheless, hardly any differences in the trombiculid structure were found among these groups. The most dominant trombiculid species was *L. fuji* and the second was *L. fukuoka*, except in the Crja forests with bamboo, where the second was *M. kochiensis*.

SF was divided into six groups (Fig. 4, Table 2). The similarity between the uppermost two groups in Fig. 4 was very high, and one forest was somewhat similar to these groups. *Leptotrombidium fuji* was the dominant in these three. Each of the other three forests presented a different trombiculid structure; namely, *L. daisen*, *G. saduski*, and *L. kitsasatoi* were the dominant in the respective forests.

At the sites of EBF, sometimes it was difficult to identify the dominant plant because of the complexity of the plant composition. EBF contained 11 groups determined by the dominant plant, including two evergreen scrubs (ES) (Fig. 5, Table 2). These groups were arranged into three clusters by the trombiculid structure, at *Pa*=0.85. Among the upper five groups in Fig. 5, *L. fuji* was the most dominant mite, and *L. fukuoka* or *G. saduski* was the second. The next two groups were distinguished by *L. pallidum* as the second dominant species. The lower four groups were characterized by the dominance of *L. fukuoka* and *L. fuji*, and by the relatively small proportion of other species.

The dominant plant in SPF was *Pinus thunbergii* (Japanese black pine, *kuro-matsu*). Two distinct clusters were formed.
<table>
<thead>
<tr>
<th>Vegetation type</th>
<th>Site No.</th>
<th>Dominant trombiculid species (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryptomeria-Cypress forest (CCF)</td>
<td>60</td>
<td>L. fujii (55), L. fukuoka (13), L. kuroshio (7.8), L. tanaka-ryo (6.5), M. kochiensis (6.3)</td>
</tr>
<tr>
<td>Cob</td>
<td>4</td>
<td>L. fujii (63), L. fukuoka (18), L. kuroshio (4.3)</td>
</tr>
<tr>
<td>Crja, Cob</td>
<td>5</td>
<td>L. fujii (61), L. fukuoka (20), L. kuroshio (11)</td>
</tr>
<tr>
<td>Crja, Psi</td>
<td>2</td>
<td>L. fujii (53), L. fukuoka (20), L. kuroshio (8.3)</td>
</tr>
<tr>
<td>Crja, Cob</td>
<td>10</td>
<td>L. fujii (63), L. fukuoka (11), M. kochiensis (10)</td>
</tr>
<tr>
<td>Crja</td>
<td>37</td>
<td>L. fujii (51), L. fukuoka (11), L. tanaka-ryo (9.6)</td>
</tr>
<tr>
<td>Crja, Ppu</td>
<td>2</td>
<td>L. fujii (46), M. kochiensis (19), L. kuroshio (11)</td>
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<tr>
<td>Secondary forest (SF)</td>
<td>10</td>
<td>L. fujii (54), L. kitasatoi (15), M. kochiensis (7.5), G. saduski (7.5), L. kuroshio (6.8)</td>
</tr>
<tr>
<td>Pde</td>
<td>2</td>
<td>L. fujii (71), L. kitasatoi (10), L. kuroshio (4.4)</td>
</tr>
<tr>
<td>Pde+</td>
<td>4</td>
<td>L. fujii (74), L. kitasatoi (12), G. saduski (8.2)</td>
</tr>
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<td>1</td>
<td>L. fujii (57), M. kochiensis (38), G. saduski (4.3)</td>
</tr>
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<td>Qac</td>
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<td>L. datzen (33), L. fujii (30), L. kuroshio (26)</td>
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<tr>
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<td>G. saduski (32), L. fujii (19), L. murotoense (18)</td>
</tr>
<tr>
<td>Qse</td>
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<td>L. kitasatoi (78), M. kochiensis (16), L. kuroshio (3.3)</td>
</tr>
<tr>
<td>Evergreen broad-leaved forest (EBF)</td>
<td>20</td>
<td>L. fujii (43), L. fukuoka (17), G. saduski (17), M. kochiensis (9.6), L. pallidum (5.1)</td>
</tr>
<tr>
<td>Qel</td>
<td>1</td>
<td>L. fujii (54), L. fukuoka (19), G. saduski (18)</td>
</tr>
<tr>
<td>Mth</td>
<td>2</td>
<td>L. fujii (53), L. fukuoka (18), G. saduski (18)</td>
</tr>
<tr>
<td>Ped</td>
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<td>L. fujii (40), L. fukuoka (18), M. kochiensis (16)</td>
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<td>Ccu</td>
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</tr>
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<td>L. fujii (48), G. saduski (30), M. kochiensis (17)</td>
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<tr>
<td>Pma</td>
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</tr>
<tr>
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</tr>
<tr>
<td>Pto</td>
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</tr>
<tr>
<td>Seaside pine forest (SPF)</td>
<td>7</td>
<td>L. pallidum (46), G. saduski (43), L. fujii (8.7), L. fukuoka (1.8), M. kochiensis (0.4)</td>
</tr>
<tr>
<td>Pith</td>
<td>E07</td>
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<td>Pith</td>
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</tr>
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<td>G. saduski (100)</td>
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<td>Pith</td>
<td>E11</td>
<td>G. saduski (57), L. fujii (33), L. fukuoka (10)</td>
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<tr>
<td>Grassland (GL)</td>
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<td>Sha, Msa, Sal</td>
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<td>B12</td>
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<td>Sha, Msa, Psi</td>
<td>B17</td>
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<td>Apr, Poth, Psi</td>
<td>B29</td>
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<tr>
<td>Rsa, Osa</td>
<td>B44</td>
<td>L. fujii (83), G. saduski (6.8), L. datzen (6.0)</td>
</tr>
<tr>
<td>Bni, Poth</td>
<td>B41</td>
<td>L. fujii (79), L. kitasatoi (12), G. saduski (5.5)</td>
</tr>
</tbody>
</table>
Table 2. (Continued)

| Grassland (GL) | Phja | Pb2 | L. fuji (34), C. ikaeornis (30), N. mitamurai (17) |
| Montane deciduous forest (MDF) | Total | 3 | L. tanaka-ryo (36), L. kuroshio (30), L. daies (13), L. fuji (8.2), G. saduski (4.3) |
| | Fcr, Tsi | D06 | L. kuroshio (34), L. tanaka-ryo (28), L. fuji (25) |
| | Fcr | D08b | L. kuroshio (56), L. daies (22), L. tanaka-ryo (22) |
| | Qcr, Fcr | A20 | L. tanaka-ryo (56), G. saduski (13), L. daies (13) |

The top five species are given for the main vegetation types (Total), while three species for other categories. Crja. Cob in CCF means the complex of the Crja forest and the Cob forest. Number in parentheses indicate the mean percentage. For abbreviations of plants, see Appendix.

![Diagram](image1)

Fig. 3. Similarity of community structure of trombiculid mites among Cryptomeria-Cypress forests. For abbreviations of dominant plant species, see Appendix.

![Diagram](image2)

Fig. 4. Similarity of community structure of trombiculid mites among secondary forests. Pde+, mixed forest of *Pinus densiflora* and deciduous tree. For abbreviations of other dominant plant species, see Appendix.

among the seven sites (Fig. 6). *Leptotrombidium pallidum* was dominant at the upper four sites in Fig. 6, while *G. saduski* was dominant at the others (Table 2). *Gahrliopia saduski* was the only species common to all sites in SPF. *Leptotrombidium fuji* appeared at three sites. A small number of *L. fukuoka* and *M. kochiensis* occurred at few sites. Consequently, five trombiculid species were collected from SPF, but not more than three species inhabited each site, and no sites showed the same species composition as that of the others. In GL, the upper six sites in Fig. 7 were distinguished as a cluster by *L. pallidum*, which was the sole inhabitant at four sites (Table 2). Along with *L. pallidum*, small amounts of *L. palpale* appeared at two sites. One additional individual of *G. saduski* was collected at Akaji. These sites were located in flats, outside (or beside the
stream) the levee of the Onga River or its tributaries. Another distinct cluster, consisting of three small farmlands in mountain valleys, showed a similar trombiculid structure to that of the forests, since the Pa value between each site and the average of forests (excluding SPF, MDF, Hiraodai Plateau (A08), and Mt. Takayama (D 17)) was 0.95, respectively. Remarkable species were *N. japonica* at Ookimi (B02; an abandoned flat) and Yubaru (B34; a narrow bank of a river), and *C. ikaoensis* and *N. mitamura* at Ochiai (B27; a riverside in a mountainous area).

The three forests of MDF were located at altitudes above 600 m a.s.l., and the tree common to MDF was *Fagus crenata* (beech, *buna*). As illustrated in Fig. 8, the two sites were somewhat similar in the trombiculid structure abundant in *L. kuroshio*, but differed in the proportion of *L. fuji* and *L. daisen* (Table 2). The other site was dominated by *L. tanaka-ryoi*.

OF was composed of four forests (Appendix). Hiraodai Plateau was a forest in a doline (or sink), and was a habitat of only *L. kitasatoi*. The others were mixed forests with *C. japonica*, but no plant was distinguished as the dominant. The similarity of the trombiculid structure between the
average of forests (excluding SPF, MDF, and OF) was high at Mt. Hirayama (A01; \( \alpha = 0.89 \)) and at Takano (A05; \( \alpha = 0.98 \)), but low at Mt. Takayama (\( \alpha = 0.28 \)) where \textit{L. fukuoka} was extremely dominant (89\%).

**Horizontal comparison of trombiculid structure in forest**

There were not marked differences among the five study areas (Fig. 9) as regards the average trombiculid structure of the forests (excluding SPF, MDF, Hiraodai Plateau, and Mt. Takayama). However, area D yielded a relatively large proportion of \textit{L. kuroshio} (17\%), whereas it was under 5\% in other areas. Also, area E was characterized by \textit{L. pallidum} (12\%), while it was fewer than 2\% in others. Moreover, a remarkable difference in \textit{L. fukuoka} appeared between area A (2\%) and area C (24\%).

**Vertical comparison of trombiculid structure in forest**

The trombiculid structures in the forests were examined vertically at intervals of 100 m a.s.l., using the same data as for the horizontal distribution (Fig. 10). Almost the same structures were illustrated from 0 m to 400 m, while a difference appeared above 500 m. Thus, an altitude between 400 m and 500 m seemed to be the transitional zone. This fact was mainly connected with the abundance of \textit{L. tanaka-ryoi} and \textit{L. daisen}. The proportion of \textit{L. tanaka-ryoi} was at most 5\% below 400 m, but rose to 17\% from 400 m to 500 m, and reached 38\% above 500 m. Like \textit{L. tanaka-ryoi}, \textit{L. daisen} increased in relative abundance from at most 3\%, through 6\%, to 16\% in accordance with increase in altitude within this range. On the other hand, \textit{L. fuji} showed the reverse tendency, and reduced in proportion from at least 50\%, through 41\%, to 13\%. \textit{Gahrliepia saduski} also reduced from 12\% (below 100 m) to 0.4\% (above 500 m).

**Relationship between \textit{L. tanaka-ryoi} and \textit{L. fuji}**

Using the data of all study sites, the vertical changes in the proportion of \textit{L. tanaka-ryoi} and \textit{L. fuji}, at intervals of 100 m a.s.l., are illustrated in Fig. 11. Depending on the altitude, these species changed in their relative abundance. \textit{Leptotrombidium tanaka-ryoi} disappeared below 100
m, and showed only a proportion of 0.1% from 100 m to 200 m. However, 100% was occupied by this species above 700 m. On the other hand, *L. fujii* decreased in proportion as the altitude became higher. The vegetation types of the two sites located at the highest altitude (850 m) were CCF and MDF, respectively.

**Distribution of *L. fukuoka* and *L. kitasatoi**

Regarding the horizontal distribution of *L. fukuoka* and *L. kitasatoi*, the western part of the whole study area was mostly occupied by *L. fukuoka*. Especially in area C, no habitat of *L. kitasatoi* was recorded. The eastern part was inhabitable for *L. kitasatoi*, since this species distributed widely. Moreover, *L. kitasatoi* infested exclusively most of the easternmost and northeastern parts of this region (Fig. 12).

**On the vectors of Tsutsugamushi disease**

The distribution of two vector species of Tsutsugamushi disease, *L. pallidum* and *L. scutellare*, is illustrated in Fig. 13. *Leptotrombidium pallidum* showed a somewhat restricted distribution. Although *L. pallidum* was dominant in SPF in the eastern part of area E, and in the riverside of the Onga River, this species occurred sporadically in small numbers (less than 10%) in hilly or mountainous areas in the southern part of this study region. Moreover, most sites in area D lacked this species.

*Leptotrombidium scutellare* was one of the rare species in this study region. Mt. Miyajidake (D14), assigned to CCF that adjoined a grassy field was the only site where this species was collected from host animals. However, several habitats of *L. scutellare* were discovered in the eastern part of this region, using other methods than the capture of host animals. These sites were small (under 1 ha) grasslands near agricultural fields or housing, and a narrow forest zone on a tide embankment neighboring a farmland and a field of weeds. Larvae of *L. scutellare* appeared from late October to mid-April at the site indicated by the uppermost open square in Fig. 13.

Fig. 12. Distribution of *L. fukuoka* (White) and *L. kitasatoi* (Black). Gray circles indicate coexistence. Site numbers are also shown. MT means the formerly reported Mt. Takatori laurel forest (Kitazawa, 1993).
Fig. 13. Distribution of *L. pallidum* (Gray circles) and *L. scutellare* (Black circle and open squares). Black circle indicates coexistence. Squares indicate the habitats of *L. scutellare* collected by other methods than the capture of host. Site numbers are also shown. SM means the formerly reported Sanri-matsubara pine forest (Kitazawa, 1993). The southernmost part of the study region is eliminated in this figure, because of the absence of the both species.

**DISCUSSION**

**General view of trombiculid fauna**

As was expected from the scale of the present study, 24 trombiculid species, including such a rare species as *A. kitajimai* and locally rare species such as *L. palpale*, were recorded from host mammals. On the other hand, some species that had been recorded in Kyushu, such as *L. intermedium*, *L. kawamurae*, and *N. tamiyai*, were not collected. However, not many species may be added in this region in future surveys from captured rodents. Besides the mites from hosts, eight trombiculid species were collected by the Tulgren funnel including those known as parasites of birds (Sasa, 1956; Tamiya, 1962), as was suggested by Suzuki (1973). Using this method, more species, especially deep-soil dwellers, may be discovered in this region.

In Kyushu, surveys on a scale somewhat similar to the present study had been performed in Oita Prefecture (Miura, 1959; Ono et al., 1986), in Miyazaki Prefecture (Yamamoto, 1960), in Kagoshima Prefecture (Yamamoto, 1961), and in Fukuoka Prefecture (Yamasaki, 1987). In comparison with those areas, the present region, which included most of Yamasaki's study area, was not very unique in the trombiculid structure. However, *L. scutellare* and *L. pallidum* were not as abundant as in Kagoshima Prefecture. Moreover, as Yamasaki (1987) pointed out, *L. fukuoka* seemed to be a species mostly indigenous to this region.

**Host mammals and trombiculid mites**

The relationship between the trombiculid mites and their host mammals showed the same tendencies as reported in previous work (Sasa, 1956; Tamiya, 1962). In the present study, a gradient was detected in the similarity of trombiculid structure among the forest-inhabiting hosts (excluding the data in SPF, GL, at Hiraodai Plateau and Mt. Takayama), as a series from *A. argenteus*, *A. speciosus*, *E. smithii*, to *U. talpoides*. Since this series corresponded to the vertical niche of each host (e.g., *U. talpoides* adapted to deeper underground), the gradient seemed to be a reflection of the particular vertical niche
of each trombiculid species.

Nadchatram (1970) concluded that orange- to red-colored larvae of trombiculid mites live on the ground surface, while white to yellow mites are nidicolous in ground burrows of ground-dwelling animals. Trombiculid mites on *U. talpoides* fit his conclusion in this study, since white or whitish species occupied the top six positions in abundance on this host. Moreover, increasing tendencies in abundance, according to the series mentioned above, were observed on two whitish species, *L. fukuoka* and *L. murotoense*. On the other hand, *L. miyajimai*, a reddish species, decreased in abundance in the order of that series. However, *L. kuroshio*, a white species, infested *A. argenteus* and did not occur on *U. talpoides*. Considering the states of many trombiculid species, which did not show clear tendencies between the color and the abundance among hosts, now speculation remains about the need for more examinations.

**Vegetation types and trombiculid mites**

It was an unexpected result that such high similarities of trombiculid structure were detected among the three different forest types, namely CCF, SF, and EBF. This fact was mainly ascribed to the dominance of *L. fujii*, whose abundance in forests has been well known throughout Japan, except in Hokkaido (Sasa, 1956). An ordinary forest in this region may have a trombiculid structure similar to these three vegetation types, regardless of being natural forest (e.g., most EBF), artificial forest (e.g., all CCF), young forest (e.g., SF), or mature forest (e.g., many EBF). From another point of view, a forest that lacks or has a small amount of *L. fujii* must be a special forest, such as SPF and MDF. As a result, adding GL, the vegetation types could roughly be classified into four groups by the community structure of trombiculid mites.

It was natural that the more a vegetation type was subdivided, the more differences in the trombiculid structure appeared. CCF was the artificial and the most widespread forest in this region, and its most remarkable characteristic was the high similarity in the trombiculid structure among sub-types. Concerning CCF, it might be possible to ascribe this similarity to the actual or observed environmental uniformity among the forests. Some heterogeneous trombiculid structures were found in SF. *Leptotrombidium kitasatoi* was characteristic of many sites of SF. However, the main trombiculid species that made a distinct cluster was *L. fujii*. Therefore, regarding the trombiculid structure, SF was an ordinary forest, including some peculiar forests such as an artificial forest in a mountainous area, and the isolated forests on the campus of a university in a town area. Among the three clusters of EBF, *L. fukuoka*-cluster (Cca-Pto in Fig. 5) contained two sites of ES, and the *L. pallidum*-cluster faced the sea. However, in each cluster, common and clear factors to distinguish one from any other were scarcely found vegetationally or geographically. This fact may prove the quite weak association between the plant species and the trombiculid species.

The poor trombiculid species composition in SPF had been pointed out by Kitazawa (1993). The occurrence of five ordinary species, at most three species at each site, and the different species composition among sites, were confirmed in the present study. These facts made SPF interesting. The similarities of trombiculid structure between SPF and the seaside EBF (including Mt. Tateishi, C18), and the inland EBF, were both low (Pa = 0.52, and 0.48), while that between the seaside EBF and the inland EBF was high (Pa = 0.96). These facts mean that the peculiarity of SPF was not caused by its location, but by its own properties, probably including the changeable and severe climatic condition. In SPF, host mammals were not captured at two places (no descriptions of the sites in this paper); besides, trombiculid mites were not found on the captured mammals.
at three sites (Appendix). Therefore, SPF seemed to be a critical environment for both rodents and mites. In addition, considering the differences in the species composition at each site, the chance of invasion or immigration followed by the establishment of the population might be very restricted. Therefore, there might occur a stagnation of the ecological succession of trombiculid mites, and the actual species structure of SPF displayed the early stage of the succession. Judging from the abundance of mites and the two distinct clusters in Fig. 6, the pioneers to SPF may be *G. saduski* and *L. pallidum*.

A state similar to SPF, but more extreme, took place at riverside grasslands. The capture of host mammals failed at more than ten grassland sites outside the levee in the middle to lower reach of the Onga River system. Moreover, the captured rodents had no trombiculid mites at four sites (Appendix). At six sites inhabited by trombiculid mites, *L. pallidum* was almost the sole species. This fact proved this species' high adaptability to severe environments. *Leptotrombidium palpale*, known as an ordinary species in the grasslands in Honshu (Sasa, 1956; Uchikawa et al., 1984; Uchikawa and Kumada, 1987) and occurring along with *L. pallidum* at two sites in the present study, might also possess the tolerance to harsh environments.

In other grasslands, *G. saduski* was the common species, but the “typical” trombiculid structure of the grasslands could not be distinguished. The trombiculid structure on host mammals in grasslands seemed to be strongly influenced by the state of the surroundings, especially in small grasslands, as shown at the three farmlands.

In MDF, Mt. Takanosu (1) (A20) was distinguished from the others by an abundance of *L. tanaka-ryoi* and a lack of *L. kuroshio* and at the same time by its dominant tree. However, the difference in the trombiculid structure was considered not to be associated with the vegetation, since Crja forests near each site of MDF were also dominated by *L. tanaka-ryoi* and lacked *L. kuroshio*.

At Hiraodai Plateau of OF, *L. kitasatoi* was the sole trombiculid mite. Furthermore, no mammal was captured in the surrounding grassland. These peculiar phenomena were considered to be the effects of the yearly burning of the grassland.

On the basis of the relationships between vegetation types and trombiculid mites, a successive change in the trombiculid community structure, comprising three phases, was speculated to correspond roughly to the succession of plants: Phase 1—the pioneer species such as *G. saduski*, *L. scutellare*, and *L. pallidum* inhabit the early stage of succession, e.g., grasslands, facing severe climatic conditions, made possible by their high tolerance; Phase 2—besides the species of Phase 1, the members of the second group, including such common species as *L. fujii*, *L. fukuoka*, *M. kochiensis*, and *L. kitasatoi*, inhabit the newly established forests of the milder environments such as SPF; Phase 3—in the stable environmental conditions in the real forests, *L. kuroshio*, *L. murotoense*, and many other trombiculid species become able to survive; however, some pioneers disappear from the forests.

The question may be: why do pioneers disappear while the other species continue to live in Phase 3? In my supposition, they are forced to leave the crowded habitats by interspecific competition. Of course, this is not a proven fact but an application of a general concept in ecology: that living organisms adapted to a harsh or fluctuating environment tend to be weak in interspecific competition (e.g., Pianka, 1988).

Nadchatram (1970) concluded that pigmented trombiculid mites are relatively highly adaptable to fluctuating environmental conditions, while pale mites are less adaptable to them. In the present study, most species agreed with his conclusion in the occurrence phases in succession. For example, *L. pallidum* is orange-
colored, *L. fuji* is orange but somewhat pale, and *L. kuroshio* is white. However, *G. saduski* is whitish-yellow, but recognized to be a pioneer. Although there may be tunnels under the ground in the early stage of succession, it may be worth confirming the ability of this species to live on the ground surface.

**Horizontal comparison of trombiculid structure in forest**

Few marked differences in the trombiculid structure were found among the forests of the five study areas (Fig. 9). This proved that a continuous distance of about 100 km was not enough to change the trombiculid structure. However, as mentioned in the results, differences appeared in some species. Moreover, area C lacked *L. kitasatoi*, and area E lacked *L. daisen, L. tanaka-ryoi, L. sp.*, and *L. murotoense*. Concerning area E, just facing the sea, including its fairly large amounts of *L. pallidum*, it might be possible to ascribe the special trombiculid structure to the harsh climatic environment.

**Vertical comparison of trombiculid structure in forest**

The trombiculid structure at over 500 m a.s.l. was distinct from that at the other altitudes (Fig. 10). The causes of this difference were the increased proportion of *L. tanaka-ryoi* and *L. daisen*, and the decreased proportion of *L. fuji* and *G. saduski*, corresponding with the altitude. Besides, *L. sp.* showed the same inclination in its distributional pattern as the two former species, and it disappeared below 200 m. In other species, clear changes were not found in relation to the altitude. The number of species differed from 13 (400–500 m, and above 500 m) to 19 (200–300 m), but there was no gradient corresponding with the altitude.

**Relationship between L. tanaka-ryoi and L. fuji**

*Leptotrombidium tanaka-ryoi* and *L. fuji* are morphologically allied to each other. Figure 11 shows the proportion (mean percentage) of each species to the total of both species, at intervals of 100 m a.s.l., in all the study sites that yielded either or both species. *Leptotrombidium fuji* was predominant at the low altitudes, while *L. tanaka-ryoi* was so at the high altitudes. At the middle altitudes, these species changed their dominance regularly, depending on the altitudes. This fact, especially the decreasing number of *L. fuji* in accordance with gaining altitude and its disappearance above 700 m a.s.l. (the altitude of the highest site that yielded *L. fuji* was 600 m), could not be explained only by the inherent characteristics of this species, since in other areas in Honshu (Takada et al., 1988; Uchikawa and Kuma-da, 1989), as well as in Kyushu (Yamamoto and Noda, 1995), *L. fuji* inhabits above 1,000 m. However, at those sites, *L. tanaka-ryoi* does not occur. When a restricted habitat (or niche) of a species is observed, and when, at the same time, the coexistence of another morphologically closely related species is detected, the phenomenon might be ascribable to an interspecific competition. I suppose there is competition between these species. However, the resources among which *L. tanaka-ryoi* and *L. fuji* are competing, and the reasons that one species prevails over the other according to the altitude, have not been clarified. In this connection, the possibility of another type of interspecific relation among trombiculid mites was suggested in relation to the attachment sites on the body of hosts (Uchikawa et al., 1984).

**Distribution of L. fukuoka and L. kitasatoi**

*Leptotrombidium kitasatoi* is widespread and abundant species in Japan, whereas *L. fukuoka* is indigenous to Kyushu, being predominant in northern Kyushu. These two morphologically very close species showed an allopatric distribution, though they were sympatric at several sites (Fig. 12). Although *L. kitasatoi* inhabited 90% of SF in area A, no special relationship was discovered be-
between this mite and SF, because the other main vegetation types, except SPF, provided also habitats for L. kitasatoi. Therefore, the occurrence of L. kitasatoi might be related to the location of its habitat. Although there is no data to demonstrate this distribution pattern, some speculations may be possible. If there is some interference between L. kitasatoi and L. fukuoka, this distribution pattern may be explained in two ways: (1) L. fukuoka is the native species, and L. kitasatoi is invading the habitats of L. fukuoka from the eastern side of this region; (2) L. kitasatoi is the native species, and L. fukuoka has been derived from L. kitasatoi in northern Kyushu, expelling the progenitor. It would be interesting to survey further the sites where the two species coexisted.

On the vectors of Tsutsugamushi disease

The vector species of Tsutsugamushi disease, L. pallidum and L. scutellare, especially the latter, showed a restricted distribution (Fig. 13). One reason why these vectors did not occur frequently in this region might be ascribable to the inclusion of relatively few grassland sites in this study. However, concerning L. scutellare, even if some habitats were discovered in the eastern area, considering the difficulty in collecting this chigger, it seemed certain that this region provided fewer habitats for this species. Excepting GL and SPF, L. pallidum inhabited 16 sites, corresponding to 16% of the forests. However, it could not be estimated whether these numbers were large or small, because of the lack of sufficient data from other regions for comparison.

The surroundings of Mt. Miyajidake (D14), where L. scutellare was collected along with L. pallidum, had been known as habitats of L. scutellare (Yamasaki, 1987) and as the only definite endemic focus of Tsutsugamushi disease in Fukuoka Prefecture (Kodera, 1996). In Fukuoka Prefecture, Tsutsugamushi disease is endemic on a small scale, not exceeding 10 patients a year, unlike the case of other prefectures in southern Kyushu. This small number of patients in this region may be attributed to the sparse distribution of the vector trombiculid mites, especially L. scutellare.

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I am grateful to Prof. T. Kanazawa, University of Occupational and Environmental Health, Japan (UOEH), and Prof. M. Shimada, Nagasaki University, former Professor of UOEH, for their valuable suggestions. I thank Dr. H. Suzuki, Nagasaki University, who identified a trombiculid species and provided materials for the study, and Dr. K. Uchikawa, Shinshu University, who provided materials for the study. Also I thank Mr. C.P. Carman, UOEH, for editing the English in this paper.

References


**摘要**

北部九州のツツガムシ相、および植生と地理的環境に関連した分布

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福岡県を主とする北部九州の123か所で小哺乳類を捕獲し、84,413個体のツツガムシを得た。他の採集方法も併用し、合計33種のツツガムシを確認した。優占植物や景観による植生タイプは、ツツガムシの群集構造からは、一般的な森林（スギ・ヒノキ林、二次林、常緑広葉樹林）、海岸クロマツ林、草原、山地落葉樹林の4種類に大別された。しかし各種植生タイプ内では、場所によるツツガムシ構造の違いも見られた。植物移動と関連させ、サダスツツガムシ（以下ツツガムシを省略）、タテ、フトゲなどから始まるツツガムシ群集構造の移動を推察した。2組の近縁種の分布、すなわちタナカリウムとフジの垂直分布と、フクオカとキタサトの水平分布から、ツツガムシどうしの種間関係の存在が示唆された。この地域では、つつが虫病の媒介者であるタテとフトゲの分布がやや限定されており（特に前者）、このことが北部九州と比較して患者数が少ない原因であろうと考えた。
Appendix  Study sites, botanical environment, host mammals, and trombiculid mites. The last word or abbreviation in the space for the site is City, Town, or Village. Asterisk means Oita Prefecture, otherwise Fukuoka Prefecture.

**Abbreviation**

<table>
<thead>
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<th>Site</th>
<th>ALT</th>
<th>Site number</th>
<th>Altitude above sea level</th>
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<td>Kokuraminami</td>
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<td>Wakamatsu</td>
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<tr>
<td>FK</td>
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<td>Fukuoka</td>
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**UOEH** University of Occupational and Environmental Health, Japan

**WP** Woodland path

**Vegetation type**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>EBF</td>
<td>evergreen broad-leaved forest</td>
</tr>
<tr>
<td>GL</td>
<td>grassland</td>
</tr>
<tr>
<td>MDF</td>
<td>montane deciduous forest</td>
</tr>
<tr>
<td>OF</td>
<td>other forest</td>
</tr>
<tr>
<td>SF</td>
<td>secondary forest</td>
</tr>
<tr>
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<td>seaside pine forest</td>
</tr>
<tr>
<td>ES</td>
<td>evergreen scrub</td>
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<tr>
<td>FL</td>
<td>farmland</td>
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<tr>
<td>RGL</td>
<td>riverside grassland</td>
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**Plant type**

| DBT | deciduous broad-leaved tree |
| EBT | evergreen broad-leaved tree |

**Plant species**

Aas  Aphananthe aspera (asiatic nettle-tree, mukanuki)

Ade  Acata decurrens (wattle, morishimaakashi)

Aja  Alinus japonica (alder, hannoki)

Ala  Actinodaphne lanceolata (Lauraceae, EBT, kagunoki)

Apr  Artemisia princeps (wormwood, yomogi)

Bni  Boehmeria nipponica (false nettle, karamushi)

Caja  Camellia japonica (camellia, yabustubaki)

Cca  Cinnamomum camphora (camphor tree, kusunoki)

Ccu  Castanopsis cuspidata (chinquapin, sudajii)

Cja  Cinnamomum japonicum (cinnamon, yabunikkei)

Cle  Celtis leveillei (hackberry, kobanochusen-enoki)

Cob  Chamaecyparis obtusa (cypress, hinoki)

Crj  Cryptomeria japonica (cryptomeria, sugi)

Dte  Daphniphyllum teijmannii (Daphniphyllaceae, EBT, himeyuzaitha)

Fcr  Fagus crenata (beech, buna)

Iin  Illex integra (holly, machinoki)

Lja  Litsea japonica (Lauraceae, EBT, hamabiwa)

Msa  Micanthus sacchariflorus (euralia, ogi)

Msi  Micanthus sinensis (euralia, susuki)

Mth  Machilus thunbergii (Lauraceae, EBT, tabunoki)

Nae  Neolitsea sericea (Lauraceae, EBT, shirodama)

Osa  Oryza sativa (rice, inu)

Pco  Phragmites communis (reed, ashi)

Pde  Pinus densiflora (Japanese red pine, akamatsu)

Ped  Paspalum edulis (Fagaceae, EBT, matebashi)

Phja  Phragmites japonica (reed, tsuruyoshi)

Pith  Pinus thunbergii (Japanese black pine, kuro-matsu)

Prja  Prunus jamasakura (cherry, yamazakura)

Pme  Podocarpus macrophyllus (podocarpus, inumaki)

Poth  Polygonum thunbergii (knotweed, misosoba)

Ppu  Phyllostachys pubescens (bamboo, mousouchiku)

Psl  Pleioblastus simonii (shrublike bamboo, medake)

Pto  Pittosporum tobrira (brisbane, tobera)

Qac  Quercus acutissima (oak, DBT, kunugi)

Qcr  Quercus crispula (oak, DBT, miunara)

Qgl  Quercus glauca (oak, DBT, arakashi)

Qse  Quercus serrata (oak, DBT, konara)

Raa  Raphanus sativus (radish, daikon)

Rsu  Rhus succedanea (sumac, hazenoki)

Sal  Solidago altissima (goldenrod, seita kawadachi so)

Sh  Sorghum halepense (sorghum, seiban morokoshi)

Su  Symplocos lucida (sweetleaf, kurik)

Tsi  Tsuga sieboldii (hemlock, tsuga)

**Host mammal species**

Aar  Apodemus argenteus

Asp  Apodemus speciosus

Esm  Eothenomys smithii

Mni  Micromys minutus

Mmo  Microtus montebelli

Mmu  Mus musculus

**Uta** Urotrichus talpoides

**Trombiculid species**

sad  Gahriepia saduski

dai  Leptotrombidium daisen

fuj  Leptotrombidium fujii

fuk  Leptotrombidium fukuoka

kit  Leptotrombidium kitasatoi

kur  Leptotrombidium kuroshio

mij  Leptotrombidium miyajimai

mur  Leptotrombidium murotoense

pld  Leptotrombidium pallidum

tan  Leptotrombidium tanaka-royi

koc  Miyotrombicula kochiensis

ika  Cheladonta ikaensis

jap  Neotrombicula japonica

kan  Leptotrombidium kansai

ktj  Ascoschoengastia kitajimai

Lsp  Leptotrombidium sp.

mii  Leptotrombidium miyairi

mit  Neotrombicula mitamurai

oka  Dolosia okabei

owu  Leptotrombidium owuense

plp  Leptotrombidium palpale

sct  Leptotrombidium scutellare

tar  Chalia taralis

tos  Leptotrombidium tosa
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<p>| B01 | Syoubudani Pond, Koishi, WM, KT | 110     | EBF             | Nse, Cija, Mth         | Asp(3)            |
| B02 | Oookimi, Yamaga, Ashiya        | &lt;10     | GL              | Sal, Msi, Pco          | Asp(1)            |
| B03 | Teragaura Pond, Honjou, Yn, KT | 20      | EBF             | Ccu, Cca, Slu          | Asp(1), Uta(2)    |
| B04a| UOEH Campus (a), Iseigaoka, Yn, KT | 10      | SF              | Ade, Aas, Prja         | Asp(24), Uta(1)   |
| B04b| UOEH Campus (b), Iseigaoka, YU, KT | 30      | SF              | Qse, Rsu               | Asp(3)            |
| B05 | Mt. Myojuingatsuiji, Eburi, Mizumaki | 30      | EBF             | Ccu, Cca, Mth          | Asp(1)            |
| B06 | Shimo-rengeji, Nakama          | 40      | EBF             | Cca, Cja               | Uta(2)            |
| B07 | Onga River, Dotenouchi, Nakama | &lt;10     | GL(RGL)         | Msa, Pco, Sal          | Mmu(5), Mmo(10)   |
| B08 | Kami-sokoino, Nakama           | 10      | EBF             | Ccu, Ppu, Cija         | Asp(7)            |
| B09 | Nishi River, Kizuki, Kurate    | &lt;10     | GL(RGL)         | Sal, Pco               | Mmu(2)            |
| B10 | Mt. Kongou, Kongou, Yn, KT     | 100     | CCF             | Crja                    | Asp(3), Arg(6)    |
| B11 | Onga River, Koyano, Yn, KT     | &lt;10     | GL(RGL)         | Sha, Msa, Sal          | Mmo(1)            |
| B12 | Inunaki River, Shimo-shinnyu, Noogata | &lt;10     | GL(RGL)         | Sal, Msa               | Mmu(1)            |
| B13 | Nakahata, Muroki, Kurate       | 40      | GL(F)           | Sal, Msi               | Mmi(1)            |
| B14 | Mt. Mutsugatake, Ryutoku, Miyata | 150     | CCF             | Crja                    | Asp(2), Arg(1), Uta(1) |
| B15 | Hikosan River, Shimozakai, Noogata | 10      | GL(RGL)         | Msa, Sha               | Mmu(1)            |
| B16 | Inunaki River, Tsuruda, Mitata | 10      | GL(RGL)         | Msa                    | Asp(2)            |
| B17 | Onga River, Akaji, Kotake      | 10      | GL(RGL)         | Sha, Msa, Psi          | Asp(3), Mmo(4)    |
| B18 | Kyuuragi, Seita, Kaita         | 80      | EBF             | Cca, Nse               | Asp(1), Arg(2), Uta(2) |
| B19 | Mt. Kawaradake, Gotoku, Kawara | 150     | CCF             | Cob, Crja              | Asp(2), Arg(4)    |
| B20 | Onga River, Rokutanbata, Kaita | 10      | GL(RGL)         | Sal, Sha               | Mmu(1)            |
| B21 | Onga River, Shin-izuku, Izukua | 20      | GL(RGL)         | Sal, Sha               | Mmi(1)            |
| B22 | Mt. Sekinoyama, Akamatsu, Shounai | 100     | CCF             | Crja, Cob              | Asp(4), Arg(1)    |
| B23 | Mt. Kanakuni, Inokuni, Tagawa  | 150     | CCF             | Crja                    | Asp(2), Arg(6)    |
| B24 | Hikosan River, Toyokawa, Soeda | 60      | GL(F)           | Sal, Msi               | Asp(2)            |
| B25 | Mt. Gajaku, Soeda, Soeda       | 150     | CCF             | Pde, Qse               | Asp(12), Arg(5), Uta(4) |
| B26 | Mt. Kumagahata, Kumagahata, Yama da | 300     | CCF             | Crja                    | Asp(4), Arg(2), Uta(1) |
| B27 | Ochiai, Ochiai, Soeda          | 200     | GL(RGL)         | Phja                    | Asp(1)            |
| B28 | Shiba, Pass, Ochiai, Soeda     | 400     | CCF             | Crja                    | Asp(2), Arg(5), Esm(3), Uta(2) |</p>
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