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Short communication

Preliminary survey of habitat use by *Sciurus vulgaris orientis* in a natural forest of Hokkaido Island, Japan

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The Eurasian red squirrel *Sciurus vulgaris* Linnaeus, 1758 is widely distributed in the northern part of Eurasian Continents, Sakhalin Island (Russia), and Hokkaido Island (Japan) (Gurnell and Wauters 1999; Wilson and Reeder 2005). The distribution area of this squirrel is widest of all the world's squirrel species (Gurnell 1987). In Russia, this squirrel occurs in boreal coniferous forests consisting of larch (*Larix*), pine (*Pinus*), and spruce (*Picea*) (Lurz et al. 2005).

The Hokkaido population of the Eurasian red squirrel is regarded as an endemic subspecies: *S. vulgaris orientis* (e.g., Imaizumi 1960). This subspecies occurs from lowlands to mountains (1,650 m) in Hokkaido (Takaragawa 1996). Ecological characteristics of *S. vulgaris orientis* living in forests isolated by agricultural and urban areas are reported (Lee and Fukuda 1999; Lee 2001, 2002). In urban areas, this squirrel frequently feeds cones of *Pinus koraiensis* (Lee 2002), which was introduced to Hokkaido by human activity (Maeda 1970; Miyaki and Miyaki 1980). In Hokkaido's original environments, however, the ecological characteristics of *S. vulgaris orientis* are little known. Therefore, this subspecies should be studied in its original habitats, such as the natural and mountainous forests of Hokkaido. Vegetation of Hokkaido's natural forests mainly contains *Abies sachalinensis*, *Picea jezoensis*, *Quercus mongolica*, *Betula* spp., and *Tilia japonica* (Tatewaki 1958; Horikawa 1976; Okitsu 2002). This is different from forests of northern Eurasia where *S. vulgaris* populations are extensive. *Abies sachalinensis*, which is confined to Hokkaido Island, the southern parts of Sakhalin Island, and the Kuril Islands (Satake 1989), is the most abundant conifer tree in Hokkaido's natural forests. Unlike the coniferous forests of northern Eurasia, several kinds of hardwoods account for 60% of the trees in Hokkaido's forests (Okitsu 2002). In this unique vegetation structure, there may be an association between *S. vulgaris orientis* distribution and forest type. Ognev (1966) described *S. vulgaris* in Russia as inhabiting coniferous forests containing spruce and pine. In south-central Sweden, this squirrel inhabits Norway spruce-dominated forests (Andrén and Delin 1994). In the natural forests of Hokkaido, therefore, this subspecies should prefer coniferous forests, even though hardwoods are more dominant. Here, we present preliminary results of microhabitat use by *S. vulgaris orientis* in the mountainous natural forests of Hokkaido.

Study area

This study was conducted in the University Forest in Hokkaido, The University of Tokyo, Furano, Hokkaido, Japan (43°10'–20'N, 142°20'–40'E). This forest has an area of 22,894 ha and is covered with natural mixed forests. It has abundant stands of *Abies sachalinensis* (44.75%), *Tilia japonica* (8.96%), *Acer mono* (7.98%), and *Picea jezoensis* (7.84%) (Yamamoto et al. 1995).

Methods

From May to October 2008 and February 2009, we randomly walked through the forest to find *S. vulgaris orientis*. Whenever we found squirrels, the site was recorded on the map (Fig. 1). We also used data of squirrel sightings in every season from 2005 to 2008 by staff of the University Forest in Hokkaido. During their work in the forest, the staff sometimes observed squirrel individuals in the forest (pers. com.). We considered these observations as randomly sampled data. Although squirrels are more active in early morning (Tonkin 1983), our surveys were 9:00 to 16:30, when the forest is open to the public. At each location reported to have

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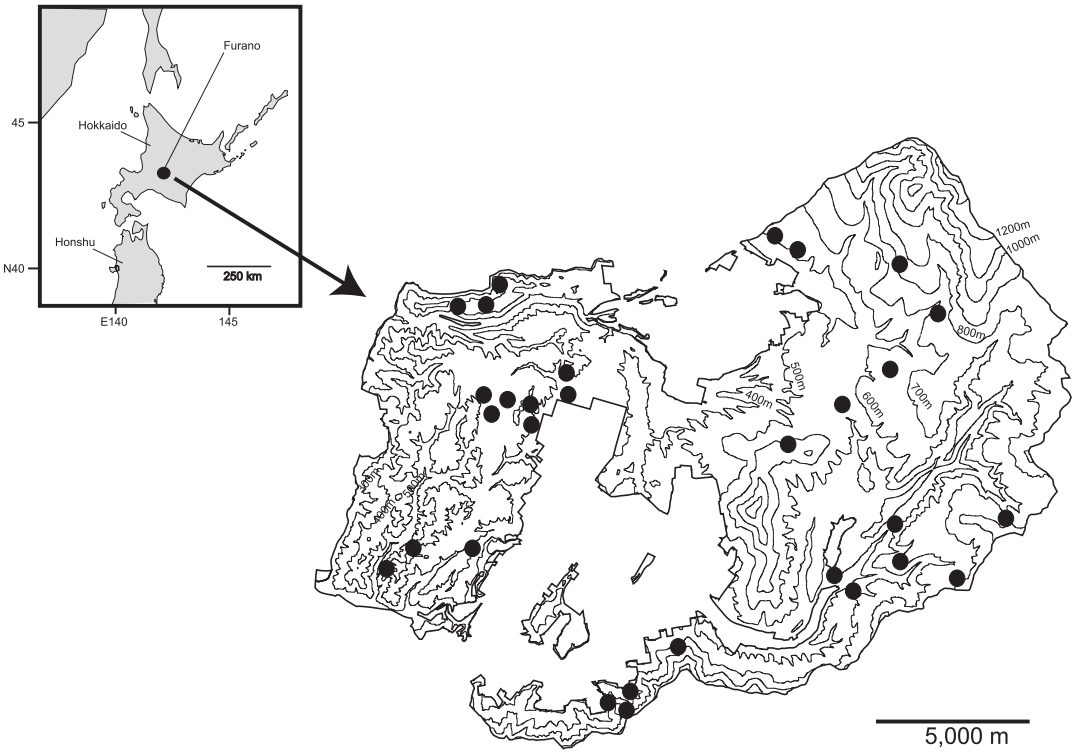

Fig. 1. Map of the sub-arctic mixed forest habitat in The University Forest in Hokkaido, The University of Tokyo, Furano, Japan showing 30 plots (closed circles) in which individuals *Sciurus vulgaris orientis* were observed on trees.

a squirrel, we set a circle plot (0.04 ha) according to James and Shugart (1970). The squirrel location was the center of the circle. In this plot, we counted all trees and recorded their species. Within one plot, any tree species with an abundance >20% was designated a dominant tree species. To weight plot data, each dominant tree was scored as +1, +2, or +3 based on abundance (21–30%, 31–50%, or >50%, respectively). To evaluate habitat use by squirrels, we compared the weighted plot data to data from Yamamoto et al. (1995) on tree abundance (%) within the University Forest. Spearman rank correlation assessed correlation between tree abundance within the forest and weighted dominance of tree species in squirrel plots.

Results and discussion

We found *S. vulgaris orientis* in a total of 30 locations (Fig. 1). In the 30 circle plots in these locations, we recorded 40 tree species (Appendix 1). Plots were categorized based on the abundant tree species (Fig. 2). Abundance scores for dominated trees totaled 79 (Fig. 2). The most dominant trees were *Abies sachalinensis*, *Picea jezoensis*, *Tilia japonica*, *Acer mono*, and *Salix* spp. in descending order (Fig. 2). Spearman's test showed that ranks of these tree species were negatively correlated with abundance of tree species in the entire forest ($r = –0.6$), although four of five tree species were commonly appeared in both ranks (Fig. 2). *Sciurus vulgaris orientis* used the most abundant forest trees. They did, however, seem to prefer conifers to hardwoods. Lee and Fukuda (1999) reported that coniferous forests were selected by *S. vulgaris orientis* in isolated lowland forests during the summer because these trees provided good food resources and ideal sites for building dreys. In fact, *S. vulgaris* feed on wide range of foods, but seeds are the most important part of their diet (Moller 1983; Gurnell 1987; Wauters et al. 1992). Pine seeds can provide food year round (Wauters et al. 1992). Stomach content analysis shows that pine seeds are the most important component of *S. vulgaris* diet (Grönwall and Pehrson 1984). Spruce and pine trees also provide nest-building resources (Wiegand 1995). We more frequently found squirrels in stands dominated by *Abies sachalinensis* or *Picea jezoensis* (Fig. 2 and Appendix 1). *Picea jezoensis* is ranked forth in the whole forest, but, *S. vulgaris orientis* were observed the second most frequently in *Picea jezoensis*-dominated forest. Although this squirrel may have adapted to the unique mixed forests of Hokkaido Island, it still showed a preference

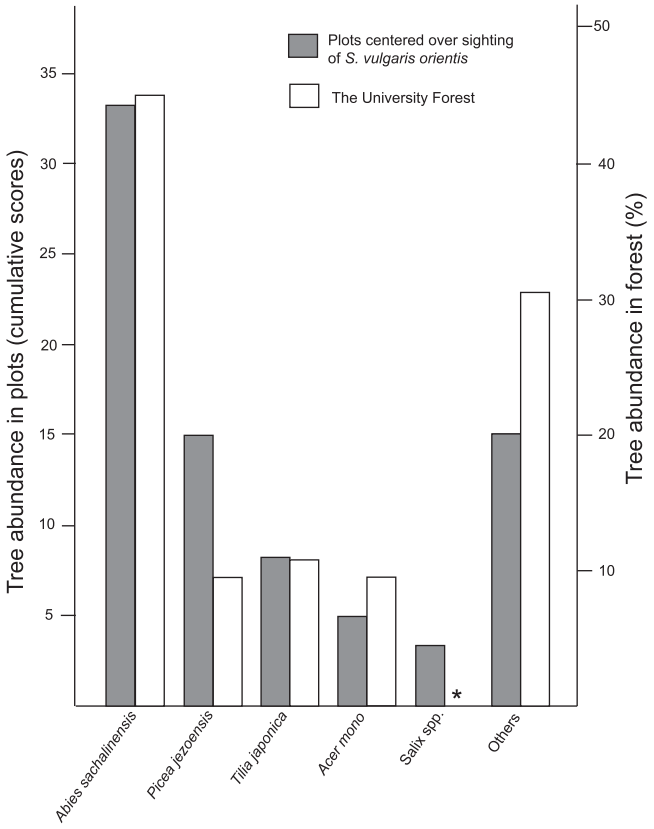

Fig. 2. Vegetation scores for most abundant trees in plots centered over sightings of *Sciurus vulgaris orientis* compared to overall relative abundance (%) of tree species in The University Forest in Hokkaido, The University of Tokyo, Furano, Japan. Tree abundance was scored in three levels: +1 (21–30% abundance), +2 (30–50% abundance), and +3 (>50% abundance). Relative abundance (%) of trees in the University Forest from Yamamoto et al. (1995). Asterisk shows unavailable data from Yamamoto et al. (1995), as they included the data into others.

for coniferous forests. To further understand the importance of this preference of *S. vulgaris orientis* in the Hokkaido's natural forest, we need information on food and nest resource preferences. Unfortunately, the frequency of observations (especially, in early morning) was insufficient in the present study. Therefore, there would be much room for improvement in investigation of habitat use by *S. vulgaris orientis*.

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Appendix 1.

Abundances of tree species found in the total study plots

Species	Number of trees/ha	% of total in plots	% of total in forest[a]
Conifers			
Abies sachalinensis	230.8	26.6	44.8
Picea jezoensis	92.5	10.7	7.8
Picea glehnii	2.5	0.3	1.8
Hardwoods			
Tilia japonica	90.8	10.5	9.0
Acer mono	83.3	9.6	8.0
Betula maximowicziana	35.0	4.0	1.8
Salix spp.	30.8	3.6	–
Tilia maximowicziana	29.2	3.4	–
Sorbus commixta	27.5	3.2	–
Acer japonicum	25.0	2.9	–
Quercus crispula	21.7	2.5	3.9
Magnolia obovata	18.3	2.1	–
Ulmus davidiana var. *japonica*	15.8	1.8	–
Betula ermanii	12.5	1.4	–
Prunus ssiori	11.7	1.3	–
Phellodendron amurense	10.8	1.2	–
Syringa reticulata	10.8	1.2	–
Ulmus laciniata	10.0	1.2	–
Magnolia kobus	9.2	1.1	–
Alnus hirsuta	8.3	1.0	–
Kalopanax pictus	8.3	1.0	2.9
Acer palmatum var. *matsumura*	7.5	0.9	–
Ostrya japonica	7.5	0.9	–
Prunus sargentii	7.5	0.9	–
Sorbus alnifolia	7.5	0.9	–
Fraxinus mandshurica	6.7	0.8	0.4
Styrax obassia	6.7	0.8	–
Cornus controversa	5.0	0.6	–
Prunus maximowiczii	5.0	0.6	–
Acanthopanax sciadophylloides	4.2	0.5	–
Taxus cuspidata	3.3	0.4	–
Betula platyphylla	2.5	0.3	–
Juglans ailanthifolia	2.5	0.3	–
Carpinus cordata	1.7	0.2	–
Crecidiphyllum japonicum	1.7	0.2	0.5
Fraxinus lanuginosa	1.7	0.2	–
Acer palmatum	0.8	0.1	–
Euonymus planipes	0.8	0.1	–
Viburnum furcatum	0.8	0.1	–
Dead snags[b]	8.3	1.0	–

[a]Data from Yamamoto et al. (1995); [b]tree species unidentified, bacause these did not have informative characteristics, such as leaf and bark.