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短　報
Note

Assessments of Seasonal and Sexual differences in Nest Site Selection by *Pteromys volans* in a Small Woodlot, Hokkaido, Japan

By

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Summary：We compared distances among used nests and available nests of seven Siberian flying squirrels (*Pteromys volans*) to understand their nest selection behavior in a small woodlot with limited nest resources. Distances of male and female did not significantly differ. This may be due to the fact that all the *P. volans* depended on nests only within the small woodlot and did not use any nests in nearby forests. Our results showed selectivity of nest sites in summer to autumn, because they used significantly short distance nests in snow-free season compared with available nests. Whereas, in snowy season, there was no significant difference between the mean distance among selected nest sites and that among available nest sites. It was suggested that the flying squirrel selects available nests nearby in the snow-free season, whereas in the snowy season they travel longer distances to use the rarer better nests in the small habitat. For conservation of the Siberian flying squirrel, multiple nests including the winter nest are necessary in a woodlot.

Key words：distance, nest, *Pteromys volans*, seasonal and sexual differences, small woodlot

1. Introduction

The Siberian flying squirrel (*Pteromys volans*) is widely distributed in the boreal forests from Finland to Far Eastern Asia including Hokkaido Island of Japan[1]. The necessity of broad leaved forest with food and nest resources is shown for existence of *P. volans*[2]. In addition, Siberian flying squirrels are known as an arboreal and nocturnal mammal that uses gliding locomotion to travel long distances. The limits on its practical gliding ability, however, prevent it from traveling in fragmented forests without assistance from intermediately placed trees[3]. Therefore, clear-cutting for land development and resultant forest fragmentation are causing a decline in flying squirrel populations. This also prevents flying squirrels from acquiring food and nest resources from forests, due to loss of forest area.

The use of multiple nests by the Siberian flying squirrel[4,5] and the northern flying squirrel (*Glaucomys sabrinus*)[6] is thought to be a strategy for avoiding the effects of ectoparasites and predators. In large forests, CAREY *et al.*[6] noted that males of the northern flying squirrel travel longer distances among nests than females ; however, the distances among nests used by *P. volans* in fragmented small habitats have hitherto not been studied. Besides, it is known that number and type of used nests and food habits differ between the snow-free season (August-November) and the snowy season (January-March)[5,7].

We predicted the following two results. One is that the distances among nests used by male would be longer than those by female, since male has larger home range than female. Another is that distances used in the snowy season would be shorter than those in the snow-free season, since *P. volans* shows low activity[8,9] and has a smaller home range in winter[10].

We would also be able to make allowances for the placing of nests for conservation purposes in the future if we had a knowledge of the distance among nests used by *P. volans*. Our aim in this study was to reveal the difference among nests used by *P. volans* and the distance among available nests in a small habitat with

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limited resources.

2. Material and methods

Our study area was a small woodlot in Obihiro, Hokkaido, Japan (3.1 ha ; 42° 52′ N, 143° 10′ E), occupied by broad-leaf trees such as *Betula platyphylla* var. *japonica* and *Quercus dentata*, and conifers such as *Abies sachalinensis* and *Larix leptolepis*. Tree height was mean 19 m in the woodlot. The woodlot is about 25 m from the nearest forest. Seven flying squirrels (two males and five females) were captured from nest boxes and cavities in August 2005–March 2006, and their sex and weight recorded. The flying squirrels were radio-tagged (Holohil Systems Ltd., Ontario, BD-2C : 1.8 g) and released at the capture site. Five female flying squirrels were proved, judging by the condition of their teats and belly, to be non-pregnant or non-nursing, (i.e., there were no indications that they were in a breeding state). The day following their release, we started daily observation of their nest sites during the day using a radio receiver with Yagi antenna (Yaesu, Tokyo, FT-290 mk II).

Nest locations used by flying squirrels were recorded by GPS (Garmin, Kansas, GPS76) in both the snow-free season (August–November) and the snowy season (January–March). Flying squirrels were tracked for 165 days and 80 days during snow-free season and snowy season. All the available fifteen nest resources (cavities, nest boxes, dreys) were also recorded in the small woodlot (Table 1). The available cavities were defined as cavities with diameter of over 3 cm, and with a depth which allowed *P. volans* to hide inside the cavity. We could not find more than one nest in any single tree. Using GIS (ESRI ArcGIS 9.2), distances between an available nest resource and other resources were measured for all the nest resources (Fig. 1).

For the actual distances travelled by flying squirrels, the distances from one nest to the next nest were measured (Fig. 1), because flying squirrels were tracked every day. Distances among all the nest resources were regarded as feasible distances among nests in the small woodlot, and were compared with the actual distances traveled by flying squirrels. We used a nonparametric statistical method (Mann-Whitney U test) for each comparison of sex and season, since our data showed a non-normal distribution.

3. Results

Seven flying squirrels used two to thirteen nest trees, respectively. These numbers include cases in which we were unable to identify the nest type but could record which tree it was in. All the flying squirrels used the nest resources in the small woodlot.

Table 1 Types of fifteen nest resources in a small woodlot. DBH of nest box trees was not measured.

No.	nest type	tree	height (m)	DBH (cm)
1	nest box	spruce	3.0	—
2	nest box	spruce	3.0	—
3	nest box	spruce	3.0	—
4	nest box	spruce	3.0	—
5	nest box	spruce	3.0	—
6	nest box	spruce	3.0	—
7	nest box	spruce	3.0	—
8	cavity	oak	1.2	40
9	cavity	oak	4.1	32
10	cavity	oak	1.7	36
11	cavity	oak	1.9	35
12	cavity	birch	5.8	32
13	drey	spruce	12.5	23
14	drey	spruce	12.9	28
15	drey	spruce	13.4	30

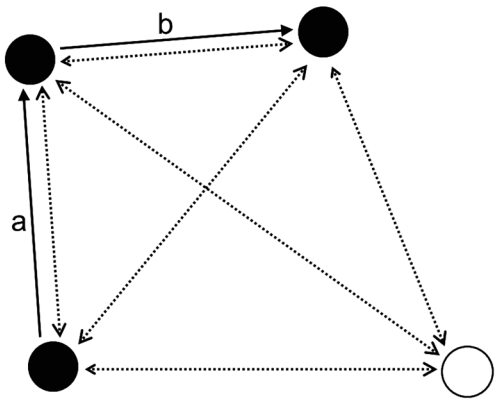

Fig. 1 Measurement of distance among used nests and among available nests. Black circle shows used nests by the flying squirrel, while white circle shows available nests (unused nests). Distances among used nests were measured according to the radio-tagged flying squirrel's pathway (solid lines ; a, b). Distances among available nests were the distances from one nest to the other nests (dotted lines). Distances were measured in all combinations.

Mean distance (±SD) of the seventy-nine trips among nests was 47.6 (±25.7) m. There was no significant difference between males and females ($P > 0.05$, $U = 498.0$; Table 2), although males (57.9±32.4 m ; n=21) traveled somewhat further than females (43.9±21.9 m ; n=58). We analyzed the pooled data for both sexes, therefore, in our comparison with the distance among available nests. The distance among nests was estimated in each season,

since the distances in the snow-free season (44.8 ± 24.2 m ; n = 57) were significantly shorter than in the snowy season (54.9 ± 28.3 m ; n = 22 ; P < 0.05, U = 57.0 ; Table 3). In both sexes, moreover, the mean distance in the snowy season (two males : 114.0 m, female : 49.0 ± 21.9 m) was longer than that in the snow-free season (male : 52.0 ± 27.9 m ; female : 41.3 ± 21.7 m). The daily frequencies of movements (total number of movements/total number of observation days) per squirrel in the snowy season (male : 0.08/day ; females : 0.20, 0.41, 0.34/day) were similar to those in the snow-free season (male : 0.29 ; females : 0.50, 0.35/day).

Distances among available nests in the small woodlot (75.4 ± 45.4 m ; n = 105) were significantly longer than those among the nests actually used by the seven flying squirrels (47.6 ± 25.7 m ; n = 79 ; P < 0.0001, U = 2608.0). Distances among used nests were significantly shorter than those among available nests in the snow-free season (P < 0.0001, U = 1715.5). There was no significant difference between used nests and available nests in the snowy season (P > 0.05, U = 892.5 ; Table 3).

We categorized distances among nests into six classes in units of 20 m, since the snow-free season and snowy season distances ranged from 9.0 to 113.0 m and 6.0 to 114.0 m, respectively (Fig. 2). Concerning the distances traveled among nests, the snow-free season had the most examples in the 20–40 m class (27 cases), with the 20–60 m categories accounting for 75.4% of all cases ; the snowy season had the most cases in the 40–60 m class (8 cases) with the 40–80 m categories accounting for 68.2% (Fig. 2). The distance among nests in the snow-free season tended to be shorter than in the snowy season (P < 0.05, U = 421.0), although there was wide variation in distance. Among available nests, most cases were in the longer-than-100 m class for distance, with a fairly even distribution for the other distances.

4. Discussion

The Siberian flying squirrels we tracked are likely to be permanent inhabitants of our study woodlot, since they used nests only within the woodlot. Males of the northern flying squirrel move longer distances among nests than females to contact with more females[6,11,12]. Our results, however, showed no significant differences between males and females, although males moved longer distances than females. The mean distance among nests of *P. volans* (male : 57.9 m, female : 43.9 m) in this small woodlot was shorter than that of the northern flying squirrel (male : 114–212 m, female : 86–107 m)[6] in large forests (13–20 ha). This may be due to the fact that all the *P. volans* depended on nests only within the small woodlot and did not use any nests in nearby forests. The reason appears to be that the distance (25 m) between our study woodlot and the nearest forest is greater than the distance (20 m) of most glides[3].

It was suggested that *P. volans* selectively uses nests

Table 2 Mean distances (m) among nests used by male and female *P. volans*

	N	Mean	SD	Range	Results of statistical test
Male	21	57.9	32.4	11.0-114.0	P > 0.05
Female	58	43.9	21.9	6.0-113.0	
All individuals	79	47.6	25.7	6.0-114.0	

Table 3 Mean distances (m) among nests used by *P. volans* and available nest resources

	Mean	SD	Range	Results of statistical tests
Snow-free season	44.8	24.2	9.0-113.0	P > 0.05
Snowy season	54.9	28.3	6.0-114.0	P < 0.0001
Availability	75.4	45.4	6.0-218.0	

Table 4 Frequencies* and mean distances of movement by each *P. volans*

I. D.	Sex	Season	Movement	Distance (m)	
			Daily Frequency	Mean	Range
1	F	snow-free	0.50 (10)	34.4	9 - 71
2	M	snow-free	0.29 (19)	52.0	11-113
3	F	snow-free	0.35 (28)	60.5	25-113
4	F	snowy	0.20 (1)	53.6	15 - 70
5	F	snowy	0.41 (9)	42.4	6 - 61
6	F	snowy	0.34 (10)	61.0	61
7	M	snowy	0.08 (2)	114.0	114

*: number of movements / number of observation days.
Numbers in parenthesis indicate number of movements.

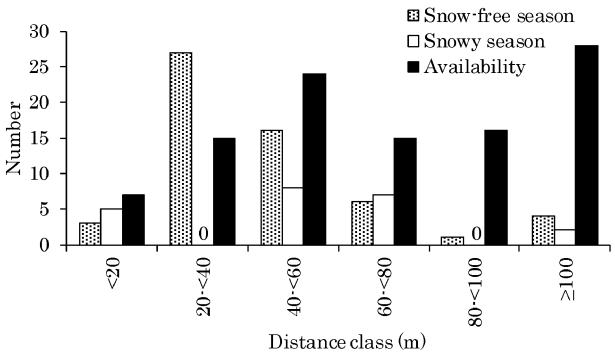

Fig. 2 Numbers in each category of distances among nests used by *P. volans* in two seasons and available nest resources

at shorter distances from other nests, since the distance among used nests in the snow-free season was significantly shorter than that among available nests. Asari and Yanagawa[10] showed that mean home range of *P. volans* in the snowy season (1.52 ha) was smaller than that in the snow-free season (5.86 ha), due to a decline in their activity. We therefore presumed that the Siberian flying squirrel selects closer nests in the snowy season than in the snow-free season. Contrary to our prediction, however, Siberian flying squirrels in the snowy season traveled to more distant nests than in the snow-free season (Table 2). Categorizing the distances also showed that the lower limit of the most frequently traveled distance in the snowy season (40 m) was greater than that in the snow-free season (20 m). It was revealed that the Siberian flying squirrel in small habitats traveled to more distant nests in the snowy season than in the snow-free season. Asari and Yanagawa[7] investigated nest site used by the Siberian flying squirrel in both the snow-free and snowy season, and revealed that the Siberian flying squirrel uses specific cavities and dreys in the snowy season. The northern flying squirrel[6] and the southern flying squirrel (*Glaucomys volans*)[13] appear to need suitable nests in the snowy season due to the lower temperatures, since they share a nest as a group in winter to reduce their energy consumption. It was previously thought that cavity used by the Siberian flying squirrel was affected by the vertical depth of the cavity, since groups of flying squirrels also share nests in the winter[14]. However, cavities of this type are rare. Concerning available nests in the small woodlot, therefore, we suggest that the Siberian flying squirrel selects available nests nearby in the snow-free season, whereas in the snowy season they travel longer distances to use the rarer better nests that are dispersed further apart in the woodlot (Table 4).

In conclusion, there was no difference of distance among nests that male and female used in the small woodlot. Our study also shows that *P. volans* selectively used nests at shorter distance in snow-free season, and used more distant nests in snowy season because of cavity scarcity in the small wood.

It is known that a Siberian flying squirrel have several nests including cavity, nest box and drey[4,7]. In particular, they use the specific nest in winter[4,14]. The Siberian flying squirrel is also affected by forest fragmentation, because the flying squirrel don't walk on the ground except for dropping. For conservation of the Siberian flying squirrel, therefore, multiple nests including the winter nest are necessary in a woodlot, and connectivity with adjacent forests is important for improving the gene flow.

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狭小森林に生息するタイリクモモンガ *Pteromys volans* による巣場所選択における季節的および性的違いの評価

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要約：われわれは巣資源が限られた狭小森林において，タイリクモモンガ（*Pteromys volans*）の巣場所を選択の行動を理解するため，7 個体によって利用された巣と利用可能な巣の巣間距離を比較した。雄と雌の距離は有意に異ならなかった。これは，すべての個体が狭小森林内にある巣だけを利用し，近隣のどの巣も利用しなかったためかもしれない。タイリクモモンガが利用可能な巣と比べて有意に近い距離にある巣を非積雪期に利用したため，われわれの結果は夏～秋での巣場所選択性を示した。一方，積雪期には，利用された巣間の距離と利用可能な巣間の距離に有意な差はなかった。これは，タイリクモモンガが非積雪期に近くの利用可能な巣を選択する一方で，積雪期には数少ない良質の巣を利用するために遠くまで移動したためであると示唆された。特に，タイリクモモンガの保全にあたっては，冬季の巣を含む複数の巣の存在が森林内に不可欠である。

キーワード：距離，巣，*Pteromys volans*，季節および性差，狭小森林

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