Mammal Study 41: 97–100 (2016)

Short communication

A preliminary study of communal nesting of Siberian flying squirrels *Pteromys volans* in Japan

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Abstract. To maintain local populations of the Siberian flying squirrel *Pteromys volans* in restricted small habitats, it is necessary to understand their nesting and food biology. Communal nesting of *P. volans* is well documented in the Eurasian continent, but the details of this behavior have been poorly investigated in Japan. We investigated a group composition of *P. volans* in Hokkaido, Japan. The mean numbers of individuals using each nest box and tree cavity were 2.17 and 2.44, respectively. Although each female had its own exclusive home range, communal nesting composed by two females was observed in nest boxes. This result suggested that females frequently used nest boxes and formed same-sex groups in urban areas where nest resources might be scarce. Communal nesting of *P. volans* was found in both nest boxes and cavities with seasonal difference, and cavities were mainly used in winter. Communal nesting of *P. volans* in Japan may be associated with reproduction, because most cases of communal nesting were composed of one male and one female. To conserve local population of the Siberian flying squirrel, the preservation of cavities, which are usable for more than two individuals, is needed to enable them to breed stably and overwinter safely.

Key words: cavity, communal nesting, nest box, *Pteromys volans*, urban area.

Forest fragmentation and habitat destruction caused by land modification affect the movement of gliding mammals that have developed arboreal adaptations (Lampila et al. 2009). Defragmentation is therefore an important issue for their conservation. Indeed, in order to mitigate negative effects of road construction and habitat fragmentation on arboreal mammals, artificial poles have been installed to help squirrel gliders *Petaurus norfolcensis* (in Australia) and Siberian flying squirrels *Pteromys volans* (in Japan) to glide over roads (Asari and Yanagawa 2008a; Soanes et al. 2013). To conserve their local populations, improving habitat quality (e.g., nest and food supplies) and understanding their behavior in fragmented landscapes are important.

Communal nesting, by which multiple individuals share a nest, has been interpreted as thermoregulation or breeding strategy (Ebensperger 2001; Edelman and Koprowski 2007). It allows them to save energy for thermogenesis and provides breeding benefits for male individuals, and therefore some tree squirrel species engage in communal nesting (e.g., Abert's squirrel *Sciurus aberti*, Edelman and Koprowski 2007; the red squirrel *Tamiasciurus hudsonicus*, Williams et al. 2013; and the southern flying squirrel *Glaucomys volans*, Reynolds et al. 2009, Thorington and Weigl 2011).

The Siberian flying squirrel is distributed in boreal forests from northern Finland south to the eastern shores of the Baltic Sea and eastward to Chukotka and to Hokkaido, Japan (Thorington et al. 2012). This species is known to form communal nest during winter (Selonen et al. 2014). It has been reported that Siberian flying squirrels living in the Eurasian continent form aggregations of two or three individuals in a nest (Selonen et al. 2014), whereas the fact of communal nesting of flying squirrels living in Japan have not been clarified. The fragmentation and degradation of their habitat caused by road construction, residential development, and expansion of farmland areas are concerns of recent years in Japan. Elucidating the communal nesting status of this species in Japan will help us to conserve local population by improving their reproduction and overwintering.

To determine the group composition of communal

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nests of Siberian flying squirrels in Japan, we conducted field surveys by capturing them in cavities and nest boxes in Hokkaido, Japan.

Methods

Study area and methods

The study was conducted in forests near residential areas and meadows in eastern Hokkaido, Japan from June 2002 to March 2008. The forests ranged from 1.7 to 13 ha in area and were fragmented by roads, buildings, and meadows (42°51–42°53'N, 143°09'–143°10'E). The forests consisted of conifers such as *Pinus koraiensis*, *Picea glehnii*, and *Abies sachalinensis* and broadleaf trees such as *Betula platyphylla* var. *japonica* and *Quercus dentata*.

Study sites, which include 28 cavities and 64 nest boxes, were checked at least twice a month. Nest boxes were made of wood following Yanagawa (1994). Entrance dimension of a nest box was 4 cm by 4 cm, and inside dimension was 11 cm by 16 cm by 20 cm. Use of cavity nests by flying squirrels was observed with a fiberscope; when flying squirrels were found inside we placed a trap that we had designed at the cavity entrance (Asari 2015). Use of nest boxes was confirmed by observation of the insides of the boxes, and the number of individuals inside each nest, and their sex, age (adult, sub-adult, or young), and weight were recorded. For age classification we followed the method of Yamaguchi and Yanagawa (1995).

To avoid bias associated with the aggregation of offspring (i.e., sub-adults before dispersal) and families (i.e., both adults and young), only data on adult individuals were used to determine the composition of communal nests.

Results

A total of 150 individuals were captured during the study period. Communal nesting was found in 15 nest boxes and nine cavity nests, and single nesting was found in 115 cases (single use by an adult or sub-adult). Adult-only groups were found in 12 of the nest boxes and in three of the cavities (Table 1). Of nine cavity groups, all individuals were not captured in six groups, and the sex of these individuals therefore remained uncertain. This may be because they lowered activity levels and randomly active over a short period of time in mid-winter (Yamaguchi and Yanagawa 1995). For these six groups, the composition of each group was either "an adult male with an indi-

Table 1. Communal nesting in nest boxes and cavities by Siberian flying squirrels in Japan

Group	Nest type	Individuals in a nest				Capture season
		Total	Male	Female	Unknown	
NA	Nest box	3	1	2		Snow-free season (Sep.)
NB	Nest box	2	1	1		Snow-free season (Oct.)
NC	Nest box	2		2		Snow-free season (Oct.)
ND	Nest box	2	1	1		Snow-free season (Oct.)
NE	Nest box	2	1	1		Snow-free season (Nov.)
NF	Nest box	2	1	1		Snow-free season (Jun.)
NG	Nest box	2	1	1		Snow-free season (Oct.)
NH	Nest box	2	1	1		Snow-free season (Nov.)
NI	Nest box	2	1	1		Snow-free season (Apr.)
NJ	Nest box	2	1	1		Snow-free season (Nov.)
NK	Nest box	2	1	1		Snowy season (Mar.)
NL	Nest box	3	1	2		Snowy season (Dec.)
CA	Cavity	2	1	1		Snowy season (Jan.)
CB	Cavity	2	1	1		Snowy season (Dec.)
CC	Cavity	2	1		1	Snowy season (Jan.)
CD	Cavity	2	1		1	Snowy season (Jan.)
CE	Cavity	4	1	2	1	Snowy season (Feb.)
CF	Cavity	2	1		1	Snowy season (Feb.)
CG	Cavity	2	1		1	Snowy season (Feb.)
CH	Cavity	3	2	1		Snowy season (Feb.)
CI	Cavity	3	1	1	1	Snowy season (Mar.)

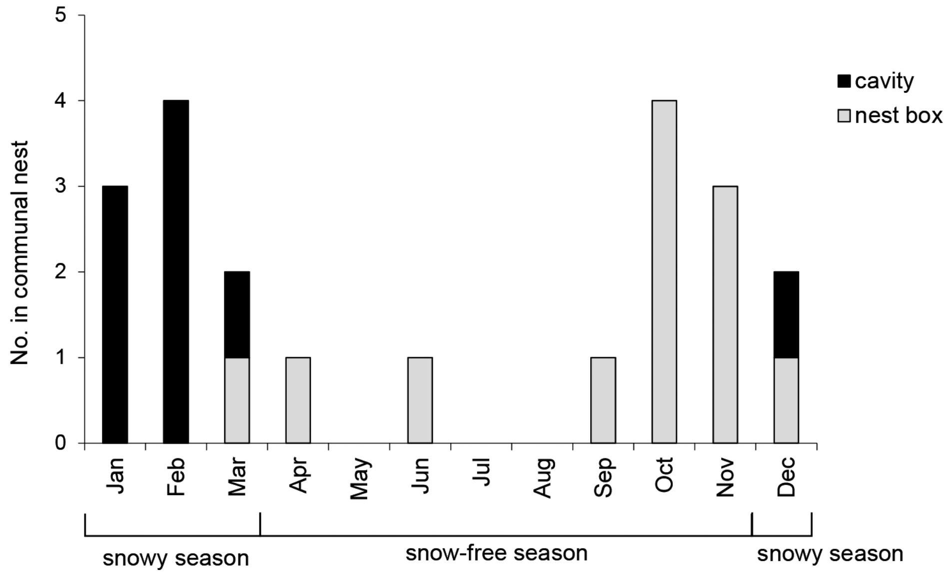

Fig. 1. Seasonal changes in communal nesting. Open and solid bars indicate the use of nest boxes and cavities, respectively.

vidual of unknown sex" or "adult male and female with an individual of unknown sex." We considered that the unknown individuals were adults, for the following two reasons. First, their body sizes were similar to those of the other adult individuals, as determined by the fiberscope observations. Second, they were found in winter after dispersal. Thus, data on all nine communal nests in cavities were used to estimation of communal nesting.

We found two or three individuals (mean ± *SD*; 2.17 ± 0.39, $n = 12$) in each nest box. Of the 12 adult communal nest groups, only two were found in the snowy season (December and March, Fig. 1). Individuals of two to four (mean ± *SD*; 2.44 ± 0.73, $n = 9$) in the cavities were found only in the snowy season (Fig. 1). The number of individuals per communal nesting was not different between nest boxes and cavities (*t*-test, $P > 0.05$).

In the nest boxes, communal groups composed of one male and one female were most commonly found, while group composed of one male and two females were found only two boxes. As for the cavity nest, there were two types of communal group, one male with one female or two males with one female, in the three cavities (CA, CB, and CH) in which the sexes of all individuals could be identified. The overall sex ratio (male:female) of the communal groups using nest boxes was 1:1.4, whereas that of groups using cavities was 1:0.8. The sex ratio of communal groups using the cavities was calculated by using the data from cavity CA, CB, and CH.

Discussion

Our findings suggested that the numbers of individual Siberian flying squirrels using each nest box or cavity nest at our study site were the same as in the study in Finland (two to three individuals; Selonen et al. 2014). The Siberian flying squirrel forms smaller aggregations than the Southern flying squirrel (*Glaucomys volans*) (mean 7.2 adult individuals: Layne et al. 1994; mean 3.7: Reynolds et al. 2009). This difference might reflect species-specific traits (e.g., exclusiveness or cooperation with neighbors) or density differences among habitats. Our study also showed seasonal differences in nest type used by Siberian flying squirrels in Japan. They likely selected cavities in winter, probably because cavities were warmer than nest boxes (Asari and Yanagawa 2008b; Nakama and Yanagawa 2009).

Female–female groups were rare and found only in nest box type. In the case of cavity nests, the sample size of nests which we were able to identify the sex of all occupants was small (three). In general, each female Siberian flying squirrel in Japan has its own exclusive home ranges, whereas the home ranges of males overlap with those of other males (Asari et al. 2006). In spite to this rule, we found four cases of more than one adult females sharing one nest box (including cases of two females with one male). In Finland, female–female groups and females with male groups have been found only during the snowy season (Selonen et al. 2014), whereas we found them during both the snow-free and the snowy seasons. This might be because females frequently used nest boxes and formed same-sex groups without exclusion in cases where better nest resources (i.e., cavities) were scarce in urban green spaces such as those at our study site.

Communal nesting of Siberian flying squirrels in Japan was found throughout the year: nest boxes were used mainly from spring to autumn and cavities were used in winter (Fig. 1). Communal groups consisting of one male and one female were the most common in Japan. This suggests that communal nesting of Siberian flying squirrels in Japan may be motivated primarily by reproduction, as is the case in Finland (Selonen et al. 2014). Further studies are needed to prove the relationship between communal nesting and reproduction.

In conclusion, Siberian flying squirrels in Japan formed communal nesting of two or more individuals. Asari and Yanagawa (2008b) reported that flying squirrels used several types of nests (nest boxes, cavities, and dreys), and that cavity was the most important nest because of their usability throughout the year. Moreover, it is reported that, in winter, Siberian flying squirrels particularly use cavities that have the capacity to fit several individuals (Nakama and Yanagawa 2009). To conserve local population of the Siberian flying squirrel, the preservation of cavities, which are usable by more than two individuals, is needed to enable them to breed stably and overwinter safely.

Acknowledgments: We thank students of Laboratory of Wildlife Ecology, Obihiro University of Agriculture and Veterinary Medicine for helping with the field research. We also thank Miss Aya Asai for English proofreading of the manuscript.

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Received 5 November 2015. Accepted 25 March 2016.
Editor was Takuya Shimada.