

Seasonal Characteristics of Fecal Sites of the Siberian Flying Squirrel *Pteromys volans*

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Abstract

Characteristics of fecal sites of the Siberian flying squirrel *Pteromys volans* was analyzed based on 132 sites of total 19 places. The fecal sites were more frequently found in winter (43.9%), and then followed by autumn (27.3%), spring (23.5%), and summer (5.3%). With the exception of summer, the fecal sites were more frequently found at the root collar than on the forked tree ($p < 0.01$). Among 132 fecal sites, 88 sites (66.7%) were found on the root collars and the other 44 sites (33.3%) were posited in the forked trees. Brown or red clay pellets were found at 44 fecal sites (33.4%) and 43 fecal sites (32.6%), and then black and yellow pellets were at 22 fecal sites (16.7%) and 19 fecal sites (14.3%), respectively. Green pellets were rarely found only at 4 sites (3.0%). Feces tend to have bright colors (brown, red clay and yellow) in winter and black in summer. Fecal sites with yellow pellets were much less found in all of the three seasons with the exception of winter, but highly increased in 25.4% in winter. The fecal sites with brown (33.4%) and red clay pellets (32.6%) were most frequently found through the four seasons.

Key Words: flying squirrel, *Pteromys volans*, endangered species, feces, natural monument

Introduction

The flying squirrel *Pteromys volans* is an endangered species (National Institute of Biological Resources 2017) and natural monument 328 in South Korea (Cultural Heritage Administration 2017). The species is distributed over wide range from Finland to Eurasia (Ognev 1966; Hanski and Selonen 2009; Jackson and Schonten 2012) and lives heavy natural forests or artificial forests of over 20 year ages. With the exception of Jeju-do and Ulreung-do, the flying squirrels are found in most of South Korean mainland (Yoon et al. 2004; National Institute of Biological Resources 2017).

The flying squirrels prefer mixed forests with dominant broad leaf trees, which are able to provide seasonally enough

foods and cover. The flying squirrels tend to excrete under their food trees or cave trees (Airapetyants and Fokin 2003). Thus, the flying squirrels appear to use the feces for their territorial marking like otters or weasels (Kruuk 2006; Han and Yoon 2012). In this study, we investigated fecal excretion behavior of the flying squirrels, including fecal color and fecal sites which are preferred according to seasons.

Materials and Methods

Fecal survey of flying squirrels was conducted over wide range of South Korean forests during the period of 2009 to 2014. To find traces of the flying squirrels, their feces or caves were investigated by walking along mountainous valleys or ridges. Seasons were discriminated as spring (March

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to May), summer (June to August), autumn (September to November) and winter (December to February of next year). Position of the fecal sites was indicated by the root collar which is contact point of tree trunk and ground and by the forked tree which is branch point of tree trunk on ground. Fecal color was categorized into five colors (black, brown, red clay, green, and yellow) and analyzed in relation to the seasons.

Results and Discussion

Sample collection

Feces of flying squirrels were found in 132 sites of total 19 places, including 9 places (Yanggu, Inje, Yangyang, Hoengseong, Pyeongchang, Wonju, Jeongseon, Samcheok and Yeongwol) in Gangwon province, 4 places (Pocheon, Dongducheon, Yangju and Yangpyeong) in Gyeonggi province, 4 places (Uljin, Mungyeong, Sangju and Ulju) in Gyeongsangbukdo province, one place (Danyang) in Chungcheongbukdo province and one place (Jeongeup) in Jeollabukdo province.

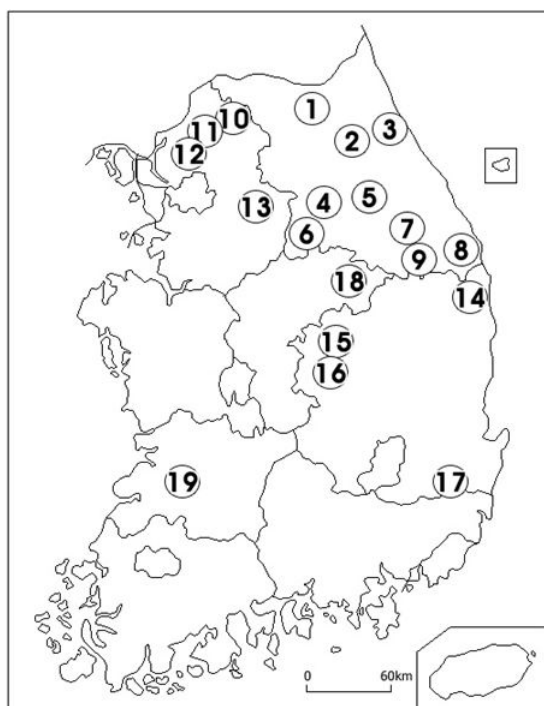


Fig. 1. Study areas (1; Yanggu, 2; Inje 3; Yangyang, 4; Hoengseong, 5; Pyeongchang, 6; Wonju, 7; Jeongseon, 8; Samcheok, 9; Yeongwol, 10; Pocheon, 11; Dongducheon, 12; Yangju, 13; Yangpyeong, 14; Uljin, 15; Mungyeong, 16; Sangju, 17; Ulju, 18; Danyang, 19; Jeongeup).

Table 1. The fecal sites were sorted according to seasons and collection localities

Season	Gangwondo									Gyeonggi-do				Gyeongsangbukdo				Ulsan		Chung-cheong -bukdo		Jeolla-bukdo		Total
	Yang-gu	Yang-yang	Hoeng-seong	Pyeong-chang	Won-ju	Jeong-seon	Sam-cheok	Yeong-wol	Po-cheon	Dong-ducheon	Yang-ju	Yang-pyeong	Uljin	Mun-gyeong	Sang-ju	Ulju	Danyang	Jeongeup	Jeongeup					
S	-	3	1	11	1	3	1	-	-	-	-	4	-	-	1	1	5	-	-	31				
Su	1	-	2	1	-	1	0	-	-	-	-	-	-	-	-	-	-	-	-	7				
A	1	1	0	2	3	2	5	3	-	-	-	-	3	1	-	2	9	-	-	36				
W	-	-	11	3	-	0	2	-	-	26	4	-	-	-	-	11	-	-	1	58				
Total	2	4	14	17	4	6	8	3	2	4	4	4	3	1	1	14	14	1	1	132				

S, Spring; Su, Summer; A, Autumn; W, Winter. -, were no data; 0, no excrement.

Jeollabuk province, respectively (Fig. 1).

The fecal sites were sorted according to seasons and collection localities (Table 1). Of 132 fecal sites, 60 sites were found in Gangwon province, where the fecal sites were most frequently found, and then 38 sites were in Gyeonggi province (Table 1). In a previous study (Jeon et al. 2014), based on data of the 3rd National Nature Environment Survey (2006-2010), the fecal sites of the flying squirrels were mainly found in the Baekdu mountains (also called Baekdudaegan). Our data also showed that the fecal sites of the flying squirrels were more frequently found in the Baekdudaegan. The reason might be probably because the forests of the mountains have been protected relatively well than other regions by Baekdudaegan Protection Act since 2003.

Seasonal change of fecal frequency

Fecal sites were more frequently found in winter (43.9%), and then followed by autumn (27.3%), spring (23.5%) and summer (5.3%) (Fig. 2). The reason why the

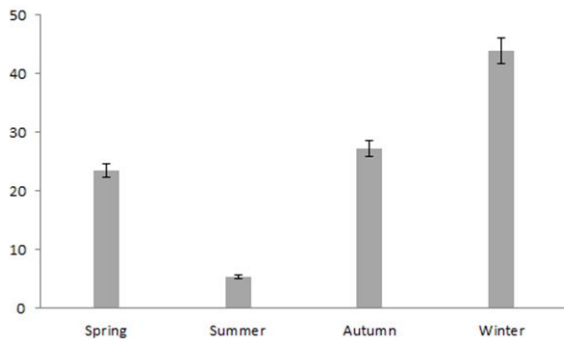


Fig. 2. Seasonal frequency of the flying squirrel fecal sites found during field surveys.

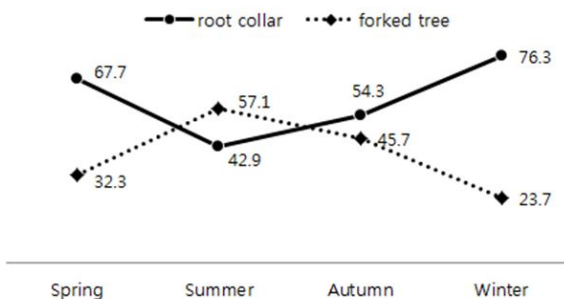


Fig. 3. Seasonal change in positioning of the flying squirrel fecal sites.

fecal sites were less found in summer appears probably to be related to the breeding. In Europe, the flying squirrels breed twice a year. The first breeding occurs between late April and May, and then the young are independent from their parents after around two months from their birth (Airapetyants and Fokin 2003). The flying squirrels have their second breeding of the year between late July and mid-August (Hanski et al. 2000; Jackson 2012). Thus, because of their offspring breeding, moving time and range of the flying squirrels might be relatively limited in summer compared with the other seasons, resulting in lower findings of the fecal sites during the surveys. In winter, one of main food sources of the flying squirrels is winter buds of trees (Hanski et al. 2000; Airapetyants and Fokin 2003; Hanski and Selonen 2009). Since kinds of food sources and their amounts are relatively less in winter than the other seasons, they might extend their territory to more trees which are able to be used as food source, resulting in more findings of fecal sites.

Seasonal change in position of fecal sites

Fecal pattern or habit of the flying squirrels is one of indirect indicators showing their activity and population size (Airapetyants and Fokin 2003). With the exception of summer, the fecal traces were more frequently found at the root collar than on the forked tree ($p < 0.01$) (Fig. 3). Among 132 fecal sites, 88 sites (66.7%) were found on the root collars and the other 44 sites (33.3%) were posited in the forked trees. In summer, the fecal sites were more found on the forked trees (57.1%) than at root collar (42.9%). In

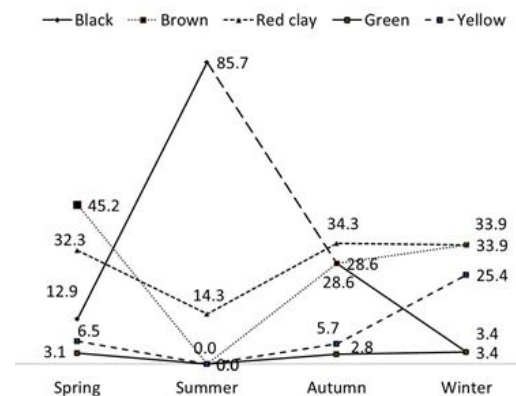


Fig. 4. Seasonal change of the flying squirrel feces color.

this survey, only 7 fecal sites were found in summer and used for position analysis of fecal sites. Thus, more samples should be added for understanding the positioning of the summer fecal sites on trees.

Seasonal change of feces color

Fecal pellets of the flying squirrels are average size of 2.7 mm in diameter (Woo et al. 2013) and found in piles around trees. Fecal pellets were able to be categorized into the five color types of black, brown, red clay, green and yellow and their color was analyzed in relation to the seasons. Among the fecal pellets of total 132 sites, brown or red clay pellets were found at 44 sites (33.4%) and 43 sites (32.6%), and then black and yellow pellets were at 22 sites (16.7%) and 19 sites (14.3%), respectively. Green pellets were found only at 4 sites (3.0%) (Fig. 4).

Fecal sites with brown pellets in spring (45.2%), black pellets in summer (85.7%), red clay pellets in autumn (34.3%), and brown or red clay pellets (33.9%) in winter were more frequently found, respectively (Fig. 4). Feces tend to have bright colors (brown, red clay and yellow) in winter and blacken in summer. Fecal sites with yellow pellets were much less found in all of the three seasons with the exception of winter, but highly increased in 25.4% in winter.

Of the five colors, the fecal sites with brown (33.4%) and red clay pellets (32.6%) were most frequently found through the four seasons. When it has been a long time after brown or red clay color, their colors became a little de-colored with appearance of fungus-caused white spots, and then finally became grey-colored after more time.

In conclusion, characteristics of fecal sites of the flying squirrel *Pteromys volans* was analyzed based on 132 sites of total 19 places. Fecal sites were more frequently found in winter, and then followed by autumn, spring, and summer. With the exception of summer, the fecal traces were more frequently found at the root collar than on the forked trees in the other three seasons. Fecal sites with brown or red clay

pellets were commonly found, but ones with green pellets were rare. The fecal sites with brown and red clay pellets were most frequently found through the four seasons.

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