

# Habitat use of reintroduced Long-tailed Gorals (*Naemorhedus caudatus*) in Woraksan (Mt.) National Park in Korea<sup>1</sup>

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## ABSTRACT

This study aimed to analyze characteristics of the seasonal habitat use of reintroduced Long-tailed Gorals (n=7) in Woraksan (mountain) National Park. We collected 10,721 goral coordinates in Woraksan (mountain) National Park via transmitters, and analyzed habitat use (e.g., aspect, distance from stream and road) from November 2006 to January 2013. Aspect use was southwest (22.6 %), and seasonal aspect use had a southwestern slope (in the spring, summer, and autumn). A northwestern aspect was detected in winter, but slope of 30°~35° (19.0 %) was used regardless of the season and mean elevation use was 500 m. Moreover, seasonal use was higher in the summer and lower in the winter and spring. The distance from the stream was mainly 50 m in 17.2 %, except in the winter (distance of 300 m), and it was within 50 m in the spring, summer, and autumn. The distance from the road was 100 m in 25.7 %, and seasonal use was within 100 m except for the winter. Thus, we examined significant differences in the habitat use of reintroduced gorals in Woraksan (mountain), and provide elementary data for habitat stabilization of Woraksan (mountain) National Park where goral restoration has advanced.

**KEY WORDS: ASPECT, ELEVATION, ROAD, SLOPE, STREAM**

## INTRODUCTION

Long-tailed Gorals (*Naemorhedus caudatus*) are an endangered species that was distributed throughout Korea in the early 1900s. Because of heavy snow in the 1950s–1960s, approximately 6,000 Long-tailed Gorals moved to villages and were poached by local residents (Won, 1967). Following this occurrence, Long-tailed Gorals inhabited an extremely limited area and became endangered species in Korea (KNPS, 2009). Within Woraksan (mountain) National Park, Long-tailed Gorals were found until the 1980s, but no individuals were sighted after this period. Therefore, Everland and the Korean Forest Service released six Long-tailed Gorals in 1994, 1997, and 1998. Monitoring

reports in 2005 revealed the presence of 10 Long-tailed Gorals in Woraksan (mountain) National Park (KNPS, 2014). Although they inhabit sunny and southward rock areas and are known to move to lower forest areas in the winter because of heavy snow, Long-tailed Gorals typically do not leave their main territory (Mead, 1989; Mishra and Johnsingh, 1996; Yang, 2002). In heavy snow areas, Long-tailed Gorals mainly inhabit southward areas where snow melts faster (Won, 1967; Nasimovich, 1955), and they prefer a steep slope, which may be an effective defense from predatory threats (Myslenkov and Voloshina, 1989). The elevation use of Korean Long-tailed Gorals differs by more than 200 m in the summer and winter (Cho, 2013), and Long-tailed Gorals also select their habitat

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based on the distribution of rock and bedrock without any regard to elevation (Yang, 2002; Park, 2011). A total of 51 reintroduced Long-tailed Gorals inhabit Woraksan (mountain) National Park, and studies of their restoration are currently underway (KNPS, 2014). However, research examining characteristics of habitat uses is nonexistent. Moreover, it was reported that goral numbers decreased due to heavy snow, extreme climate change, habitat destruction by forest development, and poaching, Long-tailed Gorals, an IUCN protected, category I Vulnerable species, is on the list of National Endangered Animals, Endangered Animal I and is protected by the natural monument no. 217 in Korea (IUCN, 2013). Therefore, this study was conducted to analyze characteristics of habitat use of released Long-tailed Gorals fitted with GPS collars in Woraksan (mountain) National Park. Therefore, this study presents data pertaining to the restoration and conservation focusing on behavioral characteristics of Long-tailed Gorals (reintroduced into Woraksan (mountain) National Park needed to restore and conserve wild animals that are currently endangered.

## MATERIALS AND METHODS

### 1. Study Site

Woraksan (mountain) National Park is located between E 128° 01' 35.3" ~ 128° 19' 04.3" and N 36° 58' 24.3" ~ 36° 47' 33.6", and was designated the 17th Korea National Park on December 31, 1984. The average temperature is 10.1°C, the annual precipitation is 1,295.1mm, and the vegetation consists of deciduous and mixed forest. We analyzed characteristics of habitat use of released

Table 1. Radio telemetry Long-tailed Gorals in Woraksan (mountain) National Park

Individual	Sex	Age	Weight (kg)	Observation period (point)
WF-01	F	Adult	35	2006.11-2007.11 (1,189)
WM-02	M	Adult	38	2007.04-2007.11 (2,726)
WF-03	F	Adult	36	2008.02-2008.09 (191)
WF-04	F	Adult	37.5	2006.11-2007.11 (869)
WF-05	F	Adult	37	2007.03-2009.03 (1,496)
WF-06	F	Adult	25	2010.01-2012.12 (3,201)
WF-07	F	Adult	29	2012.01-2013.01 (1,049)

W: Woraksan, F: Female, M: Male

Long-tailed Gorals that were fitted with GPS collars in Woraksan (mountain) National Park. A total area of 287.977km<sup>2</sup> was designated as Woraksan (mountain) National Park, and this area has several small and large peaks. The study period spanned from November 2006 to January 2013, and we conducted analyses of characteristics of habitat use based on the activities of the seven Long-tailed Gorals with GPS transmitters, which were reintroduced into Woraksan (mountain) National Park (Figure 1).

### 2. Methods

We used GPS collars (3300s, LOTEK, Canada). Because previous research found that animal behavior is affected if the GPS collar is heavier than 5% of the animal's weight (Aldridge and Brigham 1988), we made certain that our GPS collars were all around 0.9–1.0% of our subjects' body weight. To check the aspect, coordinates, and any device error, we used IC-R20 receivers (i Com Co., Japan), 3-Element Yagi-antennas (ATS Inc., USA), roof mounted antennas (Omni-directional whip antenna, Amico, USA., etc), and an eye compass (Silva Inc., Sweden). We collected and utilized a total of 10,721 coordinates (mean = 1,531) from seven Long-tailed Gorals (WF-01, 1,189; WM-02, 2,726; WF-03, 191; WF-04, 869; WF-05, 1,496; WF-06, 3,201; WF-07, 1,049 coordinates)(Table 1). The program Arc GIS 9.3.1 was used to analyze the numerical maps of Woraksan (mountain) National Park (1:25,000; NGII) and DEM (resolution 10 m). A two-way ANOVA of SPSS version 20.0 was also performed to analyze

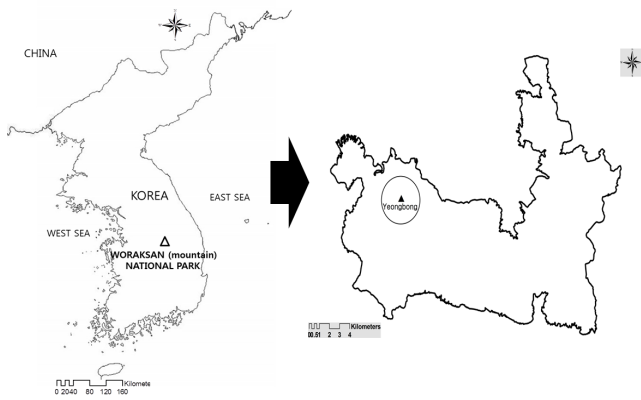


Figure 1. Location of Woraksan (mountain) National Park (△) and reintroduced area of Long-tailed Gorals (▲)

changes in the habitats used between individuals and seasonal changes.

## RESULTS

### 1. Aspect preference

According to the characteristics of habitat use results for the seven Long-tailed Gorals in Woraksan (mountain) National Park, we found that the southwestern slope was mostly used, and the remaining slopes were utilized in the following order: west slope (19.9%; 2,319 points) > southwest slope (19.1%; 2,214 points) > south slope (19.1%; 1,337) > northern slope (14.5%; 921 points) (Figure 2, Table 2). Analyses of individual aspect use indicated no significant differences among individuals ( $F=3.455$ ,  $p<0.01$ ), and specific aspects were significantly different ( $F=745.754$ ,  $p<0.01$ ). The results of analyses that

examined characteristics of aspect use and seasonal change showed southwestern slope usage in the spring, summer, autumn, and winter at 28.1% (603 points), 23.6% (706 points), 23.3% (642 points), and 20.9% (642 points), respectively (Figure 3, Table 3). Significant differences were detected for the aspect use of individual during seasonal changes ( $F=11.442$ ,  $p<0.01$ ), but seasonal changes for each specific aspect did not show significant differences ( $F=0.382$ ,  $p>0.05$ ).

### 2. Slope preference

We analyzed the slope characteristics of habitat use for seven Long-tailed Gorals in Woraksan (mountain) National Park, and the results showed that the mean slope of 30°–35° was 19.0% (2,038 points), which was the most preferred slope. This was preferentially followed by the 35°–40° (16.4%: 1,762 points) and the 25°–30° (13.3 %:

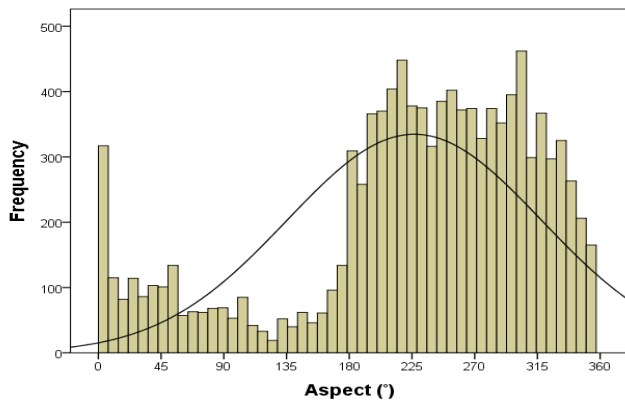


Figure 2. Aspect use characteristics for Long-tailed Gorals in Woraksan (mountain)

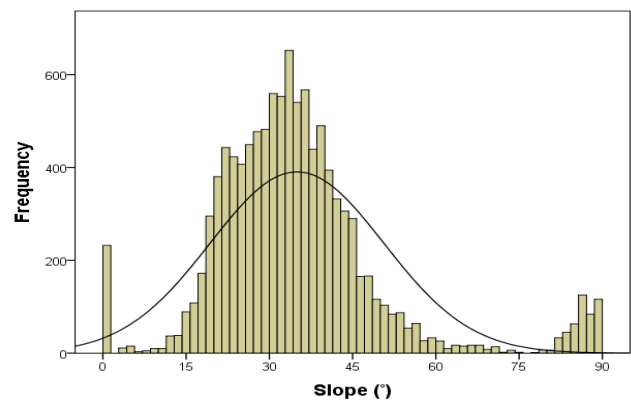


Figure 4. Slope use characteristics for Long-tailed Gorals in Woraksan (mountain)

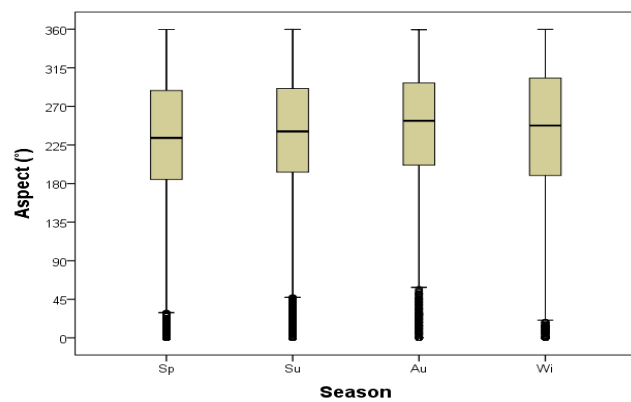


Figure 3. Aspect use seasonal characteristics for Long-tailed Gorals in Woraksan (mountain)

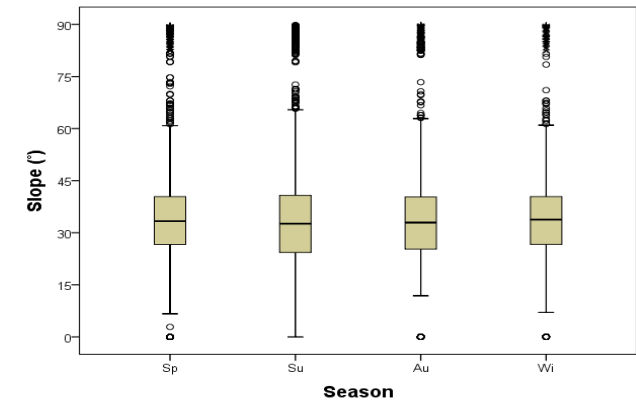


Figure 5. Seasonal characteristics of slope use for Long-tailed Gorals in Woraksan (mountain)

1,637 points) slopes. Furthermore, the results suggest that a slope greater than 55°–60° (1.3 %; 142 points) was not preferred (Figure 4, Table 2). Analyses of slopes indicated that each individual ( $F=40.836$ ,  $p<0.01$ ) and each slope showed significant differences ( $F=9774.223$ ,  $p<0.01$ ). Regarding the characteristics of seasonal slope use, a slope of 30°–35° was utilized in the spring, summer, autumn, and winter at 19.1 % (454 points), 20.8 % (541 points), 20.1 % (508 points), and 18.2 % (535 points), respectively (Figure 5, Table 3). According to seasonal slope, each individual ( $F=7.478$ ,  $p<0.01$ ) and each season per individual slope ( $F=5.671$ ,  $p<0.01$ ) showed significant differences.

### 3. Elevation preference

We analyzed the elevation characteristics of habitat use of seven Long-tailed Gorals in Woraksan (mountain)

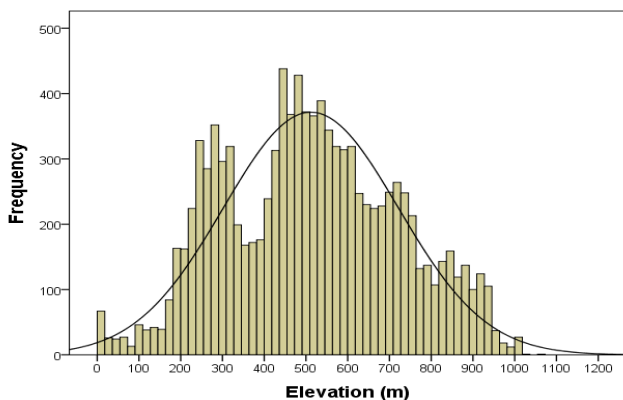


Figure 6. Elevation use Characteristics for Long-tailed Gorals in Woraksan (mountain)

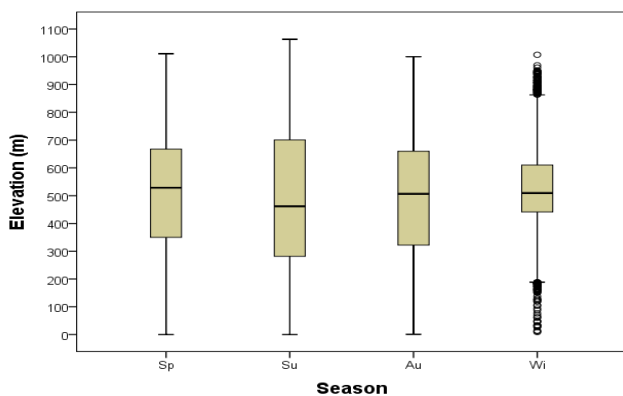


Figure 7. Elevation use seasonal Characteristics for Long-tailed Gorals in Woraksan (mountain)

National Park, and the results showed that a 500 m elevation was used by 18.7 % (2,004), which was the highest value (Figure 6, Table 2). Characteristics of elevation use for each goral were significantly different ( $F=2.468$ ,  $p<0.01$ ), but significant differences were detected for each elevation ( $F=3397.943$ ,  $p<0.01$ ). The results of seasonal elevation use characteristics showed the following elevation use: 20.0 % (417 points) at 500 m in spring, 18.2 % (633 points) at 600 m in summer, 20.0 % (472 points) at 600 m in autumn, and 24.3 % (877 points) at 600 m in winter (Figure 7, Table 3). Each seasonal elevation use for individuals showed significant differences ( $F=10.466$ ,  $p<0.01$ ), but no significant differences were found for each elevation ( $F=11.065$ ,  $p>0.05$ ).

### 4. Distance from stream preference

We analyzed the distance from streams for seven Long-tailed Gorals in Woraksan (mountain) National Park, and the results indicated that Long-tailed Gorals with 17.2% (1,843 points) of coordinates within a 50 m distance used areas near streams (Figure 8, Table 2). Although significant differences for each individual were found ( $F=10.663$ ,  $p<0.01$ ), significance differences were detected for distances from each stream ( $F=7037.325$ ,  $p<0.01$ ). The results of the seasonal distance use characteristics from streams at a 50 m distance were as follows: 19.1% (417 points) in spring, 19.6% (643 points) in summer, and 19.8% (496 points) in autumn (Figure 9, Table 3). However, 19.4% (504 points) at a distance 300 m was

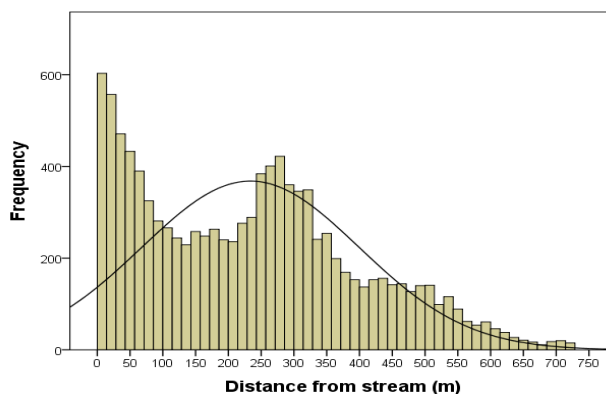


Figure 8. Distance from stream for Long-tailed Gorals in Woraksan (mountain)

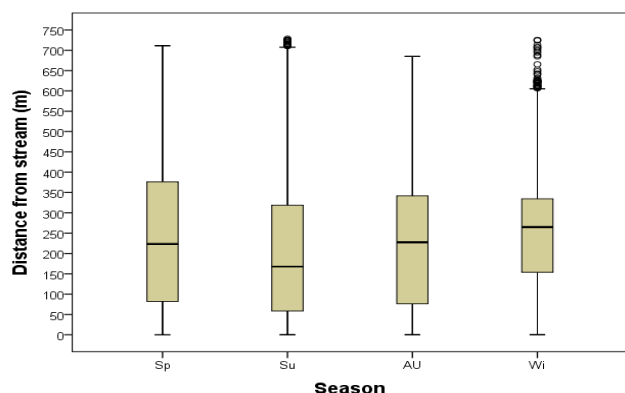


Figure 9. Seasonal distance from stream for Long-tailed Gorals in Woraksan (mountain)

measured in winter. The seasonal distance from streams for each individual was significantly different ( $F=11.955$ ,  $p<0.01$ ), but significant differences were detected for the individual distances from streams for each season ( $F=2.170$ ,  $p<0.01$ ).

### 5. Distance from road preference

We analyzed the distance from roads for seven Long-tailed Gorals in Woraksan (mountain) National Park, and the result showed that 25.7% (2,753 points) were within 100 m from the road, and 14.5% (1,556 points) were within 200 m (Figure 10, Table 2). Moreover, the results indicate that each individual ( $F=6.639$ ,  $p<0.01$ ) and each distance from the road ( $F=4.556$ ,  $p<0.01$ ) were significantly different. The results of seasonal distance use characteristics from the road at a 100 m distance were as follows: 25.9% (696 points) in spring, 22.0% (1,018 points) in summer, 22.8% (617 points) in autumn, and 22.7% (521 points) in winter (Figure 11, Table 3). Most Long-tailed Gorals in Woraksan (mountain) inhabit areas

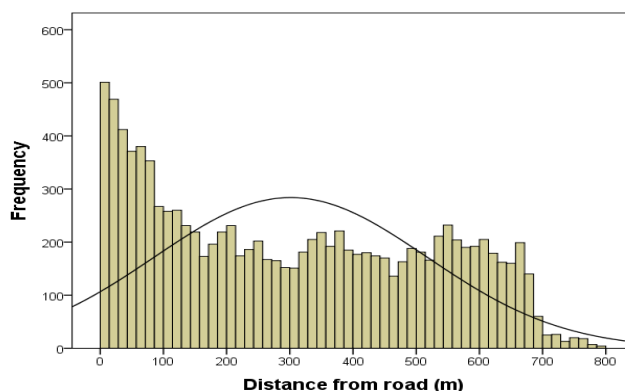


Figure 10. Distance from road for Long-tailed Gorals in Woraksan (mountain)

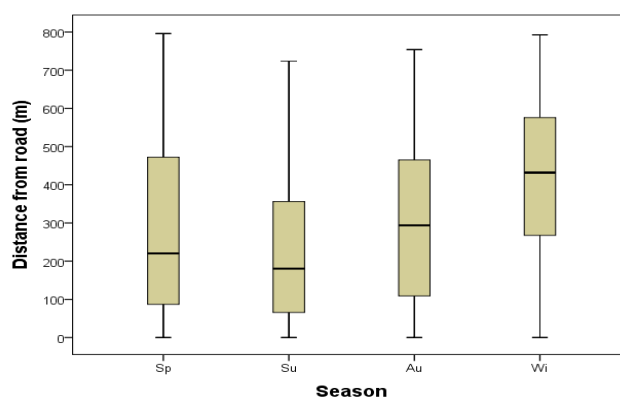


Figure 11. Seasonal distance from road for Long-tailed Gorals in Woraksan (mountain)

near Yeongbong, which is the main mountaintop of Woraksan (mountain) National Park. However, there are trails near Yeongbong, so we analyzed that they inhabited areas close to the roads. Significant differences in the seasonal distance from roads for each individual were detected ( $F=329.153$ ,  $p<0.01$ ), but the individual distances from roads for each season were significantly different ( $F=5.295$ ,  $p<0.01$ ).

Table 2. Habitat use of reintroduced Long-tailed Gorals in Woraksan (mountain)(%)

Aspect	N	NE	E	SE	S	SW	W	NW	peak			
	8.5	5.0	3.7	2.5	14.5	24.8	19.9	19.1	2.0			
Slope (°)	0°	15° <	15°~20°	20°~25°	25°~30°	30°~35°	35°~40°	40°~45°	45°~50°	50°~55°	55°~60°	60° >
	1.9	1.3	5.8	12.5	15.7	19.2	16.4	11.4	6.0	2.9	1.2	5.7
Elevation (m)	200	300	400	500	600	700	800	900	1,000			
	5.1	11.5	10.7	20.6	19.0	14.1	10.6	6.1	2.3			
Distance from stream (m)	50	100	150	200	250	300	350	400	450	500		
	19.3	13.7	8.2	7.8	8.8	12.6	10.8	6.2	4.8	7.8		
Distance from road (m)	100	200	300	400	500	600	700	800				
	23.2	14.1	11.2	11.9	11.1	15.8	11.6	1.1				

Table 3. Seasonal average ( $\pm$  SD) of reintroduced Long-tailed Gorals in Woraksan (mountain)

Variable	Spring	Summer	Autumn	Winter
Aspect	221.1 (26.5) SW	224.4 (30.7) SW	230.2 (25.9) SW	219.5 (35.0) SW
Slope ( $^{\circ}$ )	35.3 (4.4)	36.3 (5.3)	32.6 (8.0)	35.7 (5.2)
Elevation (m)	506.6 (145.5)	557.1 (179.8)	508.6 (174.2)	510.9 (156.2)
Distance from stream (m)	211.7 (103.3)	226.7 (125.3)	196.7 (108.0)	211.1 (105.6)
Distance from road (m)	297.6 (153.2)	295.5 (150.5)	312.1 (138.0)	356.7 (195.2)

## DISCUSSION

In the many study of habitat selection of Artiodactyla species, the depth of snow (Klein and Olson, 1960; Garrott *et al.*, 1987; Myslenkov and Voloshina, 2012), vegetation cover (Bloom, 1978; Wallmo and Schoen, 1980), and forests (Hobbs and Spowart, 1984; Garrott *et al.*, 1987) effect the selection of winter habitats. On the other hand, the quality of habitat (Nicholson *et al.*, 1997), forests (Zweifel-Schielly *et al.*, 2009), human disturbance (Nicholson *et al.*, 1997; Ager *et al.*, 2003), and predation (Riley and Dood, 1984) effect the selection of summer habitats. Based on the characteristics of habitat use (i.e., aspect, slope, elevation, distance from streams, and distance from roads) of seven Long-tailed Gorals in Woraksan (mountain) National Park, we found seasonal changes of habitat. The results of the aspect analyses suggest that Long-tailed Gorals inhabit areas that are southward where snow melts faster (Nasimovich, 1955). However, in our study, a southwestern slope was the most preferred aspect (22.6 %: 2,419 points) during the spring (28.1 %: 603 points), summer (28.1 %: 603 points), autumn (23.3 %: 642 points), and winter (20.9 %: 642 points). This study found that Long-tailed Gorals did not prefer the southwestern slope in winter because of little snow, but generally used the southwestern slope. Long-tailed Gorals select habitats according to food, refuge, and slope, and they particularly prefer a 30 $^{\circ}$  slope and refuge areas such as cliffs and canyons (Mishra and Johnsingh, 1996). With regard to the habitat use of Long-tailed Gorals, the slope is known as an important factor for survival. The results of slope use analyses indicate that areas with a mean slope of 30 $^{\circ}$ –35 $^{\circ}$  (19.0 %: 2,038 points) were most preferred, followed by areas with 35 $^{\circ}$ –40 $^{\circ}$  (16.4 %: 1,762 points) and 25 $^{\circ}$ –30 $^{\circ}$  (15.3 %: 1,637 points) slopes. Furthermore, areas with a 55 $^{\circ}$ –60 $^{\circ}$  slope (1.3 %: 142 points)

were least preferred. Long-tailed Gorals use a slope with a steep gradient in the summer, and use a place with slight gradient in the winter (Chen *et al.*, 2012). However, our results suggest that Long-tailed Gorals typically use areas with a mean slope of 30 $^{\circ}$ –35 $^{\circ}$ , and that seasonal changes in slope use do not occur. We suggest that in our study area, there are no predators, so Long-tailed Gorals do not select steeply sloped areas for refuge. Regarding elevation use, Long-tailed Gorals in Pakistan exhibit group movement in elevation according to seasonal changes (Abbas, 2012). We think that in case of Korean gorals, they do not use steep slope because there is no predator. Moreover, Long-tailed Gorals in Thailand used 1,500 m–1,800 m elevations, and move to lower areas in the rainy season and higher areas in the dry season (Chaiyarat *et al.*, 1999). In the case of Korean Long-tailed Gorals, it was reported that they moved to higher elevations during June, July, and August and lower elevations during December, January, and February (Cho *et al.*, 2014). From our analyses, a mean elevation of 500 m (18.7 %: 2,004 points) is mostly preferred. The elevation use characteristics for each season were as follows: 500 m elevation (20.0 %: 417 points) in spring, 600 m (18.2 %: 633 points) in summer, 600 m (20.0 %: 472 points) in autumn, and 500 m (24.3 %: 887 points) in winter. We suggest that this result is related to available vegetation. The main habitat for Long-tailed Gorals is 0–500 m (63 %) away from streams, and they also use the steep slopes around streams and drink the stream water (Park, 2011). Woraksan (mountain) does not have heavy snowfall compared to Seoraksan (mountain). So, we thought that the altitude use width of goral was less in Woraksan (mountain). The results of our distance from streams analyses showed that use at a 50 m distance from streams was 17.2 % (1,843 points), which suggests that their habitats are closely related to the distance from streams.

Regarding the seasonal characteristics of distance from streams, a 50 m distance was 19.1% (417 points) in spring, 19.6 % (643 points) in summer, and 19.8 % (496 points) in autumn; however, a 300 m distance was 19.4 % (504 points) in winter. These results suggest that Long-tailed Gorals use snow or ice as drinking water, so there is no relationship to the distance from streams in the winter. As the result of this study, the area where many gorals inhabit is within 50m from water system. So, we think that they prefer the area where they can find water easily. With regard to the distance from roads, roads in this study include trail, motor-road, and forest road. Long-tailed Gorals use roads as easy pathways in heavy snow areas (Chen *et al.*, 2012), and the distance from roads is an important factor for goral habitat selection (Park, 2011). In our study, a 100 m distance was 25.7 % (2,753 points), which is the highest percentage, and a 200 m distance was 14.5 % (1,556 points). The results of seasonal distance from road use characteristics indicated that a distance of 100 m was 25.9 % (696 points) in the spring. Moreover, the distance was more than 100 m in the summer (22.0 %: 1,018 points), autumn (22.8 %: 617 points), and winter (22.7 %: 521 points). Most Long-tailed Gorals in Woraksan (mountain) National Park inhabit Yeongbong, the main mountaintop of Woraksan (mountain) National Park, but the trails are so close to Yeongbong that we hypothesized that they inhabit areas near the road. We found significant differences in the aspect, slope, elevation, distance from streams, and distance from roads for reintroduced Long-tailed Gorals in Woraksan (mountain) National Park. Our study of these characteristics will contribute to the stabilization of habitats in Woraksan (mountain) National Park where a goral restoration project is in progress. We also think that it is necessary to make a conservation strategy through goral habitat suitability analysis.

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