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ORIGINAL ARTICLE

Distribution and Movement Tendencies of Short-Tailed Viper Snakes (*Gloydius saxatilis*) by Altitude

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Abstract The distribution pattern of reptiles in mountainous regions is generally related to altitude. The distribution of viperine species can be limited by elevation. Short-tailed viper snakes (*Gloydius saxatilis*) of South Korea are found mostly in high elevation mountainous areas, but few studies have evaluated how their distribution relates to elevation gradient. This study was conducted from 2012 to 2013 to investigate the altitudinal distribution of short-tailed viper snakes in mountainous areas and to discover their movement patterns in Cheon-ma Mountain County Park in South Korea. A translocation method utilizing radio-tracking technology was employed to confirm whether their distribution was influenced by altitude. The results showed that most short-tailed vipers were observed in middle and high altitude areas (from 400 m to 800 m), but none were observed in low altitude areas (from 200 m to 400 m). According to the results of the translocation and tracking experiments, the individuals of the translocated group showed a significantly broader home range than those of the control group. In addition, all individuals of the translocated group moved vertically, while most of the control group moved horizontally. Therefore, all translocated individuals tended to move back toward their original habitat, a high elevation area. Consequently, we concluded that the distribution of short-tailed viper snakes was limited by altitude.

Keywords altitudinal preference, translocation, radio-tracking, Viperidae, South Korea

1. Introduction

Most animals have their preferred habitats (Brown, 2001; Martínez-Freiría *et al*., 2008), which may be influenced by species-specific temporal and spatial constraints. This habitat preference results in different distribution patterns among species (Harlan, 1976; Orians and Wittenberger, 1991; McCain, 2007a). Several studies suggested that some factors (e.g., food resources and geographical characteristics) influenced the habitat preference of animals (Luiselli, 2006; Wasko and Sasa, 2012) and these factors could vary by altitude (Tang and Ohsawa, 1997; Randin *et al*., 2009; Do and Yoo, 2014). Therefore, it is anticipated that altitude influences animal distribution (Rahbek, 1995; Lomolino, 2001; McCain, 2007b; Chettri *et al*., 2010; Kim, 2013).

The distribution patterns of reptiles in mountainous regions are generally related to altitude (Saint Girons, 1975). Previous studies clearly showed that altitude influences the distribution of species of Viperidae, particularly those living in mountainous areas (Jul and On, 2002; Orlov *et al*., 2000; Luiselli *et al*., 2007; Chettri *et al*., 2010). However, these studies only showed the distribution of individuals by altitude and it is hard to determine the altitudinal preference of these snakes.

Short-tailed viper snakes (*Gloydius saxatilis*) are distributed throughout Northeast Asia, including Russia, northern China, Mongolia, and South Korea (Gloyd and Conant, 1989). Species in the genus *Gloydius* were rarely observed in the Korean Peninsula (Gloyd, 1972) and usually inhabit higher elevation mountainous regions than other Korean vipers, such as red-tongued viper snakes (*G. ussuriensis*) and viper snakes (*G.brevicaudus*) (Beack and Shim, 1999; Do *et al*., 2016). Among Viperidae species in Korea, the distribution and movement patterns of red-tongued viper snakes were studied (Kim, 2010; Do and

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Yoo, 2014). This species is usually known to live in low altitude forested valley areas and have a very narrow home range (Kim, 2010; Do and Yoo, 2014). In case of short-tailed viper snakes, this species is known to inhabit high altitude forested mountain areas but their distribution and movement patterns are rarely known. Therefore, it is necessary to verify the altitude related habitat preference to confirm that the distribution of this species is related to altitude in the mountainous area.

Translocation and tracking experiments are effective study methods for evaluating habitat preference and behavioral changes by acquiring information of movement patterns in translocated individuals (Reinert, 1991; Brown *et al*., 2010). Several studies presented that snakes tends to adapt to a new habitat when they translocated (Reinert and Rupert, 1999; Butler *et al*., 2005). However, other studies showed that translocated snakes exhibited homing behavior (e.g., wandering), trying to return to their original habitat (Sealy, 1997; Reinert and Rupert, 1999; Reo *et al*., 2010). Therefore, these experiments are one of effective methods for studying the altitudinal preference of snakes living in the mountainous area.

The aim of this study was to determine whether the distribution of short-tailed viper snakes is related to the altitudinal gradient or not. In this study, we first described the distribution of this species in a mountainous area. We then investigated the movement patterns of this species using the translocation and tracking experiments to evaluate whether they preferred the high elevation mountainous region or not.

2. Materials and Methods

2.1 Study Area This study was conducted in Cheonma Mountain County Park (37°40′50″N, 127°16′22″E) located in Hwado-eup, Namyangju-si, Gyeonggi-do, South Korea. The park lies in a central-temperate climate zone with an annual mean temperature of 11.4 ± 3.3°C (Mean ± SD), and an annual mean precipitation of 130.9 ± 58.5 mm (Lee, 2014). The maximum altitude of the study area is 812 m and 70.6% of the study area is below 400 m with rolling terrain (Lee *et al*., 2002). The altitude of the study area is mostly higher than the average altitude (411.6 ± 304.2 m) of the 7408 mountains in South Korea (National Geographic Information Institute, 2014). Short-tailed viper snakes, red-tongued viper snakes, and viper snakes in the genus *Gloydius* live in the study area (Yang and Kang, 1999; Do and Yoo, 2014).

All experiments were conducted under appropriate licenses for capturing and implanting transmitters for the tracking of wild snakes (Namyangju-si license No. 12-01 for Jeong-Chil Yoo, No 12-03 for Min Seock Do).

2.2 Distribution in the Wild The distribution of short-tailed viper snakes in the study area was investigated three times a week between 0800 hrs and 1800 hrs from April–October in 2012 and 2013. The altitude was divided into three sections to clearly describe the distribution patterns with the lowest altitude being 200 m (i.e., 200–400 m, 400– 600 m, and 600– 800 m). Each section was subdivided into twelve 50m subsections (Luiselli *et al*., 2007; Do and Yoo, 2014).

(1) Low altitude: 200 m ≤ X<400 m (Interval 50 m: 4 subsections)

(2) Middle altitude: 400 m ≤ X<600 m (Interval 50 m: 4 subsections)

(3) High altitude: 600 m ≤ X<800 m (Interval 50 m: 4 subsections)

Short-tailed viper snakes were gathered from within 50 m from the path, more specifically, from grasslands, bushes, and beneath rocks. To avoid duplicate observations, each individual was collected and marked by cutting the tail scales on their backs (Blanchard and Finster, 1933). The morphological characteristics of all individuals, such as body mass, total body length and snout-vent length (SVL) were measured by a Pesola® spring/balance (to 0.1 g) and a ruler (to 0.1 cm). A ball-tip probe was used to distinguish their sex. The location information where the individuals were observed was acquired using by GPS (Garmin®, *e*-Trex Vista GPS).

2.3 Translocation and Tracking Eleven snakes were captured within the study area and a transmitter (Holohil Systems Ltd, Woodlawn, Canada: model PD-2, mass 3.8 g) was surgically implanted under the dorsal skin of each individual (Reinert and Cundall, 1982). The weight of the transmitter was 2.2 % (range = 1.2 %–3.6 %) of the snakes' body weight on average. Following the implantation, the snakes were placed in individual plastic cages 50 cm (L) × 28 cm (W) × 30 cm (H) for a week to recover (Do *et al*., 2014).

The snakes were then divided into two groups: a control group (n = 6) and a translocated group (n = 5). The body sizes of the individuals were similar between the control group and the translocated group (Mann-Whitney U-test; total body length: Mean ± SD = 73.4 ± 7.3 cm for the control group and 67.5 ± 5.4 cm for the translocated group, U = 9.00, df = 1, P = 0.329; SVL: Mean ± SD = 65.3 ± 5.9 cm for the control group and 59.7 ± 4.0 cm for the translocated group, U = 7.00, df = 1, P = 0.177; body mass: Mean ± SD = 217.3 ± 59.9 g for the control group and 155.3 ± 47.2 g for the translocated group, $U = 7.00$, $df = 1$, $P = 0.177$; Table 1).

Lastly, the individuals of the control group were released into the interior mountain areas at the same altitudes where they had been collected (Mean ± SD = 504.5 ± 62.2 m). The individuals of the translocated group were released into valley areas at different altitudes (Mean ± SD = 273.7 ± 1.2 m) from where they had been collected (Mean ± SD = 704.3 ± 114.7 m; Table 1). Tracking was conducted three times a week between 0800 hrs and 1800 hrs from the end of July to the beginning of October for two years (2012 and 2013). by using a receiver IC-R6 (Icom Inc., Japan), an amplifier PR-59 (ITAX Inc., Japan), and 3-element Yagi antennae (Wildlife Material Inc., Murphysboro, 1L, USA). When an individual was observed during the tracking experiment, information about the observed site was acquired using GPS. During tracking, Individual ID No. 278 was killed by a human and Individual ID No. 251 died of unknown causes (Table 1).

To identify the distribution and movement patterns of short-tailed viper snakes by altitude, the coordinates of the observed and tracked individuals were reflected in a digital map (GRS80, National Geographic Information Institute) of the study area. The location information of the observed individuals was quantified using a geographic information system (Figure 1, Arc GIS® v 9. 3.1; Esri Software).

2.4 Data Analyses In terms of distribution status in the study area, we compared the expected number of individuals for each research section with the observed number during the actual research (Luiselli *et al*., 2007). The expected individual number for each study section was calculated by multiplying the number of samples of a section by the observed number of individuals. The formula is as follows:

Sampling effort = the allocated survey time for a section / total survey time.

Expected number of individuals = sampling effort × total observed number of individuals.

A chi-square test was used to analyze the comparison between the number of observed individuals and the

Table 1 Individual, geographical, and temporal information of six control and five translocated short-tailed viper snakes at the study site, Cheon-ma Mountain in Korea.

ID No.	Information									
	Individual				Geographical				Temporal	
	Sex	Total Length (cm)	SVL* (cm)	Mass (g)	Captured Altitude (m)	Released Altitude (m)	Captured Habitat type	Released Habitat type	Tracking period	Tracking duration
Control group										
205	M	76.5	67.0	187.6	412.4	412.4	forest	forest	23 Jul.–5 Oct. 2012	75 days
251	M	72.0	62.5	233.0	624.2	624.2	valley	valley	23 Jul.–7 Sep. 2012	47 days
299	F	75.0	69.0	271.1	485.8	485.8	forest	forest	28 Jul.–24. Sep. 2012	59 days
081	F	62.0	55.0	165.8	502.3	502.3	forest	forest	25 Jul.–23 Sep. 2013	61 days
282	M	86.0	74.0	309.1	500.6	500.6	forest	forest	23 Aug.–27 Sep. 2013	36 days
264	M	69.0	64.0	137.3	501.4	501.4	forest	forest	23 Aug.–27 Sep. 2013	36 days
Mean ± SD		73.4 ± 7.3	65.3 ± 5.9	217.3 ± 59.9	504.5 ± 62.2	504.5 ± 62.2				52.3 ± 14.1
Translocated group										
278	F	64.0	59.5	121.0	795.0	272.6	forest	valley	23 Aug.–28 Sep. 2012	37 days
213	M	63.5	55.0	105.0	793.7	273.4	forest	valley	23 Aug.–5 Oct. 2012	44 days
540	M	78.0	67.0	238.1	483.6	275.8	forest	valley	12 Sep.–8 Oct. 2012	27 days
491	M	67.0	58.5	139.0	720.0	274.3	forest	valley	26 Jul.–20 Sep. 2013	57 days
415	F	65.0	58.5	173.2	729.2	272.6	forest	valley	23 Aug.–27 Sep. 2013	36 days
Mean ± SD		67.5 ± 5.4	59.7 ± 4.0	155.3 ± 47.2	704.3 ± 114.7	273.7 ± 1.2				40.2 ± 10.0

SVL* refers to the snout-vent length

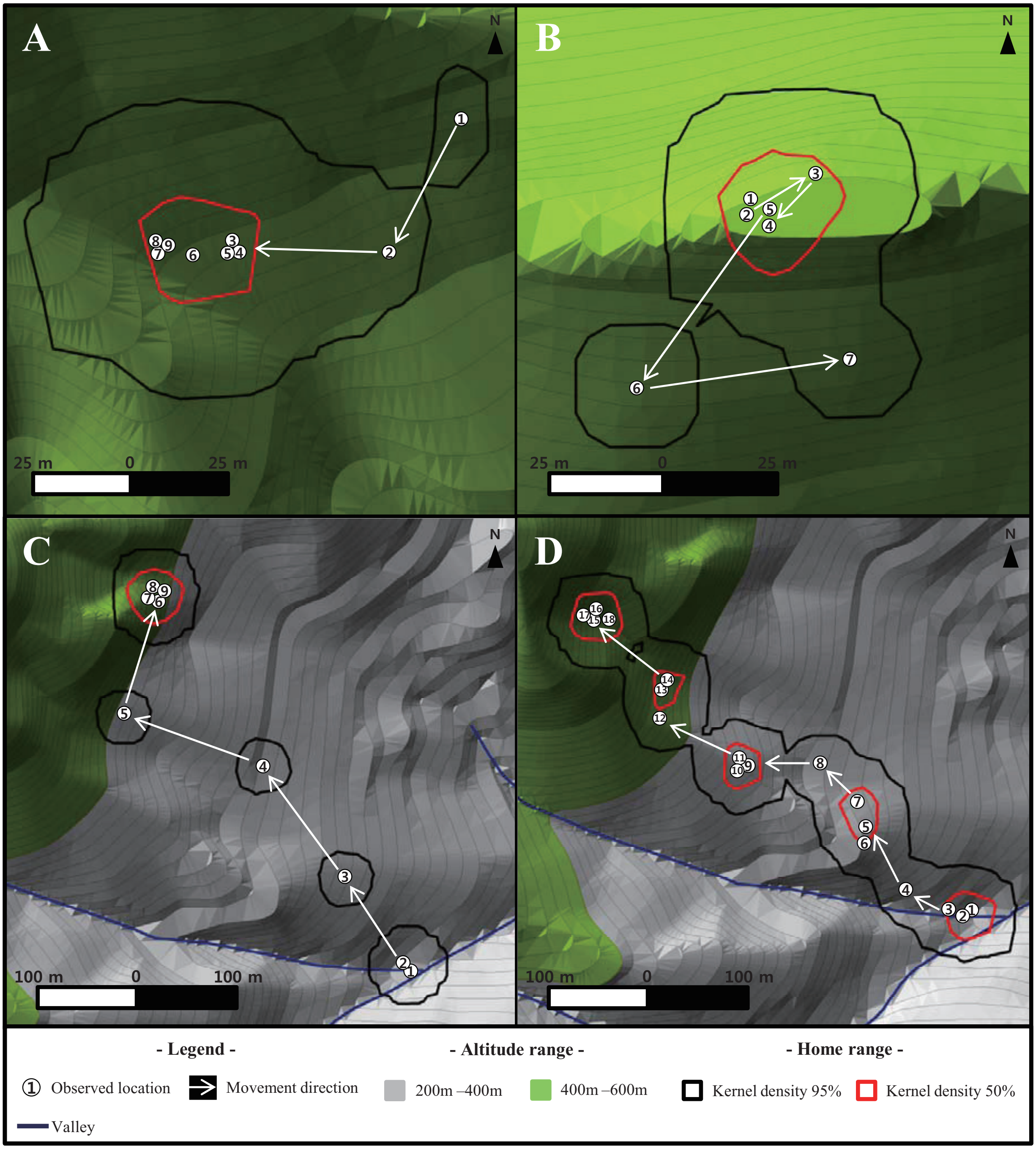

Figure 1 Examples of movement patterns of short-tailed viper snakes in the control group (A: ID 299 and B: ID 264) and the translocation group (C: ID 213 and D: ID 491) at Cheon-ma Mountain in Korea.

expected number of individuals.

In this study, the home range of each individual was estimated using both the minimum convex polygon (MCP; Hayne, 1949) and kernel density (KD; Seaman and Powell, 1996) techniques by using the Hawth's Tools extension in Arc GIS 9.3.1 (Beyer, 2004). We used 100% MCP to capture the entire area used by each individual, including all outlying points. For the kernel estimates, we fixed 95% and 50% KD estimate by applying the least squares crossed validation criterion to determine the smoothing parameters (Kenward, 2000; Wasko and Sasa, 2012).

The home range of the short-tailed viper snakes was evaluated by using a linear model with a normal error structure and identity link. We performed this analysis separately for three types of home range size (e.g., MCP, 95% and 50% KD). We used the function Box-cox in the R package car to transform the response variable to satisfy normal and heteroscedastic assumptions, when it was needed. We used home range as a response variable for these analyses. The explanatory variables were 'group type', 'sex' and 'age'. 'group type' indicates whether individual was translocated or not (control group or translocated group). 'sex' (male or female) means the gender of individual. The snout-vent length (SVL) of individuals is referred as 'age'. All two-way interaction terms between explanatory variables were also tested.

In addition, the distance per movement and the altitude change per movement were calculated to analyze the movement patterns of both groups (Webb and Shine 1997; Whitaker and Shine, 2003). These two factors were obtained by measuring the straight-line distances and height differences between successive points of individuals that were monitored using radio tracking. An interval altitude was calculated by taking the difference in altitude between the initial release site and the final observation site. The direction of the individual's movement was defined as vertical if the difference in altitude was more than 50 m and as horizontal if the difference in altitude was less than 50 m.

To analyze the distance and direction of movement in relation to altitude, we used the response variable the distance per movement and interval altitude by all individuals with group type, sex and age as fixed factors in the model. All two-way interaction terms were also tested. Statistical analyses were performed in the R environment, version 3.2.5 (R core Team, 2013). All means are reported with ± standard deviation (SD).

3. Results

3.1 Distribution Pattern In total, 13 short-tailed viper snakes were observed in the study area from 2012 to 2013 (Table 2). The number of observed individuals was significantly different among the three main sections (200 m intervals: $\chi^2_2 = 6.80$, $P < 0.01$). Most of them were observed in the middle and high altitude sections, but none were observed in the low area (low altitude = 0 individual, middle altitude = 2.00 ± 1.08 individuals, high altitude = 1.25 ± 0.48 individuals). In terms of the twelve subsections, they were observed more frequently in the four subsections from 400 m to 600 m (50 m intervals: $\chi^2_{11} = 30.22$, $P < 0.01$; Table 2) than in other subsections.

3.2 Movement Patterns in Relation to Altitude Table 3 showed movement patterns of both control and translocated groups at the study site. The three home ranges of the two groups were compared and MCP results showed that individuals of the translocated group showed a larger home range than those of the control group (Mean ± SD = 297.7 ± 90.1 for control group, 1641.3 ± 684.6 m^2 for translocated group, $P < 0.0001$; Figure 2; Table 4). Individuals of the translocated group also used a larger area than those of control group in 95% KD and 50% KD as well (989.8 ± 684.6 m^2 for control group, 2435.9 ± 1206.2 m^2 for translocated group, $P < 0.05$ in 95% KD; 128.4 ± 84.8 m^2 for control group, 444.3 ± 198.3 m^2 for

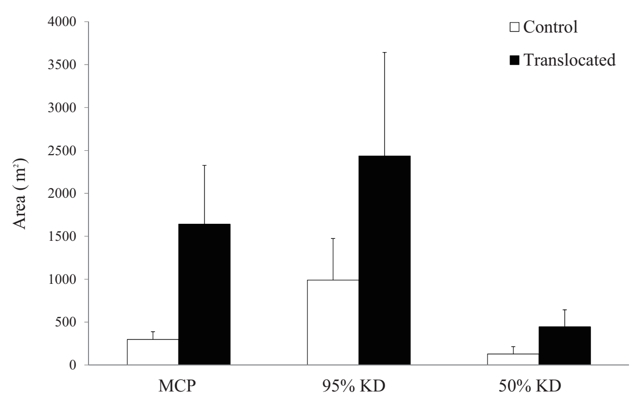

Figure 2 Home range size (Mean±SD) of both control and translocated groups of short-tailed viper snakes using three estimation methods (MCP, 95% and 50% KD).

Table 2 Altitudinal distribution of short-tailed viper snakes at the study site, Cheon-ma Mountain in Korea.

Index	Low altitude (m)				Middle altitude (m)				High altitude (m)			
	200–250	250–300	300–350	350–400	400–450	450–500	500–550	550–600	600–650	650–700	700–750	750–800
Duration time	10.1	15.6	22.4	20.2	17.9	31.1	16.1	15.6	21.2	13.2	7.2	8.3
Sampling effort	0.051	0.078	0.113	0.101	0.090	0.156	0.081	0.078	0.107	0.066	0.036	0.041
Expected individual	0.66	1.02	1.46	1.32	1.17	2.03	1.05	1.02	1.39	0.86	0.47	0.54
Observed individual	0	0	0	0	1	2	5	0	1	0	2	2

Note: "Duration time" refers to the field effort (hours), "Sampling effort" refers to the relative index of field effort per altitude interval calculated as described in the text.

translocated group, $P < 0.001$ in 50% KD; Figure 2; Table 4). All interaction terms between group type and sex, and between group type and age, were not significant ($P > 0.05$ for MCP, 95%KD, and 50% KD).

In the analysis of MCP, males showed a significantly larger home range than females did (Mean ± SD = 1026.3 ± 807.4 m^2 for males and 702.1 ± 486.9 m^2 for females; $P<0.05$ for MCP). Other two home ranges were not different between sexes ($P = 0.479$ for 95% KD; $P = 0.984$ for 50% KD; Table 4). Age did not significantly affect any of the three types of home ranges ($P = 0.534$ for MCP; $P = 0.479$ for 95% KD; $P = 0.622$ for 50% KD; Table 4).

The mean distance per movement was 21.5 ± 23.4 m and 41.3 ± 45.4 m for the control and the translocated groups, respectively. Individuals of the translocated group showed a significantly longer distance per move than those in the control group did ($P < 0.05$; Table 3 and 4). The mean distance per movement did not differ by gender or age ($P = 0.304$ for sex; $P = 0.326$ for age). Furthermore, the mean interval altitude of the translocated group was farther than that of the control group (1.83 ± 35.3 m for the control group, 147.7 ± 56.8 m for translocated group, $P < 0.001$; Figure 3; Table 3 and 4). Males showed a farther interval altitude than females did ($P = 0.014$). However, age did not affect the interval altitude ($P = 0.088$). Consequently, most individuals in the control group moved horizontally (5 out of 6 individuals), while all the individuals of the translocated group moved vertically (5 out of 5 individuals; Table 3).

4. Discussion

This study was conducted to identify the distribution patterns of short-tailed viper snakes in relation to altitude. Most short-tail viper snakes were observed in the forest area (> 400 m), which concurred with previous studies (Beack and Shim, 1999; Lee *et al*., 2011). This confirms

Table 3 Movement patterns of both control and translocated short-tailed viper snakes at the study site, Cheon-ma Mountain in Korea.

ID No.	No. of location	No. of movements	Movement pattern						
			Distance	Altitude				Habitat-type	
			Total (m)	Initial (m)	Terminal (m)	Interval (m)	Direction	Initial	Terminal
Control snakes									
205	32	13	178.4	412.4	447.3	34.9	horizontality	forest	forest
251	20	4	139.2	624.2	685.8	61.6	verticality	valley	forest
299	26	8	155.4	485.8	479.9	–5.9	horizontality	forest	forest
81	27	6	162.6	502.3	475.1	–27.2	horizontality	forest	forest
282	16	8	162	500.6	486.9	–13.7	horizontality	forest	forest
264	16	6	171	501.4	462.2	–39.2	horizontality	forest	forest
Mean ± SD	22.8 ± 6.0	7.5 ± 2.8	161.4 ± 12.3	504.5 ± 62.2	506.2 ± 81.3	1.8 ± 35.3			
Translocated snakes									
278	17	11	315.1	272.6	343.5	70.9	verticality	valley	forest
213	20	8	527.1	273.4	412.9	139.5	verticality	valley	forest
540	12	10	581.6	275.8	491.0	215.2	verticality	valley	forest
491	25	17	563.8	274.3	483.2	208.9	verticality	valley	forest
415	16	12	409.5	272.6	376.8	104.2	verticality	valley	forest
Mean ± SD	18.0 ± 4.3	11.6 ± 3.0	479.4 ± 101.7	273.7 ± 1.2	421.5 ± 58.0	147.7 ± 56.8			

Note: “No. of location” refers to the total number of radio-tracking devices, “Initial” refers to “site where first released at altitude and habitat-type”, “Terminal” refers to “last observed site at altitude and habitat-type”, “Interval” refers to the value of terminal minus initial altitudes. “Total” refers to the total movement value at distance during radio-tracking period. “Direction”, in this case, if total movement was at altitudes more than 50m, then is verticality, and if less than 50m, then is horizontality.

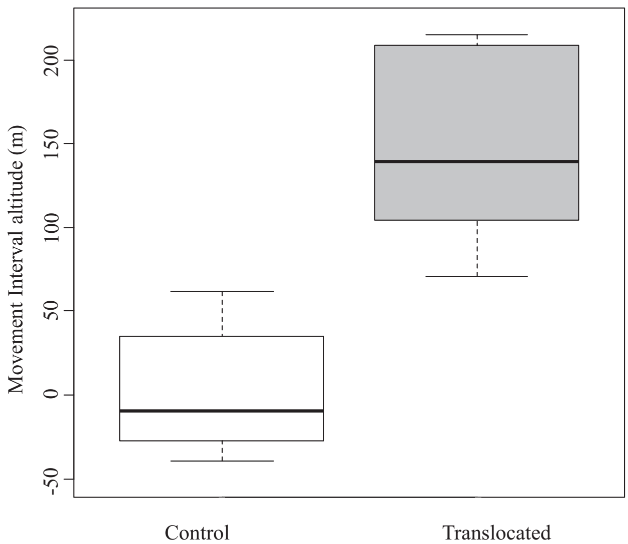

Figure 3 Movement interval altitude of two short-tailed viper snake groups at the study site (sample size = 6 for the control group and 5 for the translocated group).

that this species is most frequently observed in high elevation mountainous areas. Luiselli (2006) revealed that many other Viperidae species showed an altitudinal distribution in mountain areas. For example, short-tailed mamushi (*Gloydius blomhoffii brevicaudus*) in China only live in altitudes above 313 m and mountain pit vipers (*Ovophis monticola*) in East-south Asia inhabit areas above 800 m (Jul and On, 2002; Orlov *et al.*, 2000; Chettri *et al.*, 2010).

Results showed that individuals of the translocated group showed a wider home range than those of the control group (Table 4). Previous studies revealed that translocated snakes had a wider home range after translocation because they searched for food, a new habitat or tried to adapt to a new environment (Reinert and Rupert, 1999; Butler *et al.*, 2005). In our results, all individuals of translocated group lived above 400m before they translocated and the result of distribution patterns in the study area also showed that all individuals were observed above 400m (Table 2). In addition, the habitat of the translocation group's translocated area was almost identical with that of control group's translocated area with the exception of altitude. Consequently, the wide home range of translocated individuals could be due to due the individual's movement to a higher altitude rather than a widened home range for adaptation behavior.

This phenomenon can be confirmed from MCP, 95%KD, and 50%KD analyses as well. Particularly, the 50% KD indicates the core area repeatedly used by snakes, which has important ecological meaning with regards to habitat (Hooge *et al.*, 2001). This study showed that the control group living in their own habitats showed a home range between 400 and 800m. However, the translocated group showed a patchy style home range between 200 and 500m, and their home ranges pointed toward an area above 400m (Figure 1). These results also echoed the previous speculation that the movement pattern of translocated short-tailed viper snakes was due to their movement towards preferred habitats, rather than behaviors for adaptation to new habitats.

In our results, the translocated short-tailed viper snakes moved to higher altitude areas, showing that the snakes tend to prefer a habitat above 400 m (Table 3). The distance of movement and interval altitude were significantly different between the two groups (Table 4). This study did not confirm that the translocated short-tailed viper snakes had actually returned to the initial collection site. However, considering they had moved vertically (Table 3) and the altitude of the final observation site was close to the average altitude in which short-tailed viper snakes are generally distributed,

Table 4 Summary of linear models examining the movement patterns by group types and biological factors of short-tailed viper snakes.

Model term	Estimate ± s.e.	*d.f.*	*F*	*P*
Minimum Convex Polygon (MCP)				
Group type	0.417 ± 0.036	1	137.4	**< 0.001**
Sex	–0.096 ± 0.033	1	8.677	**0.022**
Age	0.005 ± 0.007	1	0.427	0.534
Kernel Density (95%KD)				
Group type	1.050 ± 0.369	1	8.093	**0.025**
Sex	–0.257 ± 0.344	1	0.559	0.479
Age	0.020 ± 0.081	1	0.061	0.813
Kernel Density (50%KD)				
Group type	0.060 ± 0.017	1	12.518	**0.009**
Sex	0.001 ± 0.016	1	0.001	0.984
Age	0.002 ± 0.004	1	0.266	0.622
Mean distance per movement				
Group type	0.126 ± 0.087	1	8.118	**0.025**
Sex	–0.080 ± 0.059	1	1.229	0.304
Age	–0.015 ± 0.014	1	1.115	0.326
Interval altitude				
Group type	0.867 ± 0.226	1	50.038	**< 0.001**
Sex	–0.559 ± 0.152	1	10.584	**0.014**
Age	–0.071 ± 0.036	1	3.936	0.088

Note: All interaction terms were tested and were found to be insignificant ($P > 0.05$). *F* values were obtained by fitting terms last. Significant *P* values are shown in bold.

their behavior can be interpreted as an attempt to return to their original habitats. Some studies explained this phenomenon as the homing behavior of snakes (e.g. wandering) (Nowak, 1998). Previous translocation studies using diamond-back rattlesnakes (*Crotalus atrox*), timber rattlesnakes (*C. horrdus*) and tiger snakes (*Notechis scutatus*) also showed that snakes returned to their initial collection sites (Nowak, 1998; Reinert and Rupert, 1999; Butler *et al*., 2005). Therefore, the observed tendency of the translocated individuals in this study to return to their original altitude can be interpreted as typical homing behavior.

The movement patterns of short-tailed viper snakes were identical regardless of sex and age. Only the home range analysis using MCP showed a significant difference (Table 4). Male snakes generally have a wider home range than female snakes because they roam more during a breeding season (Reinert and Zappalorti, 1988; Secor, 1994; Duvall and Schuett, 1997; Marshall *et al*., 2006). However, other studies reported that *Gloydius* species, having a home range smaller than 3,000 m^2 , did not show a difference in home range size between sexes (see Shine *et al*., 2003; Kim, 2010). Further studies are needed to clearly understand the relationship among home range, gender, and breeding season.

This study evaluated the distribution of short-tailed viper snakes living in a mountainous area. It was found that all short-tailed viper snakes inhabited high altitude areas. Additionally, it was confirmed that translocated individuals tended to move to higher altitude areas, although direct causal factors of their habitat preference were not identified. Our results implied that altitude could be one important factor limiting the distribution of short-tailed viper snakes in the mountainous area of South Korea. However, further studies are needed to understand why short-tailed vipers try to inhabit altitudes above 400m, as well as to understand the relationship between habitat environment and interspecies competition and to identify the causes of altitudinal habitat selection among the Viperidae species.

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