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Habitat Distribution and Diversity of Ground Beetles (Coleoptera: Carabidae) on Geumo Mountain

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Abstract

We investigated the habitat distribution and diversity of ground beetles (Coleoptera: Carabidae), a bioindicator for assessing environmental changes on Geumo Mountain, in survey plots at different altitudes on the southern and northern slopes of Geumo Mountain in South Korea. From April to September 2021, we collected 1,384 individuals, 41 species, and 15 families of Carabidae from the survey sites. The dominant species collected was *Synuchus cycloderus* (347 individuals), followed by *Carabus jankowskii* (193 individuals). The monthly distributions of species richness and abundance were as follows: 24 beetles of 9 species in April, 115 beetles of 28 species in May, 288 beetles of 32 species in June, peaking at 379 beetles of 32 species in July, 354 beetles of 23 species in August, and 224 beetles of 14 species in September. Additionally, we collected 305 beetles of 32 species at 400 m, 326 beetles of 31 species at 500 m, 359 beetles of 27 species at 600 m, 582 beetles of 16 species at 700 m, and 112 beetles of 7 species at 800 m near the summit. The habitat distribution by slope was 307 beetles (20 species of 8 families) on the southern slope and 1,077 beetles (34 species of 15 families) on the northern slope. For the 307 beetles of 20 species collected from the southern slope, the diversity, evenness, and dominance indices were 0.981, 0.754, and 0.156, respectively. For the 1,077 beetles of 34 species collected from the northern slope, the diversity evenness, and dominance indices were 1.187, 0.775, and 0.101, respectively.

Key Words: ground beetles, Geumo mountain, diversity index, similarity index

Introduction

Climate warming caused by environmental problems has resulted in ecosystem changes worldwide, including on the Korean Peninsula, where climate warming has damaged the forest ecosystem. In response to the increasing environmental issues, the National Natural Environment Survey has been actively performed with the goal of conserving biodiversity (NIE 2017). Geumo Mountain (849 m) is located at Jingyo-myeon across Geumnam-myeon of Hadong-gun, Gyeongsangnam-do. Because of the conveniently located expressway and Hallyeohaesang National Park adjacent to the mountain along with development of tourist facilities in the region, many tourists visit the area throughout the year. In addition, Geumo Mountain has an oceanic climate influenced by the sea, which is directly in front of the mountain to the south.

The main tree species on Geumo Mountain are *Pinus densiflora, Pinus thunbergii, Quercus mongolia, Quercus acutissima, Carpinus tschonoskii,* and *Styrax japonica,* forming

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the dominant communities, along with *Lespedeza maximowiczii* and *Miscanthus* as the dominant vegetation types (Kim 2003).

Previous studies of the distribution of ground beetles in the surrounding area of Geumo Mountain involved monitoring of Hallyeohaesang National Park (KNPRI 2020), the characteristics of the terrestrial insect community for the entire Hallyeohaesang National Park (Hong 2008), the community structure of terrestrial insects by region (Park 2012), and the habitat distribution and diversity of ground beetles on Geum Mountain (Kim 2017). These reports improved the understanding of the interaction between vegetation and climate change caused by global warming based on beetles mainly inhabiting the forest areas. Beetles, which move on the ground surface, exhibit clear changes in species diversity due to habitat fragmentation and change, and thus are considered as bioindicators (Thiele 1977; Lövei and Sunderland 1996). In particular, the hind wings of carabid beetles are degenerated, and thus they only move on the ground. Therefore, forming artificial cut-land through the construction of forest roads or hiking trails leads to severe pressure on their habitat. The abundance of beetles may be drastically altered when they are isolated or confined in a limited space, and thus, they are recognized as important indicators both domestically and internationally. The species distribution of beetles serves as a measure of species diversity affected by environmental changes (Ishitani and Yano 1994). On Geumo Mountain, facilities such as ziplines and cable cars are actively under installation to target tourists. Large-scale plants such as the Hadong Thermoelectric Power Plant of Korea and POSCO Gwangyang Steel Plant are located in the area adjacent to the mountain, causing considerable damage to the forest ecosystem. In-depth surveys of the status and distribution changes of ground beetles are required to investigate changes in the forest ecosystem of Geumo Mountain.

Therefore, in this study, we aimed to investigate the changes in the abundance and habitat distribution of ground beetles due to ecosystem destruction caused by climate warming and tourism infrastructure development on Geumo Mountain, Hadong-gun, Gyeongnam and numerous visitors and tourists visiting the mountain, to provide basic data on ecosystem changes in the forest areas.

Materials and Methods

Selection of survey area

The survey area is in Jingyo-myeon, Geumnam-myeon, Hadong-gun, Gyeongnam, where the sea is to the south of Geumo Mountain, which corresponds to the Hallyeohaesang National Park. It is adjacent to the highway to the north and Gwangyang Industrial Complex to the west. By comprehensively considering these surrounding environments, ground beetles were collected to investigate their species richness and abundance.

As survey plots to investigate the habitat distribution and abundance of ground beetles, the southern slope and northern slope were selected as survey areas; in the northern slope area, five plots were selected at altitudes of 400, 500, 600, 700, and 800 m to install traps along the forest road and hiking trail. The southern slope area is frequently visited by tourists, with tourist facilities installed up to the submit of Geumo Mountain; five plots were selected at altitudes of 400, 500, 600, 700, and 800 m to install traps. The distance between the traps was 5 m in each plots, and the traps were installed in a straight line (Fig. 1).

The main vegetation on Geumo Mountain includes *P. densiflora, P. thunbergii, Q. mongolia, Q. acutissima, C.*

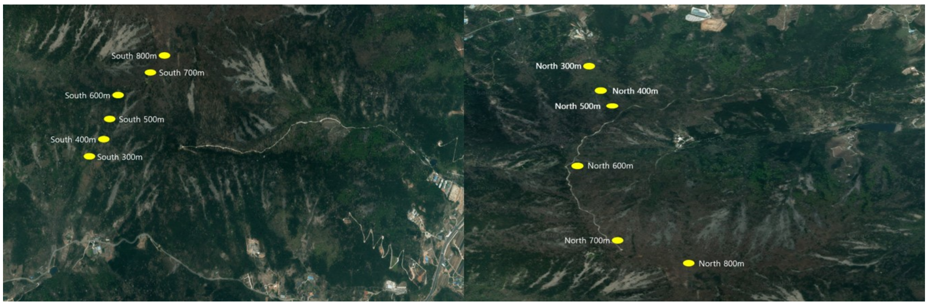

Fig. 1. Map of survey areas.

tschonoskii, S. japonica, L. maximowiczii, Pinus rigida, Pinus koraiensis, Alnus firma, Robinia pseudoacacia, Chamaecyparis obtusa, and *Miscanthus,* with each type of vegetation forming a community in the distribution.

Collection method and identification

To investigate the distribution of ground beetles following international standard practices, traps were installed. Pitfall traps were used to capture the beetles and a plastic collector (depth 12 cm, inlet diameter 8 cm, bottom diameter 5 cm) for collection. A mixture of fruit and ham was used to lure ground beetles to the collection site. In addition, direct collection and sweeping methods were used with the pitfall trap.

The survey period started in April 2021 when ground beetles began to be active, and collection was performed monthly at 2-week intervals up to September when the beetles were mostly inactive. Fix five pitfall traps were set at each altitude of 400, 500, 600, 700, and 800 m, with 5 m spacing between them, so that the southwest slope and northeast slope had the same number of traps. Collection was started in April for identification of the beetles, after which the beetles were released into the forest area. For direct collection, the ground beetles visually observed and collected for identification. For collection by sweeping, an entomological net (sack length 200 cm×inlet width 40 cm) was used to collect the beetles in the survey plots at each altitude for identification. Direct collection was performed at the same time.

For that were difficult to identify at the collection site, photos were taken and later matched with those in Insects' Life in Korea (Kim 1998). The nomenclature of the beetles was applied according to the Checklist of Korean Insects (KSA 1994).

Data analysis

The collected beetle species were classified and arranged by species and by month and altitude. Based on the species richness and abundance information of Carabidae in each survey area, species diversity was analyzed to determine the species composition and diversity. The Shannon-Wiener diversity index was used to analyze the Simpson's diversity index (D') (Simpson, 1949), dominance index (D), and Pielou's evenness index (E) (Pielou 1975). These indices were calculated as follows.

Shannon-Wiener diversity index $H' = -\Sigma Pi \log(Pi)$

Simpson's diversity index $D' = [1-(\Sigma ni(ni-1))/(N(N-1))]$

Simpson's dominance index $D = \Sigma Pi^2$

Pielou's evenness index $E = H'/\log(S)$

(Pi: ni/N, ni: number of individuals for i^{th} species, N: total number of individuals, S: sum of the number of species)

Results and Discussion

Overview of species distribution

In the survey plots of Geumo Mountain, from April to September 2021, ground beetles were collected using pitfall traps and net sweeping. Analysis of the species distribution revealed 1,384 individuals of 41 species and 15 families (Table 1). The distributions of the main species of beetles at the family level on Geumo Mountain were as follows: Attelabidae (16 individuals of 2 species), Buprestidae (19 individuals of 4 species), Cetoniidae (95 individuals of 1

Table 1. Beetle species in survey areas

Family	Species	Individual	Family	Species	Individual
Attelabidae	2	16	Elateridae	1	1
Buprestidae	4	19	Harpalodae	4	107
Cetoniidae	1	95	Rhipiphoridae	2	5
Cerabidae	5	591	Rhynchophoridae	1	4
Cerambycidae	2	16	Rutelinae	3	93
Chrysomelidae	4	79	Silphidae	4	210
Coccinellidae	3	27	Tenebrionidae	2	72
Curculionidae	3	49			
Total			15	41	1,384

species), Cerabidae (591 individuals of 5 species), Cerambycidae (16 individuals of 2 species), Chrysomelidae (79 individuals of 4 species), Coccinellidae (27 individuals of 3 species), Curculionidae (49 individuals of 3 species), Elateridae (1 individual of 1 species), Harpalodae (107 individuals of 4 species), Rhipiphoridae (5 individuals of 2 species), Rhynchophoridae (4 individuals of 1 species), Rutelinae (93 individuals of 3 species), Silphidae (210 individuals of 4 species), and Tenebrionidae (72 individuals of 2 species). Cerabidae accounted for the largest proportion out of the 1,384 individuals. These results are consistent with those of previous studies (Park and Lee 2013; Kim 2017; Jeong 2019) reporting that the abundance of Cerabidae was highest in forests in the southern regions of the Korean Peninsula. Additionally, in a study of the distribution of ground beetles in a pine wilt disease control zone (Heo et al. 2019), Cerabidae showed the highest species richness and abundance, indicating that members of Cerabidae are highly adaptive to environmental changes.

Synuchus cycloderus was the dominant species among ground beetles collected from all survey plots on Geumo Mountain at 347 individuals, accounting for 25% of identified individuals, followed by *Carabus jankowskii* at 14%, *Eusilpha brunneicollis* at 9%, *Pseudotorynorrhina japonica* at 7%, *Eusilpha jakowlewi* at 5%, *Bifurcanomala aulax* at 4%, and *Metialma cordata* at 3%, in the forest ecosystem of Geumo Mountain (Fig. 2). Thus, *Synuchus cycloderus* was identified as the dominant species. This species has been reported to be night-active along with *Pheropsophus kimaniae* and shows high resilience compared with other insects (Lee 2011). Similarly, in a study of ground beetles in the area close to Geumo Mountain (Kim 2017; Lee 2021), *S. cycloderus* was the dominant species. Based on the results of the present study and the findings of previous studies, the dominance of *S. cycloderus* is closely related to the average temperature and vegetation of the surrounding area.

Monthly trends in species richness and abundance

During the 6-month period from April to September, the monthly distribution of the identified species and number of individuals on Geumo Mountain were as follows: 24 beetles of 9 species in April, 115 beetles of 28 species in May, 288 beetles of 32 species in June, peaking at 379 beetles of 32 species in July, 354 beetles of 23 species in August, and 224 beetles of 14 species in September (Fig. 3). Therefore, a large number of individuals was collected from June in early summer through August. In 2021, the rainy season in July was relatively short and the temperature was higher than that in August; however, there was more precipitation in August than in July, and the temperature in August was lower than that in July (KMA 2021). The higher abundance observed in July was likely related to these weather conditions. According to previous studies, the abundance of ground beetles was highest in August (Choi et al. 2015; Kim 2017), which slightly differed from our findings. We observed similar trends as Kang et al. (2013), Kim (2004), and Park and Lee (2013), who reported an increase in the abundance of ground beetles between late spring and summer when the temperature rises.

The main species collected from Geumo Mountain in each month are as follows. In April, *Crepidodera pluta* (12 individuals), *Uloma latimanu* (3 individuals), and *Paridea angulicollis* (2 individuals) (Fig. 4); in May, *S. cycloderus* (17 individuals), *C. pluta* (13 individuals), and *U. latimanu* (11 individuals) (Fig. 5); in June, *C. jankowskii* accounted for the largest number of individuals at 74, followed by *S.*

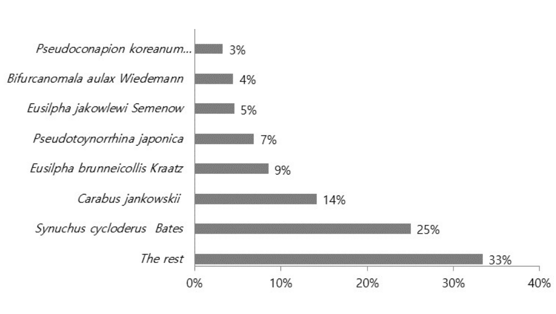

Fig. 2. Dominant species in the survey areas.

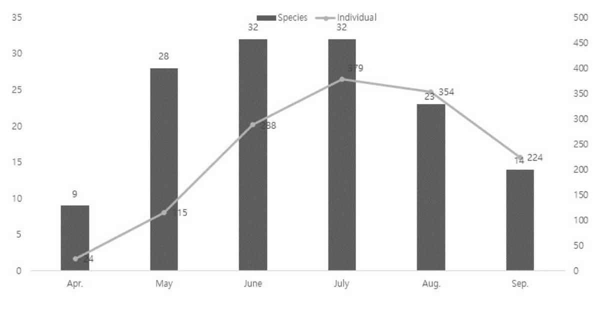

Fig. 3. Species and number of individuals by season.

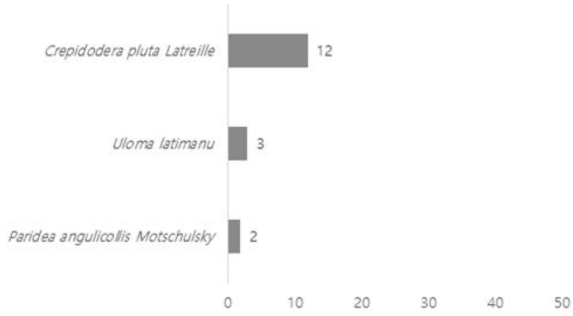

Fig. 4. Distribution of insect species in April.

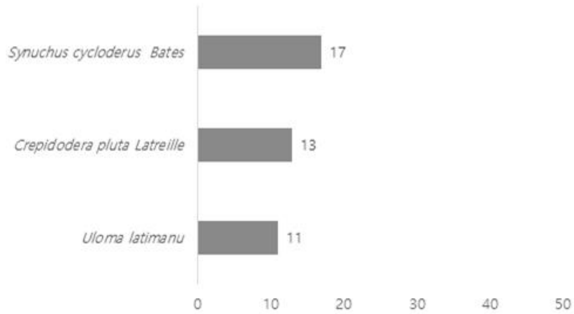

Fig. 5. Distribution of insect species in May.

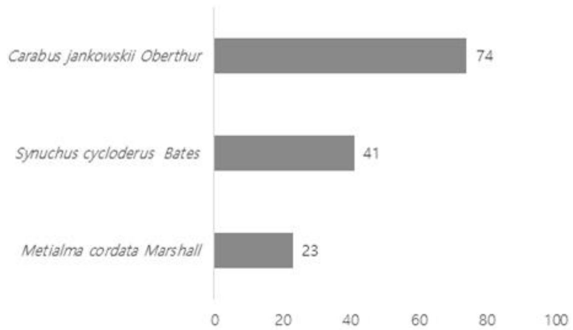

Fig. 6. Distribution of insect species in June.

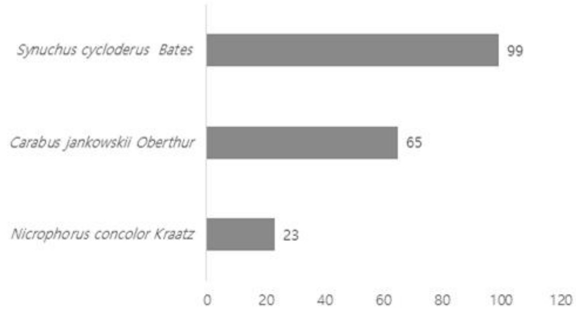

Fig. 7. Distribution of insect species in July.

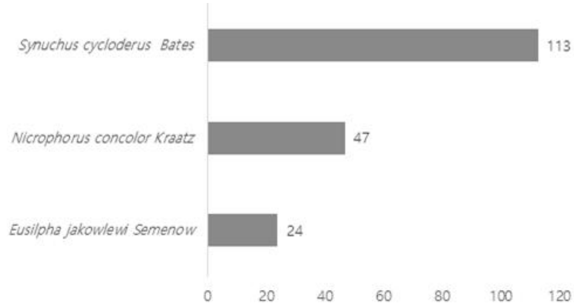

Fig. 8. Distribution of insect species in August.

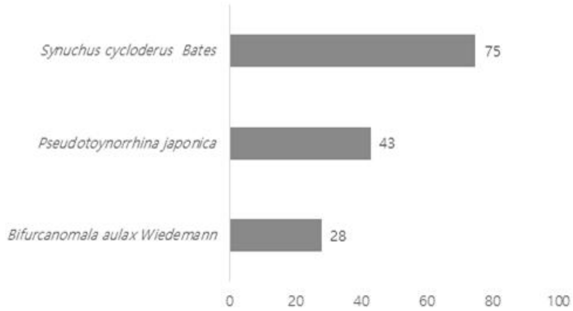

Fig. 9. Distribution of insect species September.

cycloderus (41 individuals) and *M. cordata* (23 individuals) (Fig. 6); in July, *S. cycloderus* was the dominant species with 99 individuals, followed by *C. jankowskii* (65 individuals), and *Nicrophorus concolor* (23 individuals) (Fig. 7). In August, *S. cycloderus* accounted for the largest number of beetles at 113 individuals, followed by *N. concolor* (47 individuals) and *E. jakowlewi* (34 individuals) (Fig. 8). In September, *S. cycloderus* accounted for the largest number of beetles at 75 individuals, followed by *P. japonica* (43 individuals) and *B. aulax* (28 individuals) (Fig. 9). *Synuchus cycloderus* was collected in increasingly large numbers from May to September compared to the other species, and large numbers of *C. jankowskii* and *N. concolor* were collected from June to August. These results are consistent with those of previous studies revealing large number of individuals of *C. jankowskii* and Silphidae on the trail courses of Jiri Mountain in 2014 (Choi et al. 2015), Geum Mountain in Namhae (Kim 2017), and Jiphyeonsan Mountain in Jinju (Lee 2021) during similar periods. Additionally, the results are consistent with those of a previous study (Chang and Kim 2000) demonstrating that a similar distribution of ground beetle communities was found depending on the forest stands. The distribution of *C. jankowskii* and *N. concolor* is thought to reflect the distribution of ground beetles inhabiting the forest area in southern regions.

Distribution of ground beetle species by altitude

The number of species collected in the survey areas at altitudes of 400, 500, 600, 700, and 800 m of Geumo Mountain are shown. We collected 305 beetles of 32 species at 400 m, 326 beetles of 31 species at 500 m, 359 beetles of 27 species at 600 m, 582 beetles of 16 species at 700 m, and 112 beetles of 7 species at 800 m, which is near the summit. These results indicate that the numbers of individuals of all species decreased with increasing altitude (Fig. 10). This is likely because the dominant vegetation in the summit area of Geumo Mountain is *Miscanthus* and also because of the large number of facilities near the summit such as a military facility with a radar base and tourist zipline facility of Geumosan Mountain Zip Wire; these structures led to decreases in the number of ground beetles. These results are similar to those of previous studies. For example, the largest number of ground beetles was collected at altitudes of 400-600 m in a ground beetles survey in Jangsan (Mt), Busan (Park 2013); the largest number of beetles was identified at altitudes of 400-700 m on Geum Mountain, Namhae (Kim 2017); and Heo et al. (2019) reported that species diversity was abundant in low-altitude regions. Based on these results, the most suitable habitat conditions for beetles are at altitudes of 400-700 m.

We also examined the distribution of ground beetle species by altitude. At 400 m, *M. cordata* accounted for the highest percentage with 41 individuals, followed by *P. japonica* with 27 individuals and *S. cycloderus* with 27 individuals (Fig. 11). At 500 m, the number of individuals of *S. cycloderus* was 59, followed by *C. jankowskii* at 53 and *Pseudotoynorrhina* at 29 (Fig. 12). At 600 m, 87 *C. jankowskii* individuals were collected, followed by 71 *S. cycloderus* individuals and 42 *N. concolor* individuals (Fig. 13).

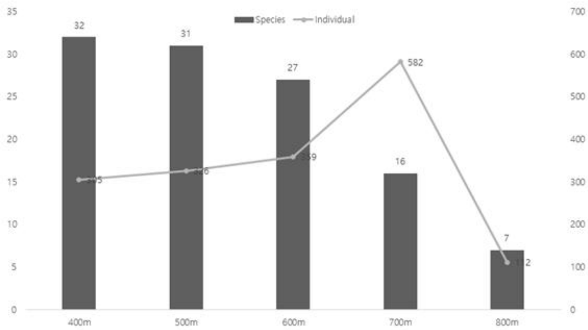

Fig. 10. Species and number of individuals by altitude.

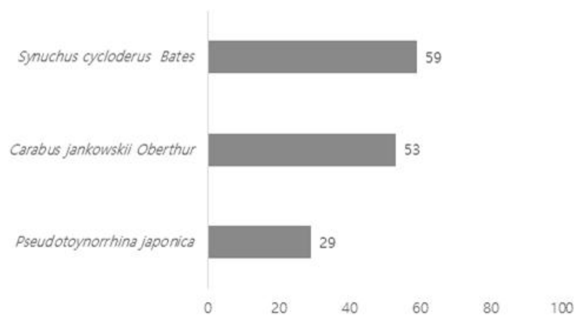

Fig. 12. Distribution of beetle species at 500 m.

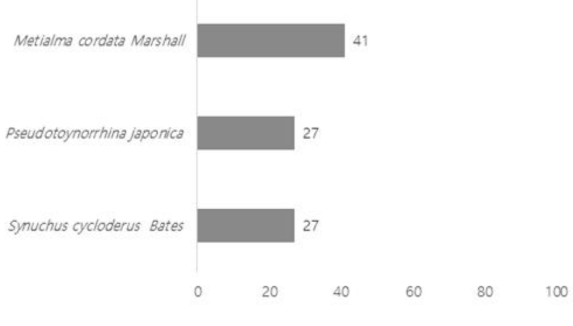

Fig. 11. Distribution of beetle species at 400 m.

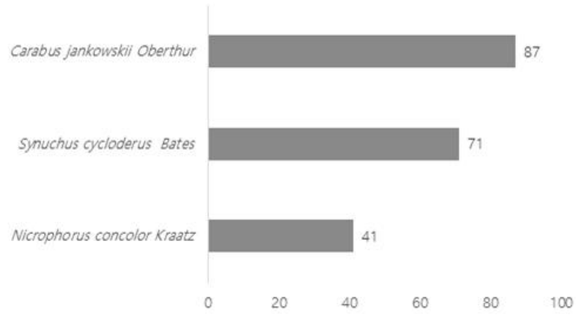

Fig. 13. Distribution of beetle species at 600 m.

At 700 m, 112 S. cycloderus individuals, 36 *N. concolor* individuals, and 32 *B. aulax* individuals were collected (Fig. 14). At 800 m, 78 *S. cycloderus* individuals were collected, followed by 17 *B. aulax* individuals and 7 *N. concolor* individuals (Fig. 15). Thus, *S. cycloderus* was abundant at all altitudes, indicating that it is the dominant species on Geumo Mountain. *Metialma cordata* and *P. japonica*, which mainly appeared at low altitudes, showed the highest abundance at 400 m, possibly because the area at this altitude on Geumo Mountain has more abundant understory vegetation compared to that at higher altitudes, thus forming an optimal habitat for these species.

Distribution of beetle species by slope

At the levels of family, species, and number of individuals by slope on Geumo Mountain, 307 individuals from 8 families and 20 species were collected from the southern slope, including Attelabidae (12 individuals of 2 species), Buprestidae (13 individuals of 3 species), Cerabidae (167 individuals of 5 species), Chrysomelidae (25 individuals of 2 species), Coccinellidae (8 individuals of 2 species), Curculionidae (2 individuals of 2 species), Harpalodae (32 individuals of 2 species), and Silphidae (47 individuals of 2 species) (Table 2). In terms of abundance by species, there were 95 *S. cycloderus* individuals and 47 *C. jankowskii* individuals, indicating that these two species dominated on the southern slope of Geumo Mountain (Table 3). Comparison of the southern and northern slopes revealed that the species richness and abundance were higher on the southern slope than on the northern slope with 1,077 individuals of 34 species. Our findings contrasted those of previous research. Previous studies revealed greater differences in abundance according to the vegetation structure of the survey area rather than according to the slope (Lee 2021); additionally, a large number of ground beetles was reported in the soil of coniferous and deciduous forest, where leaves rot into earth to form leaf mold (Lee and Lee 1995). The reason for the difference may be that although the composition of stands on Geumo Mountain did not significantly differ from those of previous studies, the construction work for cable car installation as a tourist facility was underway on the southern slope, and the zipline facility is actively used by many visitors, disrupting the natural ecosystem along and destroying the forest land in the area, leading to a decreased abundance of ground beetles. Therefore, although it is beneficial to attract tourists to the region, these facilities also cause indiscriminate damage to the ecosystem, resulting in a considerable decrease in the abundance of ground beetles, a

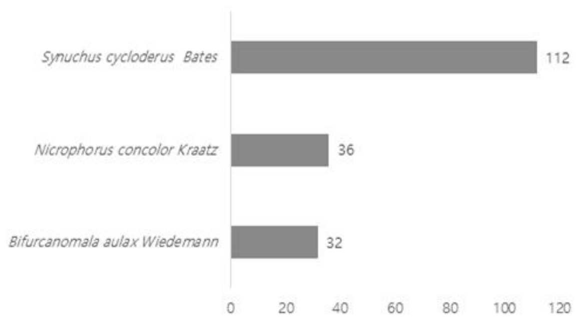

Fig. 14. Distribution of beetle species at 700 m.

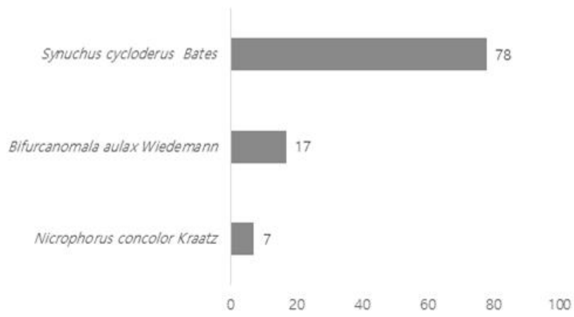

Fig. 15. Distribution of beetle species at 800 m.

Table 2. Species of beetles collected from the south slope

Family	Species	Individual	Family	Species	Individual
Attelabidae	2	12	Coccinellidae	2	8
Buprestidae	3	13	Curculionidae	2	3
Cerabidae	5	167	Harpalodae	2	32
Chrysomelidae	2	25	Silphidae	2	47
Total			8	20	307

Table 3. Species and number of individuals collected from the south slope

Family	Species	Individual
Attelabidae	*Euops lespedezae koreanus* Voss	2
	Haplorhynchies amabilis Roelofs	10
Buprestidae	*Buprestis haemorrhoidalis* Herbst	1
	Chalcophora japonica Gory	10
	Paracylindromorphus japanensis Saunders	2
Cerabidae	*Carabus jankowskii* Oberthur	47
	Carabus smaragdinus Fischer-Waldheim	17
	Calosoma maderae Kirby	1
	Leptocarabus semiopacus Reitter	7
	Synuchus cycloderus Bates	95
Chrysomelidae	*Crepidodera pluta* Latreille	7
	Dactylispa angulosa Solsky	18
Coccinellidae	*Harmonia axyridis* Pallas	7
	Propylea quatuordecimpunctata Linnaeus	1
Curculionidae	*Psilarthroides czerskyi* Zaslavskij	2
	Metialma cordata Marshall	1
Harpalodae	*Macrochlaenites naeviger* Morawitz	4
	Macrochlaenites pallipes Gebler	28
Silphidae	*Nicrophorus concolor* Kraatz	40
	Nicrophorus japonicus Harold	7

Table 4. Species of beetles collected from the north slope

Family	Species	Individual	Family	Species	Individual
Attelabidae	2	4	Elateridae	1	1
Buprestidae	3	6	Harpalodae	3	75
Cetoniidae	1	95	Rhipiphoridae	2	5
Cerabidae	4	424	Rhynchophoridae	1	4
Cerambycidae	2	16	Rutelinae	3	93
Chrysomelidae	3	54	Silphidae	3	163
Coccinellidae	2	19	Tenebrionidae	2	72
Curculionidae	2	46			
Total			15	34	1,077

representative indicator species. Therefore, after the construction work, active efforts are required to restore the ecosystem in this area.

On the northern slope, 1,077 ground beetles from 15 families and 34 species were collected, which consisted of Attelabidae (4 individuals of 2 species), Buprestidae (6 individuals of 3 species), Cetoniidae (95 individuals of 1 species), Cerabidae (424 individuals of 4 species), Cerambycidae (16 individuals of 2 species), Chrysomelidae (54 individuals of 3 species), Coccinellidae (19 individuals of 2 species), Curculionidae (46 individuals of 2 species), Elateridae (1 individual of 1 species), Harpalodae (75 individuals of 3 species), Rhipiphoridae (5 individuals 2 species), Rhynchophoridae (4 individuals of 1 species), Rutelinae (93 individuals of 3 species), Silphidae (163 individuals of 3 species), and Tenebrionidae (72 individuals of 2 species) (Table 4). Analysis of the abundance by species revealed 252 *S. cycloderus* individuals, 146 *C. jankowskii* individuals, and 95 *P. japonica*, individuals indicating that these are the dominant species on the northern slope of Geumo Mountain (Table 5). Thus, the northern slope had a much higher species richness and abundance, which agrees with the results of a

Table 5. Species and number of individuals collected at north slope

Family	Species	Individual
Attelabidae	*Euops lespedezae koreanus* Voss	1
	Haplorhynchies laevior Faust	3
Buprestidae	*Agrilus discalis* E.Saunders	2
	Buprestis haemorrhoidalis subsp	2
	Paracylindromorphus japanensis Saunders	2
Cetoniidae	*Pseudotoynorrhina* japonica	95
Cerabidae	*Carabus jankowskii* Oberthur	146
	Carabus smaragdinus Fischer-Waldheim	21
	Calosoma maderae Kirby	5
	Synuchus cycloderus Bates	252
Cerambycidae	*Moechotypa diphysis* Pascoe	5
	Spondylis buprestoides Linnaeus	11
Chrysomelidae	*Crepidodera pluta* Latreille	25
	Paridea angulicollis Motschulsky	12
	Physosmaragdi nanigrifrons Hope	17
Coccinellidae	*Myzia oblongoguttata* Linnaeus	2
	Harmonia axyridis Pallas	17
Curculionidae	*Metialma cordata* Marshall	44
	Pseudoconapion koreanum Korotyaev	2
Elateridae	*Spheniscosomus cete* Candéze	1
Harpalodae	*Brachinus scotomedes* Redtenbacher	21
	Macrochlaenites inops Chaudoir	30
	Macrochlaenites naeviger Morawitz	24
Rhipiphoridae	*Mordella brachyura brachyura* Mulsant	3
	Mordellistena comes Marseul	2
Rhynchophoridae	*Sipalinus gigas* Fabricius	4

previous study (Jeon 2007) that for Coleoptera, an environment with a high moisture content, optimal shading, and deciduous forests where the beetles can easily find food and habitats is suitable for breeding and growth. Pine forests dominated the southern slope of Geumo Mountain, whereas deciduous forests were widely distributed on the northern slope, thus providing an optimal habitat of ground beetles and leading to the collection of a large number of species and individuals. Additionally, we compared our findings with those regarding the abundance of beetles in surrounding areas; on Geum Mountain of Namhae (Kim 2017) at similar altitudes as in this study, 1,938 and 2,637 individuals were reported on the southern and northern slopes, respectively; on Jagul Mountain in Uiryeong (Jeong 2019), 1,032 and 1,870 individuals were reported on the southern and northern slopes, respectively. Thus, on Geumo Mountain, the abundance of ground beetles was lower on both slopes compared to those in other regions, possibly because of overall ecosystem changes on Geumo Mountain related to the construction work of tourism facilities carried out over a prolonged period.

Analysis of species diversity

For ground beetles of Geumo Mountain, the Simpson diversity, dominance, and Pielou evenness indices were calculated based on the number of individuals collected from the southern and northern slopes (Table 6). Based on the 307 individuals of 20 species collected from the southern slope, the diversity was 0.981, evenness was 0.754, and dominance was 0.156. For the 1,077 individuals of 34 species collected from the northern slope, the diversity was 1.187, which was 0.206 higher than that on the southern slope; evenness was 0.775, which was 0.021 higher than that on the southern slope; and dominance was 0.101,

Table 6. Species diversity index of beetles at the two study sites

Site	No. of species	No. of individual	Species Diversity (H')	Evenness (E)	Dominance (D)
South slope	20	307	2.258 (0.981)	0.754	0.156
North slope	34	1,077	2.734 (1.187)	0.775	0.101

which was 0.055 lower than that of the southern slope. The value for the diversity index was higher or similar to those found in previous studies; the diversity index on Deogyusan (Mt) was 0.991-1.000 (Jang 2008) and on Jangsan (Mt) was 0.950-0.946 (Park 2013). A high dominance index indicates that the species distribution is dominated by a specific species. The dominance index value on the southern slope was high; this is thought to be because although the number of species and individuals on the southern slope are small, the density of a specific species is high, leading to a large dominance index on the southern slope. These results are similar to those of a previous study (Kang et al. 2013) showing that in terms of species diversity, a high dominance index does not indicate an optimal environment; for lower values, more weight should be given to the environment. Thus, the construction of tourist facilities on the southern slope has led to lower species richness and abundance compared to those on the northern slope. Therefore, the development of tourist facilities on Geumo Mountain affects the distribution of ground beetles.

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