

Fauna and Relative Abundance of the Insects Collected by Black Light Traps in Gotjawal Terrains of Jeju Island, Korea (Exclusion of Lepidoptera)

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ABSTRACT: An investigation of fauna and community of insects in Gotjawal Terrain, Jeju-do, had been conducted with a way of black light trap from July to September, 2005. The investigated insects were classified into 217 species, 75 families, and 11 orders respectively. Coleoptera that occupied 55.3 percent among them and was consisted of 120 species was the richest group and Hemiptera followed it. The density of *Physopelta gutta* was highest but *Physopelta cincticollis* was overall the dominant species in all sampling areas. The species diversity index was highest at Jocheon-Hamdeog Gotjawal in Jeju-do, while it was lowest in Gujwa-Sungsan Gotjawal. Clustering analysis revealed that the insect communities of four localities were grouped in only one cluster. Included in the species unreported in Jeju Island were *Menida musiva* and *Pentatoma japonica* in Hemiptera, *Philonthus wuesthoffi* in Coleoptera, and *Phanerotoma flava* in Hymenoptera.

Key words: Black light trap, Cluster analysis, Gotjawal Terrain, Jeju Island, Species diversity index

INTRODUCTION

Gotjawal, named in Jeju dialect, where the trees, vines, and rocks are jumbled and tangled an together, represents the unique topographic features of rough lava bed created by volcanic activity. Such Gotjawal spreads widely from east to west in Jeju but this has been recognized as wasteland because Gotjawal lava of this area caused the soil to be less cultivated and less developed. Recently, Gotjawal Terrain was found to have a high quality of soil with abundant underground water resources and with very efficient geological conditions such as sufficient heat and moisture. Accordingly, building the structures is prohibited in this area by law (Song 2003a, 2003b, 2003c). However, this area has been in danger of losing its very unique ecological value because many golf courses are being constructed and some area is reclaimed for garbage in this area. Song (2000) named Gotjawal lava Terrain as Hangyeong-Andeog and Aewol Gotjawal Terrain in the west and Jocheon-Hamdeog and Gujwa-Sungsan Gotjawal Terrain in the east according to their local names. There has been no biological report on Gotjawal, except on the geological part (Song 2000, Song and Yoon 2002).

The insect species hold the largest number among the arthropod, the biggest group of fauna. They eat the plants, the first producer, produce animal protein, and become the prey of carnivorous insects, birds, amphibia or small mammalia. The insects decompose the dead bodies or excrements and play an important part in the material circulation of ecology. Besides, judging from reciprocal

action such as pollination and preying, the sustenance of the plant community, the initial producer, considerably depends on whether the insects inhabit or not. The insects that which induce other consumers and fall prey to other consumers can be also considered as a barometer of determining ecological conditions (Bae et al. 2002). Thus, analyzing the Fauna makes it possible to compare the insects' habitats and surrounding ecosystem indirectly.

This study was done in limited area of Mt. Halla National Park, especially coastal area and near the riverside and parasitic volcanos. This study focused on identifying the fauna as well as analyzing the relative abundance of species in Gotjawal Terrain on the basis of sample insects collected from 4 different locations in a way of Black Light Trap conducted from July, 2005 to September, 2005, which was aimed at obtaining the basic data to better understand the ecological features of Gotjawal Terrain from the ecological standpoint.

MATERIALS AND METHODS

The investigation was conducted from July through September 2005. The study sites were Jocheon-Hamdeog, Hangyeong-Andeog, Aewol and Gujwa-Sungsan Gotjawal Terrain (Fig. 1).

The investigations were conducted at nighttime (21:00~23:00) twice a month at designated points, collecting the samples using mercury lamps (300W, KP ELECTRIC CO., H300). Every collection activity was done in only calm and fine days. But the activity was avoided in full-moon nights because the brightness of the moon

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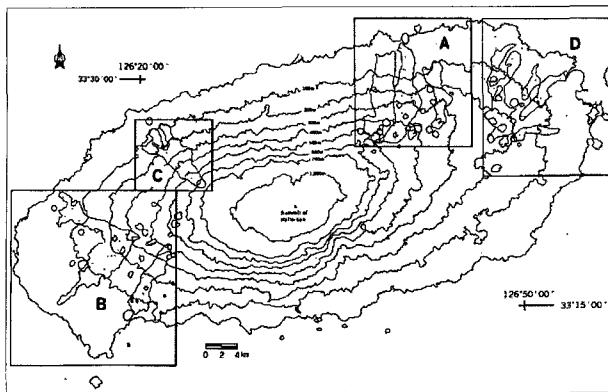


Fig. 1. Index map of Gotjawal Terrains, Jeju Island. A: Jocheon-Hamdeog Gotjawal Terrain, B: Hangeong-Andeog Gotjawal Terrain, C: Aeweol Gotjawal Terrain, and D: Gujwa-Sungsan Gotjawal Terrain (Adapted from Song 2000).

had on influence on the activities of the moth (Choi and Na 2005).

The insects sampled were brought to the lab, submerged into 70% ethyl alcohol for 3 days, washed with pre-arranged cleansing solution (95% ethyl alcohol 54 mL, DW 44 mL, benzene 7 mL, ethyl acetate 19 mL), dried and identified with a microscope (Dongwon OSM-1).

The relative abundances were evaluated into three classes (abundant, common and rare) to compare the relative percentage of component species in the aspect of temporal and spatial. The 95% confidence limits of relative percentage are given by Sakuma's (1964) formula in following way.

$$(n/N \pm \sqrt{n(N-n)/N^3}) \times 100$$

Where, N =total individual number and n = individual number of a specie. Next, the limits of the mean percentage can be calculated by using the mean individual number ($n=N/S$, where S =total species number) instead of n . In comparison of the percentage range of each species and that of the mean, the species is regarded to be abundant when the lower limit of the former exceeds the higher one of the latter, common when the two ranges overlap, and rare when opposite to the case of abundant.

To identify the differences in diversity index among the groups in the area, the following Shannon Weaver (1949) function was adopted.

$$H' = - \sum p_i \log p_i$$

where, P_i = the ratio of i species to the total number (n_i/N), n_i = the number of i species, and N = total number of individuals.

The BASIC program CLUSTER.BAS was used for a cluster analysis on the insect data of four Gotjawal terrains, and chord distance (see below) was the resemblance function used along with

the flexible clustering strategy (Ludwig and Reynold 1988). Chord distance is given by

$$CRD_{jk} = \sqrt{2(1 - c\cos_{jk})}$$

where the chord cosine (ccos) is computed from

$$ccos_{jk} = \frac{\sum (X_{ij} X_{ik})}{\sum X_{ij}^2 \sum X_{ik}^2}$$

RESULTS AND DISCUSSION

As the result of investigation, the fauna of the insects collected and identified in Gotjawal terrain in Jeju Island was 217 species, 75 families, and 11 orders (Fig. 2).

Coleoptera was the most diversified species with 28 families, accounting for 37.3% of the total, followed by Hemiptera with 15 families accounting for 20%. These two groups, also in terms of species, demonstrated more diversified species with 120 (55.3%) and 45 (20.7%), respectively, which were significantly higher than other groups.

The Fauna in Jocheon-Hamdeog Gotjawal Terrain

Total 135 species, 53 families and 10 orders were collected in Jocheon-Hamdeog Gotjawal Terrain, which break down as follows (Table 1). Coleoptera had the largest number of species with 80 (53.9%), followed by Hemiptera (15.6%), Orthoptera (13.3%), Homoptera (3.7%), Hymenoptera (3.7%), Mantodea (1.5%), Blattaria (0.7%), Dermaptera (0.7%), Phasmida (0.7%) and Diptera (0.7%).

In the area, total 12 kinds of aquatic insects including *Graphoderus adamsii*, *Hydrophilus acuminatus*, and *Hesperocorixa distant* were collected in villages over a hilly area including Seonheul-ri, Waheul-ri, and Daeheul-ri and the density of aquatic insects was high in small ponds near town or swampy land in the vicinity of

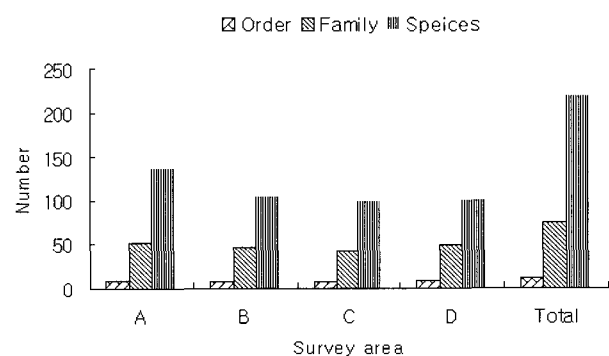


Fig. 2. A number of species in the investigated areas. The abbreviated letters in the abscissa are same as represented in Fig. 1.

Table 1. Frequency and relative abundance of the insects collected from Jocheon-Hamdeog Gotjawal Terrain

Order	Family	Scientific name	Relative Percentage			Frequency (R.A.*)	
			L. Limit	Observed	U. Limit		
Blattaria	Blattellidae	<i>Blattella nipponica</i> Asahina	-0.07	0.07	0.20	1 (±)	
Mantodea	Mantidae	<i>Statilia maculata</i> (Thunberg)	-0.07	0.07	0.20	1 (±)	
		<i>Tenodera aridifolia</i> (Stoll)	-0.07	0.07	0.20	1 (±)	
Dermaptera	Labiduridae	<i>Labidura niparia japonica</i> (de Haan)	-0.07	0.07	0.20	1 (±)	
Orthoptera	Rhaphidophoridae	<i>Diestrarmena apicalis</i> Brunner	-0.07	0.07	0.20	1 (±)	
		Tettigoniidae	<i>Conocephalus gladiatus</i> (Redtenbacher)	-0.07	0.07	0.20	1 (±)
			<i>Ducetia japonica</i> (Thunberg)	-0.03	0.20	0.42	3 (+)
			<i>Gampsocleis ussuriensis</i> Adelung	-0.07	0.07	0.20	1 (±)
			<i>Hexacentrus unicolor</i> Serville	-0.07	1.18	0.20	1 (±)
			<i>Metrioptera bonneti</i> (Bolivar)	0.63	0.07	1.73	18 (+)
			<i>Ruspolia lineosa</i> (Walker)	-0.07	0.07	0.20	1 (±)
		Gryllidae	<i>Loxoblemmus doenitzi</i> Stein	0.03	0.33	0.62	5 (+)
			<i>Teleogryllus emma</i> (Ohmachi et Matsumura)	0.83	1.44	2.05	22 (+)
			<i>Velarifictorus aspersus</i> (Walker)	-0.07	0.07	0.20	1 (±)
		Gryllotalpidae	<i>Gryllotalpa orientalis</i> (Burmeister)	1.85	2.68	3.51	41 (++)
		Tetrigidae	<i>Crietotix japonicus</i> (de Hann)	-0.07	0.07	0.20	1 (±)
			<i>Tetrix japonica</i> (Bolivar)	-0.07	0.07	0.20	1 (±)
		Pyrgomorphidae	<i>Atractomorpha lata</i> (Motschulsky)	-0.05	0.13	0.32	2 (+)
	Acrididae		<i>Aiolopus thalassinus tamulus</i> (Fabricius)	-0.07	0.07	0.20	1 (±)
		<i>Omocestus haemorrhoidalis</i> Charpentier	-0.07	0.20	0.20	1 (±)	
		<i>Shirakiacris shirakii</i> (Bolivar)	-0.03	0.07	0.42	3 (+)	
		<i>Stethophyma magister</i> (Rehn)	-0.07	0.07	0.20	1 (±)	
		Phasmida	<i>Phraortes illepidus</i> (Brunner von Wattenwyl)	-0.07	0.07	0.20	1 (±)
Hemiptera	Corixidae	<i>Hesperocorixa distantii</i> (Kirkaldy)	3.10	4.12	5.13	63 (++)	
		<i>Sigara substriata</i> (Uhler)	-0.07	0.07	0.20	1 (±)	
	Reduviidae	<i>Coranus dilatatus</i> (Matsumura)	-0.07	0.07	0.20	1 (±)	
		<i>Oncocephalus assimilis</i> Reuter	-0.05	0.13	0.32	2(+)	
	Lygaeidae	<i>Metochus abbreviatus</i> (Scott)	-0.03	0.20	0.42	3 (+)	
		<i>Neolethaeus dallasi</i> (Scott)	4.50	5.69	6.87	87 (++)	
	Pyrrhocoridae	<i>Pyrrhocoris sibiricus</i> Kuschakewitsch	-0.07	0.07	0.20	1 (±)	
	Largidae	<i>Physopelta cincticollis</i> Stal	4.56	5.75	6.94	88 (++)	
		<i>P. gutta</i> (Burmeister)	8.10	9.61	11.11	147 (++)	
	Coreidae	<i>Cletus punctiger</i> (Dallas)	1.36	2.09	2.82	32 (++)	
	Alydidae	<i>Riptortus clavatus</i> (Thunberg)	-0.07	0.07	0.20	1 (±)	
	Urostylididae	<i>Urostylis annulicornis</i> Scott	-0.07	0.07	0.20	1 (±)	

Table 1. Continued

Order	Family	Scientific name	Relative Percentage			Frequency (R.A.*)
			L. Limit	Observed	U. Limit	
	Acanthosomatidae	<i>Dichobothrium nubilum</i> (Dallas)	3.45	4.51	5.57	69 (++)
		<i>Elasmotethus humeralis</i> Jakovlev	-0.05	0.13	0.32	2 (+)
	Cydniidae	<i>Geotomus pygmaeus</i> (Dallas)	0.00	0.26	0.52	4 (+)
		<i>Macroscyrtus japonensis</i> Scott	2.47	3.40	4.33	52 (++)
	Pentatomidae	<i>Carbula putoni</i> (Jakovlev)	-0.05	0.07	0.20	1 (±)
		<i>Halyomorpha halys</i> (Stal)	1.85	2.68	3.51	41 (++)
		<i>Laprius gastricus</i> (Thunberg)	-0.07	0.07	0.20	1 (±)
		<i>Menida musiva</i> (Jakovlev)	-0.07	0.07	0.20	1 (±)
		<i>Plautia stali</i> Scott	6.53	7.91	9.29	121 (++)
Homoptera	Cicadellidae	<i>Bothrogonia japonica</i> Ishihara	-0.07	0.07	0.20	1 (±)
		<i>Ledra auditura</i> Walker	0.83	1.44	2.05	22 (+)
	Ricaniidae	<i>Orosanga japonica</i> (Melichar)	0.03	0.33	0.62	5 (+)
	Flatidae	<i>Geisha distinctissima</i> (Walker)	0.88	1.50	2.13	23 (+)
	Cicadidae	<i>Platypleura kaempferi</i> (Fabricius)	-0.07	0.07	0.02	1 (±)
Coleoptera	Carabidae	<i>Calosoma inquisitor cyanescens</i> (Motschulsky)	-0.07	0.07	0.02	1 (±)
		<i>Carabus sternbergi sternbergi</i> Roeschke	-0.07	0.07	0.02	1 (±)
		<i>Damaster jankowskii jankowskii</i> (Oberthur)	-0.07	0.07	0.02	1 (±)
	Scaritidae	<i>Clivina castanea</i> Westwood	-0.03	0.20	0.42	3 (+)
	Harpalidae	<i>Amara gigantea</i> (Motschulsky)	1.52	2.29	3.05	35 (++)
		<i>A. nipponica</i> Habu	0.58	1.11	1.65	17 (+)
		<i>Anisodactylus tricuspispidatus</i> (Morawitz)	0.33	0.78	1.24	12 (+)
		<i>Chlaenius micans</i> (Fabricius)	0.33	0.78	1.24	12 (+)
		<i>Chlaenius naeviger</i> Morawitz	-0.07	0.07	0.20	1 (±)
		<i>Colpodes atricomis</i> Bates	-0.07	0.07	0.20	1 (±)
		<i>C. buchani</i> (Hope)	-0.03	0.20	0.42	3 (+)
		<i>C. japonicus</i> (Motschulsky)	0.38	1.18	1.32	13 (+)
		<i>Dolichus halensis</i> (Schaller)	0.63	0.07	1.73	18 (+)
		<i>Drypta japonica</i> Bates	-0.07	0.07	0.20	1 (±)
		<i>Euplynes batesi</i> Harold	-0.07	2.09	0.20	1 (±)
		<i>Harpalus capito</i> Morawitz	1.36	0.07	2.82	32 (++)
		<i>H. chalcatus</i> Bates	-0.07	0.07	0.20	1 (±)
		<i>H. corporosus</i> Motschulsky	-0.07	2.68	0.20	1 (±)
		<i>H. discrepans</i> Morawitz	-0.07	3.66	0.20	1 (±)
		<i>H. eous</i> Tschitscherine	1.85	3.14	3.51	41 (++)
		<i>H. jureceki</i> (Jedlicka)	2.70	2.09	4.62	56 (++)

Table 1. Continued

Order	Family	Scientific name	Relative Percentage			Frequency (R.A.)
			L. Limit	Observed	U. Limit	
		<i>H. sinicus sinicus</i> (Hope)	2.25	0.07	4.03	48 (++)
		<i>H. tridens</i> (Morawitz)	1.36	0.07	2.82	32 (++)
		<i>Lachnolebia cribricollis</i> (Morawitz)	-0.07	0.07	0.20	1 (±)
		<i>Lebia retrofasciata</i> (Motschulsky)	-0.07	0.07	0.20	1 (±)
		<i>Lesticus magnus</i> Motschulsky	-0.07	0.85	0.20	1 (±)
		<i>Patrobus flavipes</i> Motschulsky	-0.07	0.07	0.20	1 (±)
		<i>Platynus magnus</i> (Bates)	-0.07	0.07	0.20	1 (±)
		<i>Stenolophus propinauus</i> Morawitz	-0.07	0.07	0.20	1 (±)
	Dytiscidae	<i>Copelatus koreanus</i> Mori	-0.07	0.07	0.20	1 (±)
		<i>Graphoderus adamsii</i> (Clark)	-0.07	0.07	0.20	1 (±)
		<i>Hydaticus bowringi</i> Clark	-0.07	0.07	0.20	1 (±)
		<i>H. grammicus</i> Germar	-0.07	0.26	0.20	1 (±)
		<i>H. pacificus</i> Aube	0.00	0.07	0.52	4 (+)
		<i>Laccophilus kobensis</i> Sharp	-0.07	0.07	0.20	1 (±)
	Hydrophilidae	<i>Hydrochara affinis</i> (Sharp)	-0.07	0.13	0.20	1 (±)
		<i>Hydrophilus acuminatus</i> Motschulsky	-0.07	0.07	0.20	1 (±)
		<i>H. bilineatus cashimirensis</i> Redtenbacher	-0.05	0.13	0.32	2 (+)
		<i>Sternolophus rufipes</i> Fabricius	-0.05	0.07	0.32	2 (+)
	Silphidae	<i>Necrodes asiaticus</i> Portevin	1.91	2.75	3.58	42 (++)
		<i>N. nigricornis</i> (Harold)	0.78	1.37	1.97	21 (+)
		<i>Ptomascopus morio</i> Kraatz	-0.07	0.07	0.20	1 (±)
	Staphylinidae	<i>Ocypus rambouseki nigroaeneus</i> Sharp	2.59	3.53	4.47	54 (++)
		<i>Paederus parallelus</i> Weise	-0.07	0.07	0.20	1 (±)
		<i>Philonthus japonicus</i> Sharp	-0.07	0.07	0.20	1 (±)
		<i>P. spinipes</i> Sharp	-0.07	0.07	0.20	1 (±)
		<i>P. wuesthoffi</i> Bernhauer	-0.03	0.20	0.42	3 (+)
	Lucanidae	<i>Macrodercas rectus rectus</i> (Motschulsky)	-0.07	0.07	0.20	1 (±)
		<i>Prismognathus dauricus</i> (Motschulsky)	0.00	0.26	0.52	4 (+)
		<i>Serrogathus platymelus castanicolor</i> Motschulsky	-0.07	0.07	0.20	1 (±)
	Scarabaeidae	<i>Onthophagus lenzii</i> Harold	0.07	0.39	0.71	6 (+)
	Trogidae	<i>Trox setifer</i> Waterhouse	-0.07	0.07	0.20	1 (±)
	Melolonthidae	<i>Holotrichia diomphalia</i> (Bates)	-0.05	0.13	0.32	2 (+)
		<i>H. morosa</i> (Waterhouse)	-0.05	0.13	0.32	2 (+)
		<i>Maladera japonica</i> (Motschulsky)	-0.07	0.07	0.20	1 (±)

Table 1. Continued

Order	Family	Scientific name	Relative Percentage			Frequency (R.A. *)
			L. Limit	Observed	U. Limit	
		<i>M. secreta</i> (Brenske)	-0.05	0.13	0.32	2 (+)
		<i>Miridiba castanea</i> (Waterhouse)	-0.07	0.07	0.20	1 (±)
	Aphodiidae	<i>Aphodius rectus</i> (Motschulsky)	0.20	0.59	0.98	9 (+)
	Rutelidae	<i>Adoretus tenuimaculatus</i> (Waterhouse)	0.03	0.33	0.62	5 (+)
		<i>Anomala albopilosa</i> (Hope)	3.33	4.38	5.43	67 (++)
		<i>A. chamaeleon</i> Fairmaire	-0.07	0.07	0.20	1 (±)
	Elateridae	<i>Agrypnus binodulus coreanus</i> (Kishii)	0.15	0.52	0.89	8 (+)
	Lampyridae	<i>Lychnuris rufa</i> (Olivier)	0.07	0.39	0.71	6 (+)
	Cantharidae	<i>Podabrus heydeni</i> Kiesenwetter	-0.07	0.07	0.20	1 (±)
	Nitidulidae	<i>Glischrochilus japonicus</i> (Motschulsky)	-0.05	0.13	0.32	2 (+)
		<i>Lasiodactylus pictus</i> (MacLeay)	0.00	0.26	0.52	4 (+)
	Coccinellidae	<i>Coccinella septempunctata</i> Linne	-0.05	0.13	0.32	2 (+)
		<i>Harmonia axyridis</i> (Pallas)	0.33	0.78	1.24	12 (+)
		<i>H. yedoensis</i> (Takizawa)	-0.03	0.20	0.42	3 (+)
	Tenebrionidae	<i>Gonocephalum sexuale</i> (Marseul)	-0.07	0.07	0.20	1 (+)
		<i>Heterotarsus carinula</i> Marseul	0.20	0.59	0.98	9 (+)
	Cerambycidae	<i>Acalolepta fraudatrix</i> (Bates)	-0.07	0.07	0.20	1 (+)
		<i>Anoplophora malasiaca</i> (Thomson)	-0.07	0.07	0.20	1 (+)
		<i>Spondylis buprestoides</i> (Linne)	-0.07	0.07	0.20	1 (+)
		<i>Xystrocera globosa</i> (Olivier)	-0.07	0.07	0.20	1 (+)
	Chrysomelidae	<i>Aulacophora indica</i> (Gmelin)	-0.07	0.07	0.20	1 (+)
		<i>Galeruca vicina</i> Solsky	-0.03	0.20	0.42	3 (+)
		<i>Galerucella grisescens</i> (Joannis)	-0.07	0.07	0.20	1 (+)
		<i>Monolepta pallidula</i> (Baly)	-0.05	0.13	0.32	2 (+)
	Curculionidae	<i>Curculio sikkimensis</i> (Heller)	-0.05	0.13	0.32	2 (+)
Hymenoptera	Braconidae	<i>Phanerotoma flava</i> Ashmead	-0.05	0.13	0.32	2 (+)
		<i>Xiphozele compressiventris</i> Cameron	-0.07	0.07	0.20	1 (+)
	Ichneumonidae	<i>Homotropus tarsatorius</i> (Panzer)	-0.05	0.13	0.32	2 (+)
	Vespidae	<i>Polistes chinensis antennalis</i> Perez	-0.07	0.07	0.20	1 (+)
	Apidae	<i>Amegilla florea</i> Smith	-0.07	0.07	0.20	1 (+)
Diptera	Asilidae	<i>Neoitamus angusticornis</i> (Loew)	-0.07	0.07	0.20	1 (+)
TOTAL						
	S = 135	Mean = 11.33	0.30		1.18	

* Relative abundance

Gotjawal Terrain.

Swampy area is limited in Jeju-do because of less river or stream in the region (Kim et al. 2001). Though, a small size of pond, reservoir are well developed. Because they are easily destroyed or disappeared and vulnerable to external conditions, they requires constant care and endeavors for conservation.

The Fauna in Hangyeong-Andeog Gotjawal Terrain

Total 104 species, 47 families and 7 orders were collected in Hangyeong-Andeog Gotjawal Terrain, which break down as follows (Table 2). Coleoptera had the largest number of species with 54 (51.9%), followed by Hemiptera (26.9%), Orthoptera (10.6%), Homoptera (5.8%), Hymenoptera (1.9%), Dermaptera (1.9%) and Blattaria (1.0%).

More Scarabaeidae such as *Onthophagus fodiens* and *Onthophagus atripennis*, which have not been found in other Gotjawals, were observed and this result may come from nearby horse riding track and horse stable grassland. A horse stable grassland reportedly increases the density of Scarabaeidae such as *Onthophagus fodiens* (Yang et al. 2004).

The Fauna in Aewol Gotjawal Terrain

Total 97 species, 43 families and 8 orders were collected in Aewol Gotjawal Terrain, which break down as follows (Table 3). Coleoptera had the largest number of species with 53 (53.6%), followed by Hemiptera (19.6%), Orthoptera (9.7%), Homoptera (7.2%), Hymenoptera (5.2%), Dermaptera (2.1%), Mantodea (1.0%) and Neuroptera (1.0%).

In this area, *Copris ochus* was collected and *Copris tripartitus* was visually observed, which was apparently attributed to stock farms grazing cattle. *Copris tripartitus* on the decline in number are designated as category 2 protected insects, which are in need of particular attention for conservation.

The insects such as Scarabaeidae living near the topsoil are vulnerable to soil pollution and insecticide, which has caused them to become extinct (Kim 1994).

The Fauna in Gujwa-Sungsan Gotjawal Terrain

Total 100 species, 49 families and 9 orders were collected in Gujwa-Sungsan Gotjawal Terrain, which break down as follows (Table 4). Coleoptera had the largest number of species with 49 (49.0%), followed by Hemiptera (28.0%), Orthoptera (10.0%), Homoptera (7.0%), Hymenoptera (2.0%), Blattaria (1.0%), Dermaptera (1.0%), Mantodea (1.0%), and Neuroptera (1.0%).

Hemiptera appeared more often in this area than in other areas (28%), which appeared to be attributable to narrow land with more

cultivated area where Hemiptera can get abundant food easily.

This might be resulted from the fact that Hemiptera live on the grass harm crops directly by sucking up crops sap and injure crops indirectly as well by spreading diseases (Choe 1984).

Diversity of Species

Shannon index (H') (Shannon and Weaver 1949) is the most widely used index in synecology. Species diversity index for insect crowding in Gotjawal Terrain is indicated in Fig. 3.

H' was highest in Jocheon-Hamdeog Gotjawal and lowest in Gujwa-Sungsan Gotjawal. This may come from the fact that Jocheon-Hamdeog Gotjawal had a various species such as *Physopelta gutta*, *Plautia stali*, *Physopelta cincticollis*, *Neolethaeus dallasi*, and *Anomala albopilosa* in relative abundance (Table 2), while the abundance of *Anomala albopilosa* was significantly higher than others in Gujwa-Sungsan Gotjawal. Remaining two terrains showed a similar diversity since they had a balanced abundance.

Clustering Analysis

The pattern of clustering for the four locations (communities) was summarized in the dendrogram in Fig. 4. The four communities formed a single cluster at the distance level of 1.06. This results disclosed that the four Gotjawal Terrains have ecological environment not so different from each other. Jocheon-Hamdeog Gotjawal (A) formed a cluster with Hangyeong-Andeog Gotjawal (B) at the lowest chord distance (0.59). Referring to Table 1 and 2, it can be seen that the two terrains were not only dominated by *Teleogryllus emma*, *Physopelta gutta*, and *Amara gigantea* but also had the 65 common species.

At the higher chord distance of 0.63, Aewol Gotjawal (C) fused the cluster of Jocheon-Hamdeog and Hangyeong-Andeog Gotjawal.

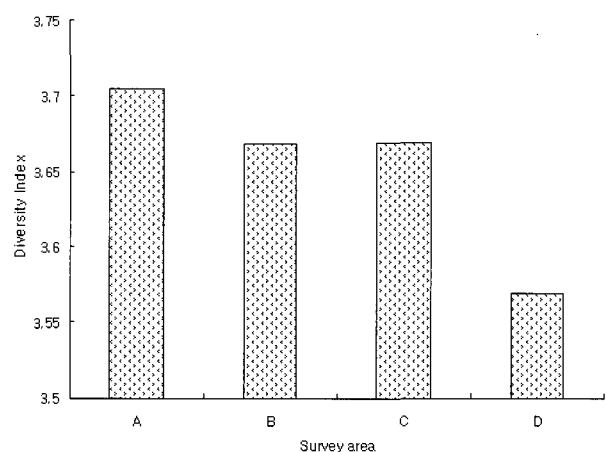


Fig. 3. Diversity indices of the surveyed areas. The abbreviation of the abscissa are same as represented in Fig. 1.

Table 2. Frequency and relative abundance of the insects collected from Hangyeong-Andeog Gotjawal Terrain

Order	Family	Scientific name	Relative Percentage			Frequency (R.A. *)
			L. Limit	Observed	U. Limit	
Blattaria	Blattellidae	<i>Blattella nipponica</i> Asahina	-0.05	0.31	0.67	3 (+)
Dermaptera	Labiduridae	<i>Labidura riparia japonica</i> (de Haan)	-0.10	0.10	0.31	1 (±)
	Forficulidae	<i>Timomenus komarovi</i> (Semenov)	-0.10	0.10	0.31	1 (±)
Orthoptera	Rhaphidophoridae	<i>Diestrarmena apicalis</i> Brunner	-0.10	0.10	0.31	1 (±)
	Tettigoniidae	<i>Ducetia japonica</i> (Thunberg)	-0.05	0.31	0.67	3 (+)
		<i>Hexacentrus unicolor</i> Serville	-0.10	0.10	0.31	1 (±)
		<i>Phaneroptera falcata</i> (Poda)	-0.10	0.10	0.31	1 (±)
	Oecanthidae	<i>Oecanthus indicus</i> Saussure	-0.10	0.10	0.31	1 (±)
	Gryllidae	<i>Teleogryllus emma</i> (Ohmachi et Matsumura)	0.61	1.35	2.10	13 (+)
		<i>Velarifictorus aspersus</i> (Walker)	-0.05	0.31	0.67	3 (+)
	Gryllotalpidae	<i>Gryllotalpa orientalis</i> (Burmeister)	0.00	0.42	0.83	4 (+)
	Tetrigidae	<i>Criotettix japonicus</i> (de Hann)	-0.10	0.10	0.31	1 (±)
		<i>Tetrix japonica</i> (Bolivar)	-0.10	0.10	0.31	1 (±)
Acrididae	<i>Stethophyma magister</i> (Rehn)	-0.10	0.10	0.31	1 (±)	
Hemiptera	Belostomatidae	<i>Muljarus japonicus</i> (Vuillefroy)	1.32	2.29	3.25	22 (+)
	Corixidae	<i>Hesperocorixa distanti</i> (Kirkaldy)	0.53	1.25	1.97	12 (+)
	Miridae	<i>Creontiades pallidifer</i> (Walker)	-0.10	0.10	0.31	1 (±)
		<i>Ectmetopterus micantulus</i> (Horvath)	-0.10	0.10	0.31	1 (±)
		<i>Lygus saundersi</i> Reuter	-0.10	0.10	0.31	1 (±)
	Reduviidae	<i>Oncocephalus assimilis</i> Reuter	-0.05	0.31	0.67	3 (+)
	Lygaeidae	<i>Lethaeus assamensis</i> (Distant)	-0.09	0.21	0.50	2 (+)
		<i>Metochus abbreviatus</i> (Scott)	-0.09	0.21	0.50	2 (+)
		<i>Neolethaeus dallasi</i> (Scott)	2.17	3.33	4.49	32 (++)
		<i>Paradieuches dissimilis</i> (Distant)	-0.10	0.10	0.31	1 (±)
		<i>Paraparomius lateralis</i> (Scott)	0.25	0.83	1.42	8 (+)
		Largidae	<i>Physopelta cincticollis</i> Stal	7.01	8.84	10.68
	<i>P. gutta</i> (Burmeister)		7.39	9.26	11.13	89 (++)
	Coreidae	<i>Cletus punctiger</i> (Dallas)	-0.05	0.31	0.67	3 (+)
		<i>Homoeocerus marginiventris</i> Dohrn	-0.10	0.10	0.31	1 (±)
		<i>H. unipunctatus</i> (Thunberg)	-0.09	0.21	0.50	2 (+)
		<i>Paraplesius unicolor</i> Scott	-0.05	0.31	0.67	3 (+)
		<i>Riptortus clavatus</i> (Thunberg)	-0.10	0.10	0.31	1 (±)
	Rhopalidae	<i>Rhopalus maculatus</i> (Fieber)	-0.10	0.10	0.31	1 (±)
Acanthosomatidae	<i>Dichobothrium nubilum</i> (Dallas)	2.09	3.23	4.37	31 (++)	

Table 2. Continued

Order	Family	Scientific name	Relative Percentage			Frequency (R.A.)
			L. Limit	Observed	U. Limit	
	Cydnidae	<i>Geotomus pygmaeus</i> (Dallas)	-0.05	0.31	0.67	3 (+)
		<i>Macroscytus japonensis</i> Scott	1.49	2.50	3.50	24 (+)
	Pentatomidae	<i>Eurydema rugosa</i> (Motschulsky)	-0.09	0.21	0.50	2 (+)
		<i>Eysarcoris annamita</i> Breddin	-0.09	0.21	0.50	2 (+)
		<i>E. guttiger</i> (Thunberg)	-0.09	0.21	0.50	2 (+)
		<i>Halyomorpha halys</i> (Stal)	2.26	3.43	4.61	33 (++)
		<i>Nezara antennata</i> Scott	0.46	1.14	1.83	11 (+)
		<i>Plautia stali</i> Scott	2.09	3.23	4.37	31 (++)
Homoptera	Cercopidae	<i>Eoscartopsis assimilis</i> (Uhler)	-0.10	0.10	0.31	1 (±)
	Aphrophoridae	<i>Aphrophora maritima</i> (Matsumura)	0.00	0.42	0.83	4 (+)
	Cicadellidae	<i>Ledra auditura</i> Walker	0.12	0.62	1.13	6 (+)
	Ricaniidae	<i>Orosanga japonica</i> (Melichar)	-0.09	0.21	0.50	2 (+)
	Flatidae	<i>Geisha distinctissima</i> (Walker)	1.08	1.98	2.88	19 (+)
	Dictyopharidae	<i>Orthopagus lumulifer</i> Uhler	-0.10	0.10	0.31	1 (±)
Coleoptera	Scaritidae	<i>Scarites sulcatus</i> Olivier	-0.10	0.10	0.31	1 (±)
	Harpalidae	<i>Amara gigantea</i> (Motschulsky)	1.16	2.08	3.00	20 (+)
		<i>A. niponica</i> Habu	-0.10	0.10	0.31	1 (±)
		<i>Chlaenius micans</i> (Fabricius)	-0.09	0.21	0.50	2 (+)
		<i>Colpodes buchanani</i> (Hope)	-0.09	0.21	0.50	2 (+)
		<i>Dolichus halensis</i> (Schaller)	-0.05	0.31	0.67	3 (+)
		<i>Drypta japonica</i> Bates	-0.10	0.10	0.31	1 (±)
		<i>Harpalus corporosus</i> (Motschulsky)	1.91	3.02	4.12	29 (++)
		<i>H. eous</i> Tschitscherine	-0.05	0.31	0.67	3 (+)
		<i>H. jureceki</i> (Jedlicka)	2.96	4.27	5.57	41 (++)
		<i>H. sinicus sinicus</i> Hope	6.35	8.12	9.88	78 (++)
		<i>Harpalus tridens</i> Morawitz	-0.10	0.10	0.31	1 (±)
		<i>Planetes puncticeps</i> Andrewes	-0.10	0.10	0.31	1 (±)
		<i>Pterostichus haptoderoides</i> Tschitscherine	-0.10	0.10	0.31	1 (±)
		<i>P. quelpartensis</i> Habu	-0.10	0.10	0.31	1 (±)
		<i>Stenodophus quinquepustulatus</i> (Wiedemann)	-0.10	0.10	0.31	1 (±)
	Brachinidae	<i>Pheropsophus jessoensis</i> Morawitz	-0.10	0.10	0.31	1 (±)
	Silphidae	<i>Necrodes asiaticus</i> Portevin	2.79	4.06	5.33	39 (++)
		<i>N. nigricornis</i> (Harold)	0.18	0.73	1.28	7 (+)
	Staphylinidae	<i>Ocypus rambouseki nigroaeneus</i> Sharp	2.70	3.95	5.21	38 (++)

Table 2. Continued

Order	Family	Scientific name	Relative Percentage			Frequency (R.A.)
			L. Limit	Observed	U. Limit	
		<i>Paederus parallelus</i> Weise	-0.10	0.10	0.31	1 (±)
		<i>Philonthus japonicus</i> Sharp	-0.09	0.21	0.50	2 (+)
		<i>P. wuesthoffi</i> Bernhauer	-0.05	0.31	0.67	3 (+)
	Lucanidae	<i>Serrognathus platymelus castanicolor</i> Motschulsky	-0.05	0.31	0.67	3 (+)
	Hybosoridae	<i>Phaeochrous tokaraensis</i> Nomura	-0.10	0.10	0.31	1 (±)
	Scarabaeidae	<i>Onthophagus atripennis</i> Waterhouse	-0.10	0.10	0.31	1 (±)
		<i>O. fodiens</i> Waterhouse	-0.10	0.10	0.31	1 (±)
		<i>O. lenzii</i> Harold	0.00	0.42	0.83	4 (+)
	Aphodiidae	<i>Aphodius rectus</i> (Motschulsky)	1.49	2.50	3.50	24 (+)
	Melolonthidae	<i>Holotrichia diomphalia</i> (Bates)	-0.09	0.21	0.50	2 (+)
		<i>H. kiotoensis</i> Brenske	-0.10	0.10	0.31	1 (±)
		<i>H. morosa</i> Waterhouse	0.25	0.83	1.42	8 (+)
		<i>Maladera japonica</i> (Motschulsky)	-0.09	0.21	0.50	2 (+)
		<i>M. secreta</i> (Brenske)	0.06	0.52	0.98	5 (+)
	Rutelidae	<i>Adoretus tenuimaculatus</i> Waterhouse	-0.05	0.31	0.67	3 (+)
		<i>Anomala albopilosa</i> Hope	3.05	4.37	5.69	42 (++)
		<i>A. chamaeleon</i> Fairmaire	1.66	2.71	3.75	26 (++)
		<i>Mimela splendens</i> Gyllenhal	-0.09	0.21	0.50	2 (+)
	Elateridae	<i>Agrypnus binodulus coreanus</i> Kishii	0.25	0.83	1.42	8 (+)
		<i>Ectinus sericeus</i> (Candeze)	-0.10	0.10	0.31	1 (±)
		<i>Melanotus castanipes matsumurai</i> Schenkling	0.25	0.83	1.42	8 (+)
	Lampyridae	<i>Lychmuri rufa</i> (Olivier)	0.00	0.42	0.83	4 (+)
	Nitidulidae	<i>Glischrochilus japonicus</i> (Motschulsky)	-0.10	0.10	0.31	1 (±)
		<i>Lasiodactylus pictus</i> (MacLeay)	0.06	0.52	0.98	5 (+)
	Coccinellidae	<i>Coccinella septempunctata</i> Linne	1.00	1.87	2.75	18 (+)
		<i>Harmonia axyridis</i> (Pallas)	1.49	2.50	3.50	24 (+)
		<i>Propylea japonica</i> (Thunberg)	-0.05	0.31	0.67	3 (+)
		<i>P. quatuordecimpunctata</i> (Linne)	-0.10	0.10	0.31	1 (±)
	Tenebrionidae	<i>Gonocephalum sexuale</i> (Marseul)	-0.10	0.10	0.31	1 (±)
	Cerambycidae	<i>Asemum striatum</i> (Linne)	-0.10	0.10	0.31	1 (±)
		<i>Spondylis buprestoides</i> (Linne)	-0.10	0.10	0.31	1 (±)
	Chrysomelidae	<i>Galerucella griseescens</i> (Joannis)	-0.10	0.10	0.31	1 (±)
		<i>Monolepta pallidula</i> (Baly)	-0.10	0.10	0.31	1 (±)
		<i>Physosmaragdina nigrifrons</i> (Hope)	-0.09	0.21	0.50	2 (+)

Table 2. Continued

Order	Family	Scientific name	Relative Percentage			Frequency (R.A.)*
			L. Limit	Observed	U. Limit	
Hymenoptera	Braconidae	<i>Phanerotoma flava</i> (Ashmead)	-0.10	0.10	0.31	1 (±)
	Apidae	<i>Apis mellifera</i> Linne	-0.10	0.10	0.31	1 (±)
TOTAL		S = 104	Mean = 9.24		0.33	1.59

* Relative abundance.

Table 3. Frequency and relative abundance of the insects collected from Aewol Gotjawal Terrain

Order	Family	Scientific name	Relative Percentage			Frequency (R.A.)*
			L. Limit	Observed	U. Limit	
Mantodea	Mantidae	<i>Staltia maculata</i> (Thunberg)	-0.13	0.13	0.40	1 (+)
Dermaptera	Labiduridae	<i>Labidura riparia japonica</i> (de Haan)	-0.13	0.13	0.40	1 (+)
	Forficulidae	<i>Timomenus komarovi</i> (Semenov)	-0.13	0.13	0.40	1 (+)
Orthoptera	Rhaphidophoridae	<i>Diestrarmena apicalis</i> Brunner	-0.13	0.13	0.40	1 (+)
	Tettigoniidae	<i>Conocephalus chinensis</i> (Redtenbacher)	-0.13	0.13	0.40	1 (+)
		<i>C. gladius</i> (Redtenbacher)	-0.13	0.13	0.40	1 (+)
		<i>Ducetia japonica</i> (Thunberg)	-0.13	0.13	0.40	1 (+)
		<i>Metrioptera bonneti</i> (Bolivar)	-0.13	0.13	0.40	1 (+)
	Oecanthidae	<i>Oecanthus indicus</i> Saussure	-0.06	0.40	0.86	3 (+)
	Gryllidae	<i>Teleogryllus emma</i> (Ohmachi et Matsumura)	-0.06	0.40	0.86	3 (+)
<i>Velarifictorus aspersus</i> (Walker)		-0.11	0.27	0.64	2 (+)	
	Gryllotalpidae	<i>Gryllotalpa orientalis</i> (Burmeister)	-0.11	0.27	0.64	2 (+)
	Pyrgomorphidae	<i>Atractomorpha lata</i> (Motschulsky)	-0.13	0.13	0.40	1 (+)
Hemiptera	Corixidae	<i>Hesperocorixa distanti</i> (Kirkaldy)	1.70	2.94	4.17	22 (+)
	Lygaeidae	<i>Metochus abbreviatus</i> (Scott)	-0.11	0.27	0.64	2 (+)
		<i>Neolethaeus dallasi</i> (Scott)	2.68	4.14	5.59	31 (++)
		<i>Paraparomius lateralis</i> (Scott)	-0.06	0.40	0.86	3 (+)
	Largidae	<i>Physopelta cincticollis</i> Stal	3.70	5.34	6.98	40 (++)
		<i>P. gutta</i> (Burmeister)	5.67	7.61	9.55	57 (++)
	Coreidae	<i>Cletus punctiger</i> (Dallas)	-0.11	0.27	0.64	2 (+)
	Acanthosomatidae	<i>Dichobothrium nubilum</i> (Dallas)	1.92	3.20	4.49	24 (++)
	Cydniidae	<i>Geotomus pygmaeus</i> (Dallas)	-0.11	0.27	0.64	2 (+)
		<i>Macroscytus japonensis</i> Scott	2.13	3.47	4.81	26 (++)
Pentatomidae	<i>Carbula putoni</i> (Jakovlev)	-0.13	0.13	0.40	1 (+)	

Table 3. Continued

Order	Family	Scientific name	Relative Percentage			Frequency (R.A. [*])	
			L. Limit	Observed	U. Limit		
		<i>Carpocoris purpureipennis</i> (de Geer)	-0.11	0.27	0.64	2 (+)	
		<i>Eysarcoris ventralis</i> (Westwood)	-0.13	0.13	0.40	1 (+)	
		<i>Glaucias subpunctatus</i> (Walker)	-0.11	0.27	0.64	2 (+)	
		<i>Halyomorpha halys</i> (Stal)	1.39	2.54	3.69	19 (+)	
		<i>Menida musiva</i> (Jakovlev)	-0.13	0.13	0.40	1 (+)	
		<i>Nezara antennata</i> Scott	-0.13	0.13	0.40	1 (+)	
		<i>Pentatoma japonica</i> (Distant)	-0.13	0.13	0.40	1 (+)	
		<i>Plautia stali</i> Scott	2.68	4.14	5.59	31 (++)	
Homoptera	Cercopidae	<i>Eoscartopsis assimilis</i> (Uhler)	-0.13	0.13	0.40	1 (+)	
	Aphrophoridae	<i>Aphrophora intermedia</i> Uhler	-0.13	0.13	0.40	1 (+)	
	Cicadellidae	<i>Cicadella viridis</i> (Linne)	-0.11	0.27	0.64	2 (+)	
		<i>Ledra auditura</i> Walker	-0.11	0.27	0.64	2 (+)	
		<i>Paramesodes albinervosus</i> (Matsumura)	-0.13	0.13	0.40	1 (+)	
	Ricaniidae	<i>Orosanga japonica</i> (Melichar)	0.00	0.53	1.07	4 (+)	
	Flatidae	<i>Geisha distinctissima</i> (Walker)	-0.06	0.40	0.86	3 (+)	
Neuroptera	Chrysopidae	<i>Chrysopa pallens</i> Rambur	-0.13	0.13	0.40	1 (+)	
Coleoptera	Harpalidae	<i>Amara gigantea</i> (Motschulsky)	-0.13	0.13	0.40	1 (+)	
		<i>Anisodactylus tricuspoidatus</i> (Morawitz)	0.68	1.60	2.52	12 (+)	
		<i>Chlaenius abstersus</i> Bates	-0.13	0.13	0.40	1 (+)	
		<i>C. virgulifer</i> Chaudoir	-0.13	0.53	0.40	1 (+)	
		<i>Colpodes buchani</i> (Hope)	0.00	0.13	1.07	4 (+)	
		<i>Dolichus halensis</i> (Schaller)	-0.13	0.13	0.40	1 (+)	
		<i>Euplynes batesi</i> Harold	-0.11	0.27	0.64	2 (+)	
		<i>Harpalus capito</i> Morawitz	-0.11	0.27	0.64	2 (+)	
		<i>H. eous</i> Tschitscherine	3.36	4.94	6.52	37 (++)	
		<i>H. jureceki</i> (Jedlicka)	5.79	7.74	9.70	58 (++)	
		<i>H. sinicus sinicus</i> Hope	1.70	2.94	4.17	22 (+)	
		<i>H. tridens</i> Morawitz	-0.06	0.40	0.86	3 (+)	
		<i>Lachnolebia cribricollis</i> (Morawitz)	-0.06	0.40	0.86	3 (+)	
		Silphidae	<i>Necrodes asiaticus</i> Portevin	0.88	1.87	2.86	14 (+)
			<i>N. nigricornis</i> (Harold)	1.18	2.27	3.36	17 (+)
			<i>Nicrophorus quadripunctatus</i> Kraatz	-0.13	0.13	0.40	1 (+)
Staphylinidae	<i>Ocypus rambouseki nigroaeneus</i> Sharp	2.46	3.87	5.28	29 (++)		
	<i>Philonthus japonicus</i> Sharp	-0.06	0.40	0.86	3 (+)		

Table 3. Continued

Order	Family	Scientific name	Relative Percentage			Frequency (R.A.)
			L. Limit	Observed	U. Limit	
		<i>P. spinipes</i> Sharp	-0.13	0.13	0.40	1 (+)
		<i>Philonthus wuesthoffi</i> Bernhauer	-0.11	0.27	0.64	2 (+)
	Lucanidae	<i>Prismognathus dauricus</i> (Motschulsky)	0.07	0.67	1.26	5 (+)
		<i>Serrogathus platymelus castanicolor</i> Motschulsky	0.07	0.67	1.26	5 (+)
	Scarabaeidae	<i>Copris ochus</i> (Motschulsky)	-0.11	0.27	0.64	2 (+)
		<i>C. tripartitus</i> Waterhouse	-0.11	0.27	0.64	2 (+)
		<i>Onthophagus lenzii</i> Harold	3.47	5.07	6.68	38 (++)
	Aphodiidae	<i>Aphodius rectus</i> (Motschulsky)	-0.06	0.40	0.86	3 (+)
	Melolonthidae	<i>Holotrichia diomphalia</i> (Bates)	-0.06	0.40	0.86	3 (+)
		<i>H. morosa</i> Waterhouse	-0.13	0.13	0.40	1 (+)
		<i>Maladera secreta</i> (Brenske)	1.70	2.94	4.17	22 (+)
		<i>M. orientalis</i> (Motschulsky)	-0.13	0.13	0.40	1 (+)
	Rutelidae	<i>Anomala albopilosa</i> Hope	2.79	4.27	5.75	32 (++)
		<i>A. chamaeleon</i> Fairmaire	1.39	2.54	3.69	19 (+)
		<i>A. cuprea</i> (Hope)	-0.13	0.13	0.40	1 (+)
		<i>A. daimiana</i> Harold	-0.13	0.13	0.40	1 (+)
		<i>Mimela splendens</i> Gyllenhal	-0.11	0.27	0.64	2 (+)
	Elateridae	<i>Agrypnus binodulus coreanus</i> Kishii	-0.13	0.13	0.40	1 (+)
		<i>Melanotus castanipes matsumurai</i> Schenkling	0.00	0.53	1.07	4 (+)
	Lampyridae	<i>Lychnuris rufa</i> (Olivier)	-0.13	0.13	0.40	1 (+)
	Nitidulidae	<i>Glischrochilus japonicus</i> (Motschulsky)	-0.11	0.27	0.64	2 (+)
		<i>Lasiodactylus pictus</i> (MacLeay)	-0.06	0.40	0.86	3 (+)
	Coccinellidae	<i>Coccinella septempunctata</i> Linne	1.28	2.40	3.52	18 (+)
		<i>Harmonia axyridis</i> (Pallas)	3.81	5.47	7.14	41 (++)
	Lagriidae	<i>Lagria nigricollis</i> Hope	-0.13	0.13	0.40	1 (+)
	Tenebrionidae	<i>Heterotarsus carimula</i> Marseul	-0.11	0.27	0.64	2 (+)
	Cerambycidae	<i>Spondylis buprestoides</i> (Linne)	0.00	0.53	1.07	4 (+)
	Chrysomelidae	<i>Aulacophora indica</i> (Gmelin)	-0.13	0.13	0.40	1 (+)
		<i>Cassida piperata</i> Hope	-0.13	0.13	0.40	1 (+)
		<i>Chrysolina aurichalcea</i> (Mannerheim)	-0.13	0.13	0.40	1 (+)
	Curculionidae	<i>Curculio sikkimensis</i> (Heller)	-0.11	0.27	0.64	2 (+)
		<i>Hylobitelus gebleri</i> (Boheman)	-0.13	0.13	0.40	1 (+)
		<i>Scepticus griseus</i> Roelofs	-0.13	0.13	0.40	1 (+)
	Rhynchophoridae	<i>Cryptoderma fortunei</i> (Waterhouse)	-0.13	0.13	0.40	1 (+)

Table 3. Continued

Order	Family	Scientific name	Relative Percentage			Frequency (R.A. *)
			L. Limit	Observed	U. Limit	
Hymenoptera	Braconidae	<i>Phanerotoma flava</i> Ashmead	-0.06	0.40	0.86	3 (+)
		<i>Xiphozele compressiventris</i> Cameron	0.00	0.53	1.07	4 (+)
	Ichneumonidae	<i>Diplazon laetatorius</i> (Fabricius)	-0.11	0.27	0.64	2 (+)
		<i>Homotropus tarsatorius</i> (Panzer)	-0.13	0.13	0.40	1 (+)
	Vespidae	<i>Parapolybia varia</i> (Fabricius)	-0.13	0.13	0.40	1 (+)
TOTAL		S = 97	Mean = 7.72	0.29	1.77	

* Relative abundance.

Table 4. Frequency and relative abundance of the insects collected from Gujwa-Sungsan Gotjawal Terrain

Order	Family	Scientific name	Relative Percentage			Frequency (R.A. *)
			L. Limit	Observed	U. Limit	
Blattaria	Blattellidae	<i>Blattella nipponica</i> Asahina	-0.09	0.21	0.50	2 (+)
Mantodea	Mantidae	<i>Tenodera aridifolia</i> (Stoll)	-0.10	0.10	0.31	1 (±)
Dermoptera	Labiduridae	<i>Labidura riparia japonica</i> (de Haan)	0.46	1.14	1.83	11 (+)
Orthoptera	Tettigoniidae	<i>Ducetia japonica</i> (Thunberg)	-0.05	0.31	0.67	3 (+)
		<i>Phaneroptera falcata</i> (Poda)	-0.10	0.10	0.31	1 (±)
	Oecanthidae	<i>Oecanthus indicus</i> Saussure	-0.10	0.10	0.31	1 (±)
	Gryllidae	<i>Loxoblemmus doentzi</i> Stein	-0.09	0.21	0.50	2 (+)
		<i>Ornebius kanetataki</i> (Matsumura)	-0.09	0.21	0.50	2 (+)
		<i>Teleogryllus emma</i> (Ohmachi et Matsumura)	1.00	1.87	2.74	18 (+)
		<i>Velarifictorus aspersus</i> (Walker)	-0.09	0.21	0.50	2 (+)
	Gryllotalpidae	<i>Gryllotalpa orientalis</i> (Burmeister)	-0.09	0.21	0.50	2 (+)
	Tetrigidae	<i>Tetrix japonica</i> (Bolivar)	1.32	2.28	3.24	22 (+)
	Pyrgomorphidae	<i>Atractomorpha lata</i> (Motschulsky)	-0.10	0.10	0.31	1 (±)
Hemiptera	Corixidae	<i>Hesperocorixa distanti</i> (Kirkaldy)	-0.10	0.10	0.31	1 (±)
		<i>Sigara substriata</i> (Uhler)	-0.09	0.21	0.50	2 (+)
	Nabidae	<i>Nabis stenoferus</i> Hsiao	-0.09	0.21	0.50	2 (+)
	Miridae	<i>Polymerus palustris</i> (Reuter)	-0.09	0.21	0.50	2 (+)
		<i>Stenotus rubrovittatus</i> (Matsumura)	-0.09	0.21	0.50	2 (+)
	Reduviidae	<i>Oncocephalus assimilis</i> Reuter	-0.10	0.10	0.31	1 (±)
		<i>Sphedanolestes impressicollis</i> (Stal)	-0.10	0.10	0.31	1 (±)
	Lygaeidae	<i>Lethaeus assamensis</i> (Distant)	-0.10	0.10	0.31	1 (±)

Table 4. Continued

Order	Family	Scientific name	Relative Percentage			Frequency (R.A. [*])
			L. Limit	Observed	U. Limit	
		<i>Metochus abbreviatus</i> (Scott)	-0.09	0.21	0.50	2 (+)
		<i>Neolethaeus dallasi</i> (Scott)	-0.10	0.10	0.31	1 (±)
		<i>Paraparomius lateralis</i> (Scott)	0.00	0.41	0.83	4(+)
	Coreidae	<i>Cletus punctiger</i> (Dallas)	1.82	2.90	3.99	28 (++)
		<i>Homoeocerus marginiventris</i> Dohrn	-0.10	0.10	0.31	1 (±)
		<i>H. unipunctatus</i> (Thunberg)	-0.10	0.10	0.31	1 (±)
	Alydidae	<i>Riptortus clavatus</i> (Thunberg)	0.00	0.41	0.83	4 (+)
	Largidae	<i>Physopelta cincticollis</i> Stal	3.04	4.36	5.67	42 (++)
		<i>P. gutta</i> (Burmeister)	3.22	4.56	5.91	44 (++)
	Plataspididae	<i>Megacopta punctatissima</i> (Montandon)	-0.09	0.21	0.50	2 (+)
	Acanthosomatidae	<i>Dichobothrium nubilum</i> (Dallas)	0.53	1.24	1.96	12 (+)
	Cydnidae	<i>Geotomus pygmaeus</i> (Dallas)	0.06	0.52	0.98	5 (+)
		<i>Macroscytus japonensis</i> Scott	0.76	1.56	2.35	15 (+)
	Pentatomidae	<i>Carbula putoni</i> (Jakovlev)	1.82	2.90	3.99	28 (++)
		<i>Eysarcoris guttiger</i> (Thunberg)	-0.10	0.10	0.31	1 (±)
		<i>E. ventralis</i> (Westwood)	0.06	0.52	0.98	5 (+)
		<i>Halyomorpha halys</i> (Stal)	2.43	3.63	4.84	35 (++)
		<i>Laprius gastricus</i> (Thunberg)	-0.10	0.10	0.31	1 (±)
		<i>Nezara antennata</i> Scott	2.25	3.42	4.59	33 (++)
		<i>Plautia stali</i> Scott	2.08	3.22	4.35	31 (++)
Homoptera	Aphrophoridae	<i>Aphrophora maritima</i> (Matsumura)	-0.10	0.10	0.31	1 (±)
	Cicadellidae	<i>Ledra auditura</i> Walker	-0.10	0.10	0.31	1 (±)
		<i>Nephotettix cincticeps</i> (Uhler)	0.00	0.41	0.83	4 (+)
		<i>Paramesodes albinervosus</i> (Matsumura)	-0.10	0.10	0.31	1 (±)
	Ricaniidae	<i>Orosanga japonica</i> (Melichar)	0.00	0.41	0.83	4 (+)
	Flatidae	<i>Geisha distinctissima</i> (Walker)	2.86	4.15	5.43	40 (++)
	Tropiduchidae	<i>Ossoides lineatus</i> Bierman	-0.10	0.10	0.31	1 (±)
Neuroptera	Ascalaphidae	<i>Hybris subjacens</i> (Walker)	-0.10	0.10	0.31	1 (±)
Coleoptera	Carabidae	<i>Damaster jankowskii jankowskii</i> (Oberthur)	-0.10	0.10	0.31	1 (±)
	Scaritidae	<i>Scarites sulcatus</i> Olivier	-0.10	0.10	0.31	1 (±)
	Harpalidae	<i>Amara gigantea</i> (Motschulsky)	-0.10	0.10	0.31	1 (±)
		<i>Anisodactylus punctatipennis</i> Morawitz	-0.10	0.10	0.31	1 (±)
		<i>A. signatus</i> (Panzer)	2.78	4.05	5.31	39 (++)
		<i>A. tricuspis</i> (Morawitz)	-0.10	0.10	0.31	1 (±)

Table 4. Continued

Order	Family	Scientific name	Relative Percentage			Frequency (R.A.)
			L. Limit	Observed	U. Limit	
		<i>Chlaenius micans</i> (Fabricius)	-0.09	0.21	0.50	2 (+)
		<i>C. virgulifer</i> Chaudoir	-0.10	0.10	0.31	1 (±)
		<i>Drypta japonica</i> Bates	-0.05	0.31	0.67	3 (+)
		<i>Harpalus corporosus</i> Motschulsky	1.49	2.49	3.49	24 (+)
		<i>Harpalus eous</i> Tschitscherine	2.17	3.32	4.47	32 (++)
		<i>H. jureceki</i> (Jedlicka)	1.08	1.97	2.87	19 (+)
		<i>H. sinicus sinicus</i> Hope	1.24	2.18	3.12	21 (+)
		<i>H. tridens</i> (Morawitz)	0.46	1.14	1.83	11 (+)
		<i>Stenolophus quinquepustulatus</i> (Wiedemann)	-0.09	0.21	0.50	2 (+)
	Dytiscidae	<i>Hydaticus grammicus</i> Germar	-0.09	0.21	0.50	2 (+)
		<i>H. pacificus</i> Aube	-0.10	0.10	0.31	1 (±)
	Silphidae	<i>Necrodes asiaticus</i> Portevin	-0.05	0.31	0.67	3 (+)
		<i>N. nigricornis</i> (Harold)	0.25	0.83	1.41	8 (+)
	Staphylinidae	<i>Ocypus rambouseki nigroaeneus</i> Sharp	3.49	4.88	6.26	47 (++)
		<i>Philonthus japonicus</i> Sharp	-0.05	0.31	0.67	3 (+)
		<i>P. wuesthoffi</i> Bernhauer	-0.05	0.31	0.67	3 (+)
	Lucanidae	<i>Serrognathus platymelus castanicolor</i> Motschulsky	-0.09	0.21	0.50	2 (+)
	Hybosoridae	<i>Phaeochrous emarginatus</i> Castelnau	0.06	0.52	0.98	5 (+)
	Scarabaeidae	<i>Onthophagus lenzii</i> Harold	-0.05	0.31	0.67	3 (+)
	Aphodiidae	<i>Aphodius rectus</i> (Motschulsky)	0.18	0.73	1.27	7 (+)
	Melolonthidae	<i>Holotrichia diomphalia</i> (Bates)	-0.10	0.10	0.31	1 (±)
		<i>H. morosa</i> Waterhouse	-0.05	0.31	0.67	3 (+)
		<i>Maladera japonica</i> (Motschulsky)	-0.10	0.10	0.31	1 (±)
		<i>M. secreta</i> (Brenske)	0.06	0.52	0.98	5 (+)
	Dynastidae	<i>Allomyrina dichotoma</i> (Linne)	-0.10	0.10	0.31	1 (±)
	Rutelidae	<i>Adoretus tenuimaculatus</i> Waterhouse	1.32	2.28	3.24	22 (+)
		<i>Anomala albopilosa</i> Hope	16.36	18.88	21.40	182 (++)
		<i>A. chamaeleon</i> Fairmaire	-0.09	0.21	0.50	2 (+)
	Elateridae	<i>Agrypnus binodulus coreanus</i> Kishii	0.06	0.52	0.98	5 (+)
		<i>A. fuliginosus</i> (Candeze)	-0.10	0.10	0.31	1 (±)
		<i>Aeoloderma agnata</i> (Candeze)	-0.09	0.21	0.50	2 (+)
	Lampyridae	<i>Lychmurus rufa</i> (Olivier)	-0.09	0.21	0.50	2 (+)
	Nitidulidae	<i>Glischrochilus japonicus</i> (Motschulsky)	0.76	1.56	2.35	15 (+)
		<i>Lasiodactylus pictus</i> (MacLeay)	0.00	0.41	0.83	4 (+)

Table 4. Continued

Order	Family	Scientific name	Relative Percentage			Frequency (R.A. *)
			L. Limit	Observed	U. Limit	
	Coccinellidae	<i>Coccinella septempunctata</i> Linne	-0.09	0.21	0.50	2 (+)
		<i>Harmonia axyridis</i> (Pallas)	1.65	2.70	3.74	26 (++)
	Tenebrionidae	<i>Cryphaeus duellicus</i> (Lewis)	-0.10	0.10	0.31	1 (±)
		<i>Heterotarsus carinula</i> Marseul	0.06	0.52	0.98	5 (+)
		<i>Tenebrio obscurus</i> Fabricius	-0.10	0.10	0.31	1 (±)
	Cerambycidae	<i>Anoplophora malasiaca</i> (Thomson)	-0.10	0.10	0.31	1 (±)
	Chrysomelidae	<i>Aulacophora nigripennis</i> Motschulsky	-0.09	0.21	0.50	2 (+)
		<i>Monolepta pallidula</i> (Baly)	-0.05	0.31	0.67	3 (+)
	Curculionidae	<i>Listroderes costirostris</i> Schoenherr	-0.10	0.10	0.31	1 (±)
Hymenoptera	Braconidae	<i>Phanerotoma flava</i> Ashmead	-0.05	0.31	0.67	3 (+)
		<i>Xiphozele compressiventris</i> Cameron	-0.09	0.21	0.50	2 (+)
TOTAL						
	S= 100	Mean=9.64	0.36		1.64	

* Relative abundance.

The communities of the three terrains were commonly dominated by *Ocypus rambouseki nigroaeneus* and *Anomala albopilosa*, and

there were 48 species commonly.

Finally, Gujwa-Sungsan Gotjawal (D) fused with the rest three terrains, forming a single cluster at the highest chord distance of 1.06. The common species were numbered 44 in all four communities.

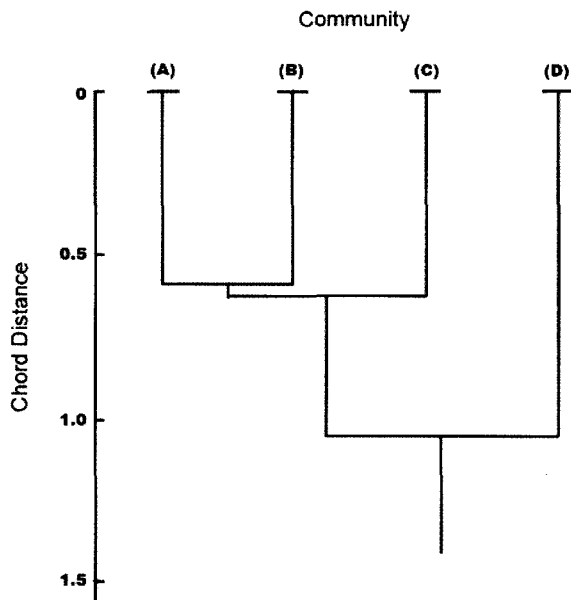


Fig. 4. Dendrogram for the cluster analysis of four Gotjawal terrains of Jeju Island using chord distance and the flexible strategy. The abbreviations of the communities are same as represented in Fig. 1.

The List of Unreported Species on Jeju Island

The Korean terminology was in accordance with the Check List of Insects from Korea (1994).

Order. Hemiptera 노린재목

Family. Pentatomidae 노린재과

Genus. *Menida* Motschulsky, 1861 깡보라노린재속

Menida musiva (Jakovlev, 1876) 무시바노린재

<Materials examined>

Aeweol Gotjawal Terrain (1ex, 13-VIII-2005); Jocheon-Hamdeog Gotjawal Terrain (1ex, 1-VIII-2005)

<Distribution>

Korea (North, Central, South), Japan (Hokkaido, Honshu, Shikoku, Kyushu), China (Heilongjiang, Sichuan), USSR (Maritime Territory)

<Remarks>

The length of body is around 8-9mm in grayish yellow or dark brown, and glossy. A head is in dark brown with antennae having a longest 4th 5th segment. A prodorsum has dark brown pattern on front edge. A shoulder with an antealar is as

large as prodorsum. The third segment on abdomen has an acanthus conala projected in the middle, which slightly extends metapede's basal segment.

Genus. *Pentatoma* Olivier, 1789 왕노린재속

Pentatoma japonica (Distant) 분홍다리노린재

<Materials examined>

Aeweol Gotjawal Terrain (1ex, 7-IX-2005)

<Distribution>

Korea (North, Central, South), Japan (Hokkaido, Honshu, Shikoku, Kyushu), China (Manchuria, North), USSR (Maritime Territory)

<Remarks>

A 17 to 20 mm-long body, having a metallic gloss on the dorsal valve. A fine and dark puncturations scattered over entire body surface. The legs are mostly dark brown, with a long antennae where the first segment is the shortest. A projected prodorsum with a wide shoulder, and a humeri slightly slanting with sharp points at both ends. A membrane part of antealar is longer and better developed in brown color than the end of abdomen. A black belt and dark brown pattern runs alternately in each segment on the edge of abdomen.

Order Coleoptera 딱정벌레목

Family Staphylinidae 반날개과

Genus *Philonthus* Stephens, 1829 좀반날개속

Philonthus wuesthoffi Bernhauer 극동좀반날개

<Materials examined>

Hangyeong-Andeog Gotjawal Terrain (2ex, 4-IX-2005 · 1ex, 20-IX-2005); Aeweol Gotjawal Terrain (2ex, 21-VIII-2005); Jocheon-Hamdeog Gotjawal Terrain (1ex, 6-VII-2005 · 1ex, 16-VIII-2005 · 1ex, 2-IX-2005); Gujwa-Sungsan Gotjawal Terrain (3ex, 14-VIII-2005)

<Distribution>

Korea, China, Japan (Hokkaido, Honshu, Shikoku, Kyushu, Oki, Sado, Yakushima), Russia (Sakhalin).

<Remarks>

A 7 to 9mm-long slim and long body, with a prodorsum with 5-line crackled puncturations on. A long antennae has segments longer than width. An appendix is slim and paralleled. The earnest research on Korean Staphylinidae began recently. Adapting to various microhabitats, they were known to have been showing a very interesting habit. A steady study on life mode and habit need to be continued.

Order. Hymenoptera 벌목

Family. Braconidae 고치벌과

Genus. *Phanerotoma* Wesmael, 1838 황고치벌속

Phanerotoma flava Ashmead, 1906 황고치벌

<Materials examined>

Hangyeong-Andeog Gotjawal Terrain (1ex, 20-VII-2005); Aeweol Gotjawal Terrain (1ex, 16-VII-2005 · 1ex, 24-VII-2005 · 1ex, 13-VIII-2005); Jocheon-Hamdeog Gotjawal Terrain (1ex, 6-VII-2005 · 1ex, 19-VII-2005); Gujwa-Sungsan Gotjawal Terrain (1ex, 26-VIII-2005 · 1ex, 9-IX-2005 · 1ex, 21-IX-2005)

<Distribution>

Korea, China, Japan, Taiwan (Formosa).

<Remarks>

A 7 to 9 mm-long body, with abdomen having 3-segments and a round end. An entire body in red brown, with an antennae in dark brown. Wings are transparent, with a subcosta in yellow and stigma in dark brown. The half of the forewings slightly is darker.

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