J. Ecol. Field Biol. 32 (2): 129～135, 2009

〈Report〉

Diversity of Moths (Insecta: Lepidoptera) on Bogildo Island, Wando-gun, Jeonnam, Korea

Park, Marana, Jeong-Seop An[1], Jin Lee, Jin-Taek Lim[2] and Sei-Woong Choi*

Department of Environmental Education, Mokpo National University, Jeonnam 534-729, Korea

[1]Department of Biology, Mokpo National University, Jeonnam 534-729, Korea

[2]Mokpo Natural History Museum, Jeonnam 530-839, Korea

ABSTRACT: We investigated the moth diversity on an island of southern sea of Korea. We collected moths at three sites on the island of Bogildo, Wando-gun, Jeonnam using a 22-watt ultraviolet light trap from May to October, 2008, and identified a total of 272 species and 948 individuals in 13 families. Species of Noctuidae was the most abundant, with 107 species and 318 individuals, followed by Geometridae (62 species and 147 individuals) and Pyralidae (53 species and 269 individuals). The graph of the estimated species richness in Chao 1 (432.25 ± 37.39) did not reach an asymptote, which suggests that more moth species could be identified on the island through further sampling. An arctiid moth, *Miltochrista striata*, was the most abundant species captured in this study. Monthly changes in moth species richness and abundance formed M-shaped curves, with peaks in early summer (June) and late summer (August). Cluster analysis of seven sites on three islands (Aphaedo Island, Sinan-gun, Oenarodo Island, Goheung-gun and Bogildo Island) divided the sites into two groups. Distances among sites and habitat types may play an important role in determining the similarities of moth faunas among sites.

Key words: Biodiversity, Inventory, Island, Lepidoptera, Moths

INTRODUCTION

Islands play a prominent role in ecological and biogeographic studies, since they are numerous in number and vary in size and degree of isolation. In addition, the characteristics of islands' biotas are relatively easy to observe and quantify (MacArthur and Wilson 1967, New 2008). The Korean peninsula is surrounded by more than 3,100 islands mainly in its western and southern seas. However, most of these islands are small in size: about 75% of the islands are less than 0.1 km^2 in area (Korea National Statistics Office, 2005). While the Korean islands are attractive to taxonomists and ecologists, relatively few faunistic studies have been done due to difficulties in accessibility and logistics (National Institute of Environmental Research 2002).

Arthropoda, including insects, comprise approximately 2/3 of the known organisms in the world. They are suitable as indicator organisms because they are both abundant and diverse, and different species have adapted to different environmental conditions (Samways 2005). Lepidoptera (moths and butterflies) are one of the mega-diversity groups with more than 120,000 species worldwide. Moth and butterflies are noteworthy for their wings, which show vivid colors and a multiplicity of forms, providing advantages in identification. They also serve as major herbivores, linking primary producers and consumers in ecosystems (Scoble 1992). Moths and butterflies have been widely used in ecological and conservation research worldwide (Kitching et al. 2000, Summerville et al. 2001, Summerville and Crist 2002). On islands, moths and butterflies are well-suited as indicators of habitat change and environmental gradients on many scales, including geographic scales across and within islands and temporal scales across seasons and years (Miller 1997, Dennis et al. 2008, New 2008).

The purpose of the present study is to understand the moth fauna on Bogildo Island, Wando-gun, southeastern Jeonnam province. In addition, we compared moth diversity on Bogildo Island to that of neighboring islands to investigate patterns of similarity among islands.

METHODS

Study Sites

The study area, Bogildo Island, Nohwa-myeon, Wando-gun, is located in the southeastern part of the Dadohae Ocean National Park (Fig. 1, N34° 20', E126° 42'). Wando-gun has 201 islands (147 uninhabited and 54 inhabited islands) and Bogildo Island is famous for its cultural and natural resources. The climate is the typical southern coastal type, with annual precipitation of 1,417.5 mm and an annual mean temperature of 13.9℃ (Korea Meteorological Admi-

* Corresponding author; Phone: +82-61-450-2783, e-mail: choisw@mokpo.ac.kr

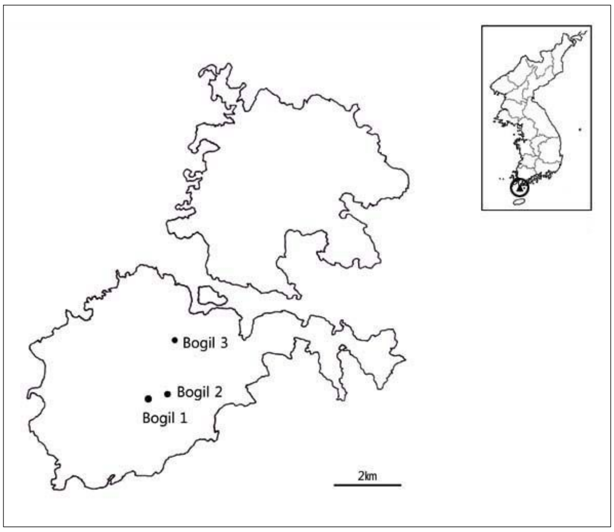

Fig. 1. Map showing the study sites, Bogildo Island, Wando-gun. Black dots indicate the three survey sites (Bogildo 1: N 34° 08' 46.8", E126° 32' 40.6" 85 m, Bogildo 2: N 34° 08' 48.3" E 126° 32' 49.0" 79 m, Bogildo 3: N 34° 09' 38.4", E 126° 33' 10.9" 22 m).

nistration 2007). The total area of the island is about 33 km^2 and the coastline is about 41 km long. The highest peak on Bogildo Island is Mt. Bojuksan, at 425 m above sea level (a s l), and the island also has many low hills < 300 m a s l. Is. Bogildo is covered with a subtropical evergreen broad-leaved forest, including 54 plant families, 91 genera, 113 species, 9 varieties and 1 forma (Kim et al. 2000). Many plant species (45 species) are evergreen species, and six tree species are abundant (*Camellia japonica, Ligustrum japonicum, Eurya japonica, Smilax china, Trachelospermum asiaticum* var. *intermedium, Carex lanceolata*) (Kim et al. 2000).

Sampling and Statistical Analysis

Moths were sampled once per month from May to October, 2008 using a portable light trap (22-Watt circular black light operated by a 12 volt battery, BioQuip, USA) (Table 1). To reveal the total fauna of the island, we sampled the moth fauna at three different sites. We selected sites that were different in forest type and close to the road for ease of access: Bogildo 1 (N34° 08' 46.8", E126° 32' 40.6", 85 m) was mainly covered with conifer trees and low vegetation; Bogildo 2 (N34° 08' 48.3", E126° 32' 49.0", 79 m) was covered with a mixture of deciduous and conifer trees; and Bogildo 3 (N34° 09' 38.4", E126° 33' 10.9", 22 m) was covered with a relatively dense evergreen forest.

Sampling was carried out approximately 5 hours after sunset. We avoided sampling under conditions of heavy rain or strong winds and during the full moon because the activity of moths is influenced by weather and moon phase (Yela and Holyoak 1997). All of the specimens that we collected were identified to species and are preserved in Mokpo National University.

Table 1. Dates of surveys on Bogildo Island, Wando-gun, Jeonnam, Korea. Sampling was carried out at three sites at the same time

Year	Month	Day
2008	May	12
	Jun.	30
	Jul.	22
	Aug.	22
	Sep.	18
	Oct.	17

Since three sites were sampled, we examined the diversity and richness of each site. Simpson's Indices of heterogeneity and evenness were calculated using Species Diversity and Richness (ver. 4.0; Seaby and Henderson 2006). Magurran (2004) noted that Simpson's Index of heterogeneity is one of the most meaningful and robust measures available, although this index is heavily weighted towards the most abundant species in the sample. Fisher's alpha was also calculated to measure local diversity. The Berger-Parker dominance Index (d) was calculated to determine the dominance of the most common species (Southwood and Henderson 2000). The numbers of species and individuals by families did not show a normal distribution (Kolmogorov-Smirnov minimum $Z = 0.311$, each $p < 0.05$). To compare the total species richness (number of species) and abundances (number of individuals) of moths among three sites, the mean numbers of individuals and species in each family were compared using the Kruskal-Wallis test (SPSS Inc. 2003). Monthly changes in moth richness and abundance at the three sites were also examined to determine whether the patterns were different at different sites using *t*-tests (SPSS Inc. 2003) since they showed a normal distribution (Kolmogorov-Smirnov Z, $p > 0.05$).

Since moth sampling was conducted in only one year, the total number of species was estimated with the Chao 1 estimator, using Estimate S (Ver. 8.0; Colwell 2006). The Chao 1 estimator is the sum of the observed number of species and the quotient $a^2/2b$ (a, the number of singletons and b, the number of doubletons). The Chao 1 estimator is widely accepted as reliable, although the estimated richness increases with increasing observed richness at some sites (Beck and Linsenmair 2006).

We used cluster analysis in PC-ORD (Ver. 5.12; McCune and Mefford 1999) to investigate the similarity among sites on three different islands. Moth data from three sites on Aphaedo Island, Sinan-gun (Lim J-T, unpublished data) and from one site on Oenarodo Island, Goheung-gun (An et al. 2008) were compared with that from the three sites on Bogildo Island. Aphaedo Island is located about 72 km northwest of Bogildo Island, and Oenarodo Island is located about 91 km northeast of Bogildo Island. In our analysis, we used a semi-metric distance measure, the Sørensen distance with flexible beta, with $\beta = -0.25$. To reduce the effects of large numbers of rare species, we analyzed the data matrix after deleting the species that occur exclusively in one site.

RESULTS AND DISCUSSION

Throughout the present study, we identified a total of 948 individuals and 272 species in 13 families from May to October in 2008. The attraction radii of light traps for moths is small, less than 30 meters in most situations, which suggests that inter-site comparisons of night-flying insects provide valid results as long as the sampling method is standardized across the habitats to be compared (Beck and Linsenmair 2006). In the present study, we sampled moths at the same time at three different sites at least 1 km apart to reveal the total moth fauna of the island and to compare the diversity at each sampling site characterized by different vegetation structure.

The total numbers of species and individuals were the highest at Bogildo 1 (152 species and 428 individuals), followed by Bogildo 2 (140 species and 405 individuals) and Bogildo 3 (71 species and 115 individuals), but the mean richness and abundance did not different significantly among sites (Kruskal-Wallis test abundance $\chi^2 = 2.525$, $p = 0.283$, richness $\chi^2 = 1.097$, $p = 0.578$). The family composition differed among the three sites. At Bogildo 3 site, no species in the families Lymantriidae and Sphingidae were collected, and only one species of Epiplemidae, *Dysaethria moza* (Butler), was collected. These differences could have resulted from differences in habitat characteristics such as forest structure. Bogildo 1 and Bogildo 2 were covered with mixed forest of deciduous and conifer trees, whereas Bogildo 3 was covered with evergreen *Camellia japonica* trees.

The estimated species richness did not reach an asymptote (Fig. 2), which suggests that our faunal survey of Bogildo Island was insufficient because of the short survey period.

We recorded thirteen families of moths on Bogildo Island (Table 2). The family Noctuidae was the most species-rich group (107 species), followed by Geometridae (62 species), Pyralidae (53 species) and Arctiidae (13 species). For the number of individuals collected, Noctuidae (318 individuals) was also the most abundant, followed by Pyralidae (269 individuals), Geometridae (147 individuals) and Arctiidae (119 individulas). The observed pattern of moth dominance on the family level is similar to the results of previous studies on island and mainland communities (Lim et al.

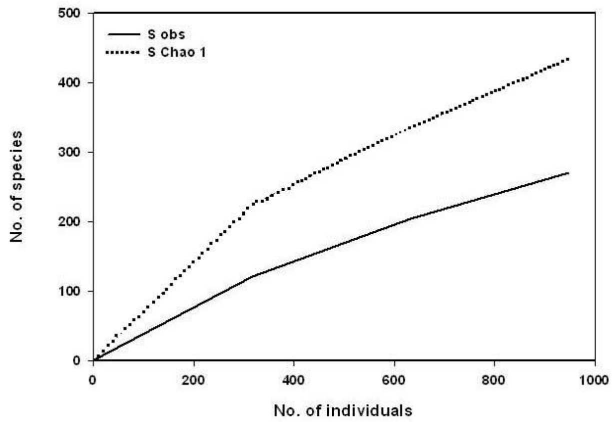

Fig. 2. The observed and estimated species richness (number of species) plotted against abundance (number of individuals) on Bogildo Island, Wando-gun in 2008. The estimated species richness was calculated with the Chao 1 estimator.

Table 2. Summary of the number of species and individuals at three survey sites on Bogildo Island, Wando-gun, Jeonnam, Korea. Each site refers to Fig. 1. Differences between sites were not significant for numbers of species (K-W test $\chi^2 = 1.097$, $p = 0.578$) or individuals (K-W test $\chi^2 = 2.525$, $p = 0.283$)

Family	Bogildo 1		Bogildo 2		Bogildo 3		Total	
	Species	Individuals	Species	Indivi-duals	Species	Individuals	Species	Individuals
Arctiidae	10	35	7	77	3	7	13	119
Drepanidae	5	17	5	34	2	2	8	53
Epiplemidae	0	0	0	0	1	1	1	1
Geometridae	29	63	35	60	15	24	62	147
Lasiocampidae	1	2	1	1	2	3	3	6
Limacodidae	1	3	2	2	2	2	5	7
Lymantriidae	1	1	4	4	0	0	5	5
Noctuidae	66	145	53	132	26	41	107	318
Nolidae	4	5	1	3	2	2	6	10
Notodontidae	2	2	3	3	1	1	5	6
Pyralidae	32	152	26	85	17	32	53	269
Sphingidae	1	3	1	1	0	0	2	4
Thyrididae	0	0	2	3	0	0	2	3
Total	152	428	140	405	71	115	272	948

2007, Park et al. 2007, An et al. 2008).

The Noctuidae are the most diverse group of Lepidoptera and are highly mobile, being found in a wide range of habitats from the lowlands to montane forests, as well as both undisturbed and disturbed habitats (Kitching et al. 2000, Abang and Karim 2005). The Geometridae are also among the most diverse moth groups and are distributed worldwide (Holloway 1984). Colonization of true islands in archipelagos is generally assumed to occur from a common species pool on the mainland, and hence the probability of colonization of a particular island by a particular species should primarily depend on the distance of the island from mainland in relation to the species's capacity for movement (MacArthur and Wilson 1967, Nieminen and Hanski 1998, New 2008). The most abundant moth families observed in the present study were the Noctuidae and Geometridae (Table 2). Their dominance could result from the biology of these taxonomically and ecologically diverse groups and the short distance from a species pool (the distance from the nearest mainland area, Haenam, Jeonnam, is only about 12 km). Many insect species on oceanic archipelagoes are restricted to single islands (New 2008), but the distribution patterns of insect species on offshore islands are different, with the ranges of species not generally being restricting to single islands (Kotze 2008). Many species from large families can colonize offshore islands relatively easily, which is reflected in the dominance of species from large families on islands.

Indices of heterogeneity and evenness for each locality on Bogildo Island are shown in Table 3. Heterogeneity (Simpson's D), local diversity (Fisher's alpha) and evenness (Simpson's E) were highest at Bogildo 3, while Berger-Parker's d was highest at Bogildo 2 (Table 3). These results show that the total richness at Bogildo 3 was low, but that the composition of moths at this site was relatively even.

The percentage of singletons, species for which only one individual was captured in the total sample, at the survey sites varied from 51% (Bogildo 1) to 68% (Bogildo 3). This value was similar on neighboring islands: the percentage of singletons on Aphaedo Island was 45～72% (Lim et al. 2007) and the percentage on Oenarodo Island was 60% (An et al. 2008). When a fauna (or a flora) is sampled, few species are represented by many individuals and large numbers of species are represented by only few individuals. These relative abundances must be considered as representative of the basic pattern of niche utilization in the area (Southwood and Henderson 1999). On the other hand, rare species are of particular interest to conservation biologist because they tend to have small ranges, small populations, or both (Rabinowitz et al. 1986, Gaston et al. 1995). The percentage of singletons on Bogildo Island was higher than those on sites from mainland (Park et al., 2007, Choi et al. 2007). The factors leading to high rates of singletons on offshore islands will require further examination to determine the pattern of distribution of rare species and the mechanisms promoting rarity in island faunas.

The ten most abundant species on Bogildo Island are listed in Table 4. An arctiid moth, *Miltochrista striata* was the dominant species. Among the ten most-abundant species, the family Pyralidae was the most abundant, being represented by four species followed by the family Noctuidae (3 species; Table 4). The food preferences of moth species could be one of the most important factors affecting their ability to colonize islands. The greater diversity of host plants consumed by polyphagous species should facilitate their ability to colonize new areas and buffer their populations against extinction (Nieminen 1996). Pyraloid caterpillars are very diverse in what they eat (Solis 1997) and this wide breath of diet could explain their dominance on Bogildo Island.

Monthly numbers of species and individuals showed an "M"-shaped pattern, with peaks in June and August and a low point in July (Fig. 3). The two peaks at Bogildo 3 site were relatively low, but to the graph still follows an M-shaped pattern. Monthly changes in the number of species and individuals did not statistically differ among sites (*t*-test, number of species $t = 0.251 \sim 1.624$, $p > 0.05$, number of species $t = 0.076 \sim 1.643$, $p > 0.05$).

The M-shaped temporal pattern observed was similar to those found on Oenarodo Island (An et al. 2008), Mt. Duryunsan (Choi and Na 2005) and Mt. Seungdalsan (Park et al. 2007), but the timing of the two peaks on Bogildo Island, Mt. Duryunsan and Mt.

Table 3. Indices of heterogeneity, diversity (Fisher's alpha) and evenness from three sites on Bogildo Island, Wando-gun. Sites refer to Fig. 1

	Bogildo 1	Bogildo 2	Bogildo 3	Total
Number of species	152	140	71	272
Singletons	77 (50.65%)	83 (59.28%)	48 (67.60%)	136 (50.0%)
Simpson's D	51.54	26.15	78.98	55.78
Fisher's alpha (±S.E.)	84.17±9.867	75.77±7.776	79.09±20.57	127.6±10.45
Berger-Parker dominance	0.09579	0.158	0.05217	0.08017
Simpson's E	0.3391	0.1868	1.112	0.2051

Table 4. The 10 most abundant moths on Bogildo Island, Wando-gun, Korea

Family	Scientific name	No. of individuals (% of total individuals)	Food preference	Flight period
Arctiidae	*Miltochrista striata*	76 (8.01)	Lichen	May, Aug.
Pyralidae	*Oncocera semirubella*	50 (5.27)	Polyphagous	May, Jun, Aug, Sep
Drepaniidae	*Macrocilix mysticata*	39 (4.11)	Oligophages	May～Oct.
Pyralidae	*Endotricha olivacealis*	37 (3.9)	Unknown	Jun.～Aug.
Pyralidae	*Nacoleia tampiussalis*	32 (3.37)	Unknown	Jun.～Aug.
Pyralidae	*Herpetogramma luctuosalis*	26 (2.74)	Oligophages	Jun.～Aug.
Noctuidae	*Paragona inchoata*	20 (2.10)	Unknown	Jun.～Sep.
Arctiidae	*Spilarctia seriatopunctata*	18 (1.89)	Polyphagous	May, Aug, Sep.
Noctuidae	*Anachrostis nigripunctalis*	18 (1.89)	Oligophages	Jun, Aug, Sep.
Noctuidae	*Athetis albisignata*	17 (1.79)	Polyphagous	Aug.

Seungdalsan showed an one-month delay relative to Oenarodo Island. The cause of this difference warrants further study.

Raimondo et al (2004) noted that Lepidopteran species appear to be synchronized by local weather conditions and larval plant quality, and that climatic factors such as temperature and relative humidity are closely related to moth abundance and richness (Choi 2008). The M-shaped pattern of richness and abundance observed in our study may have resulted from long-term evolutionary adaptations to local macro-climatic factors like a heavy rainy season (i.e., a monsoon), rather than short-term responses to current weather conditions (e.g. Choi and An 2008). However, recent climate change may lead to dramatic and unexpected changes in the timing of seasons and patterns of precipitation (Korea Meteorological Administration 2007). In the future, we will focus on short-term changes in moth diversity on islands in Korea's southern seas to determine whether moths can adapt to recent climate change.

Our dendrogram recognized two clusters with relatively high information contents (about 35%; Fig. 4). Among the three islands, the three sites on Aphaedo Island were clearly separated from a group comprised of Bogildo Island and Oenarodo Island. The dendrogram showed that the distance among sites played an important

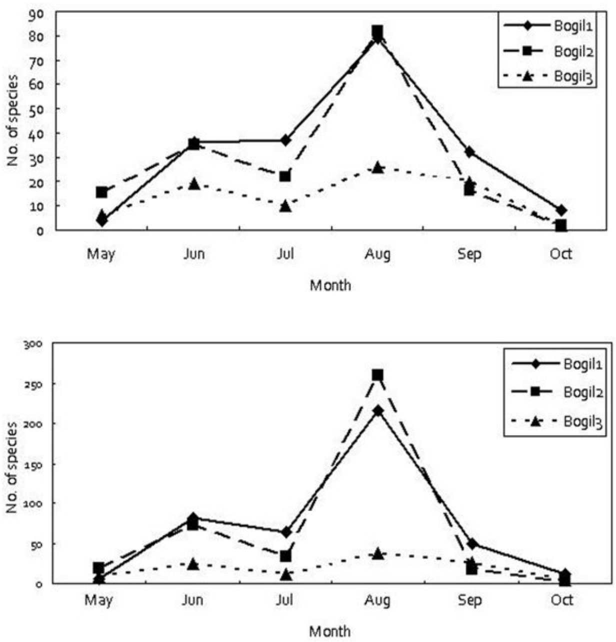

Fig. 3. Monthly changes in the number of species (top) and individuals (bottom) at three different sites on Bogildo Island, Wando-gun, Korea in 2008. Differences in monthly changes in the number of species and individuals were not statistically different among sites.

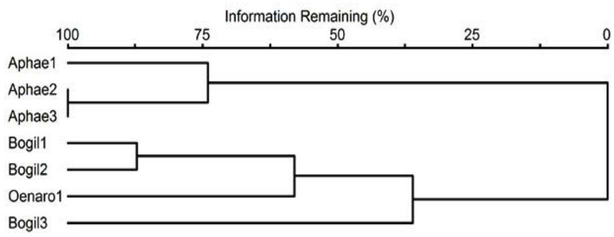

Fig. 4. Dendrogram of dissimilarity of moths among seven sites on three islands. Moth data from three sites of Aphaedo Island, Sinan-gun (Ahpae1-3) and one site of Oenarodo Island, Goheung-gun (Oenaro1) were compared with data from three sites on Bogildo Island. The data matrix of 7 sites and 349 species were analyzed by Sørensen distance measure with flexible beta ($\beta = -0.25$).

role in grouping the moth faunas. However the distance among sites on islands did not always predict the distance between faunas. Bogildo 3, which was characterized by evergreen forest, was separated from the other two sites on Bogildo Island, which were covered with conifer and deciduous mixed forest. The site on Oenarodo Island was also covered with conifer and deciduous forest (An et al. 2008) and was clustered with two sites on Bogildo Island with similar habitat type even though the distance between two islands was large. We plan to examine the underlying mechanism leading to similar moth faunas on different islands in the future.

ACKNOWLEDGMENTS

We thank the National Park Authority for permission to study moth populations on Bogildo Island. We thank three anonymous reviewers for suggestions that greatly improved the manuscript. The study was supported by a grant of the Korea Research Foundation funded by the Korean Government (MOHERD) (KRF-2006-311-C00590).

LITERATURE CITED

Abang F, Karmin C. 2005. Diversity of macromoths (Lepidoptera: Heterocera) in the Poring Hill Dipterocarp Forest, Sabah, Borneo. J Asia-Pacific Entomol 8: 69-79.

An JS, Park M, Kang ES, Choi SW. 2008. Moth (Insecta: Lepidoptera) biodiversity on Island Oenarodo, Goheung-gun, Jeonnam. Korean J Environ Biol 26: 192-202.

Beck J, Linsenmair KE. 2006. Feasibility of light-trapping in community research on moths: Attraction radius of light, completeness of samples, nightly flight times and seasonality of Southeast-Asian hawkmoths (Lepidoptera: Sphingidae). J Res Lepid 39: 18-37.

Choi SW, Park M, Chang YH. 2007. Population changes of moths (Insescta: Lepidoptera) from Mt. Wolchul National Park, Jeollanam-do, Korea. J Ecol Field Biol 30: 245-250.

Choi SW. 2008. Effects of weather factors on the abundance and diversity of moths in a temperate deciduous mixed forest of Korea. Zool Sci 25:53-58

Choi SW, An JS. 2008. Small-scale dynamics of moths in spring from a coniferous forest of Southern Korea. J Ecol Field Biol 31: 83-87.

Choi SW, Na SD. 2005. Diversity and faunal changes of the macrolepidoptera in Mt. Duryunsan and its neighboring area, Jeonnam, Korea. Korean J Ecol 28: 79-83.

Dennis RLH, Dapporto L, Shreeve TG, John E, Coutsis JG, Kudrna O, Saarinen K, Ryrholm N, Williams WR. 2008. Butterflies of European islands: the implications of the geography and ecology of rarity and endemicity for conservation. J Insect Conserv 12: 205-236.

Colwell RK. 2006. Estimates: Statistical estimation of species richness and shared species from samples. Version 8.0. User's guide and application published at: http://purl.oclc.org/estimates.

Gaston KT, Blackburn T, Loder N. 1995. Which species are described first? The case of North American butterflies. Biodivers Conserv 4: 119-127.

Holloway JD. 1984. The larger moths of Gunung Mulu National Park; a preliminary assessment of their distribution, ecology, and potential as environment indicators. Sarawak Mus J 30: 149-190.

Kim CY, Lee JS, Oh KI, Jang SK, Park JK. 2000. Community ecological study on the *Quercus acuta* forests in Bogildo-Island. Jour Korean For Soc 89: 618-629.

Kitching RL, Orr AG, Thaib L, Mitchell H, Hopkins MS, Graham AW. 2000. Moth assemblages as indicators of environmental quality of Australian rain forest. J Appl Ecol 37: 284-297.

Korea Meterological Administration. 2007. http://www.kma.go.kr.

Korea National Statistics Office 2005. Korea Statistical Yearbook 2005. Korea National Statistics Office, Daejeon.

Kotze DJ. 2008. The occurrence and distribution of carabid beetles (Carabidae) on islands in the Baltic Sea: A review. J Insect Conserv 12: 265-276.

Lim JT, Kim SY, Kim BW, Choi SW. 2007. A faunistic study of moths (Insecta, Lepidoptera) on Is. Aphae-do, Sinan-gun, Jeollanam-do, Korea. Korean J Environ Biol 25: 178-189.

MacArthur RH, Wilson EO. 1967. The Theory of Island Biogeography. Princeton University Press, Princeton.

Magurran AE. 2004. Measuring Ecological Diversity. Blackwell Publishing Oxford, 256pp.

McCune B, Mefford MJ. 1999. PC-ORD. Multivariate Analysis of Ecological Data, Version 5.12. MjM Software Design Gleneden Beach.

Miller SE. 1997. Biogeography of Pacific Insects and Other Terrestrial Invertebrates: A Status Report. Academic Publishing, Amsterdam, pp. 463-475.

National Institute of Environmental Research. 2002. Natural Environment Survey of Korean Unmanned Islands. Ministry of Environment, Seoul (in Korean).

New TR. 2008. Insect conservation on islands: setting the scene and defining the needs. J Insect Conserv 12: 197-204.

Nieminen M. 1996. Extinction risk in moths: effect of host plant characteristics. Oikos 76: 475-484.

Nieminen M, Hanski I. 1998. Metapopulations of moths on islands: a test of two contrasting models. J Anim Ecol 67: 149-160.

Park M, Oh SG, An JS, Kim KI, Choi SW. 2007. Biodiversity of Lepidopteran insects of Mt. Seungdal-san, Muan, Jeonnam, Korea. Korean J Environ Biol 25: 42-55.

Rabinowitz D, Cairns S, Dillon T. 1986. Seven forms of rarity and their frequency in the British Isles, In Soule ME (ed.) Conservation Biology: The Science of Scarcity and Diversity. Sinauer, Sunderland, MA. pp. 182-204.

Raimondo S, Liebhold AM, Strazanac JS, Butler L. 2004. Population synchrony within and among Lepidoptera species in relation to weather, phylogeny and larval phenology. Ecol Entomol 29: 96-105.

Samways MJ. 2005. Insect Conservation Biology. Cambridge University Press, Cambridge.

Scoble MJ. 1992. The Lepidoptera. Form and Function and Diversity. The Natural History Museum, London.

Seaby RH, Henderson PD. 2006. Species Diversity and Richness Version 4. Pisces Conservation Ltd. Lymington.

Solis MA. 1997. Snout moths: unraveling the taxonomic diversity of a specious group in the neotropics. In Reaka-Kudula ML, Wilson DE, Wilson EO (eds.) Biodiversity II. Joseph Henry Press, Washington D.C., 551pp.

SPSS. 2003. SPSS 12.0.1. for windows. SPSS Inc.

Southwood TRE, Henderson PA. 2000. Ecological Methods. Blackwell Science Publisher, Oxford.

Summerville KS, Crist TO. 2002. Effects of timber harvest on forest Lepidoptera: community, guild and species responses. Ecol Apps 12: 820-835.

Summerville KS, Metzler EH, Crist TO. 2001. Diversity of forest Lepidoptera at local and regional scales: how heterogeneous is the fauna? Ann Entomol Soc Am 94: 583-591.

Yela JL, Holyoak M. 1997. Effects of moonlight and meteorological factors on light and bait trap catches of noctuid moths. Environ Entomol 26: 1283-129.

(Received February 17, 2009; Accepted April 10, 2009)