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Effect of island geography on plant species on uninhabited islands in southeastern South Korea

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Abstract

We investigated the pattern of floral diversity including naturalized plant species and three ecological factors (area, elevation and distance from mainland) of plant species on 53 uninhabited islands in Gyungsangnam-do, southeastern South Korea. A total of 206 taxa in 67 families were observed, and the species of Compositae was most common. Thirteen taxa in eight families of the naturalized plants were observed on 33 islands. The numbers of total plant species, area and elevation were significantly correlated, but no relationship with distance from the mainland was observed. In addition, no relationship was found among the numbers of naturalized plants, area and elevation. However, the average rate of naturalization on islands with different elevations differed significantly, indicating the smallest proportion of naturalized plant species was on high islands. Multiple regression of total species richness identified elevation as a significant factor, while no significant variables were correlated with naturalized plant species. Nonmetric multidimensional scaling (NMS) ordination identified three major variables, distance from mainland, number of naturalized plant species and elevation. These findings indicate that the geography of islands such as area and elevation affected the species richness of plants on uninhabited islands, while human disturbance had a greater effect than geography on the species richness of naturalized plants on islands in southeastern South Korea.

Key words: biogeography, flora, naturalized plants, uninhabited islands

INTRODUCTION

The equilibrium theory of island biogeography (MacArthur and Wilson 1967) states that the number of species on an island is determined by the immigration and extinction of species. Based on this theory, more species are expected on islands closer to the mainland and larger islands. This is because islands closer to mainland have a greater chance of attracting species through immigration, while species on smaller islands have a greater chance of extinction owing to higher competition. This theory has been tested using diverse plants and animals from across the world (Whittaker et al. 2008, Losos and Ricklefs 2009) and expanded to the design of nature reserves and corridors in conservation biology (Harris 1984).

The Korean peninsula contains approximately 3,153 islands, including 2,689 uninhabited islands. Overall, 432 islands are distributed in Gyungsangnam-do (=Gyungnam) province, southeastern South Korea (Ministry of Land and Sea 2012). Because faunal and floral assemblag-

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es on islands are the combined products of geography (area, latitude, altitude, and isolation), ecology (geology, biotope availability, history, land use and management), biology (mobility, colonization capability, and presence of organisms at island sources) and time, island biota can be considered 'individuals' carrying unique information regarding complex interactions between biological, geographical and historical factors (Dapporto and Dennis 2008, Lomolino et al. 2010, Choi and An 2011). The flora of islands in South Korean waters has been well described (Park and Park 2004, Park et al. 2005, Oh and Byun 2007, Kim and Oh 2010). However, investigations of ecological variables influencing the distribution of plants on uninhabited islands of southeastern South Korea are relatively rare.

Invasion by exotic plant species has become one of the most serious threats to the ecological and economic integrity of ecosystems worldwide (Simberloff et al. 2013, Bennett 2014). Spuhler and Harrington (1997) summarized the characteristics of exotic plants as simple pollination systems, effective seed dispersal and breeding mechanisms, high intra and interspecific competitive abilities, high reproductive rates and broad environmental plasticity. Naturalized plants colonize islands relatively easily due to their high productivity and dispersal ability. For example, *Sonchus oleraceus* produces 21,500–25,000 seeds and *Conyza canadensis* produces 38,000–60,000 seeds that have an apical feather, enabling good flight and easy colonization of new habitats (Kim et al. 2000).

The ecological effects of plant invasions are scale-dependent, ranging from altered local community diversity and homogenization of the global flora to modified biogeochemical cycles and disturbance of regimes at regional or global scales (Pauchard and Shea 2006). Invasive plants may impact ecosystems in numerous ways, such as causing declines in native plant diversity and growth (Webster et al. 2006, Pyšek et al. 2012), altering disturbance regimes and other ecological processes (Brooks et al. 2004, Dukes and Mooney 2004), and even facilitating invasions by other nonnative species (Simberloff and Von Holle 1999, Heimpel et al. 2010). It is widely acknowledged that plant invasions reaching the expansion and saturation phases at the landscape scale incur greater ecological and economic costs, especially in terms of control efforts (Sakai et al. 2001, Webster et al. 2006). Pimentel et al. (2005) reported that the invasive purple loosestrife (*Lythrum salicaria* L.) costs the United States $45 million per year for control efforts and loss of wildlife forage. Therefore, describing existing patterns of invasion and forecasting future invasions are essential to effective management of global biodiversity resources.

This study was conducted to investigate the pattern of floral diversity including naturalized plant species and ecological factors on these plant species on uninhabited islands in Gyungnam, southeastern South Korea. Many studies of plant and animal species on uninhabited islands have focused on western parts of South Korea since most uninhabited islands are distributed in these areas (Choi 2000, Chung and Hong 2002, 2006, Lee 2010, Rho 2010). We expect that the results from this study will enable comparison based on the pattern of floral diversity between west and east South Korean waters and provide insight to facilitate conservation of floral diversity on uninhabited islands of South Korea.

MATERIALS AND METHODS

We surveyed 53 uninhabited islands in six official areas within the province of Gyungnam, southeastern South Korea in 2012: Geoje (16), Namhae-gun County (16), Ulsan (3), Changwon (12), Tongyoung (3), and Hadong-gun (3). Field surveys were conducted by walking along the coast line and crossing the islands and recording the plant species on the survey route. Plant species were identified through previous studies (Lee 1996a, 1996b, Kim et al. 2000, Lee 2003, Korea National Arboretum, KNA 2012). Species names refer to the Korean plant names index (KNPI, https://www.nature.go.kr).

Naturalized plants were categorized according to Kim et al. (2000) and information regarding naturalized plants such as degree, timing, origin and current distribution refers to Korea National Arboretum (KNA) (2012). The degree of naturalization was divided into five levels (Kariyama and Kobatake 1988) and the timing of naturalization was divided into four periods: 0 (-1876), 1 (1876-1921), 2 (1822-1963), and 3 (1964-2014).

We included island area (m^2), highest peak (meters above sea level), and distance from the mainland (m) to investigate the effects of environmental factors on species richness and diversity of total and naturalized plants on the islands. Dependent variables were log-transformed after adding 1. The rate of naturalization (%) was calculated by dividing invasive species by the total number of plants. Island area and highest peak were obtained from the Ministry of Land and Sea (2012) and the distance from the mainland was calculated by the distance to the nearest the port. All statistical analyses were conducted using SPSS ver. 22 (SPSS Inc., Chicago, IL, USA).

Nonmetric multidimensional scaling (NMS) ordina-

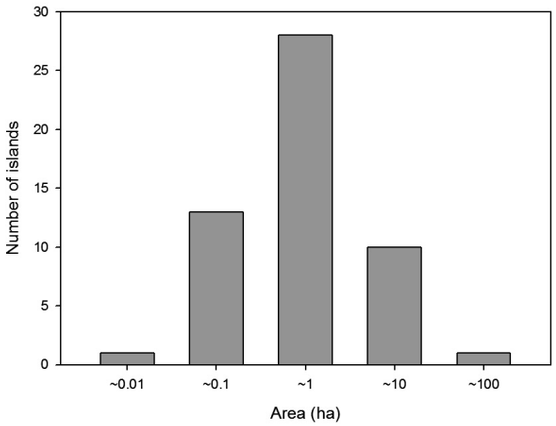

Fig. 1. Summary of size of islands in 53 islands of Gyungnam province, southeastern South Korea.

tion analysis was applied for a data matrix of 125 plant species and 53 islands using the PC-ORD software. The second matrix for the analysis comprised five variables, area, elevation, distance from mainland, number of naturalized plants and administrative region. Among 206 plant species, 81 plants that occurred on less than three islands were excluded.

RESULTS

The average area of 53 surveyed islands was 8,947 m^2, most of which (42 islands, 79%) were less than 10,000 m^2 (Table 1 and Fig. 1). The smallest island was Solttang-do (97 m^2) on Hadong-gun and the largest one was Sokkuri-do (108,612 m^2) in Changwon. The average peak was 16 m above sea level (a.s.l.), and most islands had low elevation (3–50 m a.s.l.). The distance from the mainland was between 0 and 15 km, with an average of 2.23 km. Nineteen islands (36%) were close to the mainland (< 1 km), and four islands (Kkokdu, Baebang, Dongmae, and Eumji) were connected to the mainland by a bridge, breakwater or port.

Overall, 67 families and 206 taxa of plants were observed during the field survey. The most common family was Compositae, with 23 taxa, followed by Gramineae (21 taxa), Rosaceae (13 taxa), Leguminosae (12 taxa), and Liliaceae (10 taxa) (Table 2). The average number of plant species on each island was 23.5 (SD ± 14.14). The most common plant species in this region was *Rosa wichuraiana* (Rosaceae), which was distributed on 36 islands, followed by *Lilium tigrinum* (Liliaceae), *Pinus thunbergii* (Pinaceae), *Miscanthus sinensis* var. *purpurascen* (Graminaceae),

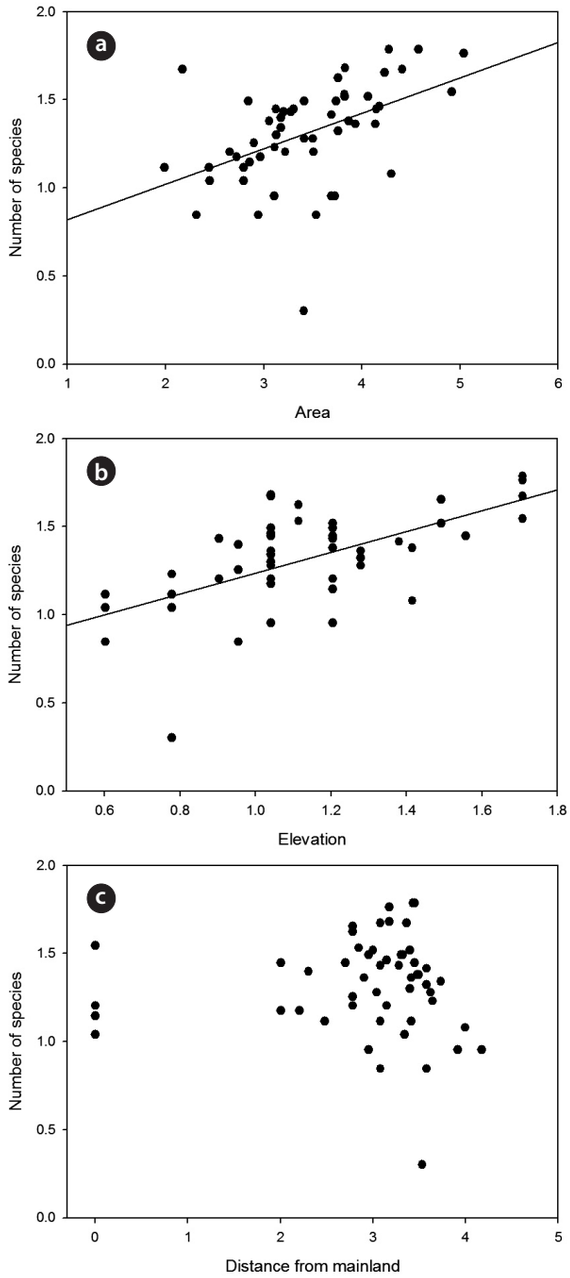

Fig. 2. Linear relationship between number of species and area (a), elevation (b) and distance from mainland (c) from 53 islands of Gyungnam province, southeastern South Korea.

Artemisia capillaris (Compositae), *Aster spathulifolius* (Compositae), *Rumex crispus* (Polygonaceae), *Euonymus japonica* (Celastraceae), *Asparagus cochinchinensis* (Liliaeceae) and *Raphiolepis umbellata* (Rosaceae). Only one species (*Aster spathulifolius*) was found on Galsan Island, Geoje, while 60 taxa in 33 families were found on two is-

Table 1. Information of 53 surveyed islands of Gyungnam province, southeastern South Korea

	Island	Official Area	Area (m^2)	Elevation (m)	Distance (m)	Total number of species	Number of naturalized species	Rate of naturalization (%)
1	Galsan	Geojae	2,560	5	3,400	1	0	0
2	Gyuk	Geojae	205	8	1,200	6	0	0
3	Gongji	Geojae	627	3	2,200	10	2	20.0
4	Daesondae1	Geojae	37,587	50	2,700	60	0	0
5	Daesondae2	Geojae	18,843	50	2,800	60	0	0
6	Daesondae4	Geojae	14,039	35	2,800	27	1	3.7
7	Daesondae5	Geojae	7,332	25	3,100	23	1	4.3
8	Baeksa	Geojae	3,426	8	3,800	6	1	16.7
9	Baekyeo1	Geojae	4,922	23	3,800	25	1	4.0
10	Baekyoe2	Geojae	5,713	18	3,800	20	2	10.0
11	Baem	Geojae	447	7	600	15	0	0
12	Sodapo	Geojae	1,587	15	1,200	26	1	3.8
13	Sodong	Geojae	922	10	100	14	1	7.1
14	Sosondae1	Geojae	2,579	18	1,100	18	0	0
15	Sosondae2	Geojae	11,504	30	2,500	32	0	0
16	Chui	Geojae	1,884	7	1,900	26	2	7.7
17	Gwanseon	Namhae	6,678	15	1,000	32	0	0
18	Gudeul	Namhae	5,314	15	15,000	8	1	12.5
19	Ggokdu	Namhae	714	15	0	13	0	0
20	Noru	Namhae	13,635	10	2,600	22	0	0
21	Minyeo	Namhae	880	3	1,200	6	2	33.3
22	Baggatnancho	Namhae	148	10	2,300	46	1	2.2
23	Bak	Namhae	1,140	15	3,000	23	0	0
24	Baebang	Namhae	1,652	10	0	15	3	20.0
25	Baek	Namhae	1,274	15	8,200	8	3	37.5
26	Samyeo1	Namhae	1,339	10	2,500	19	0	0
27	Samyeo2	Namhae	8,607	18	800	22	1	4.5
28	Sosanyeo1	Namhae	529	10	160	14	0	0
29	Sosamyeo2)	Namhae	3,209	15	1,400	15	2	13.3
30	Sojuk	Namhae	1,330	15	500	27	0	0
31	Ggong	Namhae	1,488	10	5,400	21	0	0
32	Hyungjae	Namhae	4,905	10	900	8	1	12.5
33	Myungseon	Ulsan	6,744	10	1,500	47	6	12.8
34	Mok	Ulsan	15,074	10	1,400	28	4	14.3
35	Cheoyoungam	Ulsan	622	3	1,200	12	1	8.3
36	Gaguri	Changwon	1,488	8	200	24	0	0
37	Gaeburi	Changwon	3,174	10	4,200	18	0	0
38	Daejuk	Changwon	25,785	50	1,200	46	4	8.7
39	Dottumari	Changwon	1,289	5	4,400	16	3	18.8
40	Dongmae	Changwon	282	5	0	10	2	20.0
41	Dong	Changwon	2,011	10	100	27	1	3.7
42	Makgae	Changwon	694	10	2,000	30	3	10.0
43	Maeju	Changwon	275	5	2,600	12	3	25.0
44	Sokkuri	Changwon	108,612	50	1,500	57	5	8.8
45	Songa	Changwon	6,645	12	700	33	2	6.1
46	Eumji	Changwon	82,946	50	0	34	2	5.9
47	Janggu	Changwon	795	8	600	17	0	0
48	Dolgeochilri	Tongyoung	16,995	30	600	44	2	4.5
49	Jasarijae5	Tongyoung	19,862	25	9,900	11	1	9.1
50	Tae	Tongyoung	2,579	15	2,100	30	0	0
51	Buk	Hadong	5,455	10	900	30	0	0
52	Sottang	Hadong	97	3	300	12	4	33.3
53	Jakeunsol	Hadong	5,752	12	600	41	3	7.3

lands in Geoje, Daesondaedo 1 and Daesondaedo 2.

Naturalized plants were observed on 33 islands. These plants comprised 13 taxa in eight families (Table 2). The number of naturalized plants on each island varied from one (13 islands) to six (1 island), and the average number was 2.2 (SD ± 1.3). Common naturalized plants include *Rumex crispus*, *Conyza canadensis* (Compositae), *Phytolacca americana* (Phytolaccaceae), *Sonchus oleraceus* (Compositae), and *Avena sativa* (Gramineae) (Table 3).

The correlation between number of plant species and island area was significant (Pearson's r = 0.45, P = 0.000, Fig. 2a), as was the linear relationship between area and species richness (log S = 0.212*log area + 0.55). The number of species increased as island size increased, with 15.5 (± 10.5 SD, N = 14) species on islands with areas less than 0.1 ha, 21.8 (± 10.4 SD, N = 28) on islands less than 1 ha, and 38.3 (± 16.4 SD, N = 11) species on islands less than 100 ha. The average number of species differed among groups (ANOVA F = 6.579, P < 0.01), with more plant species on larger islands.

Similarly, islands with higher elevation contained more species (Pearson's r = 0.59, P = 0.000, Fig. 2b). The average number of species on islands less than 10 m a.s.l. was 18.3 (± 11.1 SD, N = 28), while that on islands less than

Table 2. Dominant plant species in 53 surveyed islands of Gyungnam province, southeastern South Korea

Family	Species	Number of islands
Rosaceae	*Rosa wichuraiana* CREP.	36
Liliaceae	*Lilium tigrinum* KER-GAWL.	31
Pinaceae	*Pinus thunbergii* PARL.	30
Graminaceae	*Miscanthus sinensis* var. *purpurascens* RENDLE.	30
Compositae	*Artemisia capillaris* THUNB.	29
Compositae	*Aster spathulifolius* MAX.	29
Polygonaceae	*Rumex crispus* L.*	27
Celastraceae	*Euonymus japonica* THUNB.	25
Liliaceae	*Asparagus cochinchinensis* MERR.	25
Rosaceae	*Raphiolepis umbellata* (THUNB.) MAKING	22

*Naturalized plants.

Table 3. Information of naturalized plant species in 33 surveyed islands of Gyungnam province, southeastern South Korea

Family / Scientific name	Degree	Timing	Origin	Korea*	No. of islands
Solanaceae					
Solanum nigrum L.	-	0	-	-	3
Compositae					
Conyza canadensis (L.) Cronquist	5	1	NA	N,C,S	12
Sonchus oleraceus L.	-	0	-	-	6
Taraxacum officinale Weber	5	1	Europe	N,C,S	1
Polygonaceae					
Fallopia dumetorum (L.) Holub	3	1	Europe	N,C,S	1
Rumex crispus L.	5	1	Europe	N,C,S	27
Onagraceae					
Oenothera biennis L.	5	1	NA	N,C,S	2
Gramineae					
Avena sativa L.	-	-	-	-	6
Simaroubaceae					
Ailanthus altissima (Mill.) Swingle	5	1	China	C,S	1
Phytolaccaceae					
Phytolacca americana L.	3	3	NA	C,S	8
Leguminosae					
Medicago lupulina L.	3	1	Europe	N,C,S	1
Medicago polymorpha L.	2	1	Europe	N,C,S	2
Robinia pseudoacacia L.	5	1	NA	N,C,S	2

*N, northern; C, central; S, southern (including Jejedo).

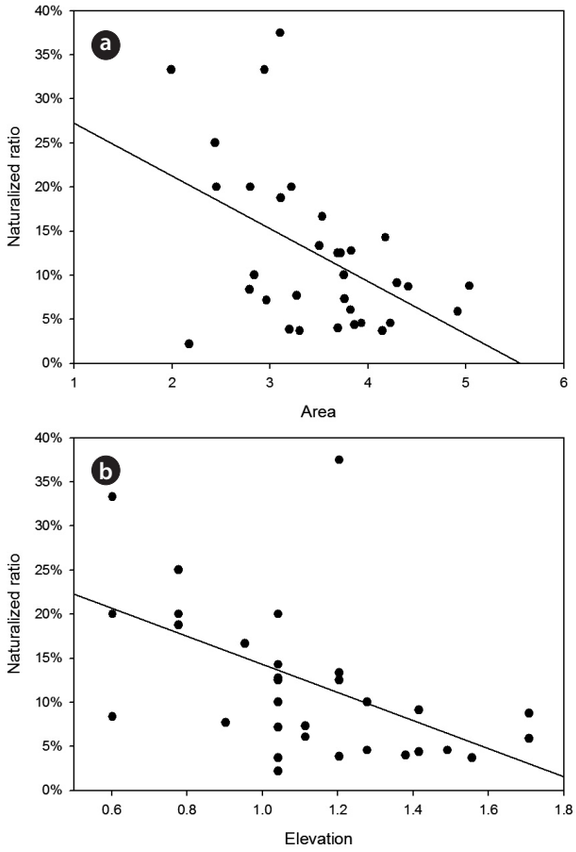

Fig. 3. The naturalized plant ratio against area (a) and elevation (b) from 33 islands of Gyungnam province, southeastern South Korea.

20 m a.s.l. was 22.6 (± 9.7 SD, N = 14), and that on islands less than 50m a.s.l. was 38.1 (± 16.5 SD, N = 11). The average number of species differed among the three elevation groups (ANOVA F = 6.539, P < 0.01), with larger numbers of plant species on high elevation islands. Islands with an elevation of less than 10 m a.s.l. (Pearson's r = 0.50, P = 0.006) and 50m a.s.l. (Pearson's r = 0.78, P = 0.005) showed the strongest relationship between number of plants and elevation. Islands with an area of less than 100 ha showed a strong relationship between elevation and number of plant species (Pearson's r = 0.60, P = 0.05). The number of plant species was not correlated with distance from the mainland (Pearson's r = -0.01, P = 0.93) (Fig. 2c).

Among 33 islands on which naturalized plants were observed, the average number of naturalized species on islands less than 0.1 ha was 2.11 (± 1.05 SD, N = 9), while that on islands less than 1 ha was 2.00 (± 1.32 SD, N = 17), and that on islands less than 10 ha was 2.71 (± 0.60 SD, N = 7). There were no significant differences in numbers of naturalized plant species among island areas (ANOVA F = 0.70, P = 0.50). However the average rate of naturalization on islands of different size differed significantly (ANOVA F = 58.7, P < 0.00001, Fig. 3a), being 47.1% (± 14.73 SD, N = 9) on islands less than 0.1 ha; 44.5% (± 16.45 SD, N = 17) on islands less than 1 ha and 7.85% (± 3.57 SD, N = 7) on islands less than 100 ha.

The average number of naturalized species on islands less than 10 m a.s.l. was 2.35 (± 1.41 SD, N = 17), while that on islands less than 20 m a.s.l. was 1.88 (± 0.83 SD, N = 8), and that on islands less than 50 m a.s.l. was 2.13 (± 1.55 SD, N = 8). The average number of naturalized plant species on islands with varying elevation showed no significant difference (ANOVA F = 0.36, P = 0.70), being 15.63% (± 9.17 SD, N = 17) on islands less than 10 m a.s.l., 11.89% (± 10.02 SD, N = 8) on islands less than 20 m a.s.l., and 6.13% (± 2.35 SD, N = 8) on islands less than 50 m a.s.l. However, the average rate of naturalization on islands of different elevation differed significantly (ANOVA F = 3.34, P < 0.05, Fig. 3b), with the smallest proportion of naturalized plant species being present on high islands. The number of naturalized plant species did not differ significantly with varying distances from the mainland. Multiple regression of the species richness of 55 islands identified elevation as a significant factor, while no significant variables were correlated with the number of naturalized plant species on 33 islands (Table 4).

Three axes were produced for 125 plants and five variables (final stress = 14.39) and explained 79% of the variance. The first axis (33% explain of variance) was related to the distance from the mainland (Pearson's r = -0.43), the second (32% explain of variance) was related to the number of naturalized plant species (Pearson's r = -0.58) and the third (14% explain of variance) was related to elevation (Pearson's r = -0.46).

Table 4. Stepwise regression of plant species including the naturalized plant species against three variables (area, elevation and distance from mainland) on 53 uninhabited islands of Gyungnam, southeastern South Korea

Dependent Variable	Factor	R^2	F-ratio	t	P
Plant species	Elevation	0.35	8.81	3.26	0.000

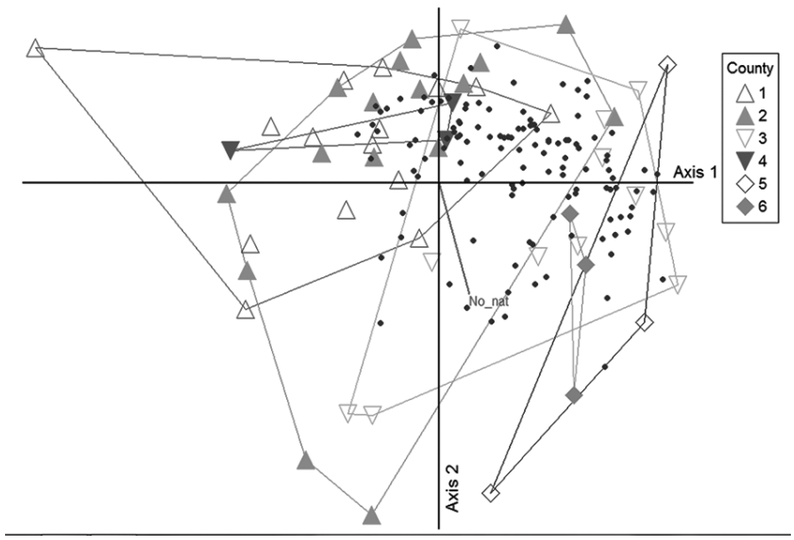

Fig. 4. Nonmetric multidimensional scaling (NMS) graph of 125 plant species and 53 islands of Gyungnam province, southeastern South Korea (Final stress = 14.39). No_nat, number of naturalized plants. 1. Geoje, 2. Namhae, 3. Changwon, 4. Tongyoung, 5. Hadong, 6. Ulsan.

DISCUSSION

We investigated the distributional pattern of plant species on the uninhabited islands of southeastern South Korea and found that the area and elevation of islands were closely correlated with plant species richness. Previous studies of plant species richness on uninhabited islands showed that island area was the strongest factor, followed by distance from the mainland and degree of disturbance (Chung and Hong 2002, 2006). Since many islands in the survey areas are grouped, we suspected that the distributional pattern of plants on islands is characteristic of each archipelago from the effects of the stepping stone. This phenomenon has also been reported for other Korean islands in investigations of butterflies, moths (Choi 2000, Choi and An 2011, An and Choi 2012) and birds (Lee 2010). Choi and An (2011) noted that moth species richness was affected by the number of islands within 2 km, indicating that more species were shared among nearby islands by closer islands. NMS ordination showed that the islands in six official areas were grouped together (Fig. 4).

Additionally, Paik and Yim (1982) showed that the z-value from the plant species-area equation was 0.226 for vascular plants of 53 islands of South Korea. In the present study, we found that the z-value was 0.21. This low z-value indicated that the islands are not far from the mainland and are less isolated.

Chung and Hong (2002) surveyed plant species among 261 uninhabited islands on west and south seas and found that the family Compositae was most common, followed by Graminaea, Leguminosaea, and Rosaceae. This dominance of families was observed in Dadohae National Marine Park (Kim and Oh 2010) and 22 uninhabited islands of Buan and Gochang counties, Jeollabuk-do (Choi and Kim 2013). This observation was similar to our findings for southeastern islands. Overall the plant species on uninhabited islands in South Korean waters showed similar trends of occupation by naturalized plants.

Chung and Hong (2006) reported that the average number of naturalized plant species on 261 uninhabited islands was 4.6 (± 4.07 SD); however, we found fewer naturalized plant species (2.2 ± 1.3). This result might reflect differences in geography and sampling size. West and South seas contain more than 60% of the islands, and most are located close to each other, which would facilitate the dispersal of naturalized plants in these areas. Chung and Hong (2006) suggested that the occurrence of naturalized plants was strongly correlated with area and distance from the mainland, while the effect of human disturbance was not significant. However, in the present study, we found that the richness pattern of naturalized plant species was not correlated with area. Instead, the ratio of naturalization showed the opposite pattern, with a higher proportion of naturalized plants on smaller and lower islands. These findings suggest that the naturalized plants more easily colonized the smaller islands than

larger islands. During the survey, we observed that the smaller islands were largely affected by humans through fishing (personal observation). This high disturbance by humans could be one of the reasons for the high ratio of naturalization on smaller islands in southeastern parts of South Korea.

Across South Korea, the plants on islands were largely affected by area and elevation (Paik and Yim 1982, Chung and Hong 2006). Increasing amounts of naturalized plants on islands have both positive and negative impacts on ecosystems and biodiversity (Sax et al. 2002, Powell et al. 2011). However, the impact of exotic plants on small, uninhabited islands could more easily devastate the native flora than on large islands. Therefore, careful plans should be made to conserve natural flora on uninhabited islands.

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LITERATURE CITED

An JS, Choi SW. 2012. Study on the pattern and ecological variables of butterfly species diversity on 19 uninhabited islands around Imja-myeon, Shinan-gun, Jeonnam, Korea. Korean J Environ Biol 30:185-192.

Bennett BM. 2014. Model invasions and the development of national concerns over invasive introduced trees: insights from South African history. Biol Invasions 16: 499–512.

Brooks ML, D'antonio CM, Richardson DM, Grace JB, Keeley JE, DiTomaso JM, Hobbs RJ, Pellant M, Pyke D. 2004. Effects of invasive alien plants on fire regimes. BioScience 54: 677–688.

Choi SW. 2000. Study on the ecological influences on the butterfly fauna of islands in Korea. Korean J Environ Biol 18: 237-246.

Choi SW, An JS. 2011. An island network determines moth diversity on islands in Dadohaehaesang National Park, South Korea. Insect Conserv Diver 4: 247-256.

Choi YE, Kim CH. 2013. A study on the flora of uninhabited islands in Buan-gun and Gochang-gun of Jellabukdo. J Korean island 25:101-115.

Chung JM, Hong KN. 2002. Relationships between geographical conditions and distribution pattern of plant species on uninhabited islands in Korea. Korean J Ecol 25: 341-348. (in Korean with English abstract)

Chung JM, Hong KN. 2006. Island biogeographic study on distribution pattern of the naturalized plant species on the uninhabited islands in Korea. J Ecol Field Biol 29: 489-494. (in Korean with English abstract)

Dapporto L, Dennis RLH. 2008. Species richness, rarity and endemicity on Italian offshore islands: complementary signals from island-focused and species-focused analyses. J Biogeogr 35: 664-674.

Dukes JS, Mooney HA. 2004. Disruption of ecosystem processes in western North America by invasive species. Rev Chil Hist Nat 77: 411–437.

Harris LD. 1984. The fragmented forest: island biogeography theory and the preservation of biotic diversity. University of Chicago Press, Chicago, IL.

Heimpel GE, Frelich LE, Landis DA, Hopper KR, Hoelmer KA, Sezen Z, Asplen MK, Wu K. 2010. European buckthorn and Asian soybean aphid as components of an extensive invasional meltdown in North America. Biol Invasions 12: 2913–2931.

Kariyama S, Kobatake H. 1988. Naturalized plants of Gagyuzan, Takahashi-City, Okayama Prefecture, Japan. Bull Kurashiki Mus Nat Hist 3: 31–40.

Kim CS, Lee IY, Oh YJ, Oh SM, Kim SC, Park JE. 2010. Occurrence of exotic weeds in several islands in Korea. Korean J Weed Sci 30: 59-67. (in Korean with English abstract)

Kim HS, Oh JG. 2010. Distribution of naturalized plants in Dadohae National Marine park. Korean J Plant Resour 23: 187-196. (in Korean with English abstract)

Kim JM, Yim YJ, Jeon ES. 2000. The naturalized plants of Korea. Science Books, Seoul.

Korea National Arboretum (KNA). 2012. Field guide, Naturalized plants of Korea. Korea National Arboretum, Pocheon.

Lee SD. 2010. Studies of avian species in the islands of Korea based on the theory of island biogeography. J Environ Impact Assess 19: 547-552.

Lee TB. 2003. Coloured Flora of Korea (I, II). Hyangmunsa, Seoul.

Lee WC. 1996a. Lineamenta florae Koreae. Academy Publishing Co., Seoul.

Lee WC. 1996b. Standard illustrations of Korean plants. Academy Publishing Co., Seoul.

Lomolino MV, Brown JH, Sax DF. 2010. Island biogeography theory. In:The theory of island biogeography revisited (Losos JB, Ricklefs RE, eds). Princeton University Press, Princeton, NJ, pp 13-51.

Losos JB, Ricklefs RE. 2009. The theory of island biogeography revisited. Princeton University Press, Princeton, NJ.

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

Ministry of Land and Sea. 2012. Survey of uninhabited islands in 2012. Ministry of Land and Sea, Seoul.

Oh HK, Byun MS. 2007. Status and distribution of vascular plants of lower Keum river in Gunsan area, Jeonbuk. Korean J Plant Resour 20: 113-124. (in Korean with English abstract)

Paik KS, Yim YJ. 1982. Studies on the distribution of vascular plants in the islands around the Korean peninsula. Korean J Ecol 5: 143-153.

Park SJ, Park SJ. 2004. The flora of Sorok island. Korean J Environ Ecol 18: 392-414. (in Korean with English abstract)

Park SJ, Woo BJ, Park SJ, Hwang GJ, Kim KS, Lee JW. 2005. A floristic study on the economic planys of Jisimdo, Naedo and Yundoldo around Koje island. Korean J Plant Resour 18: 479-489. (in Korean with English abstract)

Pauchard A, Shea K. 2006. Integrating the study of non-native plant invasions across spatial scales. Biol Invasions 8: 399-413.

Pimentel D, Zuniga R, Morrison D. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecol Econ 52: 273–288.

Powell KI, Chase JM, Knight TM. 2011. A synthesis of plant invasion effects on biodiversity across spatial scales. Am J Bot 98: 539-548.

Pyšek P, Jarošík V, Hulme PE, Pergl J, Hejda M, Schaffner U, Vilà M. 2012. A global assessment of invasive plant impacts on resident species, communities and ecosystems: the interaction of impact measures, invading species' traits and environment. Global Change Biol 18: 1725–1737.

Rho P. 2010. Species richness related to landscape characteristics of uninhabited islands in Korea. J Ecol Field Biol 33: 105-114.

Sakai AK, Allendorf FW, Holt JS, Lodge DM, Molofsky J, With KA, Baughman S, Cabin RJ, Cohen JE, Ellstrand NC, McCauley DE, O'Neil P, Parker IM, Thompson JN, Weller SG. 2001. The population biology of invasive species. Annu Rev Ecol Syst 32: 305–332.

Sax DF, Gaines SD, Brown JH. 2002. Species invasions exceed extinctions on islands worldwide: a comparative study of plants and birds. Am Nat 160: 766-783.

Simberloff D, Martin JL, Genovesi P, Maris V, Wardle DA, Aronson J, Courchamp F, Galil B, García-Berthou E, Pascal M, Pyšek P, Sousa R, Tabacchi E, Vilà M. 2013. Impacts of biological invasions: what's what and the way forward. Trends Ecol Evol 28: 58–66.

Simberloff D, Von Holle B. 1999. Positive interactions of nonindigenous species: invasional meltdown?. Biol Invasions 1: 21–32.

Spuhler DR, Harrington J. 1997. Characteristics of exotic pest plants. In: *Proceedings Fifteenth North American Prairie Conference* (Warwick C, ed). The Natural Areas Association, Bend, OR, pp 228-230.

Webster CR, Jenkins MA, Jose S. 2006. Woody invaders and the challenges they pose to forest ecosystems in the Eastern United States. J For104: 366–374.

Whittaker RJ, Triantis KA, Ladle RJ. 2008. A general dynamic theory of oceanic island biogeography. J Biogeogr 35: 977-994.