Changes of the Coastal Sand Dune Vegetation after the Construction of an Embankment in Anmado

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ABSTRACT : This study examined the coastal sand dune vegetation before and after the construction of an embankment on Anmado Island in order to compare vegetation in relation to the development of islands. A total of 24 species distributed on the sand dunes. 18 species were found to be in common before and after the construction of the embankment, which included *Vitex rotundifolia, Imperata cylindrica* var. *koenigii, Zoysia sinica*, etc. The species which were not found in this survey included *Rumex japonicus, Setaria viridis, Portulaca oleracea, Artemisia japonica, Poiygonum aviculare*, etc, and new species included *Arena fatua, Carex boottiana, Lycium chinense, Leonurus sibiricus, Torilis japonica, Solanum carolinense*, etc. The washing away of sand brought about the changes in habitat and the increase in naturalized plants, which included *Oenothera odorata, Lepidium apetalum, Bidens bipinnata, Erigeron canadensis, Datura stramonium, Xanthium strumarium, Arena fatua, Solanum carolinense* etc. In addition, the disturbance to this habitat led to the changes in vegetation. The main plant communities in the surveyed site were classified as *Vitex rotundifolia-Imperata cylindrica* var. *koenigii* community, *Zoysia sinica-Calystegia soldanella* community and *Messerschmidia sibirica* community. The sand dune vegetation on Anmado Island changed with regard to the community and the composition of species after the construction of the embankment, due to the sand being severely eroded. While *Vitex rotundifolia* community and *Commelina communis* community were found before the construction of the embankment, they were replaced by *Vitex rotundifolia-Imperata cylindrica* var. *koenigii* community, *Zoysia sinica-Calystegia soldanella* community and *Messerschmidia sibirica* community, after the construction of the embankment.

Key words : Anmado Island, Coastal sand dune, Embankment, Vegetation

INTRODUCTION

A coastal sand dune is an ecologic ecotone which shifts over from a coastal ecosystem to an inland ecosystem. This area possesses a rich variety of organisms, but many species can be lost rapidly because of disturbances to this habitat, such as land reclamation, filling-up, or an increase in tourists, and thus the biota could change remarkably (Van der Maarel 1971, Wilson 1988, Psuty 1988). Such coastal sand dune communities are home to natural vegetation which possess nature resources from antiquity which are rapidly disappearing due to man's frequent and continuous interferences and incursions. Although the studies on coastal sand dune vegetation mainly consist of species classification and community ecology(Lee and Chon 1984, Kim and Ihm 1988, Kim and Song 1983, Ihm 1989, Jung and Kim 1998, Jung 2000), there has been little focus on the changes to coastal sand dune vegetation caused by the construction of coastal embankments.

The habitat of coastal sand dune plants varies due to several factors, which include the invasion of seawater, the water content and recharge of soil, an inflow of fresh water, submergence, evaporation, mud walls, etc. In particular, since sand sediments are deposited on the coast from the waves of an ocean current, a coastal current, and the tide erode, transport, and deposit, artificial structures like an embankment or a sea dike have a direct effect on the movement and distribution of coastal sediments(Pye 1982). With such sedimentary layers on the coast, a variety of coastal halophytes and communities are distributed in accordance with the habitat.

The purpose of this study was to understand the changes of vegetation environments with regard to the development of islands by comparing the distribution and features of halophytes, which are developed in coastal sand dune areas, both before(1989 year) and after(2002 year) the construction of an embankment on Anmado Island.

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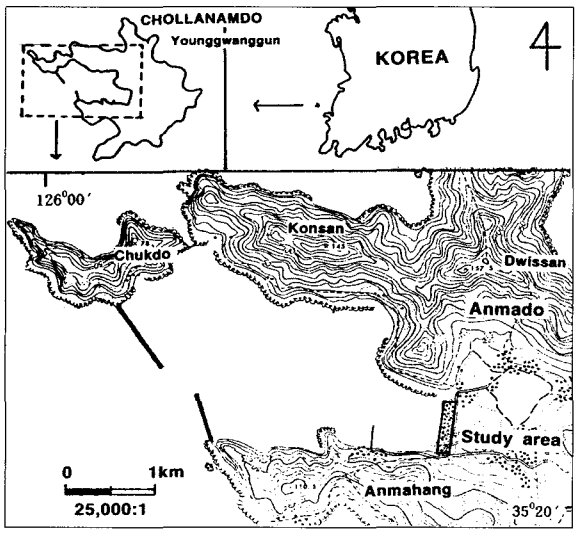
STUDY AREA AND METHODS

The site surveyed is an administrative district located in Nakwol-myeon, Yeonggawang-gun, Jeollanam-do (126°00-02′ E, 35°19-21′ N) and covers 37 square km of land with 340ha of forest land, 59ha of fields, and 13ha of rice paddies. It has 28km of coastline. Nakwol-myeon has gradually decreased in population from 3,857 people of 688 households in 1979, to 2,319 of 493 in 1988, and 1,015 of 429 in 2001 (Yeonggwang-gun 2001).

Anmado Island, which is a cardinal point of the western part of Korea, consists of Wolchon-ri, Yeongwol-ri, Singi-ri, and Jukdo-ri, in which Nakwol-myeon administrative office is located in the center of, and several other islands, such as Hoengdo, Odo, Soseok-mando, Daeseokmando, etc. are located in the vicinity. The topography of the island is gentle with a hill(177m) to the back of the branch office to the east, highlands (157.5m) to the north, and Makbong (167.9m) to the south. A black pine community has developed across the entire island, but disturbances and the appearance of artificial vegetation, the restoration of natural vegetation is occurring. Anma Harbor, located on Wolchon-ri, has a horseshoe shape which is open to the west. Sand accumulates on the inside of the harbor, but the shape of the sand dunes has changed continuously, owing to the ocean current. After the construction of an embankment was completed on Anmado, sediments moved or changed in accordance with the altering coastal current or the weakening of waves. Furthermore, it causes the changes to the variety of coastal plants and animals to the interior of the embankment. Recently, after the construction of the embankment, sand sedimentary layers on the coast have decreased, while sandbar layers have increased. (Fig. 1)



This study was conducted at Anmado Island from July 2 to 25, 2002. The naturalized flora in the surveyed site was limited to above vascular plants and defined through literature published by Chung (1965), Lee (1990), Makino (1979), Ohwi (1984), and Park (1995). Sampling sites were installed at the survey area and the species within the quadrat and dominance and sociability of each composition species were recorded using the Braun-Blanquet (1964) phytosociological method. Examined data of vegetation determined the unit, based on table operation (Ellenberg 1956) and a vegetation table was made.

RESULTS AND DISCUSSION

Flora of the sand dune

A total of 24 species grew on the sand dune area in Anmado Island(Table 1). 18 species were in common in comparison to the flora of the sand dune before the construction of the embankment in 1989 (Kim and Yang, 1989) according to survey data in 2002, which included *Vitex rotundifolia, Imperata cylindrica* var. *koenigii, Zoysia sinica, Calystegia soldanella, Messerschmidia sibirica, Carex pumila, Artemisia princeps* var. *orientals, Chenopodium glaucum, Oenothera odorata, Lepidium apetalum, Salsola komarovi, Elymus mollis, Bidens bipinnata, Artemisia capillaris, Erigeron canadensis, Datura stramonium, Digitaria sanguinalis, Xanthium strumarium,* etc. The species, which were surveyed in 1989 year, but did not appear in this survey, included *Rumex japonicus, Setaria viridis, Portulaca oleracea, Artemisia japonica, Poiygonum aviculare*, etc. New species appearing in this survey included *Arena fatua, Carex boottiana, Lycium chinense, Leonurus sibiricus, Torilis japonica, Solanum carolinense*, etc. Lee and You (1989) reported 10 families and 19 species of naturalized plants, whereas Kim *et. al.* (2002) found 16 families and 43 species. The plants noted on sand dunes have increased in the number of species and their distribution, which included *Oenothera odorata, Lepidium apetalum, Bidens bipinnata, Erigeron canadensis, Datura stramonium, Xanthium strumarium, Arena fatua, Solanum carolinense*, etc. Since the vegetation of naturalized plants varies according to disturbances to their habitat, the sand being washed led to this change, resulting in an increase in the variety of flora.

Main plant communities

The most common vegetation surveyed on this site was classified as *Vitex rotundifolia-Imperata cylindrica* var. *koenigii* community which is the coastal sand dune shurb forest, and *Zoysia sinica-Calystegia soldanella* community and *Messerschmidia sibirica* community which are sand dune herb community. The communities were classified according to dominant species and different species

Table 1. Changes of the coastal sand dune flora before (1989) and after (2002) the construction of embankment in Anmado

Common sp.	Appearance sp.(coverage)	Disappearance sp.(coverage)
Vitex rotundifolia		
Imperata cylindrica var. *koenigii*		
Zoysia sinica		
Calystegia soldanella		
Messerschmidia sibirica		
Carex pumila		
Artemisia princeps var. *orientals*	*Arena fatua* (+)	*Rumex japonicus* (+)
Chenopodium glaucum	*Carex boottiana* (1)	*Setaria viridis* (+)
Oenothera odorata	*Lycium chinense* (1)	*Portulaca oleracea* (+)
Lepidium apetalum	*Leonurus sibiricus* (1)	*Artemisia japonica* (+)
Salsola komarovi	*Torilis japonica* (+)	*Poiygonum aviculare* (+)
Elymus mollis	*Solanum carolinense* (1)	
Bidens bipinnata		
Artemisia capillaris		
Erigeron canadensis		
Datura stramonium		
Digitaria sanguinalis		
Xanthium strumarium		

Table 2. Floristic composition table of sand dune vegetation on Anmado (Kim and Yang 1989)
A: *Salsola komarovi* community B: *Vitex roundifolia* community

Community type	A					B				
Serial number	1	2	3	4	5	6	7	8	9	10
Number of species	9	9	6	5	7	8	8	10	6	5
Differential species of community										
Salsola komarovi	4.4	5.5	4.4	5.5	5.5	2.2	+	1.1		
Digitaria sanguinalis	1.1		+	+	1.1	+	+			
Chenopodium album var. *centrorubrum*	+	+	+	+	+			+		
Xanthium strumarium	+	+			+			+		
Datura stramonium	+	1.1			+					
Vitex roundifolia						5.5	5.5	5.5	5.5	5.5
Imperata cylindrica var. *koenigii*						1.1	1.1		+	3.3
Carex pumila	+					+	1.1		2.2	1.1
Companions										
Calystegia soldanella			+	2.2		1.1	1.1			+
Messerschmidia sibirica	+				+			+		
Zoysia sinica	+		2.2					2.2		1.1
Lepidium apetalum	+			+			+			
Artemisia princeps var. *orientals*		+						+		
Rumex japonicus		+						+		
Setaria viridis		+						+		
Elymus mollis			2.2					+		
Artemisia capillaris						+			+	
Oenothera odorata							1.1		1.1	
Bidens bipinnata		+								
Portulaca oleracea		+								
Artemisia japonica					+					
Polygonum aviculare						+				
Erigeron canadensis									+	

of each community by physiognomy rather than by association, using the order of presence.

Vitex rotundifolia-Imperata cylindrica var. *koenigii* community

Vitex rotundifolia-Imperata cylindrica var. *koenigii* community is distinguished by *Vitex rotundifolia and Imperata cylindrica* var. *koenigii*, and could be found around the sands at Singi-ri on Anmado Island. The composition of this community is shown in Table 2. The height of the herbaceous layer was 0.5~0.8m and its field coverage was 90~100%. The number of species appearing in the community was 4~7, which included *Carex pumila, Artemisia princeps* var. *orientals*, and *Oenothera odorata* as its main species. This community is evergreen shrub where a few rhizomes grow straight or obliquely, buried by winds in semistability sand dune (Kim and Ihm, 1988) and developed as typical halophyte communities for coastal sand dunes in Korea. *Vitex rotundifolia* community is differentiated in accordance with *Vitex rotundifolia*, which is a diagnostic species of a high unit(class, order, and alliance), and *Carex kobomugi* and *Lathyrus japonica*, which are different species. These three species showed a high level of distribution and dominance, contributing greatly to the formation and development of the community (Jung and Kim 1998).

Zoysia sinica-Calystegia soldanella community

Zoysia sinica-Calystegia soldanella community is distinguished by *Zoysia sinica* and *Calystegia soldanella* and could be found around the sands at Singi-ri in Anmado Island. The composition of this community is shown in Table 3. The height of its herbaceous

Table 3. Vegetation tables of the coastal sand dune in Anmado (2002 year)
A: *Vitex rotundifolia-Imperata cylindrica* var. *koenigii* community
B: *Zoysia sinica-Calystegia soldanella* community
C: *Messerschmidia sibirica* community

Community type	A					B					C	
Serial number	1	2	3	4	5	6	7	8	9	10	11	12
Quadrt size(㎡)	2	2	2	2	2	2	2	2	1	1	1	1
Height of herb layer(m)	0.7	0.5	0.7	0.5	0.8	0.1	0.1	0.1	0.1	0.2	0.3	0.2
Coverage of herb layer(%)	100	100	90	100	90	90	80	80	70	90	70	60
Number of species	6	4	7	7	5	5	5	3	3	5	4	5
Differential species of community												
Vitex rotundifolia	5.5	5.5	4.4	5.5	5.5							
Imperata cylindrica var. *koenigii*		3.3	1.1	1.1	2.2							
Zoysia sinica			1.1			4.4	3.3	3.3	3.3	2.2		1.1
Calystegia soldanella	1.1					3.3	3.3	2.2	3.3	4.4	1.1	2.2
Messerschmidia sibirica											3.3	3.3
Companions												
Carex pumila	1.1	1.1		1.1		1.1			1.1			
Artemisia princeps var. *orientals*	1.1		2.2		1.1							
Chenopodium glaucum	1.1						1.1			1.1		
Oenothera odorata		1.1		1.1								1.1
Lepidium apetalum						1.1		1.1		+		
Commelina communis							1.1			1.1	1.1	
Datura stramonium					1.1						+	
Elymus mollis	1.1											
Bidens bipinnata		+										
Arena fatua			+									
Artemisia capillaris			1.1									
Erigeron canadensis			+									
Carex boottiana				1.1								
Lycium chinense				1.1								
Leonurus sibiricus				1.1								
Torilis japonica					+							
Solanum carolinense						1.1						
Digitaria sanguinalis							+					
Xanthium strumarium												1.1

layer was 0.1~0.2m and its field coverage was 70~90%. The number of species appearing in the community was 3~5, which included *Carex pumila, Chenopodium glaucum, Lepidium apetalum*, and *Commelina communis* as its dominant species. This community was developed on the site where sand accumulate on the coastal salt marshes. It was classified as sand dune vegetation, in accordance to the area, or appears in the salt marsh perennial plant community, in due consideration to the environment of the surveyed site and the composition of the species (Kim and Ihm 1988).

Messerschmidia sibirica community

Messerschmidia sibirica community is distinguished by *Messerschmidia sibirica*, and could be found on the coast with a small community at Singi-ri on Anmado Island. The composition of this community is shown in Table 2. The height of its herbaceous layer was 0.2~0.3m and its field coverage was 60~70%. The number of species appearing in the community was 4~5, which included *Calystegia soldanella, Oenothera odorata*, and *Commelina communis* as the main and dominant species. It is expected that continuous sand erosion will change the composition of the species. This community grew obliquely in semistability sand dune on the coast with line-shaped rhizomes (Kim and Ihm 1988).

Changes of communities

The changes of community and dominant companions were shown on Table 4.

Vitex rotundifolia community and *Commelina communis* community could be found on the sand dune site before the construction of the embankment (1987~1991 year), but they were replaced by *Vitex rotundifolia-Imperata cylindrica* var. *koenigii* community, *Zoysia sinica-Calystegia soldanella* community, and *Messerschmidia sibirica* community in 2002. *Vitex rotundifolia- Imperata cylindrica* var. *koenigii* community decreased from 7.4 to 5.6 in the average number of species, and *Carex pumila*, which was noted as having a high presence, was Class IV, and *Commelina communis* (coverage 3) and *Digitaria sanguinalis* (coverage 2), which were found before the construction of the embankment, did not appear in this survey. *Calystegia soldanella* decreased from III to I in distribution; *Artemisia capillaris*, from II to I; and *Zoysia sinica*, II to I. *Artemisia princeps* var. *orientals* had coverage + and a relatively low presence (I) in the community before the construction, but this survey showed that its distribution, coverage, and presence increased to 1~2 and III, respectively. *Commelina communis* community showed distribution 4~5 and 5~9 in its composition of species in 1989, but this survey found that it did not develop as a community, and instead appeared as one of the component species of *Zoysia sinica-Calystegia soldanella* community (coverage 1, presence II). The average number of species of *Zoysia sinica-Calystegia soldanella* community was 4.2, which included *Carex pumila, Chenopodium glaucum*, and *Commelina communis* as its main component species. While *Zoysia sinica* and *Calystegia soldanella* were composed of *Commelina communis* community and *Vitex rotundifolia* community (coverage +-2, presence II-III) respectively before the construction of the embankment, they changed into *Zoysia sinica-Calystegia soldanella* community after the sand was washed away. The average number of species of *Messerschmidia sibirica* community was 4.5, which included *Calystegia soldanella* as its main component. It is believed that since the deposits at the sand dune site, which were present before the construction of the embankment, were washed away, *Commelina communis* community declined and salt marsh perennial plant communities appeared instead. With disturbance to habitat, land plants appeared, which included *Arena fatua, Lycium chinense, Leonurus sibiricus, Torilis japonica, Solanum carolinense, Digitaria sanguinalis*, etc. Therefore if sand continues to be washed away at this site, a coastal gravel layer will appear and finally the succession of land plants is expected in accordance with the changes to soil.

Table 4. Changes of the coastal sand dune communities and dominant companions in Anmado

	1989 year	2002 year
Community	*Vitex rotundifolia*	*Vitex rotundifolia* - *Imperata cylindrica* var. *koenigii*
Dominant companions	*Imperata cylindrica* var. *koenigii* *Zoysia sinica* *Oenothera odorata* *Carex pumila* *Calystegia soldanella*	*Carex pumila* *Artemisia princeps* var. *orientals* *Oenothera odorata*
Community	*Salsola komarovi*	*Zoysia sinica* - *Calystegia soldanella* *Messerschmidia sibirica*
Dominant companions	*Digitaria sanguinalis* *Chenopodium album* var. *centrorubrum* *Xanthium strumarium* *Datura stramonium* *Calystegia soldanella* *Zoysia sinica* *Messerschmidia sibirica*	*Carex pumila* *Chenopodium glaucum* *Lepidium apetalum* *Salsola komarovi*

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