

## Coastal Dune Vegetation of South Korea

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**ABSTRACT:** We used the Braun-Blanquet method to study coastal dune vegetation of South Korea. Coastal vegetation was monitored in thirty sites from April 2004 to September 2005. Seventeen plant communities were classified into five groups as follows: A. Two associations of herbaceous sand dune plants in *Salsolietea komarovii* Ohba, Miyawaki et Tx. 1973 (*Calystegia soldanella* community, *Lathyrus japonicus*-*Calystegia soldanella* community), B. Twelve associations of herbaceous perennial sand dune plants in *Glehnietea littoralis* Ohba, Miyawaki et Tx. 1973 (*Carex pumila* community, *Elymus mollis* community, *Vitex rotundifolia*-*Elymus mollis* community, *Ixeris repens* community, *Elymus mollis*-*Ixeris repens* community, *Lathyrus japonicus* community, *Messerschmidia sibirica* community, *Glehnia littoralis* community, *Carex kobomugi* community, *Calystegia soldanella*-*Carex kobomugi* community, *Ishaemum antheophoroides* community, *Zoysia macrostachya* community), C. One association of shrubby perennial sand dune plant in *Viticetia rotundifoliae* Ohba, Miyawaki et Tx. 1973 (*Vitex rotundifolia* community), D. One association of shrubby perennial sand dune plant in *Rosetea multiflorae* Ohba, Miyawaki et Tx. 1973 (*Rosa rugosa* community), E. The naturalized community (*Diodia teres* community).

**Key words:** Coastal vegetation, Herbaceous plant, Phytosociology, Sand dune, Shrubby plant

### INTRODUCTION

Environment factors such as salinity, soil moisture content, soil texture, salt spray and evapotranspiration are the primary environmental influences that determine plant community distribution in coastal dunes (Kach and Hirose 1979, Kim and Ihm 1988, Ishikawa et al. 1995). Ihm and Lee (1998) reported that edaphic factors related to hydrology and salinity affected the distribution and abundance of coastal plants within and across coastal dunes.

In South Korea, Kim (1971) and Kim and Ihm (1988) reported halophyte communities in coastal wetlands. Park (1967) reported dispersion structure of dune plant in Jeju island. Lee et al. (1982) and Lee and Chon (1983, 1984) reported the sand dune vegetation of the western, southern and eastern coasts. Jung and Kim (1998), Ihm et al. (1999) and Lee and Kim (2000) reported coastal sand dune vegetation near Pusan city and in the eastern coast. Lee et al. (2000) studied vegetation distribution and standing biomass at the coastal sand dune of Kohung. Ihm and Lee (1998) and Ihm et al. (2006) studied soil factors in the plant communities of coastal wetlands on the southwestern coast. Kim (2005) reported invasive plants on disturbed sand dunes.

The coastal dunes of South Korea were dominated by the five shrubby communities of *Linario-Viticetum rotundifoliae*, *Imperata cylindrica*-*Viticetum rotundifoliae*, *Roso-Viticetum rotundifoliae*, *Vi-*

*tex rotundifolia* community and *Rosa rugosa* community, and by the sixteen herbaceous perennial communities of *Carex pumila* community, *Carex kobomugi* community, *Crinum asiaticum* var. *japonicum* community, *Elymo-Caricetum kobomugi*, *Elymus mollis* community, *Imperata cylindrica* var. *koenigii* community, *Ischaemum antheophoroides* community, *Wedelio-Caricetum kobomugi*, *Wedelio-Ischaemetum antheophoroidis*, *Wedelio prostratae-Zoysietum macrostachyae*, *Ixeris repens* community, *Lysimachia mauritiana* community, *Salsola komarovi* community, *Opuntia ficus-indica* var. *saboten* community, *Tertragonia tetragonoides* community and *Crepidiastrum lanceolatum* community (Kim and Ihm 1988, Kim 1994, Jung and Kim 1998, Ihm et al. 1999, Jung 2000). A part of the communities occur extensively in the coastal dunes of northeast Asia (Ohba et al. 1973, Lee et al. 1982, Miyawaki et al. 1983, Kim and Ihm 1988, Jung and Kim 1998). The objective of the current study is to clarify the synecological and syntaxonomical characteristics of coastal dune vegetation on the western, southern and eastern coasts of South Korea.

### MATERIALS AND METHODS

#### Study Area

Three coastal areas of South Korea were investigated: 1) the eastern coast at Goseong, Yangyang, Gangneung, Donghae, Samcheok, Uljin, Yeongduk and Pohang; 2) the southern coast at Ye-

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su, Goheung, Bukjeju and Haenam; and 3) the western coast at Jindo, Muan, Gochang, Buan, Gunsan, Seocheon and Taean (Fig. 1 and Table 1). Coastal vegetation in these regions was monitored from April 2004 to September 2005.

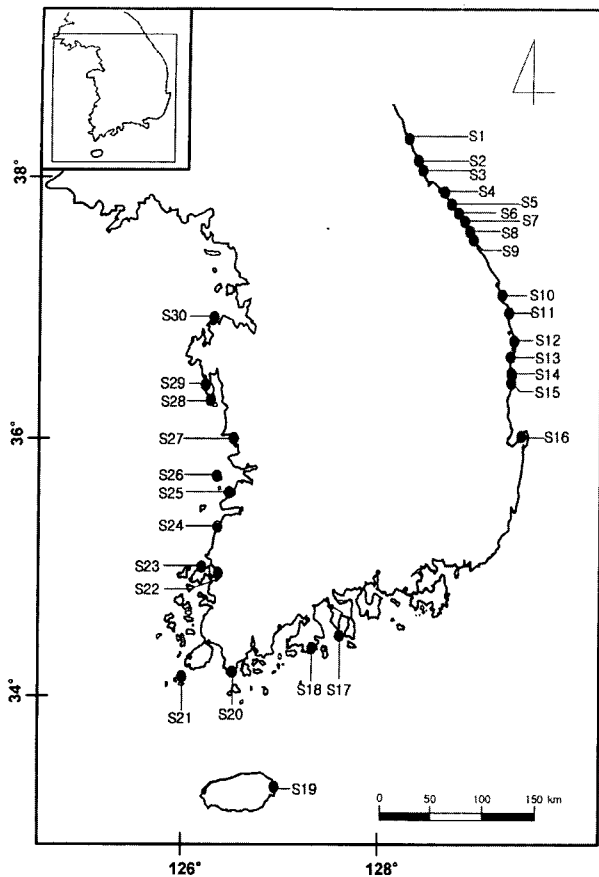


Fig. 1. Map showing the study areas.

Table 1. Local names of the surveyed areas

Site no.	Local name	Latitude	Longitude
S1	Gangwon-do Goseong-gun Hyeonnae-myeon Chodo-ri Hwajinpo	38°29'01"	128°26'24"
S2	Gangwon-do Goseong-gun Ganseong-eup Gajin-ri	38°21'33"	128°30'33"
S3	Gangwon-do Goseong-gun Ganseong-eup Gonghyeonjin-ri	38°20'53"	128°30'48"
S4	Gangwon-do Yangyang-gun Sonyang-myeon Dongho-ri	38°03'08"	128°41'23"
S5	Gangwon-do Yangyang-gun Hyeonbuk-myeon Jangyo-ri	37°59'24"	128°44'38"
S6	Gangwon-do Yangyang-gun Hyeonnam-myeon Bukbun-ri	37°59'35"	128°45'22"

Table 1. Continued

Site no.	Local name	Latitude	Longitude
S7	Gangwon-do Yangyang-gun Hyeonnam-myeon Gwangjin-ri	37°56'38"	128°46'40"
S8	Gangwon-do Yangyang-gun Hyeonnam-myeon Jigyeong-ri	37°55'28"	128°48'10"
S9	Gangwon-do Gangneung-si Jumunjin-eub Jumun-ri	37°54'06"	128°49'32"
S10	Gangwon-do Donghae-si Mangsang-dong Nobong	37°34'47"	129°06'30"
S11	Gangwon-do Samcheok-si Geundeok-myeon Maewon-ri	37°19'30"	129°16'44"
S12	Gyeosangbuk-do Uljin-gun Wonnam-myeon Mangyang-ri	36°51'32"	129°25'24"
S13	Gyeosangbuk-do Uljin-gun Onjeong-myeon Wolsong-ri	36°44'08"	129°28'33"
S14	Gyeosangbuk-do Yeongduk-gun Byeong-gok-myeon Backseok-ri	36°38'07"	129°25'09"
S15	Gyeosangbuk-do Yeongduk-gun Byeong-gok-myeon Byeonggok-ri	36°34'02"	129°25'20"
S16	Gyeosangbuk-do Pohang-si Donghae-myeon Honghwan-ri	36°01'50"	129°30'15"
S17	Jellanam-do Yeosu-si Hwajeong-myeon Nangdo-ri	34°36'15"	127°32'34"
S18	Jellanam-do Goheung-gun Doha-myeon Deokjung-ri	34°29'16"	127°20'19"
S19	Jeju-do Bukjeju-gun Seongsan-eub Sinyang-ri	33°20'46"	127°11'04"
S20	Jellanam-do Haenam-gun Songji-myeon Tongho-ri Sagumi	34°19'02"	126°34'52"
S21	Jellanam-do Jindo-gun Jodo-myeon Kwanmaedo-ri	34°13'57"	126°02'38"
S22	Jellanam-do Muan-gun Haejae-myeon Songseok-ri	35°08'57"	126°20'25"
S23	Jellanam-do Muan-gun Hyeongyeong-myeon Haeun-ri	35°03'27"	126°26'35"
S24	Jellabuk-do Gochang-gun Sangha-myeon Yongjeong-ri	35°01'50"	126°27'30"
S25	Jellabuk-do Buan-gun Byeosan-myeon Mapo-ri	35°39'12"	126°30'21"
S26	Jellabuk-do Gunsan-si Okdo-myeon Seonyudo-ri	35°49'01"	126°25'06"
S27	Chungcheongnam-do Seocheon-gun Biin-myeon Dasa-ri	36°07'10"	126°36'32"
S28	Chungcheongnam-do Taean-gun An-myeon-eub Jungjang-ri	36°28'36"	126°20'42"
S29	Chungcheongnam-do Taean-gun An-myeon-eub Gijipo	36°04'06"	126°19'23"
S30	Chungcheongnam-do Taean-gun Wonbuk-myeon Banggal-ri Hakampo	36°52'35"	126°12'00"

## Vegetation Analysis

Sample relevé method was performed using the phytosociological approach of Braun-Blanquet (1964), and the dominance and sociability of all vascular plant species were included. Plant communities were determined by tabular comparison (Mueller-Dombois and Ellenberg 1974, Kim and Ihm 1988). To distinguish coastal dune vegetation units, the classified communities were compared with those of other studies (Ohba et al. 1973, Miyawaki et al. 1983, Kim and Ihm 1988, Jung and Kim 1998). Taxonomic nomenclature followed that of Lee (2003); names of syntaxa based on the codes for phytosociological nomenclature (Weber et al. 2000).

## RESULTS AND DISCUSSION

Following the Braun-Blanquet methodology, we placed all associations into the following classes:

### Class Salsolitea komarovii

The two associations in this class are *Calystegia soldanella* community and *Lathyrus japonicus-Calystegia soldanella* community (Table 2 and 3).

#### *Calystegia soldanella* community

This community occurred in nine sites of S2 (Gajin-ri), S3 (Gonghyeonjin-ri), S5 (Jangyo-ri), S10 (Nobong), S11 (Maewon-ri), S12 (Mangyang-ri), S13 (Wolsong-ri), S16 (Honghwan-ri) and S22 (Songseok-ri) and was studied during the period of active growth (June~July). Total community area was 2.26 km<sup>2</sup>. This community had mean height of 48 cm and mean coverage of 69% in nine sites. Companion species were *Bidens bipinnata*, *Linaria japonica*, *Oenothera odorata*, *Digitaria sanguinalis* and *Carex laticeps*. This community is herbaceous perennial plant community and occur in low dunes exposed by aerial dispersion of salts. This also plays an important role in the growth and establishment of dunes. If the plant growth continues rapidly enough to prevent sand coverage, the community serves the double purpose of holding the sand already deposited and aiding in further deposition of soil. This is in accordance with the community distribution in the eastern, western and southern coasts of South Korea, as proposed by Lee et al. (1982), Lee and Chon (1983, 1984), Kim (1994) and Lee and Kim (2000).

#### *Lathyrus japonicus-Calystegia soldanella* community

This community occurred in S11 (Maewon-ri) and was studied during the period of active growth (June~July). This community had mean height of 25 cm and mean coverage of 60%. This community is very effective to increase sand dune stability and occur in stable coastal dunes.

### Class Glehnietea littoralis

The communities in class *Glehnietea littoralis* (Table 2 and 3) were characterized by herbaceous perennial sand dune plants that stabilized sand dunes through their production of rhizomes. Each community comprised three to five species, in accordance with the schemes for northeast Asian sand dune vegetation that was proposed by Ohba et al. (1973), Miyawaki et al. (1983), Kim and Ihm (1988), Jung and Kim (1998) and Ihm et al. (2001). The twelve associations belonging to this class are *Carex pumila* community, *Elymus mollis* community, *Vitex rotundifolia-Elymus mollis* community, *Ixeris repens* community, *Elymus mollis-Ixeris repens* community, *Lathyrus japonicus* community, *Messerschmidia sibirica* community, *Glehnia littoralis* community, *Carex kobomugi* community, *Calystegia soldanella-Carex kobomugi* community, *Ishaeum antheboroides* community and *Zoysia macrostachya* community.

#### *Carex pumila* community

This community occurred in seven sites of S1 (Hwajinpo), S2 (Gajin-ri), S3 (Gonghyeonjin-ri), S16 (Honghwan-ri), S17 (Nangdo-ri), S20 (Sagumi), and S26 (Seonyudo-ri). Total community area was 4.62 km<sup>2</sup>. This community had mean height of 16 cm and mean coverage of 44%. Companion species were *Achyranthes japonica*, *Linaria japonica*, *Oenothera odorata*, *Chenopodium glaucum*, *Carex laticeps* and *Asparagus schoberioides*. This community is herbaceous perennial plant community and occur in semi-stable, human-disturbed or stable dunes. The rhizomes of *Carex pumila* help to stabilize coastal dunes (Kim and Ihm 1988, Kim 1994, Lee and Kim 2000).

#### *Elymus mollis* community

This community occurred in twenty five sites of S1 (Hwajinpo), S2 (Gajin-ri), S3 (Gonghyeonjin-ri), S4 (Dongho-ri), S5 (Jangyo-ri), S6 (Bukbun-ri), S7 (Gwangjin-ri), S8 (Jigyeong-ri), S9 (Jumun-ri), S10 (Nobong), S11 (Maewon-ri), S12 (Mangyang-ri), S13 (Wolsong-ri), S14 (Baekseok-ri), S15 (Byeonggok-ri), S16 (Honghwan-ri), S20 (Sagumi), S22 (Songseok-ri), S24 (Yongjeong-ri), S25 (Mapo-ri), S26 (Seonyudo-ri), S27 (Dasa-ri), S28 (Jungjang-ri), S29 (Gijipo) and S30 (Hakampo). Total community area was 155.27 km<sup>2</sup>. This community had mean height of 69 cm and mean coverage of 85%. Companion species were *Cnidium japonicum*, *Aster hispidus*, *Rumex crispus*, *Metaplexis japonica*, *Linaria japonica*, *Oenothera odorata* and *Plantago depressa*. This community is typical herbaceous perennial plant community in coastal dunes (Jung and Kim 1998, Kim and Ihm 1988, Min 2004). This occur in cold temperate zone and between high water line and shrubby communities in coastal dunes.

*Vitex rotundifolia-Elymus mollis* community

This community occurred in S22 (Songseok-ri). This community had mean height of 34 cm and mean coverage of 70%. This is very effective to increase sand dune stability and occur in unstable coastal dunes near highest water lines.

(Jigyeong-ri), S9 (Jumun-ri) and S26 (Seonyudo-ri). Total community area was 0.65 km<sup>2</sup>. This community had mean height of 6 cm and mean coverage of 32%. Companion species were *Metaplexis japonica*. This is herbaceous perennial plant community and occur in unstable coastal dunes and human-disturbed dunes (Kim and Ihm 1988, Lee and Kim 2000).

*Ixeris repens* community

This community occurred in four sites of S4 (Dongho-ri), S8

*Elymus mollis-Ixeris repens* community

Table 2. Synthesis table of coastal dune plants of South Korea.

A. *Salsotelea komarovii*, B. *Glehnietea littoralis*, C. *Viticetea rotundifoliae*, D. *Rosetea multiflorae*, E. The naturalized community; 1. *Calystegia soldanella* community, 2. *Lathyrus japonicus-Calystegia soldanella* community, 3. *Carex pumila* community, 4. *Elymus mollis* community, 5. *Vitex rotundifolia-Elymus mollis* community, 6. *Ixeris repens* community, 7. *Elymus mollis-Ixeris repens* community, 8. *Lathyrus japonicus* community, 9. *Messerschmidia sibirica* community, 10. *Glehnia littoralis* community, 11. *Carex kobomugi* community, 12. *Calystegia soldanella-Carex kobomugi* community, 13. *Ishaemum antheophoroides* community, 14. *Zoysia macrostachya* community, 15. *Vitex rotundifolia* community, 16. *Rosa rugosa* community, 17. *Diodia teres* community.

Community No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Class classification	A	A	B	B	B	B	B	B	B	B	B	B	B	B	C	D	E
Average height of species (cm)	48	25	16	69	34	6	50	16	28	18	21	9	49	35	51	70	34
Average coverage of species (%)	69	60	44	85	70	32	70	38	38	35	88	70	58	75	83	43	60
Quadrat size (m <sup>2</sup> )	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Number of relevé	28	4	22	98	4	14	10	12	10	6	80	6	16	14	62	10	4

Character species of association

<i>Calystegia soldanella</i>	V	I	I	II	I	.	.	I	I	I	I	I	.	I	I	.	.
<i>Lathyrus japonicus-Calystegia soldanella</i>	.	III	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Carex pumila</i>	I	.	III	I	.	.	.	I	I	I	I	.	.	I	I	.	.
<i>Elymus mollis</i>	I	.	.	V	II	I	.	.	.	.	II	.	.	.	I	.	.
<i>Vitex rotundifolia-Elymus mollis</i>	.	.	.	I	IV	.	.	.	.	.	.	.	.	.	.	.	.
<i>Ixeris repens</i>	.	.	I	II	.	II	I	.	.	.	I	I	I	I	I	.	.
<i>Elymus mollis-Ixeris repens</i>	.	.	.	.	.	.	IV	.	.	.	.	.	.	.	.	.	.
<i>Lathyrus japonicus</i>	I	.	I	II	I	.	I	II	.	I	I	.	I	I	I	.	.
<i>Messerschmidia sibirica</i>	.	I	.	I	.	.	.	I	II	.	I	.	.	.	I	.	.
<i>Glehnia littoralis</i>	I	.	.	II	I	I	.	.	.	II	I	.	.	I	I	.	.
<i>Carex kobomugi</i>	.	.	.	II	.	.	.	.	I	.	V	.	.	I	I	.	.
<i>Calystegia soldanella-Carex kobomugi</i>	.	.	.	.	.	.	.	.	.	.	.	IV	.	.	.	.	.
<i>Ishaemum antheophoroides</i>	.	.	.	I	.	.	.	.	.	.	.	.	III	.	.	.	.
<i>Zoysia macrostachya</i>	.	.	.	I	I	.	I	.	.	.	I	I	.	IV	.	.	.
<i>Vitex rotundifolia</i>	.	.	.	I	I	.	II	.	.	.	.	.	.	.	V	.	.
<i>Rosa rugosa</i>	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	III	.
<i>Diodia teres</i>	.	I	.	.	.	I	.	.	.	.	.	.	.	.	.	.	III

Character and differential species of alliance and order

<i>Carex pumila</i>	I	.	.	I	.	.	.	I	I	I	I	.	.	I	I	.	.
<i>Lathyrus japonicus</i>	I	.	I	II	I	.	I	.	.	I	I	.	I	I	I	.	.

Table 2. Continued

Community No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Class classification	A	A	B	B	B	B	B	B	B	B	B	B	B	B	C	D	E
Average height of species (cm)	48	25	16	69	34	6	50	16	28	18	21	9	49	35	51	70	34
Average coverage of species (%)	69	60	44	85	70	32	70	38	38	35	88	70	58	75	83	43	60
Quadrat size (m <sup>2</sup> )	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Number of relevé	28	4	22	98	4	14	10	12	10	6	80	6	16	14	62	10	4
Character and differential species of class																	
<i>Calystegia soldanella</i>	·	I	I	II	I	·	·	I	I	I	I	I	·	I	I	·	·
<i>Glehnia littoralis</i>	I	·	·	II	I	I	·	·	·	·	I	·	·	I	I	·	·
Companions																	
<i>Metaplexis japonica</i>	I	·	·	I	·	I	I	I	·	·	I	·	I	·	I	·	·
<i>Linaria japonica</i>	I	·	I	I	·	·	·	·	I	·	I	·	·	·	I	·	·
<i>Oenothera odorata</i>	I	·	I	I	·	·	·	·	I	·	·	·	·	·	I	·	·
<i>Erigeron bonariensis</i>	I	I	·	I	I	·	I	·	·	·	·	·	·	·	·	·	·
<i>Polygonum bellardi</i> var. <i>effusum</i>	·	·	·	I	·	·	·	·	I	·	I	·	·	I	I	·	·
<i>Asparagus schoberioides</i>	I	·	I	·	·	·	·	·	·	·	I	·	I	·	·	·	·
<i>Cnidium japonicum</i>	·	·	·	I	·	·	·	·	I	·	I	·	I	·	·	·	·
<i>Imperata cylindrica</i> var. <i>koenigii</i>	I	·	·	·	·	·	·	·	·	·	·	I	·	·	II	I	·
<i>Lactuca indica</i> var. <i>laciniata</i>	·	I	·	·	·	·	·	I	·	·	·	·	·	I	·	I	·
<i>Plantago depressa</i>	I	·	·	I	·	·	·	·	·	·	I	·	·	·	I	·	·
<i>Carex laticeps</i>	I	·	I	·	·	·	·	·	·	·	·	·	·	·	I	·	·
<i>Ampelopsis heterophylla</i>	·	·	I	I	·	·	·	·	I	·	·	·	·	·	·	·	·
<i>Potentilla discolor</i>	·	·	·	·	·	·	·	·	I	·	·	·	·	I	·	I	·
<i>Rumex crispus</i>	·	·	·	I	·	·	·	·	·	·	·	·	·	·	I	I	·
<i>Salsola komarovii</i>	·	·	·	·	·	·	·	·	·	·	I	·	·	·	I	·	·
<i>Xanthium strumarium</i>	·	·	·	I	·	·	·	·	I	·	·	·	·	·	·	·	·
<i>Setaria viridis</i> var. <i>pachystachys</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I	I	·
<i>Avena fatua</i>	·	·	·	·	I	·	·	·	·	·	·	·	·	·	I	·	·
<i>Achyranthes japonica</i>	·	·	I	·	·	·	·	·	·	·	·	·	·	·	·	I	·
<i>Sonchus brachyotus</i>	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I	I	·
<i>Bidens bipinnata</i>	I	·	·	·	·	·	·	·	·	·	·	·	·	·	I	·	·
<i>Humulus japonicus</i>	·	·	I	·	·	·	·	·	·	·	·	·	·	·	I	·	·
<i>Pueraria thunbergiana</i>	·	·	I	·	·	·	·	·	I	·	·	·	·	·	·	·	·
<i>Artemisia capillaris</i>	·	·	·	·	·	·	·	·	·	·	I	·	·	I	·	·	·
<i>Lepidium apetalum</i>	·	·	·	·	I	·	·	·	·	·	·	·	I	·	·	·	·
<i>Aster hispidus</i>	·	·	·	I	·	·	·	·	·	·	·	·	·	·	·	I	·

Species occurred once in community No. 1. *Digitaria sanguinalis* I, 3. *Chenopodium glaucum* I, *Atriplex hastate* I, *Polygonum aviculare* I, 4. *Plantago lanceolata* I, 11. *Cuscuta chinensis* I, 15. *Vicia angustifolia* var. *segetilis* I, *Amorpha fruticosa* I, *Allium grayi* I, *Oenothera laciniata* I, *Rubia akane* I, *Cynodon dactylon* I, *Zoysia simica* I, *Oxalis corniculata* I, *Tetragonia tetragonoides* I, 16. *Solanum nigrum* I, *Scutellaria strigillosa* I, *Corispermum stauntonii* I.

This community occurred in three sites of S11 (Maewon-ri), S15 (Bukbun-ri) and S20 (Sagumi). This community had mean height of 50 cm and mean coverage of 70%. This community occur in high water lines or unstable foredunes. *Elymus mollis* is known as pioneer species in coastal dunes (Lee et al. 1982).

#### *Lathyrus japonicus* community

This community occurred in four sites of S8 (Jigyeong-ri), S12 (Mangyang-ri), S25 (Mapo-ri) and S26 (Seonyudo-ri). Total community area was 0.71 km<sup>2</sup>. This community had mean height of 16 cm and mean coverage of 38%. This community occur in stable coastal dunes and is herbaceous perennial plant community (Lee and Kim 2000).

#### *Messerschmidia sibirica* community

This community occurred in three sites of S22 (Songseok-ri), S25 (Mapo-ri) and S26 (Seonyudo-ri). Total community area was 0.64 km<sup>2</sup>. This community had mean height of 28 cm and mean coverage of 38%. This occur in unstable and dry coastal dunes and is herbaceous perennial plant community (Kim and Ihm 1988).

#### *Glehnia littoralis* community

This community occurred in two sites of S11 (Maewon-ri) and S15 (Byeonggok-ri). This community had mean height of 18 cm and mean coverage of 35%. This occur in unstable coastal dunes and is herbaceous perennial plant community. The white hairs grow dense in radical leaves and petiole and yellow roots go down deep into the soil.

#### *Carex kobomugi* community

This community occurred in twenty four sites of S1 (Hwajinpo), S2 (Gajin-ri), S3 (Gonghyeonjin-ri), S4 (Dongho-ri), S5 (Jangyo-ri), S6 (Bukbun-ri), S7 (Gwangjin-ri), S8 (Jigyeong-ri), S9 (Jumun-ri), S10 (Nobong), S11 (Maewon-ri), S12 (Mangyang-ri), S13 (Wolsong-ri), S14 (Baekseok-ri), S15 (Byeonggok-ri), S18 (Deokjung-ri), S20 (Sagumi), S21 (Kwanmaedo-ri), S25 (Mapo-ri), S26 (Seonyudo-ri), S27 (Dasa-ri), S28 (Jungjang-ri), S29 (Gijipo) and S30 (Hakampo). Total community area was 127.67 km<sup>2</sup>. This community had mean height of 21 cm and mean coverage of 88%. Companion species were *Cnidium japonicum*, *Artemisia capillaris*, *Metaplexis japonica*, *Plantago depressa*, *Linaria japonica*, *Salsola komarovii* and *Polygonum bellardi* var. *effusum*. This community occur in unstable coastal dunes and is herbaceous perennial plant community (Jung and Kim 1998, Kim and Ihm 1988). *Carex kobomugi* is known as pioneer species of South Korea (Min 2004). Its germination rate does not exceed 1 percent and it has rhizomes that serve to spread the community by vegetative reproduction (Ishikawa et al. 1998,

Min 2004). This is in accordance with the community distribution in coastal dunes of the eastern, western and southern coasts of South Korea, as proposed by Lee et al. (1982), Lee and Chon (1983, 1984), Kim and Ihm (1988), Jung and Kim (1998) and Lee and Kim (2000).

#### *Calystegia soldanella-Carex kobomugi* community

This community occurred in two sites of S9 (Jumun-ri) and S5 (Nobong). This community had mean height of 9 cm and mean coverage of 70%. *Calystegia soldanella-Carex kobomugi* community occur in unstable coastal dunes (Min 2004). *Carex kobomugi* with *Elymus mollis* or *Calystegia soldanella* is known as pioneer species in coastal dunes of South Korea and Japan (Kachi and Hirose 1979, Ishikawa and Kachi 1998, Min 2004).

#### *Ishaemum antheophoroides* community

This community occurred in five sites of S19 (Sinyang-ri), S20 (Sagumi), S25 (Mapo-ri), S26 (Seonyudo-ri) and S30 (Hakampo). Total community area was 1.40 km<sup>2</sup>. This community had mean height of 49 cm and mean coverage of 58%. This is herbaceous perennial plant community and occur near high water lines (Kim and Ihm 1988). This is in accordance with the community distribution in coastal dunes of Yeongilman bay, Jeju island, the western and southern coasts, as proposed by Lee et al. (1982), Lee and Chon (1983, 1984) and Kim and Ihm (1988).

#### *Zoysia macrostachya* community

This community occurred in five sites of S1 (Hwajinpo), S11 (Maewon-ri), S15 (Byeonggok-ri), S22 (Songseok-ri) and S27 (Dasa-ri). Total community area was 0.83 km<sup>2</sup>. This community had mean height of 35 cm and mean coverage of 75%. This community occur in stable sand dunes and on top of sand dunes with dry sand and is herbaceous perennial plant community. This is in accordance with the community distribution in coastal dunes of the eastern and southern coasts of South Korea, as proposed by Lee et al. (1982) and Lee and Chon (1983).

#### Class Viticetea Rotundifoliae

Kim and Ihm (1988) have described the class Viticetea rotundifoliae for sand-dune shrub communities of South Korea. Our results support the syntaxonomical schemes proposed by Ohba et al. (1973), Kim and Ihm (1988), Jung and Kim (1998) and Jung (2000). The one association belonging to this class is *Vitex rotundifolia* community (Table 2 and 3).

#### *Vitex rotundifolia* community

This community occurred in twenty sites of S1 (Hwajinpo), S6

(Bukbun-ri), S10 (Nobong), S11 (Maewon-ri), S12 (Mangyang-ri), S13 (Wolsong-ri), S14 (Baekseok-ri), S15 (Byeonggok-ri), S16 (Honghwan-ri), S17 (Nangdo-ri), S18 (Deokjung-ri), S19 (Sinyang-ri), S20 (Sagumi), S21 (Kwanmaedo-ri), S22 (Songseok-ri), S23(Haeun-ri), S25 (Mapo-ri), S26 (Seonyudo-ri), S27 (Dasa-ri) and S30 (Hakampo). Total community area was 79.29 km<sup>2</sup>. This community had mean height of 41 cm and mean coverage of 83%. Companion species were *Amorpha fruticosa*, *Avena fatua*, *Bidens bipinnata*, *Imperata cylindrica* var. *koenigii*, *Setaria viridis* var. *pachystachys* and *Zoysia sinica*. This occur in dry, unstable or semi-stable coastal dunes and near windbreak forests. This is stress (salt, drought, sand movement) tolerant and prostrate pioneer species and shrubby community in northeast Asia (Kim et al. 1987, Miyawaki and Okuda 1990, Ohba et al. 1973, Lee and Kim 2000, Lee et al. 2000). The northern limit of distribution for *Vitex rotundifolia* community is the coast of Donghae-Samcheok (Lee and Kim 2000), or of Goseong-gun Hwajinpo in this study.

#### Class *Rosetea multiflorae*

Kim and Ihm (1988) have described the class *Rosetea multiflorae* for sand-dune shrub communities of South Korea. Our results support the syntaxonomical schemes proposed by Ohba et al. (1973), Miyawaki et al. (1983), and Jung and Kim (1998). The one association belonging to this class is *Rosa rugosa* community (Table 2 and 3).

#### *Rosa rugosa* community

This community occurred in four sites of S1 (Hwajinpo), S12 (Mangyang-ri), S22 (Songseok-ri) and S30 (Hakampo). Total community area was 0.60 km<sup>2</sup>. This community had mean height of 70 cm and mean coverage of 43%. Companion species were *Sonchus brachyotus*, *Solanum nigrum*, *Imperata cylindrica* var. *koenigii*, *Aster hispidus*, *Scutellaria strigillosa*, *Corispermum stauntonii*, *Potentilla discolor*, *Rumex crispus* and *Lactuca indica* var. *laciniata*. This occur near mantle community behind coastal dunes, in disturbed dunes or near windbreak forests of cold temperate zone. This is representative shrubby community in northeast Asia (Jung and Kim 1998). The southern limit of distribution for *Rosa rugosa* community is the coast of Pohang city Hwajin-ri (Jung and Kim 1998). This community is in accordance with the community distribution in Ohba et al. (1973), Miyawaki (1983), Jung and Kim (1998) and Lee and Kim (2000).

#### The Naturalized Community

##### *Diodia teres* community

This community occurred in S29 (Gijipo). This community had

Table 3. Syntaxonomical scheme of vegetation in the coastal dunes

A. Two associations of herbaceous perennial sand dune plants
Salsotelea komarovii Ohba, Miyawaki et Tx. 1973
Salsoletalia komarovii Ohba, Miyawaki et Tx. 1973
Salsolion komarovii Ohba, Miyawaki et Tx. 1973
1. <i>Calystegia soldanella</i> community
2. <i>Lathyrus japonicus</i> - <i>Calystegia soldanella</i> community
B. Twelve associations of herbaceous perennial sand dune plants
Glehnietea littoralis Ohba, Miyawaki et Tx. 1973
Glehnietalia littoralis Ohba, Miyawaki et Tx. 1973
Carcion pumilae Kim et Ihm 1988
1. <i>Carex pumila</i> community
2. <i>Elymus mollis</i> community
3. <i>Vitex rotundifolia</i> - <i>Elymus mollis</i> community
4. <i>Ixeris repens</i> community
5. <i>Elymus mollis</i> - <i>Ixeris repens</i> community
6. <i>Lathyrus japonicus</i> community
7. <i>Messerschmidia sibirica</i> community
8. <i>Glehnia littoralis</i> community
Carcion kobomugi Ohba, Miyawaki et Tx. 1973
9. <i>Carex kobomugi</i> community
10. <i>Calystegia soldanella</i> - <i>Carex kobomugi</i> community
11. <i>Ishaemum antheophoroides</i> community
12. <i>Zoysia macrostachya</i> community
C. One association of shrubby perennial sand dune plant
Viticetea rotundifoliae Ohba, Miyawaki et Tx. 1973
Viticetalia rotundifoliae Ohba, Miyawaki et Tx. 1973
Ischaemo-Viticion rotundifoliae Ohba, Miyawaki et Tx. 1973
1. <i>Vitex rotundifolia</i> community
D. One association of shrubby perennial sand dune plant
Rosetea multiflorae Ohba, Miyawaki et Tx. 1973
Rosetalia rugosae Ohba, Miyawaki et Tx. 1973
Rosion rugosae Ohba, Miyawaki et Tx. 1973
1. <i>Rosa rugosa</i> community
E. The naturalized community
1. <i>Diodia teres</i> community

mean height of 34 cm and mean coverage of 60%. This is annual herbaceous plant community and occur in human-disturbed dunes and near mantle communities. This is naturalized plant from north America (Park 1995, Lee and Kim 2000).

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