

Taxonomy and distribution of seagrasses, with special emphasis of family Zosteraceae in Korea

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Seagrass is one of the flowering plants which live wholly submerged in the shallow or deep sea waters, and distributed in worldwide. The seagrass beds are evaluated as a rich and natural source of biodiversity, and the researches on seagrass are actively progressed nowadays. However, particularly in Korea, seagrasses have received relatively little attention, and the study of seagrasses has long been neglected. This review is intended to discuss two topics; 1) taxonomy and distribution of seagrasses in world and 2) taxonomy and distribution of Family Zosteraceae in Korea.

Key words: distribution, seagrass, taxonomy, Zosteraceae

Seagrass is one of the flowering plants which live wholly submerged in the shallow or deep sea waters, and distributed in worldwide. They are all monocotyledons and consist of 12 genera with 48 species according to den Hartog (1970). The seagrass beds are evaluated as a rich and natural source of biodiversity, and they occur in a region, where this important component of the environment is rapidly being challenged, and sadly outcompeted by increasing demands for industrialization and unsustainable uses of the coastal zone.

The researches on seagrass are actively progressed nowadays (McRoy, 1996), and 952 papers related to seagrass have been published in worldwide from 1982 to 1997 (Table 1). From January, 1996 to March 1997, in less than two years, number of papers annually published is nearly same as those of last three years. In addition, recently, Interantional Seagrass Biology Workshop was

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Table 1. The number of papers published after 1982 to March 1997, based on CD rom of life sciences. The numbers include all aspects of seagrass biology and ecology, i.e. diversity, ecology of epiphytes.

Duration		Number of papers	Number of papers per year
From	To		
Jan. 1996	March 1997	109	87
1993	1995	257	86
1990	1992	176	59
1986	1989	196	49
1982	1985	214	54

convened at Rottnest Island, Western Australia, 1996. In this workshop, 49 manuscripts were presented (Kuo *et al.*, 1996). However, seagrasses have received relatively little attention by evolutionary biologists and countless questions await detailed study (Waycott and Les, 1996).

Particularly in Korea, to date, after 1945, although seagrasses are well represented throughout the country, the study of seagrasses has long been neglected, and there were almost no taxonomical or ecological publications on these plants reported from Korea, apart from phylogenetic research.

In this paper, two topics including 1) taxonomy and distribution of seagrasses in world and 2) taxonomy and distribution of family Zosteraceae in Korea were reviewed.

Taxonomy and distribution of the seagrasses

Hartog (1970) has classified the seagrasses into 2 families; Potamogetonaceae and Hydrocharitaceae, and 12 genera. In family Potamogetonaceae, 9 genera with 37 species were included, and in second family Hydrocharitaceae, 3 genera with 11 species were included. However, recently, seagrasses are generally classified into 4 families (Cronquist, 1981; Dahlgren *et al.*, 1985): Zosteraceae, Posidoniaceae, Cymodoceaceae and Hydrocharitaceae (Table 2).

Family Zosteraceae include 3 genera, *Zostera* L., *Phyllospadix* Hooker, and *Heterozostera* den Hartog. Family Posidoniaceae is monotypic, including one genus *Posidonia* Konig. Family Cymodoceaceae consists of 5 genera, *Halodule* Endl., *Cymodocea* Konig, *Syringodium* Kutzing, *Thalassodendron* den Hartog and *Amphibolis* Agardh. The last family Hydrocharitaceae include 3 genera, *Enhalus*

Table 2. Taxonomy of seagrasses by Hartog and others.

Hartog(1970)	Cronquist(1981) Dahlgren <i>et al.</i> (1985)
Family Potamogetonaceae	
Genus <i>Zostera</i>	Zosteraceae
<i>Phyllospadix</i>	
<i>Heterozostera</i>	
<i>Posidonia</i>	Posidoniaceae
<i>Halodule</i>	Cymodoceaceae
<i>Cymodocea</i>	
<i>Syringodium</i>	
<i>Thalassodendron</i>	
<i>Amphibolis</i>	
Family Hydrocharitaceae	
Genus <i>Enhalus</i>	Hydrocharitaceae
<i>Thalassia</i>	
<i>Halophila</i>	

Reich., *Thalassia* Banks ex Koing and *Halophila* Thouars. Among them, in Korea, to date, 2 genera, *Zostera* and *Phyllospadix*, with 7 species are known to be distributed.

Seagrasses are distributed in worldwide; from the latitude of southwest Greenland, Northern Hemisphere, passing through the tropical region, to the Tasmania, Southern Hemisphere. Generally, they are grouped into two types based on distributional region; tropical type and temperate type (Hartog, 1970, Fig. 1). The tropical types are mainly occupied in tropical areas, however, may extended their area into subtropical or even warm temperate seas, and include 7 genera; *Enhalus*, *Thalassia*, and *Halophila* of the family Hydrocharitaceae and *Halodule*, *Cymodocea*, *Syringodium* and *Thalassodendron* of the family Cymodoceaceae. The temperate type are more or less confined to the temperate seas, included 5 genera; *Zostera*, *Heterozostera* and *Phyllospadix* of the family Zosteraceae, *Posidonia* of the family Posidoniaceae and *Amphibolis* of the family Cymodoceaceae.

The most of the seagrasses are occurred in Indian Ocean and West Pacific Ocean area (Fig. 2), where contains six to eight genera, and they all are

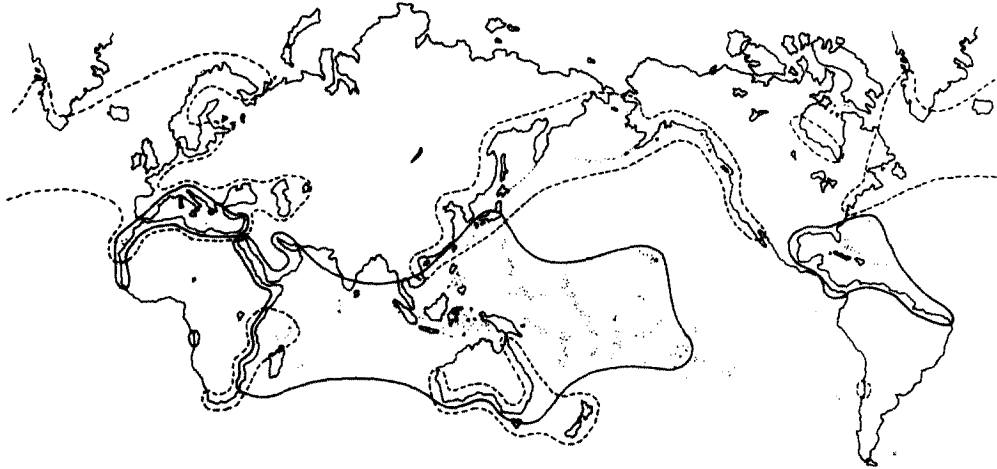


Fig. 1. Distributional type of seagrasses. The area encircled by dotted line means the temperate type, and by continuous line the tropical type. Rearranged the map in Hartog (1970).

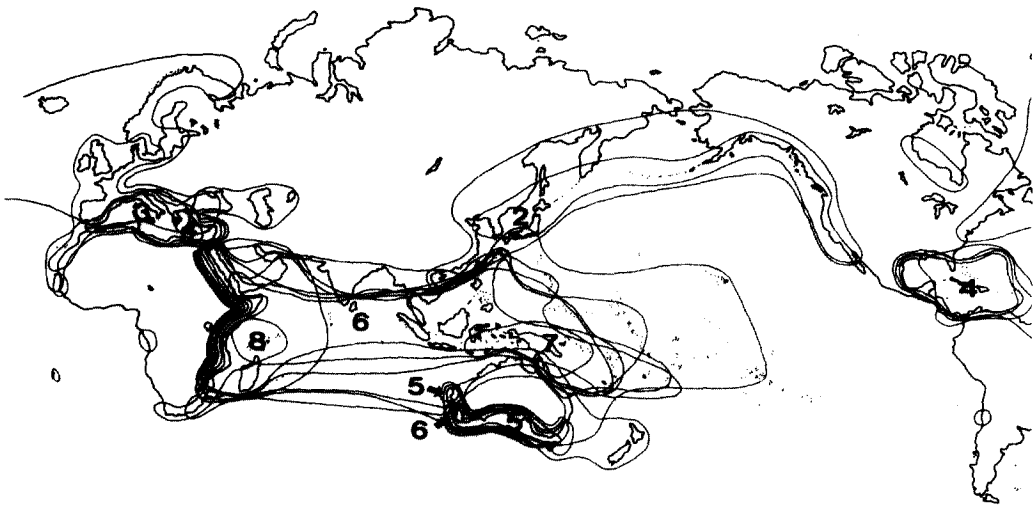


Fig. 2. The diversity map of the seagrasses at generic level. Numbers mean the kinds of genus occurred in each area.

tropical type except genus *Zostera* (*Z. capensis* Setchell), which occurred in eastern Africa and Madagascar. Next, Southern region of Australia contains five to six genera, and Caribbean Sea and Mediterranean Sea contains four genera. In north-eastern Asia, including Korea, contains two genera, *Zostera* and *Phyllospadix*.

Five genera show the typical disjunct distribution pattern (Fig. 3), and two genera show the bipolar pattern (Fig. 4). Among the genera showing disjunctive distribution, four genera, *Syringodium*, *Halodule*, *Thalassia* and *Halophila*, show the disjunct distribution between Indo-West Pacific Sea and Caribbean Sea, and one genus, *Heterozostera*, show disjunct distribution between southern Australia and western South America.

Two genera *Zostera* and *Posidonia* show the bipolar distribution, their area extends partly north of the tropical zone and partly south of it. There are several hypotheses to explain these distinctive distribution pattern. The westward route was suggested to explain the disjuncts between Indo-West Pacific Sea and Caribbean Sea, and the relict theory was suggested to explain the bipolar distribution (Hartog, 1970). However, these are under serious debates, and many more remains to explain exactly, including fossil evidence, genetic variation and plasticity of seagrasses and local taxonomic and ecological studies (Larkum and Hartog, 1989).

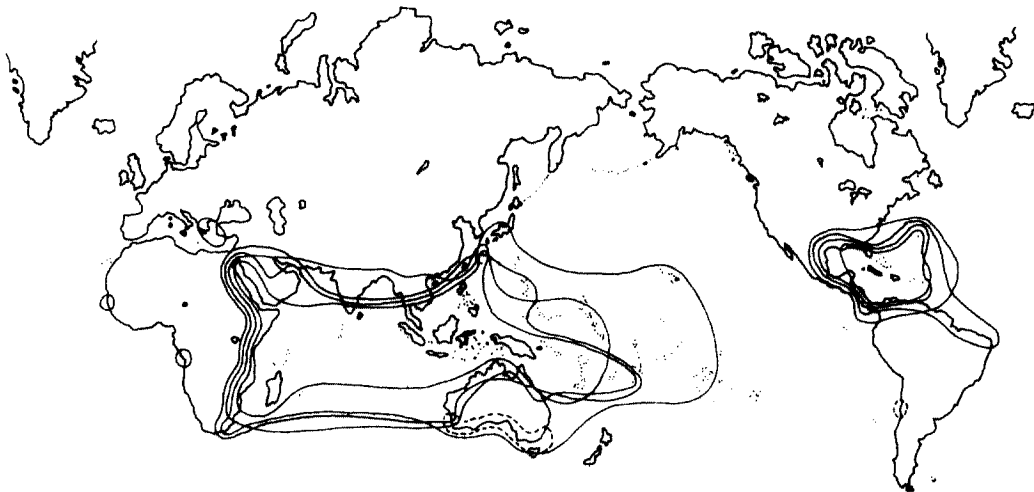


Fig. 3. Map showing the disjunct distribution between Indo-West Pacific Sea and Caribbean Sea exhibited by four genera, *Syringodium*, *Halodule*, *Thalassia* and *Halophila*, and between southern Australia and western South America by *Heterozostera* (dotted line).

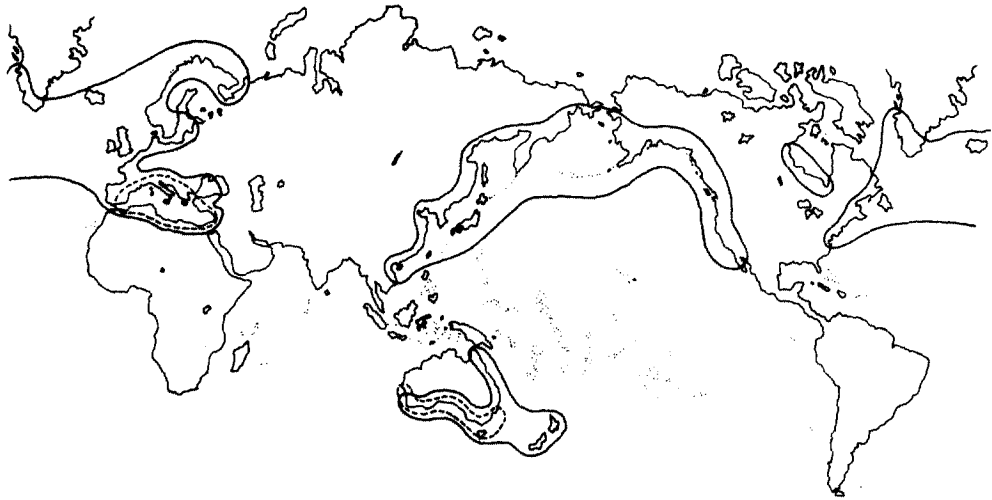


Fig. 4. Map showing the bipolar distribution. The area encircled by dotted line is the range of *Zostera*, and by continuous line is of *Posidonia*.

Taxonomy and distribution of the Family Zosteraceae

Family Zosteraceae is one of the seagrasses, and distinguished from other families by having the ligulated leaves which have not tannin cells, the flat inflorescence, and the reduced flowers. This family consists of 3 genera and 18 species according to den Hartog. The plants of family Zosteraceae is distributed in most of the temperate seacoast of both hemisphere, but a few species extend into tropical seawaters. Genus *Zostera* has the widest distribution, among family Zosteraceae. Genus *Phyllospadix* mainly on the coasts of the Pacific, and genus *Heterozostera* is found on the coasts of South America and Australia. Since Nakai (1911) reported *Zostera marina* L. from Korea, seven species of two genera, *Zostera* and *Phyllospadix*, have been reported in Korea. Among them, five species are in genus *Zostera*, and two species are in genus *Phyllospadix*.

The species of genus *Zostera* differ from those of *Phyllospadix* in having monoecious flowers, entire leaf margins, ovoid-shaped fruits and elongated internodes in rhizomes. And, the plants of *Zostera* are occurred in the sand-muddy seacoast and more or less protected area from the wave action, whereas those of *Phyllospadix* are in rocky seacoast and area directly affected by wave action (Shin *et al.*, 1993; Shin and Choi, 1998). These two genera exhibit the anatomical adaptations to rocky or sand-muddy substrates and surf exposure (Cooper and McRoy, 1988).

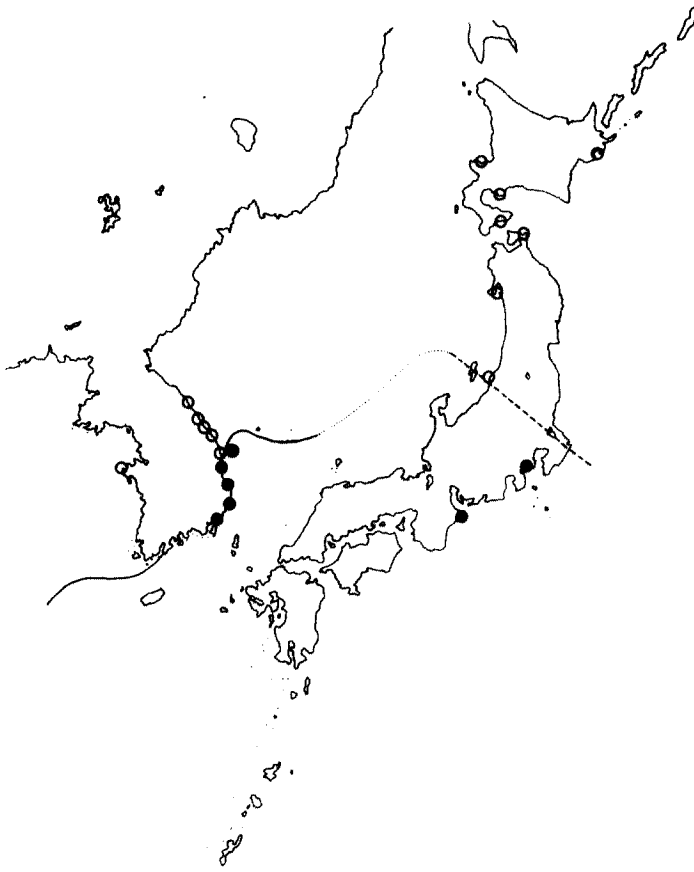


Fig. 5. Distribution map of *Phyllospadix iwatensis* and *P. japonicus*. See the text for further explanation. (open circle; *P. iwatensis*, closed circle; *P. japonicus*)

Genus *Phyllospadix* Hooker in Korea

Genus *Phyllospadix* consists of five species, among them three species occur in the northwestern Pacific, and two species in northeastern Asia. In Korea, two species, *Phyllospadix iwatensis* Makino and *P. japonicus* Makino are distributed (Shin *et al.*, 1993). These two species are distinguished by the apical shape of leaf, number of veins, and the color of fibrous remains in rhizome. The plants of *Phyllospadix iwatensis* differ from those of *P. japonicus* in having 5-veined leaves, round apex of leaf, and brown-colored fibrous remains in rhizomes. The leaf apex of *Phyllospadix iwatensis* is more or less rounded, and fin cells are less developed, whereas those of *P. japonicus* is more or less emarginate, and fin cells are well developed.

The plants of *Phyllospadix iwatensis* are occurred more or less at northern seacoast of East Sea from thirty seven north Latitude, and those of *P. japonicus* are occurred at southern seacoast from this latitude. This latitude nearly coincides with border line between Southern east coast section and South Coast section, which are divided based on mainly water temperature in Korea (Fig. 5). The surface temperature at Southern east coast section ranges four to ten degrees at Febuary, whereas those of South Coast section ranges ten to twelve degrees at Febuary. This distributional tendency also occur in Japan (Miki, 1933; Ohwi, 1984), where the plants of *Phyllospadix iwatensis* occur relative at northern seacoast from the transect line connected from the western coast of Sada Island, Honshu, to the eastern coast of Ibaraki Province, Honshu, and *Phyllospadix japonicus* occur relatively at the southern seacoast from it. No one exactly explain this distributional pattern, so many reseaches are needed to solve it. den Hartog, however, suggested that this discontinous distribution is probably due to their recent origin.

Genus *Zostera* L. in Korea

Genus *Zostera* consists of eleven species, and distributed in the northern and southern temperate seawaters, but a few species extend into tropical seawaters. The genus *Zostera* can be divided into two subgenera, *Zostera* and *Zosterella*, based on mainly absence or presence of retinacula at spadix and sheath shape of leaf (Fig. 6). Subgenus *Zostera*, with four species, has closed sheathed leaves and no retinaculum in spadix. Subgenus *Zosterella*, with seven species, has open sheathed leaves and retinacula in spadix.

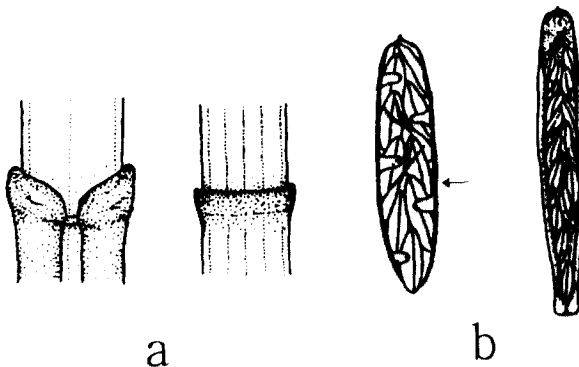


Fig. 6. Difference between subgenera *Zostera* and *Zosterella* of genus *Zostera*. Arrow shows the retinaculum. a: ligule, b: inflorescence.

The species of subgenus *Zostera* are distributed in mainly eastern Asia, Europe, whereas those of subgenus *Zosterella* are distributed in Europe, East Africa and Madagascar, eastern Asia, and Australia. Among the species of Subgenus *Zostera*, three species, *Z. asiatica* Miki, *Z. caulescens* Miki, *Z. caespitosa* Miki, are occurred in only northeastern Asia, including Korea and Japan (Shin and Choi, 1998). *Zostera marina* L. are widely distributed in temperate seawaters of Northern Hemisphere. In case of subgenus *Zosterella*, the plants of three species are occurred in only one area, such as *Zostera nolti* Horensm. in Europe, *Z. japonica* Aschers. & Graebn. in East Asia, *Z. capensis* Setchell in South and East Africa and Madagascar. However, in Australia and its neighbor areas, four species, *Z. mucronata* den Hartog, *Z. mulleri* Irmisch ex Aschers., *Z. novaezelandica* Setchell and *Z. capricorni* Aschers., are distributed.

In Korea, five species are distributed. Among them one species, *Zostera japonica* is of subgenus *Zosterella*, and the remains are of subgenus *Zostera*. *Zostera japonica* is distinctive from other the *Zostera* species in Korea, by having an open sheathed and relatively narrow and short leaves. The open sheathed leaves and retinacula in spadix are the characteristics among Korean *Zostera* species. The plants of *Zostera japonica* are distributed in broadly sheltered bays on sandy or muddy coast in depths of one to three meter, and along cool to subtropical seacoast of the East Asia, from Sakhaline, Russia to Vietnam; in Korea, occurred along the south Sea.

Zostera caulescens can be distinguished from the other species by having eleven nerved and more or less wide leaf. In addition, *Zostera caulescens* has distinctively longer ligules and auricle. Also, this species have sterile branches on upper portion of the fertile branches, exclusively. The plants of *Zostera caulescens* are distributed in more or less sheltered to semi-exposed bays on sandy or muddy bottoms in depths six to twelve meters, and along cool to temperate seacoast of northeastern Asia, from Kurile Island, Russia to Japan and Korea, in Korea, occurred along east sea to south and west sea.

Diagnostic features of *Zostera asiatica* are the truncate or emarginate apex of leaf with seven to ten fibrous strand between the midvein and side vein (Fig. 7). The plants of *Zostera asiatica* are distributed in broadly sheltered bays on sand in depths of eight to twelve meters, and along cool to temperate sea coast of northeastern Asia, from Sakhalin, Russia and Hokkaido, Japan to east coast of Korea; in Korea occurred along east sea from Hamkyungbukdo to Kyungsangbukdo.

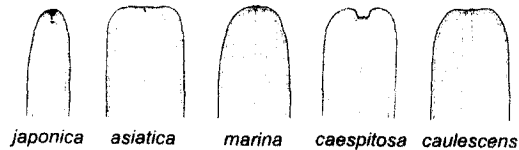


Fig. 7. Representative shape of the leaf apex of *Zostera* species from eastern Asia.

Zostera marina is characterized by having round or mucronate apex of leaf and five to seven veined leaves, and four to six fibrous strands between the midvein and side vein. The plants of *Zostera marina* are distributed in more or less sheltered bays on firm or coarse sandy to soft muddy bottoms in depths one to ten meters, and widely distributed in northern hemisphere, in Korea, widely distributed from east sea to south and west sea.

Zostera caespitosa has the rhizomes with extremely shortened internodes, and the typically obcordate apex of leaf. This characteristics are very similar to *Phyllospadix* species. However, the plants of *Zostera caespitosa* can be distinguished from *Phyllospadix* species by not having the fin cell of leaf. Until now, I can not collect any plants of *Zoatera caespitosa* in Korea, also not examine any herbarium specimens from Korea. So, its occurrence in Korea will need to be further investigated. I can examine the specimens from Japan including syntype deposited at Herbarium at University of California(UC). The plants of *Zoatera caespitosa* are distributed in semi-exposed bays on sand in depths three to eight meters, and in cool to temperate seacoast of northeastern Asia, from Hokkaido, Japan to south coast of Korea. In Korea, reported to occur from Joshin (maybe Hamkyungpukdo, North Korea) along east coast to Chinkai (maybe Kyungsangnamdo) in south coast by Miki.

Further researches on seagrasses in Korea

Although the inventory of seagrasses in Korea was clarified by two papers (Shin *et al.*, 1993; Shin and Choi, 1998), the researches on their biology, including their phylogeny, phenology, distribution range and pattern, epiphytes on leaves, and, especially their decline pattern and recovery, were not undertaken until now. In respect that the reclamation projects on seacoast in Korea, especially at the mudflat on west coast, were actively progressed, the researches on seagrasses are urgently needed in all respects.

Literature cited

- Cooper, L. W. and C. P. McRoy. 1988. Anatomical adaptations to rocky substrates and surf exposure by the seagrass genus. *Aquat. Bot.* 32: 365-381.
- Cronquist, A. 1981. An integrated system of classification of flowering plants. Columbia University Press, New York.
- Dahlgren, R. M. T., H. T. Clifford and P. F. Yeo. 1985. The families of the monocotyledons. Structure, Evolution and Taxonomy. Springer-Verlag, Berlin.
- Hartog, C. den. 1970. The sea-grasses of the world. *Verh. KonNed. Akad. Wetensch. Afd. Natuurk., Tweede Sect.* 59: 1-275.
- Kuo, J., R. C. Phillips, D. I. Walker and H. Kirkman (eds). 1996. *Seagrass Biology: Proceedings of an International Workshop*. CSIRO Division of Fisheries, Marmion.
- Larkum, A. W. D. and C. den Hartog. 1989. Evolution and biogeography of seagrasses. *In* *Biology of Seagrasses. A treatise on the biology of seagrasses with special reference to the Australian region*. Larkum, A. W. D., A. J. McComb and S. A. Shepherd (eds.), Pp.112-156, Elsevier, Amsterdam.
- McRoy, C. P. 1996. The global seagrass initiative continues. *In* *Seagrass Biology: Proceedings of an International Workshop*. Kuo, J., R. C. Phillips, D. I. Walker and H. Kirkman (eds.), Pp.3-6. CSIRO Division of Fisheries, Marmion.
- Miki, S. 1933. On the seagrasses in Japan (1). *Zostera* and *Phyllospadix*, with special reference to Morphological and ecological characters. *Bot. Mag. (Tokyo)* 47: 842-862.
- Nakai, T. 1911. *Flora Koreana II*. *J. Coll. Sci. Imp. Univ. Tokyo* 26: 1-573.
- Shin, H. and H.-K. Choi. 1998. Taxonomy and distribution of *Zostera* (Zosteraceae) in eastern Asia, with special reference to Korea. *Aquat. Bot.* (in press).
- Shin, H. and H.-K. Choi, and Y. S. Oh. 1993. Taxonomic examination of Korean seagrasses: I. Morphology and distribution of the genus *Phyllospadix* (Zosteraceae). *Korean J. Pl. Tax.* 23: 189-199.
- Waycott, M. and D. H. Les. 1996. An integrated approach to the evolutionary study of seagrasses. *In* *Seagrass Biology: Proceedings of an International Workshop*. Kuo, J., R. C. Phillips, D. I. Walker and H. Kirkman (eds.), Pp. 71-78.