

Taxonomy and Distribution of Seagrasses in Taiwan

Yuen-Po Yang^(1,3), Sun-Chio Fong⁽²⁾ and Ho-Yih Liu⁽¹⁾

(Manuscript received 20 February, 2002; accepted 18 March, 2002)

ABSTRACT: Seven species of seagrasses are recognized in Taiwan. They are, namely, *Halophila beccarii* Aschers., *Halophila decipiens* Ostenf., *Halophila ovalis* (R. Brown) Hook. f., *Thalassia hemprichii* (Ehrenb.) Aschers., *Halodule pinifolia* (Miki) den Hartog, *Halodule uninervis* (Forssk.) Aschers., and *Zostera japonica* Aschers. & Graebn. The distributional range of these seagrasses in Taiwan is mainly in the southwest coast of main island and the Penghu islands.

KEY WORDS: Taiwan, Seagrasses, Taxonomy, Phytogeography.

INTRODUCTION

Taiwan lies between 20 and 25 N latitude and almost bisected by the tropic of Cancer. It is on the continental shelf of Asia and is a continental island, separated from mainland China by the Taiwan Strait. To the south it is linked to the Philippine Archipelago, and to the northeast it neighbored on the Ryukyu islands. Except the main island, Taiwan has some nearby small islands. These include the Penghu Islands (also Pescadore, a group of over 60 flat islets) and Shiao-liu-chiu (a small island), situated west of Taiwan in the Taiwan Strait, two small islands, Lanyu (Orchid Island) and Lutao (Green Island) off the southeast Pacific coast of Taiwan. In addition, several small islands are located northeast of Taiwan in the Pacific ocean. The winding coastline of nearly 1300 Km long in Taiwan support various habitats for the growth of some tropical or temperate seagrasses.

In past years, only a few papers relevant to the taxonomy and geographical distribution of seagrasses in Taiwan have been published. The earliest paper was made by Matsumura and Hayata (1906), which listed one species, *Zostera nana* Roth. In 1932, Miki described a new species, *Diplanthera pinifolia* Miki (= *Halodule pinifolia* (Miki) den Hartog), based on three specimens. However, one of the specimens, which was collected at Takao (=Kaohsiung), was previously referred to *Zostera nana* by Hayata. In 1954, Masamune listed four species occurring in the island, which included *Halophila beccarii* (Ehrenb.) Aschers. and *Halodule pinifolia* (Miki) den Hartog. In 1978, Yang treated totally five and one doubtful species of seagrasses in the Flora of Taiwan. He added *Zostera japonica* Aschers. and *Halodule uninervis* (Forssk.) Archers. and treated *Halophila beccarii* as doubtful because of no specimen from Taiwan for examination. Nine years later, he confirmed five species of seagrasses in the islands. Mok *et al.* (1993) reported a new record, *Halophila decipiens* Ostenf., in the southern part of this island. The number of seagrass species in Taiwan is therefore increased to six. In 2000, Yang confirmed *Halophila beccarii* in the island, based on a photo of a specimen which was collected at Tungkang, Pingtung, and described seven species of seagrasses in the Flora of Taiwan (Yang, 2000).

1. Department of Biological Sciences, National Sun Yat-Sen University, Kaohsiung 804, Taiwan.

2. Department of Marine Resources, National Sun Yat-Sen University, Kaohsiung 804, Taiwan.

3. Corresponding author. Tel: +886-7-5252000 ext. 3622 E-mail: ypo@mail.nsysu.edu.tw

Seagrasses have been investigated quite well in the vicinities of Taiwan. Menez *et al.* (1983) published "Seagrasses from the Philippines." Included in the paper were two families with seven genera and 12 species. In China, seventeen species belonging to nine genera and three families were reported (Sun 1992). In his "Flora of Okinawa and the Southern Ryukyu Islands," Walker (1976) included two families with six genera and eight species. Ohwi (1965) reported two families with four genera and eight species in the "Flora of Japan." Kuo (1996) indicated that 17 species occurred in Japanese water (including Japan and the Ryukyus). Geographically, Taiwan can be recognized as an ecotone among the waters of the Philippines, the Mainland China and the Japan and Ryukyus. The number of six seagrass species previously recorded in Taiwan seems not corresponding with such phytogeographical relationship. The situation may attribute to inadequate taxonomic inventory in past years.

It is true that many plant taxonomists seldom have opportunity to go collecting specimens in the sea. Furthermore, the inconspicuous flowers as well as vegetative organs of seagrasses possibly cannot attract their attention to gather materials. The paucity of specimens of seagrasses in the herbaria of Taiwan can be the evidence. On the other hand, the martial law which was issued and executed around 45 years ago and prohibited people's activities near the coast is also a factor resulting in the poor amount of specimens.

In recent years, a plenty of ecological as well as biological studies has been made in seagrasses in the world. The functions and biology of seagrasses were exhibited in detail by Phillips and Menez (1988). In Taiwan, ecological and biological studies on the seagrasses have been initiated in the past 18 years. For example, Doebler (1984) studies on "The Seagrasses of Taiwan as a potential source." Huang (1989) made the study of the growth and adaptation of *Thalassia hemprichii* (Ehrenb.) Aschers. at Nanwan of southern Taiwan. In addition, genetic variation intra- and inter-populations of *Thalassia hemprichii* in Taiwan was studied by Huang (1995).

The objectives of this study are to inventory the species components and distribution of seagrasses in Taiwan. It is hoped that the results may provide information for studies on seagrasses in the future.

The species and distribution of Seagrasses of Taiwan seem a blank to the knowledge of some authors such as den Hartog (1970) and Phillips and Menez (1988). It can be evidenced by the distributional range of seagrasses species in the island not mapped or almost not mentioned in their publication. Herein, with the results of this study, such knowledge may be completed.

MATERIALS AND METHODS

The plants of seagrasses growing from near shore to a depth of about two meters were collected for voucher specimens. If it is necessary, a depth of about ten meters was reached for collecting specimens. Voucher specimens were desiccated or preserved in FAA (formalin: glacial acetic acid: ethyl alcohol (70%) = 5 cc : 5 cc : 90 cc.) for future studies. The specimens were deposited in the Herbarium of Department of Biology, National Sun Yat-Sen University. Specimens deposited in the herbaria of this island were also examined. Based on the information given on the labels of those examined specimens, fresh materials were tried to gather from the same collecting location, if possible. Marine researchers were also consulted because they have experienced the encounter of seagrasses while in the field work. In the meantime, the voucher specimens in their laboratory were also examined, if available.

The fragments on the shore were collected, but not be included in the results, because they may be drifted and brought there by sea from elsewhere.

RESULTS AND DISCUSSION

In the investigation, seven species of seagrasses were recognized, which are namely *Halophila ovalis*, *Halophila decipiens*, *Halophila beccarii*, *Thalassia hemprichii*, *Zostera japonica*, *Halodule uninervis*, and *Halodule pinifolia*. The first four species belong to the family Hydrocharitaceae, and the fifth to Zosteraceae, and the last two to Zannichelliaceae. Therefore, the seven species are the same as those of Yang's treatment in the Flora of Taiwan. It is evident that an intensive investigation for seagrasses is necessary in future.

These species in Taiwan are distributed in the southwest coast of main island, and the small islands Lutao, Hsiao-liu-chiu, Wang-an, and Penghu. In the east coast, Hsiao-kang, Taitung, is the only location with growth of seagrasses. However, fragments of *Cymodocea* sp. have been collected at Chiou-peng some years ago. Additionally, fragments of the species and *Syringodium isoetifolium* were found on the shore of the Island Lanyu about 20 years before. Although the investigators have been the two locations several times in the past five years, the two species are still expected. *Cymodocea rotundata* Aschers. may be the candidate species because its distribution ranges to Phillippines and the Ryukyus. *Enhalus acoroides* (L. f.) Royle is another species expected in Taiwan, because it has similar distributional range to that of *Cymodocea rotundata*. These two species have been expected by Yang since 1987.

TAXONOMICAL AND PHYTOGEOGRAPHICAL TREATMENT

Key to the species of seagrasses of Taiwan:

1. Leaves with blade and petiole well differentiated.
 2. Leaves trinerved at base, lateral nerves absent *Halophila beccarii*
 2. Lateral penninerved, lateral nerves present.
 3. Leaves pubescent on both surfaces, finely spinulose at margins *Halophila decipiens*
 3. Leaves glabrous on both surfaces, entire at margins *Halophila ovalis*
1. Leaves ribbon-like or linear, petiole and blade similar.
 4. Leaves ligulate, parallel-longitudinal nerves with fine cross nerves.
 5. Leaves less than 2 mm wide, apex entire, slightly emarginate *Zostera japonica*
 5. Leaves more than 4 mm wide, apex slightly fine-toothed, not emarginate *Thalassia hemprichii*
 4. Leaves not ligulate, parallel-longitudinal nerves without cross veins.
 6. Leaf apex obtuse or truncate with irregular teeth *Halodule pinifolia*
 6. Leaf apex trifid, the lateral teeth longer than the median, the median tooth obtuse *Halodule uninervis*

1. *Halophila beccarii* Aschers., Nuov. Giorn. Bot. Ital. 3: 302. 1871.

The species was listed as a doubtful species for the flora of Taiwan by Yang (1978). However, a photo of a specimen which was sent by Dr. John Kuo several years ago confirmed its occurrence in the island. The specimen was collected at Tungkang, Pingtung, and is deposited in the Herbarium of the University of Tokyo (TI). Collector name of the specimen is unknown. The species may be extirpated at Tungkang, since the coast around Tungkang has been severely disturbed in recent years. Some years ago, the species was reported from Tainan, and this species in Taiwan is therefore confirmed after all.

Specimens examined. **Pingtung** Co.: Tungkang, anonymous.

2. *Halophila decipiens* Ostenf., Bot. Tidsskr. 24: 260. 1902.

The species was first reported in Taiwan by Mok *et al.* (1993). According to them, it grows in the depth of 2 to 40 meters along the southeastern coast of the Hengchun Peninsula; the substrate of its habitat is sandy or muddy, and both of the substrates are suitable for the growth of the species.

Kuo (1996) stated that *Halophila decipiens* usually formed sparse, pure stands or grew adjacent to *H. ovalis* at water depths between 15 m and 18 m on flat fine sandy coralline sediment at Okinawa Island. Such community is also found in the species at Nanwan, Pingtung, except it usually grows in the water depths between 5 m and 7 m.

The leaves of the species in Okinawa were described with dense hairs on both surfaces (Kuo 1996). The plants in Taiwan are similar to those of Okinawa in leaf vesture.

In their paper, Mok *et al.* (1993) mentioned only one flowering specimens collected in April, and indicated that further investigation of its flowering season in Taiwan is in order. Den Hartog (1970) pointed out the species flowering propably more abundant from January to April in the year. Our investigation reveals that the species in Taiwan flowers all year around, but abundant from April to May.

Specimens examined: Pingtung Co.: Nanwan, *T. M. Huang s. n.* in 1992; *M. J. Chen s. n.* in 1996.

3. *Halophila ovalis* (R. Brown) Hook. f. Fl. Tasman. 2: 45. 1858.

Caulinia ovalis R. Brown, Prod. Fl. Nov. Holl. 1: 339. 1810.

The species is widely distributed in Taiwan, including Island Lutaou, Hsiaokang, Taitung, of the east coast of the main island of Taiwan, Haikou and Nanwan of Pingtung County, Islands Wang-an and Penghu. The authors were informed with the observation of a colony of the species in Hsiao-liu-chiu. However, no materials were found there in the past some years. Further investigation of the species in the island is required.

The species can grow in sandy, coral rubble, and muddy substrates in Taiwan. It usually forms seagrass meadow of pure stand in a large area. The depth of water is in the intertide zone to about seven meters. The flowering season of the species is in April to the end of July.

Great variability in leaf morphology is present in the species, as mentioned by den Hartog (1970). The number of lateral nerves and the range of length in leaves are 4 to 18 pairs and 0.4 cm to 3.8 cm, respectively. In Penghu, the plants of pure stand at Chen-chien have leaves with 4 to 9 pairs of lateral nerves and 0.4 to 0.8 cm in length, which led us to identify it as *Halophila minor*. However, compared with other plants at several locations in Penghu, the plants was after all recognized as *H. ovalis*, because the authors could not find any significant difference between them.

The leaf shape of the species is mainly oblong and occasionally obovate-oblong or ovate-oblong, which meets the description of *Halophila euphlebia* Makino. Miki (1934) indicated such kind of leaves representing one form of *H. ovalis*. Den Hartog (1970) stated "In my opinion *H. ovalis* represents a collective species in which a number of closely allied taxa are united." He treated *H. euphlebia* as a synonym of *H. ovalis*. Here, the authors tetatively followed the treatment.

Specimens examined: Pingtung Co.: Haikou, *T. M. Huang s. n.* in 1993; Nanwan, *M. J. Chen* in 1996. Taitung Co.: Chenkon, *T. M. Wang s. n.* in 1995. Penghu Co.: Chihtou, *T. M. Huang s. n.* in 1994; Chenhai, *M. J. Chen s. n.* in 1996; Chiangmei, *T. M. Huang s. n.* in 1995; Shiakang, *M. J. Chen s. n.* in 1996; Island Wangan, *M. J. Chen s. n.* in 1996.

4. *Thalassia hemprichii* (Ehrenb.) Aschers. in Petermann, Geogr. Mitth. 17: 242. 1871.

Schizotheca hemprichii Ehrenb., Abh. Berl. Ak. Wiss. 1832, 1: 429. 1834

The species grows in Islands Lutao and Hsiao-liu-chiu, and Nanwan in the southwest coast of the main island of Taiwan. The authors were informed that the species had been observed at Nanliao in the north of the western coast of the main island of Taiwan and the Island Penghu. Materials did not have been gathered in the past two years.

In Taiwan, it grows on sublittoral flats consisting of coral sand or debris. Mostly, it forms a large meadow in which *Halophila ovalis* or *Halodule univervis* is scattered.

Flowering and fruiting seasons in Taiwan are in October to the beginning of April.

Specimens examined: Pingtung Co. : Haikou, *T. M. Huang s. n.* in 1993; Houwan, *T. M. Huang s. n.* in 1993; Wanlitung, *T. M. Huang s. n.* in 1993; Nanwan, *T. M. Huang s. n.* in 1993; Island Hsiaoliuchiu, *Jane Lewis 12004*. Taitung Co.: Island Lutao, *T. M. Huang s. n.* in 1994.

5. *Halodule pinifolia* (Miki) den Hartog, Blumea 12: 309. 1964

Diplanthera pinifolia Miki, Bot. Mag. Tokyo 46: 787. 1932. f. 9.

The species is distributed in Hsiaokang, Haikou, Houwan of the main island Taiwan, and Chenchien and Wangan of Islands Penghu. Frequently, it grows with *Halophila ovalis*. The only area that it forms a large pure stand is at Haikou. The substrate is sandy or muddy in sheltered bays or platform.

The authors have never observed flowers or fruits of the species. According to Miki (1932), flowering season in Taiwan is possibly in December.

Specimens examined: Pingtung Co.: Haikou, *T. M. Huang s. n.* in 1993; Houwan, *T. M. Huang s. n.* in 1992. Taitung Co.: Hsiaokang, *T. M. Huang s. n.* in 1993. Penghu Co.: Chenchien, *M. J. Chen s. n.* in 1996; Houkang, *T. M. Huang s. n.* in 1992; Island Wangan, *M. J. Chen s. n.* in 1996.

6. *Halophila uninervis* (Forssk.) Aschers. in Boiss., Fl. Orient. 5: 24. 1882.

Zostera uninervis Forsk., Fl. Aeg.-Arab. 120 : 157. 1775.

The species is with a distributional range in the the southwestern part of the main island and Penghu islands. Its habitat is similar to that of *Halodule pinifolia* (Miki) den Hartog.

Flowering and fruiting season is in November to December. The first author has cultivated the species in an aquarium tank. Its flowers occurred in November.

The species and *H. pinifolia* may represent two forms of a species (Kuo, personal communication, 1993). In fact, the key character appearing at apex of leaves seems unstable. Studies on morphological variation related to environments as well as genetics are necessary.

Specimens examined: Pingtung Co.: Houpihu, *T. M. Huang s. n.* in 1993; Nanwan, *T. M. Huang s. n.* in 1992; Island Hsiaoliuchiu, *Jane Lewis 12017*. Penghu Co.: Houwan, *T. M. Huang s. n.* in 1992; Changhai, *M. J. Chen s. n.* in 1996; Chiangmei, *T. M. Huang s. n.* in 1994.

7. *Zostera japonica* Aschers. & Graebn., Pflanzenr. 32: 32. 1907.

The species is distributed with a wide range from the central to the south part of the west coast of the main island and in the Island Penghu. It grows in the habitat with sandy or muddy substrate. In the central part, the species is in pure stands; in the south and the Island Penghu,

it is found growing together with *Halophila ovalis*, *Halodule pinifolia*, or *Halodule uninervis*. Flowers and fruits were found in March to April.

Specimens examined: Taichung Co.: Tatu river mouth, *T. T. Chen s. n.* in 1993. Changhua Co.: Shinpao, *Y. C. Liao s. n.* in 1996. Pingtung Co.: Haikou, *T. M. Huang s. n.* in 1995. Penghu Co.: Chenchien, *M. J. Chen s. n.* in 1996; Chiangmei, *T. M. Huang s. n.* in 1994; Chitou, *T. M. Huang s. n.* in 1994; Soukang, *M. J. Chen s. n.* in 1996; Island Wangan, *M. J. Chen s. n.* in 1996.

CONCLUSION

Seven species of seagrasses are distributed in Taiwan. The species include *Halophila beccarii*, *Halophila decipiens*, *Halophila ovalis*, *Thalassia hemprichii*, *Halodule pinifolia*, *Halodule uninervis*, and *Zostera japonica*. The seagrasses are mainly distributed in the southwest coast and the Islands Penghu. Three species, *Cymodocea rotundata*, *Syringodium isoetifolia*, and *Enhalus acoroides*, are expected in the islands in future.

ACKNOWLEDGEMENTS

The study was financially supported by the National Science Council, under projects NSC-83-0203-B-110-001 and NSC-85-2311-B110-003. The authors wish to extend their gratitude to Dr. Jane Lewis, Institute of Marine Biology, National Marine University, for kindly providing us information and making a loan of specimens for examination. They also extend thanks to Dr. John Kuo for sending a photo of *Halophila ovalis*. Thanks are given to Mr. Tien-Ming Huang, a previous graduated student of the Graduate Institute of Life Sciences, and Mr. Cheng-Wong Chen, the junior specialist of the Institute of Marine Biology, of the National Sun Yat-Sen University for collection of specimens in the sea.

LITERATURE CITED

- Den Hartog, C. 1970. The Sea-grasses of the World. North Holland, Amsterdam, 275 pp.
- Doebler, P. K. 1984. Seagrasses of Taiwan as a Potential Source, Master thesis, National Taiwan University.
- Huang, T.-M. 1995. Genetic variation within and between population of *Thalassia hemprichii* (Ehrenb.) Aschers. in Taiwan. Master thesis, National Sun Yat-sen University.
- Huang, Y.-C. 1989. The study of the Growth and Adaptation of *Thalassia hemprichii* (Ehwenb.) Aschers. of Nanwan, Southern Taiwan. Master thesis, National Sun Yat-Sen University.
- Kuo, J., Z. Kanamoto, T. Toma and M. Nishihira. 1996. Occurrence of *Halophila decipiens* Ostenfeld (Hydrocharitaceae) in Okinawa Island, Japan. *Aquat. Bot.* **51**: 329-334.
- Li, H.-L., T.-S. Liu, T.-C. Huang, T. Koyama and C. E. DeVol. 1978. Flora of Taiwan, vol. 5, Epoch Publishing Co., Taipei. 1166 pp.
- Masamune, G. 1954. A List of Vascular Plants of Taiwan. Hokurikunoshokubutsnokai, Kanazawa. 172 pp.
- Matsumura, J. and B. Hayata. 1906. Enumeratio Plantarum Formosanum. The Imperial University of Tokyo, Tokyo. 702 pp. Miki, S., 1932. On sea-grasses new to Japan. *Bot. Mag. Tokyo.* **46**: 774-788.

- Miki, S., 1934. On the sea-grasses in Japan. Bot (II). Mag. Mag. Tokyo. **48**: 131-142.
- Menez, E. G., R. C. Phillips and H. P. Calumpong. 1983. Seagrasses from the Philippines. Smithsonian Institution Press, Washington DC. 40 pp.
- Mok, H.-K., J.-D. Lee and C.-P. Lee. 1993. A new record of seagrasses, *Halophila decipiens* Ostenfeld (Hydrocharitaceae), in Taiwan. Bot. Bull. Academia Sinica. **34**: 353-352.
- Ohwi, J. 1965. Flora of Japan (English ed.). Smithsonian Institution, Washington DC. 1067 pp.
- Phillip, R. C. and E. G. Menez. 1988. Seagrasses. Smithsonian Institution Press, Washington DC. 104 pp.
- Sun, X. 1992. Flora Reipublicae Popularis Sinicae. Tomus 8. Science Press, Peiking. 206 pp.
- Walker, E. H. 1976. Flora of Okinawa and the Southern Ryukyu Islands. Smithsonian Institution Press, Washington DC.
- Yang, Y.-P. 1978. Hydrocharitaceae. In: Li, H.-L., T.-S. Liu, T.-C. Huang, T. Koyama, and C. E. DeVol (eds.). Flora of Taiwan, Vol. 5. Epoch Publ. Co., Taipei, pp. 14-24.
- Yang, Y.-P. 1987. A synopsis to the aquatic angiospermous plants of Taiwan, Bot. Bull. Academia Sinica **28**: 191-209.
- Yang, Y.-P. 2000. Hydrocharitaceae, Zannichelliaceae and Zosteraceae. In: Huang, T.-C., C.-S. Kuo, C.-F. Hsieh, H. Ohashi and H.-J. Su (eds.). 2000. Flora of Taiwan 2nd ed. vol. 5. Editorial Committee, pp. 11-19, 28-29, 30-31.

台灣海草之分類與分佈

楊遠波^(1,3)、方新疇⁽²⁾、劉和義⁽¹⁾

(收稿日期：2002年2月20日；接受日期：2002年3月18日)

摘 要

台灣的海草可分類為7個種，分別為：貝克鹽草 (*Halophila beccarii* Aschers.)、毛葉鹽草 (*Halophila decipiens* Ostenf.)、喜鹽草 (*Halophila ovalis* (R. Br.) Hook.)、泰來藻 (*Thalassia hemprichii* (Ehrenb.) Aschers.)、細葉二藥藻 (*Halodule pinifolia* (Miki) den Hartog) 和單脈二藥藻 (*Halodule uninervis* (Forssk.) Aschers.)。這些種類的大海草主要分佈於台灣本島西南沿岸和澎湖島。

關鍵詞：台灣、海草、分類、植物地理。

1. 國立中山大學生物科學系。
2. 國立中山大學海洋生物研究所。
3. 通信作者。