Bot. Bull. Acad. Sin. (2005) **46:** 163-168

Seagrasses of Tongsha Island, with descriptions of four new records to Taiwan

Hsing-Juh LIN*, Li-Yung HSIEH, and Pi-Jen LIU

Department of Life Sciences, National Chung Hsing University, Taichung, Taiwan 402, ROC

(Received September 7, 2004; Accepted November 2, 2004)

Abstract. The composition, abundance, and distribution of seagrasses on Tongsha Island were studied from 21 to 29 April 2004. A total of seven seagrass species from six genera and two families were identified. Among them, four species were new to Taiwan, including *Cymodocea rotundata* Ehrenb. et Hempr. ex Aschers., *Cymodocea serrulata* (R. Br.) Aschers. and Magnus, *Syringodium isoetifolium* (Aschers.) Dandy, and *Thalassodendron ciliatum* (Forsk.) den Hartog. The species number of seagrasses was 14% of the total global number. The total coverage area of the seagrass beds was estimated to be 8.2 km^2 distributed around Tongsha Island and the lagoon. Mean percentage cover and shoot density were high, ranging from 20 to 95% and < 1250 to > 2500 shoots m^{-2}, respectively. The large area of the seagrass bed, the high shoot density and coverage of seagrasses, and the diverse species of Tongsha Island indicate that the seagrass resource on Tungsha Island is very abundant. These seagrass beds must be conserved to ensure the sustainable management of Tongsha Island.

Keywords: Coverage; *Cymodocea rotundata*; *Cymodocea serrulata*; Pratas Island; Shoot density; *Syringodium isoetifolium*; *Thalassiodendron ciliatum*.

Introduction

Seagrasses are one of the most conspicuous communities of the shallow waters of the world. They comprise only about 50 species worldwide (Den Hartog, 1970), but this number is not indicative of their ecological and economic importance. Seagrass beds are among the most productive areas of aquatic ecosystems (Zieman and Wetzel, 1980). They are important in providing food resources (Klumpp et al., 1989), as well as nursery and feeding grounds, for invertebrates (Orth et al., 1996) and juvenile fishes (Bell and Pollard, 1989). Furthermore, they may help in stabilizing sediments and preventing coastal erosion and siltation of coral reefs (Fonseca and Fisher, 1986).

Knowledge of seagrass in Taiwan is little documented and very limited to the Henchun Peninsula. Five linear-leaf species and possibly two oval-leaf species of seagrass were first reported in Taiwan (Yang, 1978). We say "possibly" because a lack of available specimens raises doubt about the occurrence of some species. Using a remotely operated underwater vehicle, a new record of *Halophila decipiens* was found in the subtidal zone along the coast of the Henchun Peninsula (Mok et al., 1993). Later, Lin and Shao (1998) determined the area, abundance, and productivity of seagrasses in the intertidal zone of the Henchun Peninsula. They also documented seasonal changes in abundance and productivity of *Thalassia hemprichii* and found that wind speed and rainfall were most responsible for the observed seasonal pattern.

Seagrasses, together with mangroves and coral reefs, have a center of generic richness and diversity in the Indo-West Pacific (Fortes, 1989). In the South China Sea, Tongsha Island is the largest island of the Tungsha Atoll. No published information regarding seagrasses on Tongsha Island is available yet. Tongsha Island possesses large numbers of resident and migratory organisms (Fang and Lee, 1994). The coast of Tongsha Island is densely covered by diverse seagrass species. However, these seagrasses are poorly understood. Chian (1975) first found *Thalassia hemprichii* and *Halodule uninervis* on Tongsha Island. Lewis and Lin (1994) found five seagrass species on the island, including *Cymodocea* sp., *Halodule* sp., *Halophila ovalis*, *Syringodium isoetifolium*, and *Thalassodendron ciliatum*. At the same time, Huang et al. (1994) recorded *Halodule uninervis*, *Halophila ovalis*, *Syringodium isoetifolium*, and *Thalassia hemprichii* on the island. Despite this, no descriptions of these seagrasses were found. Species composition, abundance, and distribution of seagrasses on Tongsha Island remained unclear. The purpose of this study was to determine the species composition, abundance, and distribution of the seagrasses on Tongsha island. Four seagrass species new to Taiwan were also described.

Materials and Methods

Tongsha Island (20°42'N; 116°43'E), also known as Pratas Island, is located about 480 km southwest of Taiwan.

*Corresponding author. Tel: +886-4-22840416; Fax: +886-4-22874740; E-mail: hjlin@dragon.nchu.edu.tw

It is 2.80 km long and 0.87 km wide, with an area of 1.74 km^2. There is a lagoon in the western side of Tongsha Island, with only one inlet (20 m wide) permanently connecting it to the sea. The lagoon has a 0.64-km^2 surface area with a mean depth of < 1 m at low tide.

Tongsha Island is dominated by a tropical climate, with distinct dry and wet seasons. Maximum air temperature (about 29°C) often occurs in July, and the minimum (about 21°C) occurs in January (Dai and Chiau, 2003). During the dry season of October-May, when northeast winds prevail, mean monthly rainfall normally does not exceed 50 mm. From June to September, average monthly rainfall frequently exceeds 170 mm, when southwest winds bring considerable quantities of rain. Typhoons occur every year and bring strong winds and heavy rainfall during the wet season.

Seagrasses were surveyed underwater at nine study sites around Tongsha Island and the lagoon on 21~29 April, 2004 (Figure 1). The substrata at all sites were covered by sand and coral rubble.

A quadrat (50 cm × 50 cm) divided into 25 squares (10 cm × 10 cm) was randomly placed on each seagrass bed (five replicates), and the coverage in each of the 25 squares was scored using the classes developed by Saito and Atobe (1970). The percentage cover of seagrasses in each quadrat was estimated according to the weighted average of the scores of 25 squares following the methods of Saito and Atobe (1970). Shoot density of seagrasses was estimated simultaneously by five counts within five permanent squares (10 cm × 10 cm) in each quadrat when scoring the percentage cover. Specimens of seagrasses were deposited at the Department of Life Sciences, National Chung Hsing University.

Results

Total coverage area of the seagrass beds around Tongsha Island and in the lagoon was estimated to be 8.2 km^2. They were often found on fringing reefs. Spatial variations in the percentage cover of seagrasses were obvious (Table 1). The percentage cover at Sites #1 and #5 on the western coast averaged 95%, greater than that observed at other sites. No seagrass shoots were found at Site #7 outside the northern coast. In the lagoon, Site #8b in the outer region possessed greater coverage than Site #8a in the inner region. Percentage cover averaged 90% at Site #8b, but only 20% at Site #8a.

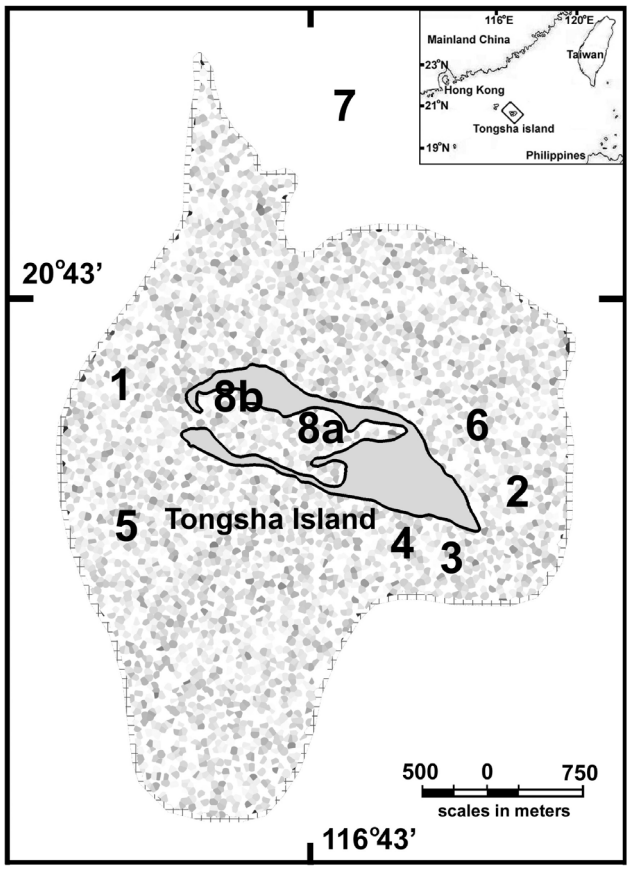

Figure 1. Study sites and the distribution of seagrasses delineated by the spots around Tongsha Island.

Table 1. Composition, abundance, and distribution of seagrasses at nine study sites on Tongsha Island. Shoot density: Abundance (A): > 2500 shoots m^{-2}; Common (C): 1250~2500 shoots m^{-2}; Occasion (O): < 1250 shoots m^{-2}.

Species\Site	#1	#2	#3	#4	#5	#6	#7	#8a	#8b
Potamogetonaceae									
Cymodocea serrulata	+			+		+			
Cymodocea rotundata	+		+	+	+	+			+
Syringodium isoetifolium	+	+	+	+	+				
Halodule uninervis	+	+	+	+	+			+	+
Thalassodendron ciliatum		+		+		+			
Hydrocharitaceae									
Halophila ovalis	+	+	+	+	+			+	
Thalassia hemprichii	+	+		+	+	+		+	+
Species number	6	5	4	7	5	4	0	3	3
Mean percentage cover	95	85	82	60	95	58	0	20	90
Mean shoot density	C	A	C	O	C	O	–	C	A

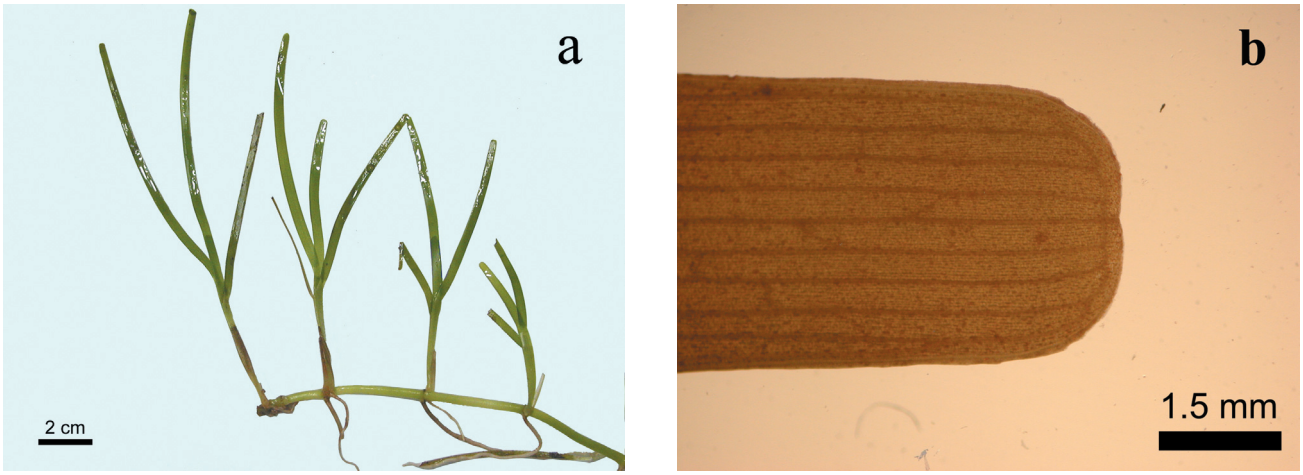

Figure 2. a, *Cymodocea rotundata* Ehrenb. et Hempr. ex Aschers and b, photomicrograph of the leaf tip.

The spatial pattern of shoot density was not consistent with that of coverage on Tongsha Island (Table 1). In general, shoot densities of seagrasses were high at all sites with the exception of Site #7. Mean shoot densities ranged from > 2500 shoots m^{-2} at Sites #2 and #8b to < 1250 shoots m^{-2} at Sites #4 and #6.

A total of seven seagrass species from six genera and two families were identified on Tongsha Island, including *Cymodocea serrulata*, *Cymodocea rotundata*, *Syringodium isoetifolium*, *Halodule uninervis*, *Thalassodendron ciliatum*, *Halophila ovalis*, and *Thalassia hemprichii* (Table 1). Among these species, *Thalassia hemprichii* and *Halodule uninervis* occurred among seven of the nine study sites and were the most frequently observed species. Nevertheless, *Cymodocea rotundata* and *Halodule uninervis* were most dominant in the subtidal zone of Tongsha Island. Seagrass species were most diverse at Site #4, in which all the seven species were present. In general, there were four to six seagrass species at sites around the coast of Tungsha island. However, only three species were collected at each site in the lagoon.

Among the identified seagrass species, four species were new records to Taiwan, including *Cymodocea rotundata* Ehrenb. et Hempr. ex Aschers., *Cymodocea serrulata* (R. Br.) Aschers. and Magnus, *Syringodium isoetifolium* (Aschers.) Dandy, and *Thalassodendron ciliatum* (Forsk.) den Hartog. They belong to Family Potamogetonaceae and their descriptions follow.

Cymodocea rotundata Ehrenb. et Hempr. ex Aschers. in Sitz.-Ber. Ges. Naturf. Fr. Berlin 1870: 84. 1870; den Hartog, The seagrasses of the world. 166-171, 1970.; Lanyon, Seagrasses of the Great Barrier Reef. 10-13, 1986. Figure 2

Material. The specimens were collected from Tongsha Island 23 April 2004 and deposited at the Department of Life Sciences, National Chung Hsing University, No: TCB 48517.

Diagnosis. Rhizome with a short erect lateral shoot at each node, bearing 2~7 leaves; leaf sheath well developed, 1.5~5.5 cm long, not shed along with the blade; closed circular scars on the shoot; ligule present; leaves linear, 7~15

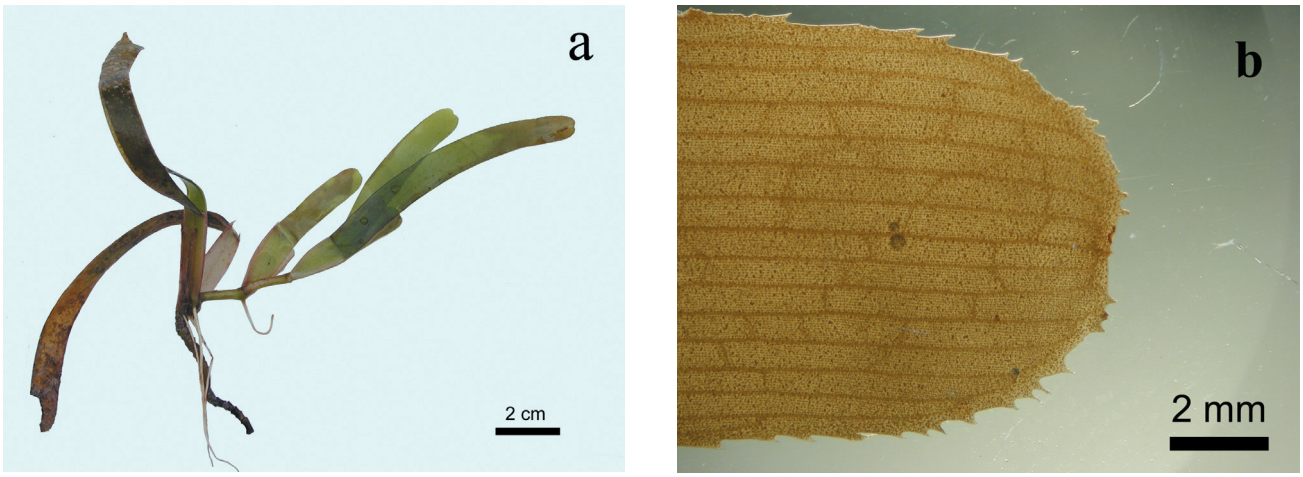

Figure 3. a, *Cymodocea serrulata* (R. Br.) Aschers. and Magnus and b, photomicrograph of the leaf tip.

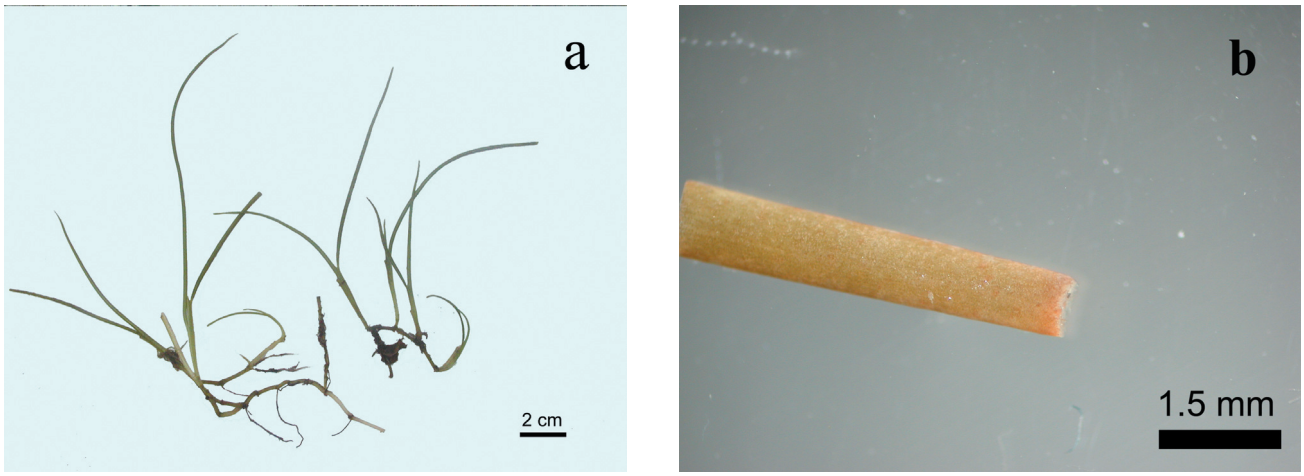

Figure 4. a, *Syringodium isoetifolium* (Aschers.) Dandy and b, photomicrograph of the leaf tip.

cm long, 2~4 mm wide; 7~15 longitudinal veins in the leaves with numerous tannin cells in circular-shaped aggregations; leaf tip bluntly rounded, slightly heart-shaped.

Cymodocea serrulata (R. Br.) Aschers. and Magnus in Sitz.-Ber. Ges. Naturf. Fr. Berlin 1870: 84. 1870; den Hartog, The seagrasses of the world. 171-176, 1970.; Lanyon, Seagrasses of the Great Barrier Reef. 14-15, 1986. Figure 3

Material. The specimens were collected from Tongsha Island 23 April 2004 and deposited at the Department of Life Sciences, National Chung Hsing University, No: TCB 48516.

Diagnosis. Rhizome with short, erect shoots and fibrous rootlets at each node, bearing 2~5 leaves; leaf sheath broadly triangular, narrowed at the base; open circular scars on the shoot; ligule present; leaves linear, 6~15 cm long, 4~9 mm wide; 13~17 longitudinal veins in the leaves with numerous tannin cells in circular-shaped aggregations; leaf tip bluntly rounded, distinctly serrated.

Syringodium isoetifolium (Aschers.) Dandy in J. Bot. 77: 116. 1939. den Hartog, The seagrasses of the world. 177-183, 1970.; Lanyon, Seagrasses of the Great Barrier Reef. 34-35, 1986. Figure 4

Material. The specimens were collected from Tongsha Island 23 April 2004 and deposited at the Department of Life Sciences, National Chung Hsing University, No: TCB 48518.

Diagnosis. Rhizomes thin, with a short erect shoot at each node, bearing 2~3 leaves; leaf sheath 1.5~4.0 cm long; ligule present; leaves round in cross-section, thin, 1~2 mm diameter, narrowed at the base, gradually tapering off to a point at the leaf tip, 7~30 cm long.

Thalassodendron ciliatum (Forsk.) den Hartog *nov. comb.* in The seagrasses of the world, 188-194, 1970; Lanyon, Seagrasses of the Great Barrier Reef. 38-39, 1986. Figure 5

Material. The specimens were collected from Tongsha Island 24 April 2004 and deposited at the Department of

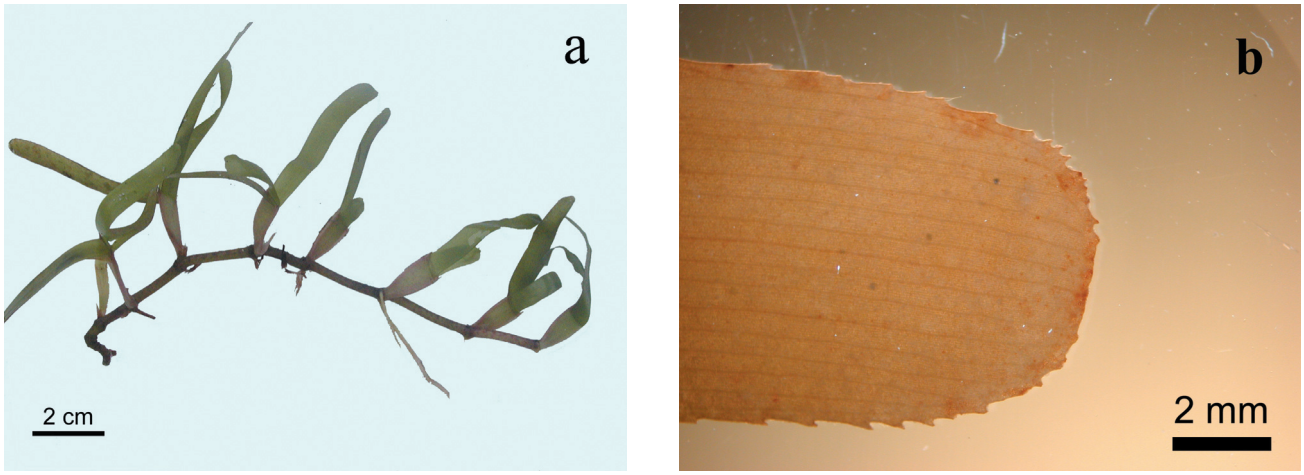

Figure 5. a, *Thalassodendron ciliatum* (Forsk.) den Hartog and b, photomicrograph of the leaf tip.

Life Sciences, National Chung Hsing University, No: TCB 48520.

Diagnosis. Rhizomes tough, woody, up to 5 mm thick; scars on the rhizome between successive erect shoots; leaf sheath wide, compressed; leaf base shed with the leaf; ligule present; erect shoots elongate, 10~65 cm long; a cluster of ribbon-like, sickle-shaped leaves; leaves narrowed at the base, 10~15 cm long, 0.5~1.4 cm wide; 17~27 longitudinal veins in the leaves; roots coiled, branched from the internode preceding the shoot; leaf tip rounded, forked with numerous denticulate.

Discussion

This is the first study to determine species composition, abundance, and distribution of seagrasses on Tongsha Island. Seagrasses comprise only about 50 species worldwide (den Hartog, 1970). A total of nine seagrass species from seven genera and five families has been recorded in Taiwan (Yang, 1978; Mok et al., 1993) though the occurrence of some species remains uncertain. After a whole-island survey, a total of seven seagrass species from six genera and two families were determined on Tongsha Island. The seagrass species reported for the Indo-West Pacific region were summarized by Fortes (1989). For example, in Ryukyu Island, six seagrass species were reported. The Philippines has the second highest number of seagrass species in the world, with 16 recorded. In Hong Kong, only four species are known. The species number and composition of seagrasses observed on the island were comparable and similar to those reported for the Indo-West Pacific region (Fortes, 1989). The species number of seagrasses collected on Tongsha Island was 14% of the total species number in the world. Our results showed that although Tongsha is a small island (1.74 km^2), the seagrasses are rather diverse as compared to the relatively long-coastlines of Taiwan, Hong Kong, and Ryukyu Island.

In order to evaluate the resource potential of seagrasses, their coverage area must be determined. Although the area of Tongsha Island is only 1.74 km^2, the seagrass beds covered about 8.2 km^2, about five times the area of the island. In Taiwan, the largest seagrass beds were found at Dakwan and Nanwan along the coast of the Henchun Peninsula, southern Taiwan. Each seagrass bed covered only 0.004 and 0.003 km^2, respectively (Lin and Shao, 1998). The total area of seagrass beds of Tongsha Island is about 1000 times that of Taiwan.

The coverage and shoot density of seagrasses on Tongsha Island was within the range observed for tropical seagrass beds in northeastern Australia (Lanyon and Marsh, 1995) and in Indonesia (Erftemeijer and Herman, 1994), respectively. In southern Taiwan, Lin and Shao (1998) showed that the percentage cover of seagrasses was 10~50%, and the shoot density was 200 ~1000 shoot m^{-2}. The coverage and shoot density levels on Tongsha Island were about two and three times those reported in southern Taiwan, respectively.

In summary, the large area of the seagrass bed, the high coverage and shoot density of seagrasses, and the diverse species of Tongsha Island indicate that the seagrass resource is very abundant. These seagrass beds must be conserved to ensure the sustainable management of Tongsha Island.

Acknowledgments. This study was supported by the National Science Council under Grant NSC92-3114-B-291-001. We are grateful to Dr. J.-P. Chen, Dr. S.-M. Lin, and the Coast Guard Administration of Taiwan, ROC at Tongsha Island for field assistance.

Literature Cited

Bell, J.D. and D.A. Pollard. 1989. Ecology of fish assemblages and fisheries associated with seagrasses. *In* A.W.D. Larkum, A.J. McComb, and S.A. Shepherd (eds.), Biology of Seagrasses. A Treatise on the Biology of Seagrasses with Special Reference to the Australian Region. Aquatic Plant Studies 2. Elsevier, Amsterdam, pp. 565-609.

Chian, Y.M. 1975. The investigation report of the Tongsha Islands, II Marine flora. Institute of Oceanography, National Taiwan University, Taipei, pp. 16-20. (in Chinese)

Dai, C.F. and W.Y. Chiau. 2003. The feasibility assessment and planning of the Tungsha Islands as marine protected areas. Taiwanese Coral Reef Society, Taipei, 81 pp. (in Chinese)

Erftemeijer, P.L.A. and P.M.J. Herman. 1994. Seasonal changes in environmental variables, biomass, production and nutrient contents in two contrasting tropical intertidal seagrass beds in South Sulawesi, Indonesia. Oecologia **99:** 45-59.

Fong, L.S. and C.C. Lee (eds.). 1994. The research report of ecological and environmental survey in the South China Sea. The Council of Agriculture of Taiwan, R. O. C., Taipei, 471 pp. (in Chinese)

Fonseca, M.S. and J.S. Fisher. 1986. A comparison of canopy friction and sediment movement between four species of seagrass with reference to their ecology and restoration. Mar. Ecol. Prog. Ser. **29:** 15-22.

Fortes, M.D. 1989. Seagrasses: a Resource Unknown in the ASEAN Region. ICLARM Education Series 5, Manila, 46 pp.

Den Hartog, C. 1970. The Seagrasses of the World. North-Holland, Amsterdam, 275 pp.

Huang, T.C., H.F. Huang, and C.H. Hsieh. 1994. The terrestrial floral ecology of Tungsha Island. *In* L.S. Fong and C.C. Lee (eds.), The Research Report of Ecological and Environmental Survey in the South China Sea. The Council of Agriculture of Taiwan, R. O. C., Taipei, pp. 433-442. (in Chinese)

Klumpp, D.W., R.K. Howard, and D.A. Pollard. 1989. Trophodynamics and nutritional ecology of seagrass communities. *In* A.W.D. Larkum, A.J. McComb, and S.A. Shepherd (eds.), Biology of Seagrasses. A Treatise on the Biology of Seagrasses with Special Reference to the Australian region. Aquatic Plant Studies 2. Elsevier, Amsterdam, pp. 394-457.

Lanyon, J. 1986. Seagrasses of the Great Barrier Reef. Great Barrier Reef Marine Park Authority, Special Publication Series 3. Townsville, Australia, 54 pp.

Lanyon, J.M. and H. Marsh. 1995. Temporal changes in the abundance of some tropical intertidal seagrasses in North

Queensland. Aquat. Bot. **49:** 217-237.

Lewis, J.E. and S.M. Lin. 1994. The benthic marine algal flora of the Tungsha Islands. *In* L.S. Fong and C.C. Lee (eds.), The Research Report of Ecological and Environmental Survey in the South China Sea. The Council of Agriculture of Taiwan, R. O. C., Taipei, pp. 127-143. (in Chinese)

Lin, H.J. and K.T. Shao. 1998. Temporal changes in the abundance and growth of intertidal Thalassia hemprichii seagrass beds in southern Taiwan. Bot. Bull. Acad. Sin. **39:** 191-198.

Mok, H.K., J.D. Lee, and C.P. Lee. 1993. A new record of seagrass, *Halophila decipiens* Ostenfeld (Hydrocharitaceae), in Taiwan. Bot. Bull. Acad. Sin. **34:** 353-356.

Orth, R.J., J. van Montfrans, R.N. Lipcius, and K.S. Metcalf. 1996. Utilization of seagrass habitat by the blue crab, *Callinectes sapidus* Rathbun, in Chesapeake Bay: A review. *In* J. Kuo, R.C. Phillips, D.I. Walker, and H. Kirkman (eds.), Seagrass Biology. Proceedings of an international workshop. Rottnest Island, Western Australia, pp. 213-224.

Saito, Y. and S. Atobe. 1970. Phytosociological study of intertidal marine algae. I. Usujiri Benten-Jima, Hokkaido. Bulletin of the Faculty of Fisheries, Hakkaido University **21:** 37-69.

Yang, Y.P. 1978. Hydrocharitaceae, Ruppiaceae, Zannichelliaceae and Zosteraceae. *In* H.L. Li, T.S. Liu, T.C. Huang, T. Koyama, C.E. Devol (eds.), Flora of Taiwan. Vol. V, Monocotyledon. Epoch, Taipei, pp. 14-35.

Zieman, J.C. and R.G. Wetzel. 1980. Productivity in seagrasses: methods and rates. *In* R.C. Phillips and C.P. McRoy (eds.), Handbook of Seagrass Biology. Garland STPM, New York, pp. 87-116.

東沙島海草種類與豐度，兼記四種台灣新紀錄種

林幸助　謝莉顒　劉弼仁

國立中興大學生命科學系

本報告為作者於 2004 年 4 月 22-29 日至東沙島潛水全面普查海草之結果。本次調查在東沙島四周共調查 8 個測站，確認 2 科 6 屬 7 種海草，其中有 4 種在台灣地區海域未曾紀錄過，包括圓葉水絲草（*Cymodocea rotundata*）、鋸齒葉水絲草（*Cymodocea serrulata*）、水韭菜（*Syringodium isoetifolium*）與鐮葉叢草（*Thalassiodendron ciliatum*）。東沙海草種類佔全球種類數的 14%。東沙島週遭及潟湖內遍布海草，估計海草床面積為 8.2 km^2，平均覆蓋度 20~95%，平均植株密度 < 1250~ > 2500 shoot m^{-2}。研究結果均顯示東沙島的海草不僅種類多，多樣性高，草床面積大，豐富度亦高，需及早規劃東沙島成為海洋國家公園加以保護此國家珍貴自然資產。

關鍵詞：覆蓋度；圓葉水絲草；鋸齒葉水絲草；植株密度；水韭菜；鐮葉叢草。