THREE NEW SPECIES OF *SARGASSUM* (SARGASSACEAE, FUCALES) FROM VIETNAM

Nguyen Huu Dai

Abstract

Three new species of *Sargassum* from Vietnam, descriptions of which were previously published in Vietnamese, are redescribed in English, including collections of the species added since 1997. *Sargassum cotoense* has slender thalli, thick leaves, and very narrow, nearly terete, solitary, and monoecious receptacles. *Sargassum phamhoangii* has long leaves, longer than its lateral branches, and solitary and dioecious receptacles. *Sargassum quinhonense* is special because of its phyllocysts and vesicles with earlike expansions. It differs from *S. herklotsii* Setchell, first described from Hong Kong, in the shape of the leaves and receptacles.

Introduction

In the mid-19th century, species of *Sargassum* from Vietnamese waters were collected and identified by European researchers such as Gaudichaud and Busseuil. Almost all of those collections were deposited in the Muséum National d'Histoire Naturelle (Paris, PC). More than 100 years passed before Dawson (1954) published an extensive article on the marine flora in the vicinity of the Institute of Oceanography in Nha Trang, central Vietnam. Pham Hoang Ho (1969), who also studied at the Institute of Oceanography, published an article on the general flora, similar to that of Dawson's and describing more species. In 1993, Nguyen Huu Dinh et al. published a book on the marine algae of North Vietnam that contains descriptions of some species of *Sargassum* not previously listed.

Publications on *Sargassum* in Vietnam are nearly as numerous as those that deal with all other elements of the marine flora. Vietnamese authors are led by Pham Hoang Ho (1967), who contributed a very comprehensive article on the species in Vietnam. More recently, Nguyen Huu Dai (1997), Nguyen Huu Dinh, and Huynh Quang Nang were coauthors of articles on Vietnamese *Sargassum* published in 1995 (Ajisaka et al.), 1997 (Ajisaka, Huynh, Nguyen, Lu, Chiang, and Yoshida 1997; Ajisaka, Huynh, Nguyen, Lu, Put, et al. 1997; Ajisaka, Huynh, Nguyen, and Yoshida 1997); and 1999 (Nguyen and Huynh). The 1995, 1997, and 1999 contributions were published in the *Taxonomy of Economic Seaweeds* series. Because of the difficulties of exchanges and loans for comparison of specimens with materials in other herbaria of the world, progress was very slow. The eighth Sea Grant workshop on taxonomy of economic seaweeds was the best opportunity for reexamination and discussion of our specimens.

The following material is based on the publication *Sargassaceae in Vietnam: Resources and Utility* by Nguyen Huu Dai (1997). New materials of *Sargassum* have been collected since 1968 by Huynh Quang Nang in Quang Ninh Province in

the north and since 1982 by Nguyen Huu Dai in Quang Nam, Quang Ngai, and Binh Dinh provinces in central Vietnam (Fig. 1).

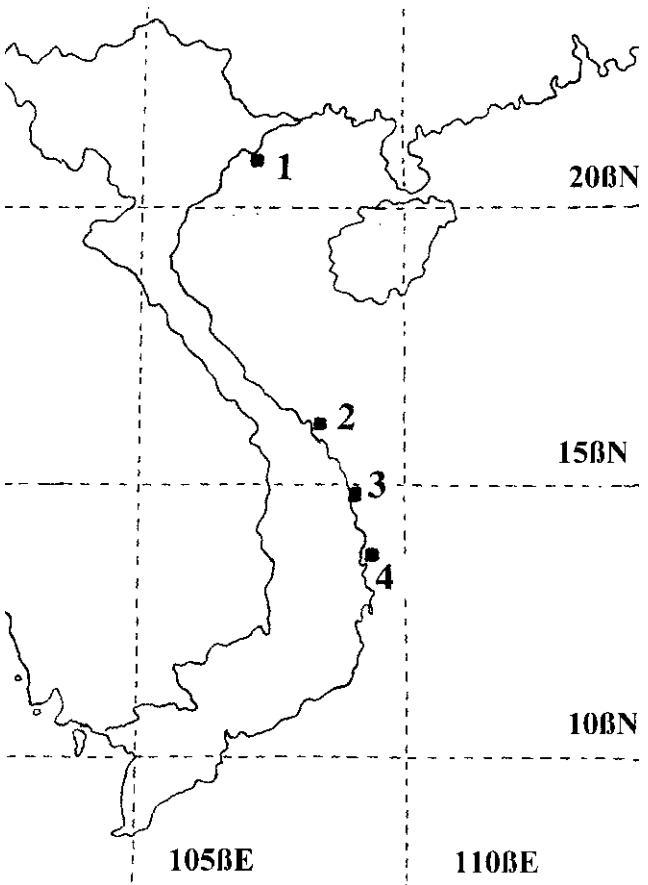

Fig. 1. Map of Vietnam with collecting places numbered. 1 indicates Quang Ninh Province (Co To Island); 2, Quang Nam Province, Da Nang City (Nam O); 3, Quang Ngai Province (Ly Son Island); 4, Binh Dinh Province, Quy Nhon City (Ganh Rang).

Description of the Species

Sargassum cotoense Nguyen Huu Dai, sp. nov.
(Figs. 2–4)

Planta flavobrunnea in sicco. Thallus plerumque ad 30–40 cm altus, filiformis; haptero discoidea-conico circa 1 cm diametro. Caulis brevis, teres, 3 mm longus, 2–4 primariis ramis cylindricis, levibus, circa 1 mm diametro. Folia brevia, crassa, folia prope basim 3 cm longa, 0.7 mm lata, folia ramulorum breviora circa 0.4 mm lata, cylindriforma, margine integro, cyptostomatibus non conspicuibus, costa conspicua. Vesiculae obovatae 2–5 mm diametro, aliquando spina longa obtusa acuta ad apicem, petiolo cylindricae tam longo quam vesicula.

Planta monoica. Receptacula fusiformia, minuta, solitaria ad folii axillam, circa 2 mm longa.

Holotype: 68550, collected by Huynh Quang Nang, April 30, 1968, from Co To Island, Quang Ninh Province. Deposited in the herbarium of the Institute of Oceanography, Nha Trang, Vietnam.

Plants yellow-brown, filiform, up to 30–40 cm tall, attached to substratum by conical discoid holdfast about 1 cm in diameter. Stem very short, terete, 3 mm long, usually bearing 2 to 4 primary branches from its upper part; secondary branches terete, smooth, alternately arising from the foliar axil of primary branches, up to 20 cm long. Leaves thick and very narrow, nearly cylindrical, up to 3 cm long, 0.7 mm wide on primary branches, only 0.4 mm wide on branchlets, margins entire, midrib not apparent, cryptostomata conspicuous, vesicles obovate, 2–5 mm in diameter, sometimes with an obtuse and long spine at the apex, petioles cylindrical, as long as vesicles.

Plants monoecious. Receptacles small, fusiform, solitary at the base of small leaves, warty, about 2 mm long.

Other Specimens Examined: 68053, 68054, and 68055, collected by Huynh Quang Nang, May 30, 1968, from Co To Island, Quang Ninh Province.

Habitat: Growing on intertidal and subtidal rocks.

Etymology: Named for the type locality, Co To Island.

Sargassum phamhoangii Nguyen Huu Dai, sp. nov.
(Figs. 5–6)

Planta atrobrunnea in sicco. Thallus plerumque ad 0.5–1 m altus, colligatus ad substratum, haptero discoideo-conico circa 1 cm diametro. Caulis cylindricus, brevis, circa 5 mm altus. Principalis ramus cylindricus, levis, circa 1 mm diametro. Secundarius ramus teres et levis. Folia principalium ramorum lanceolata, crassa 5 mm lata, 12 cm longa, aliquando usque 20 cm, longiora quam secundarii rami, margine integro aut pouches spinis obtusis, costa non conspicua, cyptostomatibus non conspicuus. Folia ramorum secundariorum, et terminalium angusta, 2–4 mm

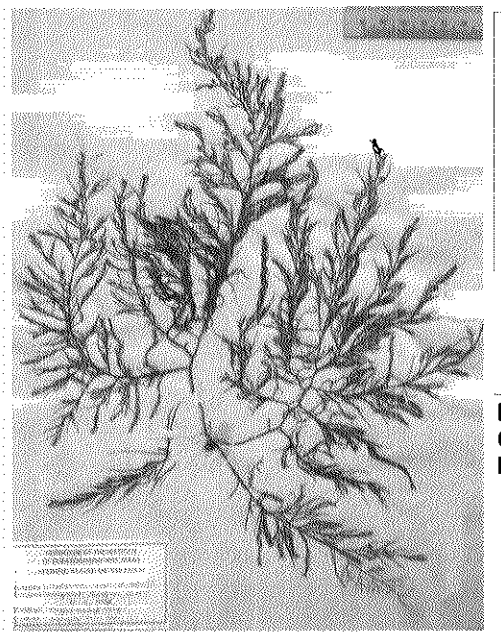

Fig. 2. *Sargassum cotoense* sp. nov. Habit of plant showing several erect axes with spiraling branching pattern.

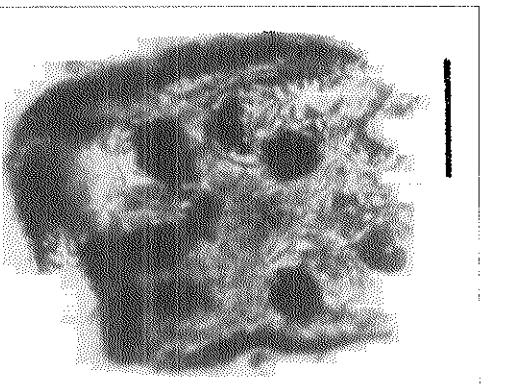

Fig. 3. *Sargassum cotoense* sp. nov. Cross section of female receptacle. Scale bar = 20 μm.

lata. Vesiculae obovatae aut ovato-oblongae, 2–3 mm diametro, aliquando spina longa ad apicem, petiolo cylindrico et brevi.

Planta dioica. Receptacula fusiformia, solitaria ad folii axillam, dura, aliquando furcata, 3–5 mm longa.

Holotype: 82107, collected by Nguyen Huu Dai, May 4, 1982, from Nam O, Da Nang. Deposited in the herbarium of the Institute of Oceanography, Nha Trang.

Plants dark brown, up to 0.5–1 m tall. Holdfast small, conical, discoid, about 1 cm in diameter, with a short stem, 5 mm tall. Primary branches terete, filiform, smooth, cylindrical, and erect, about 1 mm diameter; secondary branches terete, smooth, arranged alternately along primary branches at irregular intervals. Leaves linear-lanceolate, relatively thick, leaves on primary branches 5 mm wide, 12 cm long, sometimes up to 20 cm or more long, longer than the secondary branches, petiole long and slender, margins entire or with few obtuse spines; midrib and cryptostomata not clearly visible; leaves on secondary and terminal branches narrow, 2–4 mm wide. Vesicles obovate to ovate-oblong, 2–3 mm in diameter, sometimes with a long spine at the apex, petiole short, cylindrical.

Plants dioecious. Receptacles fusiform, warty, solitary at the base of small leaves, sometimes forked, 3–5 mm long.

Other Specimens Examined: Female plants collected at Nam O, Da Nang, by

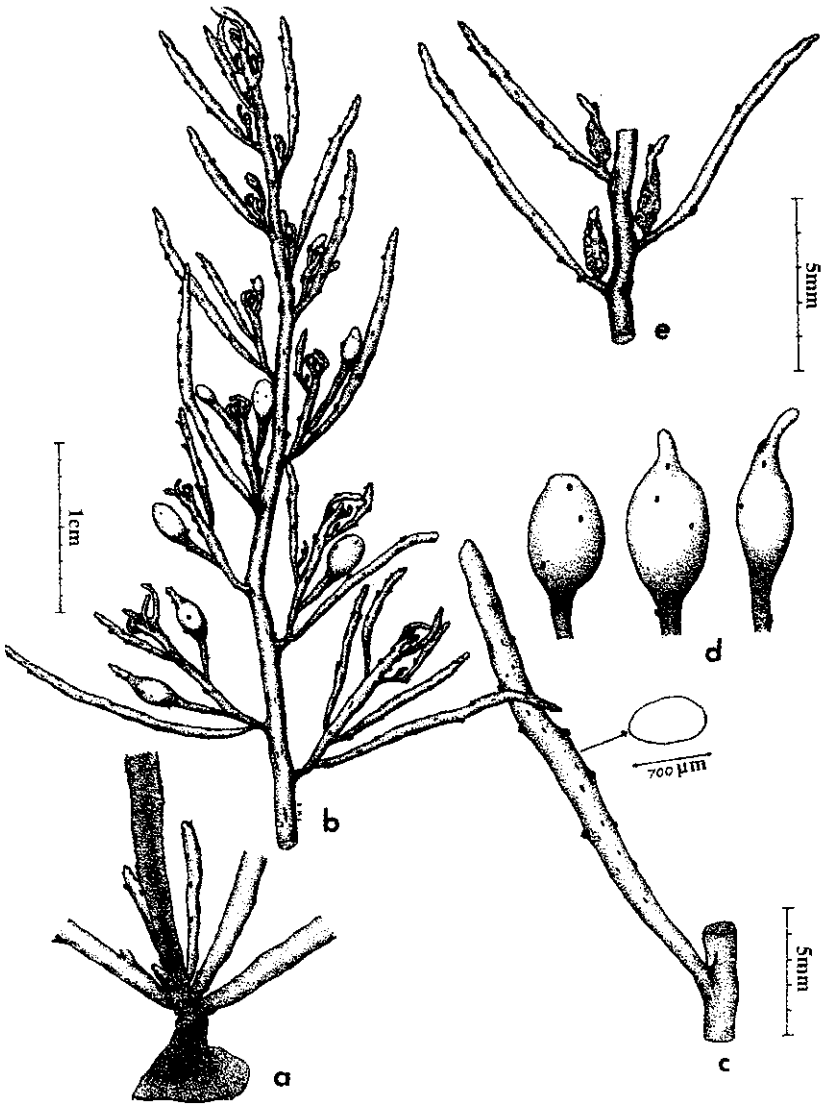

Fig. 4. *Sargassum cotoense* sp. nov. a, Holdfast. b, Habit. c, Terete to slightly compressed stems. d, Vesicles. e, Small monoecious receptacles at bases of leaves.

Nguyen Huu Dai: 82109, 82110, and 82114, collected May 4, 1982, and 83111, collected May 15, 1983.

Habitat: Growing on subtidal rocks.

Etymology: Named for Dr. Pham Hoang Ho, the first Vietnamese botanist who

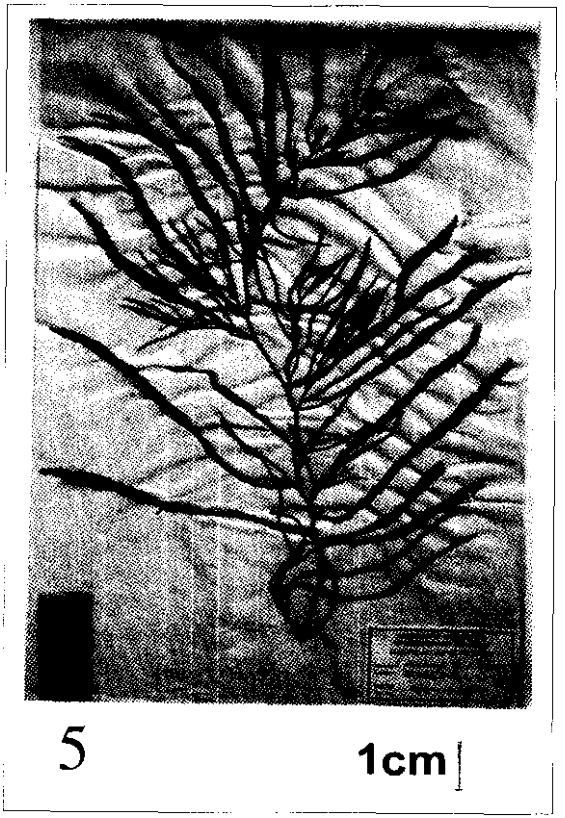

Fig. 5. *Sargassum phamhoangii* sp. nov. Habit of plant showing very long leaves, longer than lateral branches.

Fig. 6. *Sargassum phamhoangii* sp. nov. a, Shape of very long leaf. b, Shape of vesicles. c, Branchlet with female receptacles.

left a rich legacy of studies of both the flowering plants of Vietnam and marine algae.

Sargassum quinhonense Nguyen Huu Dai, sp. nov.
(Figs. 7–9)

Planta brunnea vel atrobrunnea in sicco. Thallus plerumque ad 0.8–1 m altus, colligatus ad substratum haptero discoidea circa 1.5 cm diametro. Caulis cylindricus, brevis, 2–3 mm longus. Principalis ramus cylindricus, levis, 1 mm diametro. Secundarius ramus ex axillis foliaribus rami principalis, alternatus, cylindricus et levis, ad 20 cm longus. Folia principalis rami lanceolata, usque 5–8 cm longa, 0.5–1.0 cm lata, apice obtuso, margine integro, vel parce denticulatato, petiolo longo et gracili. Vesiculae obovatae aut ovato-oblongae, 0.5–1 cm diametro, biauriculatae.

Planta dioica. Receptacula solitaria, aut racemosa ad axillam locata; feminea receptacula triquetra, 3.5 mm long, spinulis obtusis ad margines et apicem.

Holotype: 83243, collected by Nguyen Huu Dai, April 10, 1983, from Ganh Rang, Quy Nhon, Binh Dinh Province. Deposited at the herbarium of Institute of Oceanography, Nha Trang.

Plants brown to dark brown, up to 0.8–1 m tall, attached strongly to substratum by a discoid holdfast about 1.5 cm in diameter. Stem very short, 2–3 mm long, usually 2–4 primary branches arising from its upper part. Primary branches filiform, terete, smooth, about 1 mm in diameter; secondary branches arising from the foliar axils of primary branches, alternate, cylindrical, smooth, up to 20 cm long. Leaves relatively thick, lanceolate; leaves on primary branches 5–8 cm long, 0.5–1 cm wide; leaves on branchlets 3–4 cm long, 0.3–0.5 cm wide, obtuse at the apex, margins entire or very slightly and sparsely denticulate, petiole long and slender, midrib apparent, cryptostomata scattered irregularly, arranged on both sides of the midrib. Vesicles obovate to oblong-ovate, 0.5–1 cm in diameter; phyllocysts expanded into earlike appendages, often located at the apex of leaves, phyllocysts in branchlets smaller and usually earlike.

Plants dioecious. Receptacles solitary or 2–3 racemosely arranged; female receptacles triquetrous, 3–5 mm long, with some obtuse spinules at the apex and margins. Male plants not found.

Other Specimens Examined: All collected by Nguyen Huu Dai. From Quang Ngai, Ly Son Island: 82189 and 82190, female plants, collected May 18, 1985. From Ganh Rang, Binh Dinh: 82060, female plant, collected May 10, 1982; 83247, female plant, collected April 25, 1983; 83246, female plant, collected May 10, 1983; 8507, female plant, collected May 14, 1985; 83247 and 83248, nonfertile plants, collected April 25, 1983; and 85073, nonfertile plant, collected May 14,1985.

Habitat: Growing on subtidal rocks from February to May in areas of strong waves.

Fig. 7. *Sargassum quinhonense* sp. nov. Habit of plant.

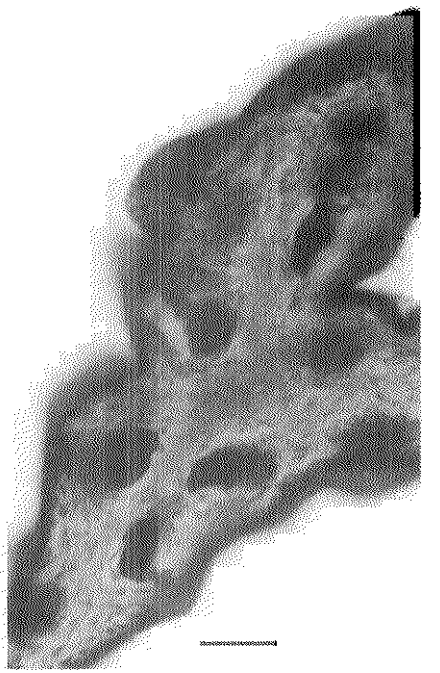

Fig. 8. *Sargassum quinhonense* sp. nov. Cross section of female receptacle. Scale bar = 20μm.

Etymology: Named for Quy Nhon City, near the type locality.

Acknowledgments

I thank Dr. Isabella Abbott, University of Hawaii, for reading and carefully editing this manuscript, and Dr. Karla McDermid, University of Hawaii, Hilo, for correcting the Latin descriptions. I am grateful to Dr. Hoang Quoc Truong, Faculty of Biology, Saigon University, for the Latin that describes these new species. Thanks to Dr. C. K. Tseng, Mr. Lu Baoren, Dr. T. Yoshida, Dr. T. Noro, and Dr. T. Ajisaka for reexamination of our specimens and for helping me with the characterization.

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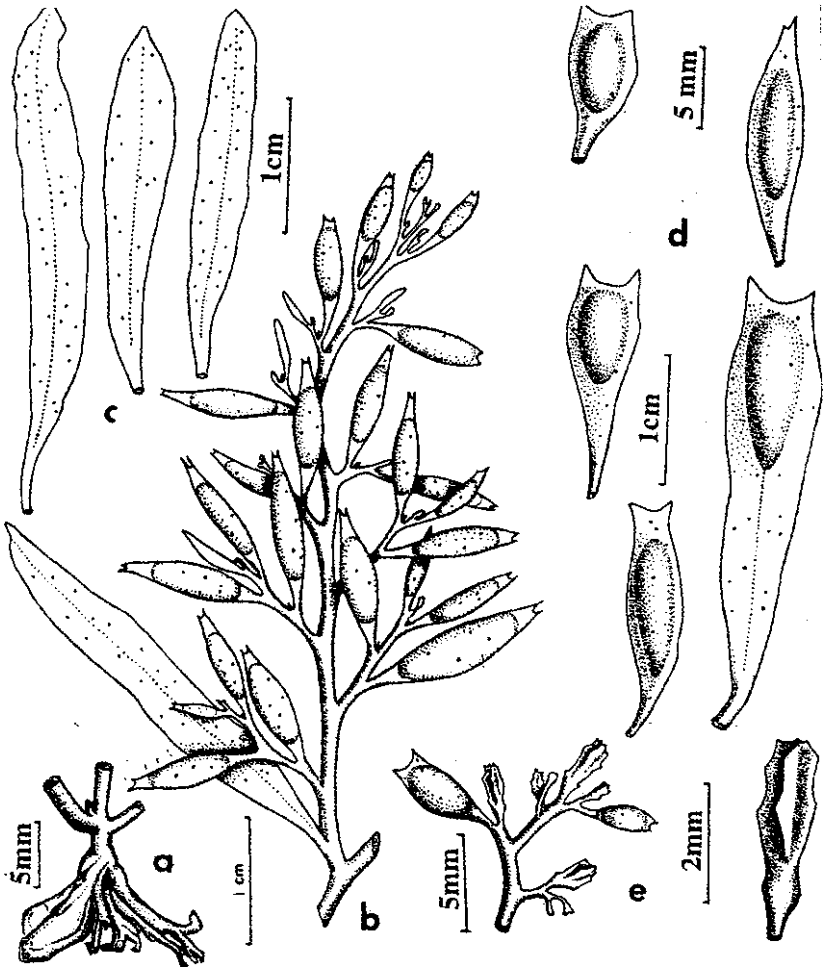

Fig. 9. *Sargassum quinhonense* sp. nov. a, Holdfast. b, Young secondary branches. c, Leaves. d, Vesicles with expanded margins. e, Female receptacle.

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SARGASSUM SPECIMENS WITH BULBOUS STRUCTURES FROM CHINA, VIETNAM, AND BAHRAIN

Tetsuro Ajisaka, C.K. Tseng, Lu Baoren, Nguyen Huu Dai, and Tadao Yoshida

Abstract

Several *Sargassum* specimens with bulbous structures from China, Vietnam (the South China Sea), and Bahrain (the Arabian Sea) were examined and their morphological characters compared. The function of bulbous structures is discussed, and a temporary name, "*perennis*," is given to distinguish these plants. A new variety name will be required.

Introduction

Sargassum bulbiferum Yoshida has been described on the basis of specimens collected in the Sea of Japan (Yoshida 1994). This species grows on rocks at a depth of 15–18 m and is characterized by the formation of short, thick bulbous structures, which were found for the first time in the genus *Sargassum*.

However, several *Sargassum* specimens with bulbous structures from China, Vietnam (the South China Sea), and Bahrain (the Arabian Sea) were recently found. The bulbous structure, also called "fusiform structure" (Yendo 1907) and "tophulose structure" (= tophule) (Roberts 1977), is well known in several species of the genus *Cystoseira* (e.g., *C. hakodatensis*, *C. elegans*, *C. spinosa*, *C. zosteroides*, and *C. nodicaulis*), but it has been reported only in *S. bulbiferum* in the genus *Sargassum*.

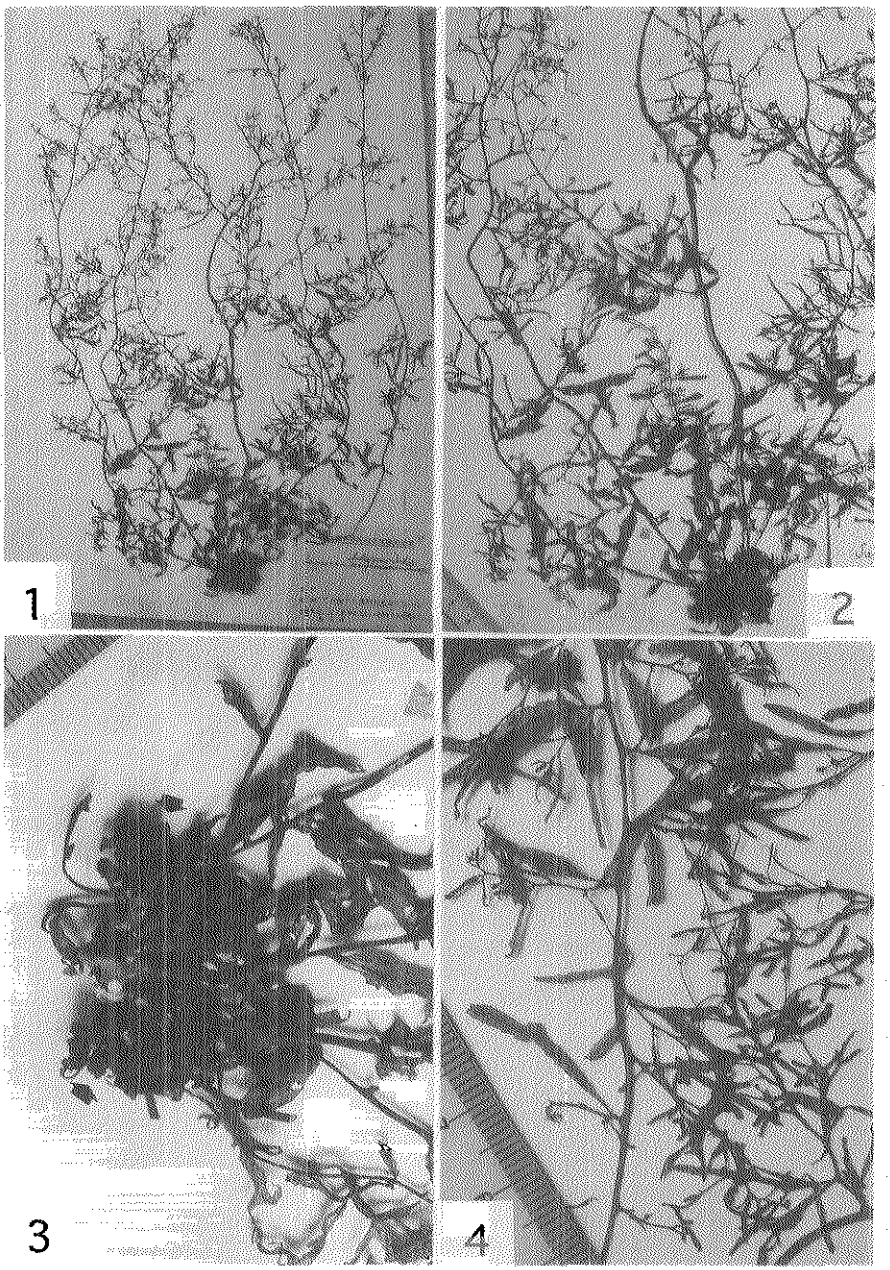
In this chapter, we provide morphological descriptions of the *Sargassum* specimens with bulbous structures from China, Vietnam, and Bahrain and compare their characters with those of the type specimens of *S. bulbiferum*. We also discuss the function of bulbous structures and the taxonomic treatment of the specimens that bear bulbous structures. The terminology for various parts follows that of Yoshida (1983).

Specimens From China

Specimen AST 55-1830. Collected April 28, 1955, from Weizhou Island, Guangxi Province, China.

(Figs. 1–4)

Holdfast discoid, up to 8 mm in diameter. Stem cylindrical, 5 mm tall, 2 mm in diameter. Main branches arising radially from the apex of the stem, 40 cm or more long, slightly compressed, up to 2 mm wide in the basal part, cylindrical distally, smooth on the surface, with alternate leaves; secondary branches 8 cm or more long; short, thick bulbous structures formed from the stem, about 6 mm long, 3 mm in diameter. Leaves on the lower parts of main branches lanceolate, up to 3



Figs. 1–4. *Sargassum bulbiferum* from China (AST 55-1830). Fig. 1, Whole plant. Fig. 2, Basal part of plant. Fig. 3, Holdfast with bulbous structures (arrows). Fig. 4, Upper branchlets with leaves and receptacles.

cm long, 5 mm wide, entire or with sparse and small denticulations on the margin, midrib reaching the apex; leaves on the distal parts of main and secondary branches linear, becoming narrower and shorter; leaves often 1–3 times forked; cryptostomata very small, scattered on the surface of leaves; vesicles spherical, with round apex, without appendages, 4 mm in diameter, with cylindrical petioles up to 5–8 mm long.

Plant monoecious. Receptacles androgynous, slender, cylindrical to fusiform, up to 5 mm long, up to 0.8 mm in diameter, 1–2 times forked, without spines, pseudozygocarpic.

Specimen AST 55-1922. Collected April 28, 1955, from Weizhou Island, Guangxi Province, China. [*Sargassum bulbiferum* Yoshida]

(Figs. 5–8)

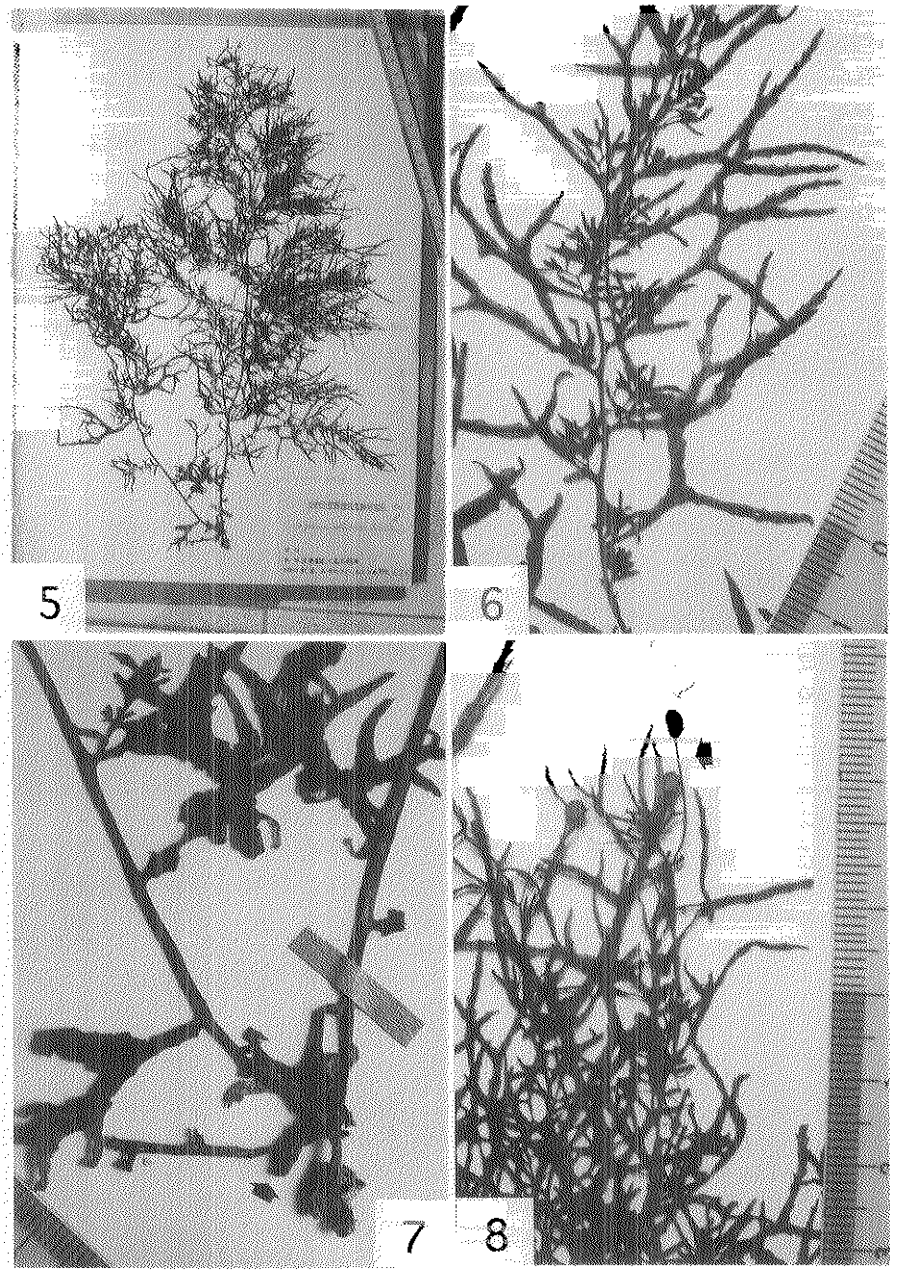
Holdfast discoid, up to 5 mm in diameter. Stem cylindrical, 6 mm tall, 2 mm in diameter. Main branches arising radially from the apex of the stem, 37 cm or more long, slightly compressed, up to 2 mm wide in the basal part, cylindrical distally, smooth on the surface, with alternate leaves; secondary branches 14 cm or more long; short, thick bulbous structures formed from the stem, about 5 mm long, 2 mm wide. Leaves on the lower parts of main branches lanceolate, up to 5 cm long, 5 mm wide, entire or with sparse and small denticulations on the margin, papyraceous, midrib reaching the apex; leaves on the distal parts of main and secondary branches finer in texture, becoming narrower and shorter; leaves often 1–4 times forked; cryptostomata very small, scattered on the surface of leaves; vesicles spherical, with round apex, without appendages, 3 mm in diameter, with cylindrical petioles up to 5–8 mm long, sometimes longer, up to 17 mm.

Plant monoecious. Receptacles androgynous, slender, cylindrical to fusiform, up to 6 mm long, up to 0.8 mm in diameter, 1–3 times forked, without spines, pseudozygocarpic.

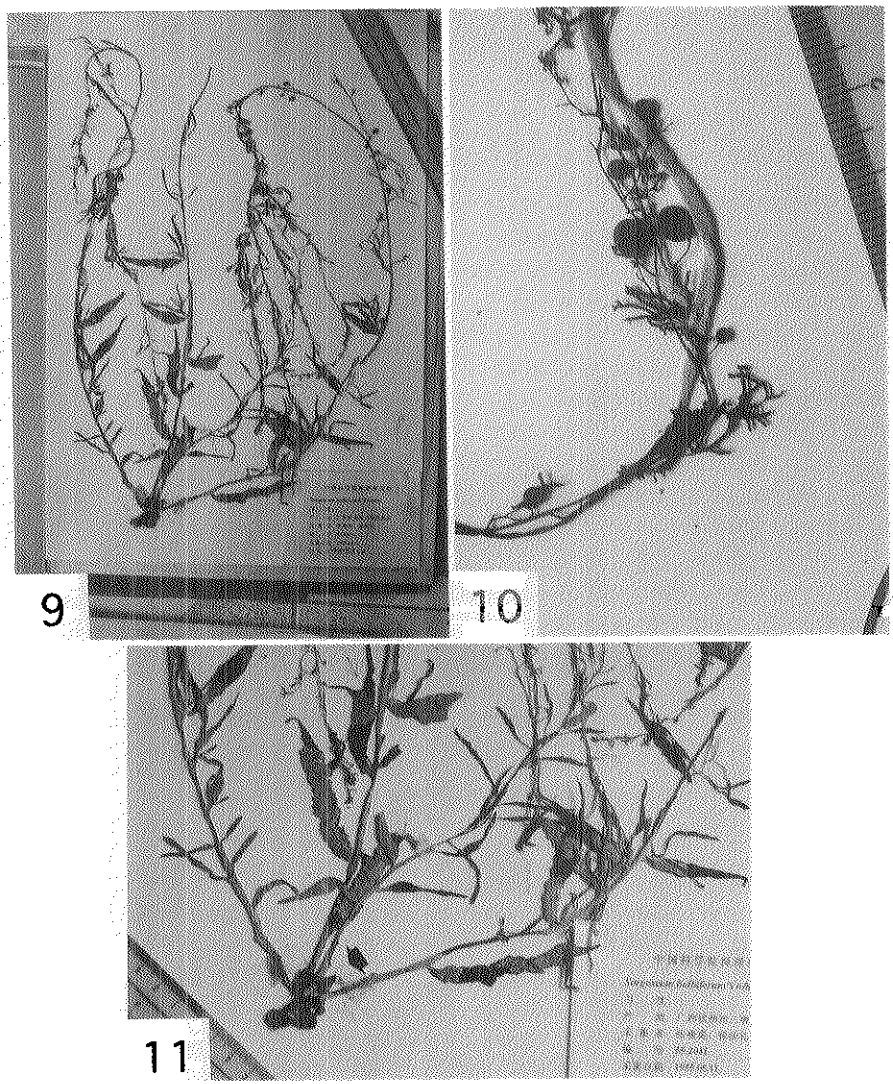
Specimen AST 55-2041. Collected May 11, 1955, from Qinzhou Bay, Guangxi Province, China. [*Sargassum bulbiferum* Yoshida]

(Figs. 9–11)

Holdfast discoid, up to 5 mm in diameter. Stem cylindrical, 15 mm tall, 2 mm in diameter. Main branches arising radially from the apex of the stem, 40 cm or more long, slightly compressed, up to 3 mm wide in the basal part, cylindrical distally, smooth on the surface, with alternate leaves; secondary branches 5 cm or more long; short, thick bulbous structures formed from the stem, about 10 mm long, 4 mm in diameter. Leaves on the lower parts of main branches linear to linear-lanceolate, up to 7 cm long, 9 mm wide, entire or with sparse and small denticulations on the margin, midrib reaching the apex; leaves on the distal parts of main and secondary branches linear, becoming narrower and shorter; leaves often 1–3



Figs. 5–8. ***Sargassum bulbiferum*** **from China (AST 55-1922). Fig. 5, Whole plant. Fig. 6, Upper branchlet with furcate leaves and receptacles. Fig. 7, Holdfast with bulbous structure (arrow). Fig. 8, Vesicles with long cylindrical petioles (arrow).**



Figs. 9–11. *Sargassum bulbiferum* from China (AST 55-2041). Fig. 9, Whole plant. Fig. 10, Upper branchlets with vesicles and receptacles. Fig. 11, Holdfast with bulbous structures (arrow).

times forked; cryptostomata very small, scattered on the surface of leaves; vesicles spherical, with round apex, without appendages, 4.5 mm in diameter, with cylindrical petioles up to 4–6 mm long.

Plant monoecious. Receptacles androgynous, slender, cylindrical to fusiform, up to 6 mm long, up to 0.8 mm in diameter, 1–4 times forked, without spines, pseudozygocarpic.

Specimen AST 87-1329; named *S. weizhouense* by Tseng and Lu, (pp. 135–138, this volume). Collected April 23, 1987, from Weizhou Island, Guangxi Province, China.

(Figs. 12–14)

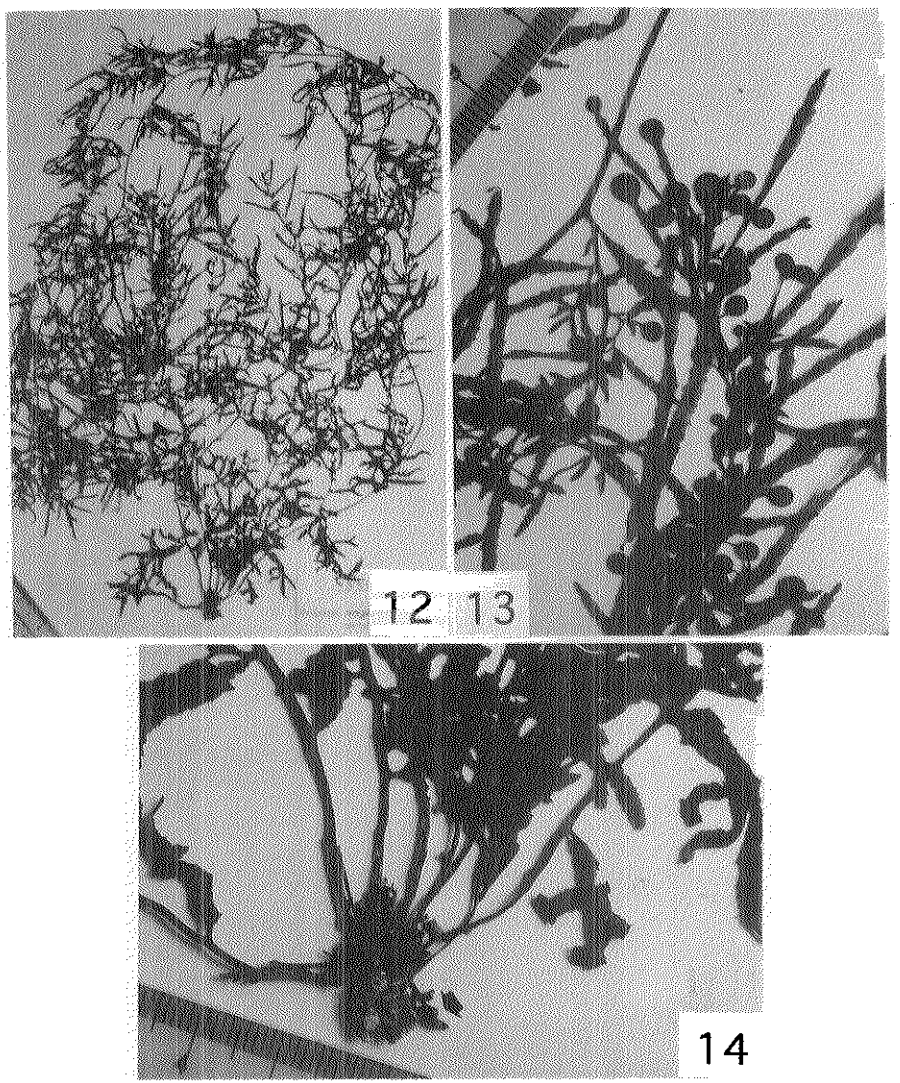
Holdfast discoid, up to 8 mm in diameter. Stem cylindrical, 5 mm tall, 2 mm in diameter. Main branches arising radially from the apex of the stem, 70 cm or more long, cylindrical, up to 1 mm wide in the basal part, smooth on the surface, with alternate leaves; secondary branches 15 cm or more long; short, thick bulbous structures formed from the stem, about 5 mm long, 1.5 mm in diameter. Leaves on the lower parts of main branches linear to linear-lanceolate, up to 4 cm long, 4 mm wide, entire or with sparse and small denticulations on the margin, midrib reaching the apex; leaves on the distal parts of main and secondary branches linear, becoming narrower and shorter; leaves often 1–3 times forked; cryptostomata very small, scattered on the surface of leaves; vesicles spherical, with round apex, without appendages, 3 mm in diameter, with cylindrical petioles up to 3 mm long or leafy petioles up to 13 mm long.

Plant monoecious. Receptacles androgynous, slender, cylindrical to fusiform, up to 4 mm long, up to 1 mm in diameter, 1–3 times forked, without spines, pseudozygocarpic.

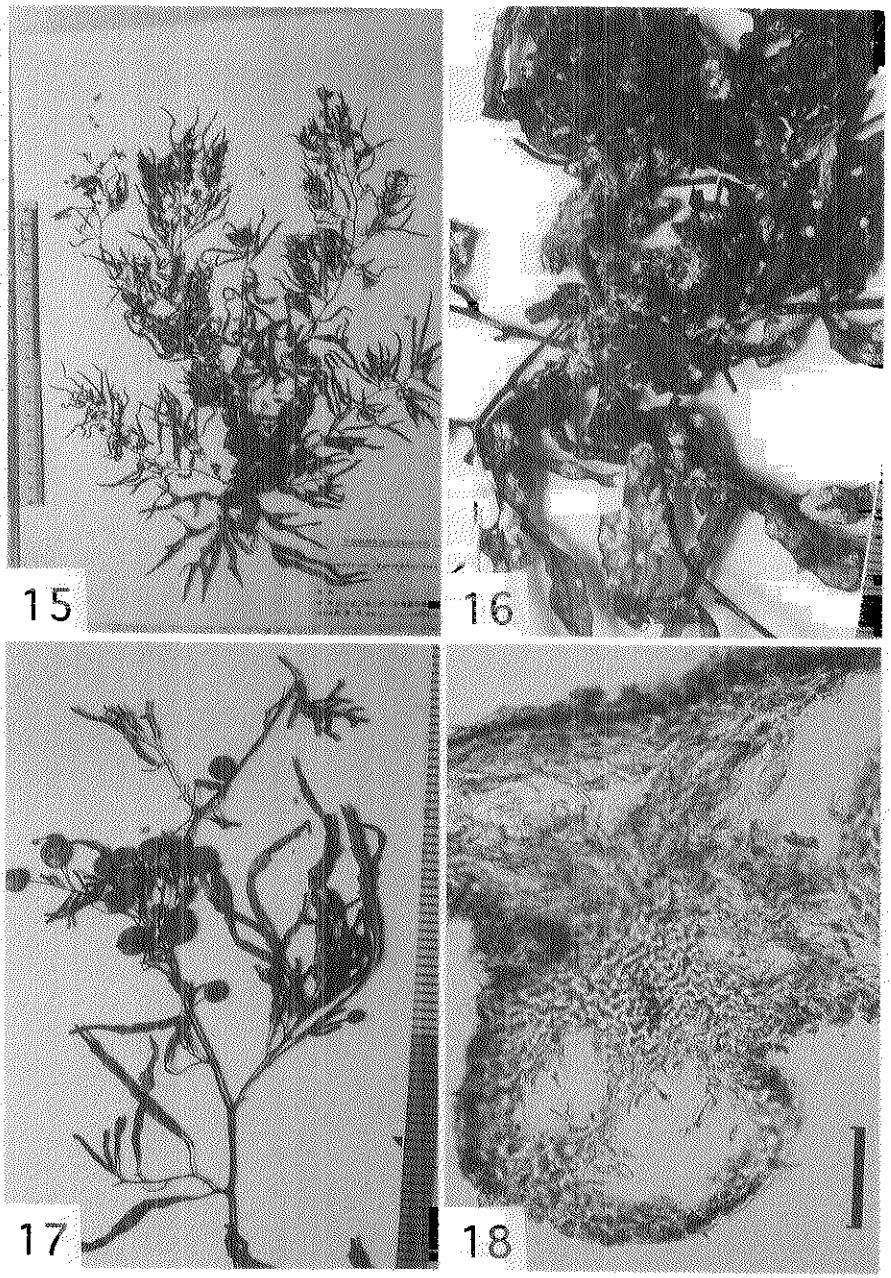
Specimen AST 55-2112 (male and female, 2 sheets); temporarily named "*S. gemmipherum*" by Tseng and Lu. Collected May 11, 1955, from Fang Cheng, Guangxi Province, China.

(Figs. 15–22)

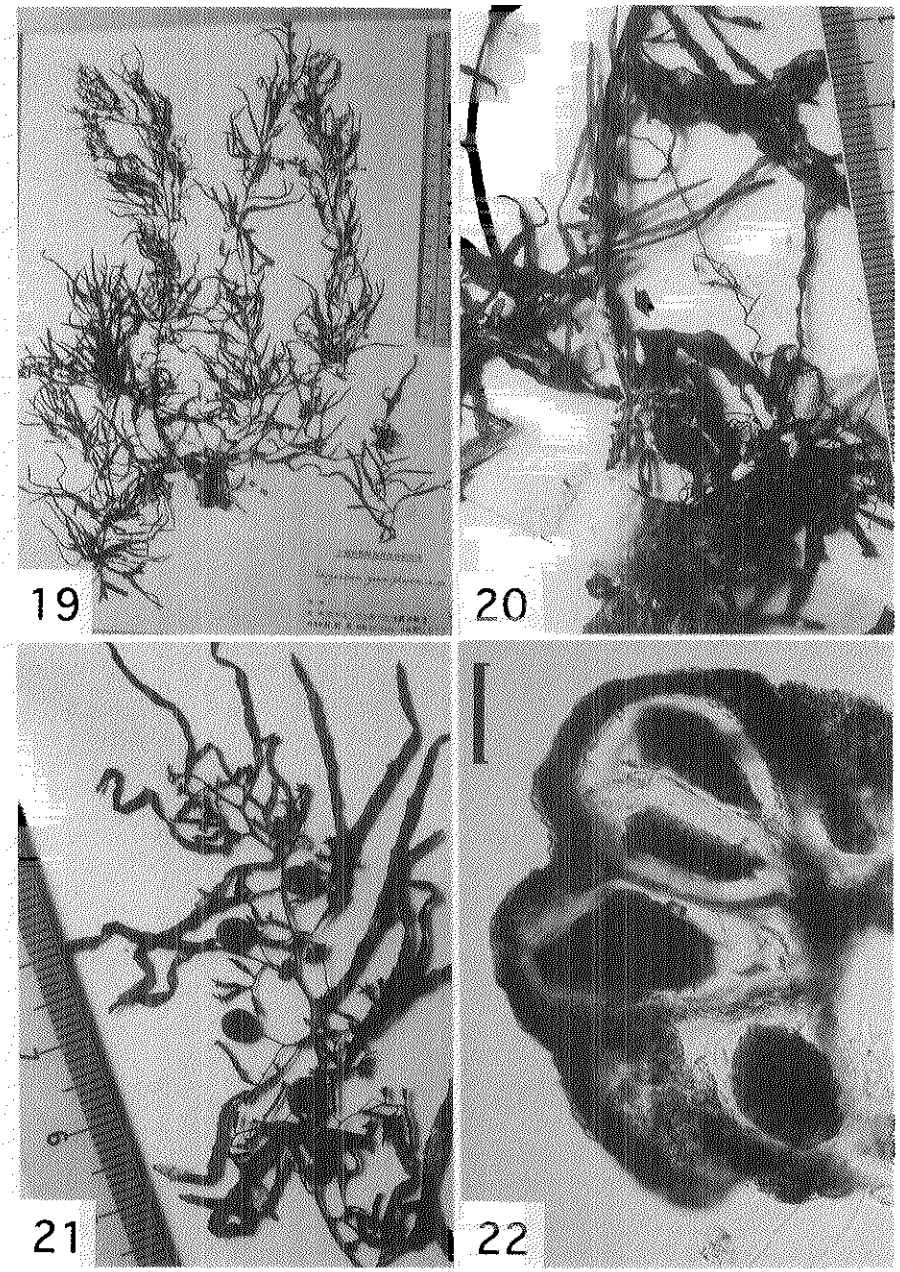
Holdfast discoid, up to 10 mm in diameter. Stem cylindrical, 8 mm tall, 2 mm in diameter. Main branches radially arising from the apex of the stem, 30 cm or more long, cylindrical, up to 1 mm wide in the basal part, smooth on the surface, with alternate leaves; secondary branches 7 cm or more long; short, thick bulbous structures formed from the stem, about 5 mm long, 2 mm in diameter. Leaves on the lower parts of main branches linear to linear-lanceolate, up to 7 cm long, 4 mm wide, entire or with sparse and small denticulations on the margin, midrib reaching the apex; leaves on the distal parts of main and secondary branches linear, becoming narrower and shorter; leaves often 1–3 times forked; cryptostomata very small, scattered on the surface of leaves; vesicles spherical, with round apex,



Figs. 12–14. ***Sargassum weizhouense*** **from China (AST 87-1329). Fig. 12, Whole plant. Fig. 13, Upper branchlets with leaves, vesicles with leafy petioles, and receptacles. Fig. 14, Holdfast with bulbous structures (arrow).**



Figs. 15–18. ***Sargassum*** **specimen (male) from China (AST 55-2112). Fig. 15, Whole plant. Fig. 16, Holdfast with bulbous structures (arrow). Fig. 17, Upper branchlets with leaves, vesicles, and receptacles. Fig. 18, Transection of male receptacle; scale bar = 100 μm.**



Figs. 19–22. *Sargassum* specimen (female) from China (AST 55-2112). Fig. 19, Whole plant. Fig. 20, Holdfast with bulbous structures (arrow). Fig. 21, Upper branchlets with leaves, vesicles, and receptacles. Fig. 22, Transection of male receptacle; scale bar = 100 μm. Note: Figs. 15–22 show separate sexes on separate plants (= dioecious) and therefore are not *S. bulbiferum* or *S. weizouense*.

without appendages, 3 mm in diameter, with cylindrical petioles up to 5 mm long. Plants dioecious. Male receptacles slender, cylindrical to fusiform, up to 7 mm long, up to 0.5 mm in diameter, sometimes forked, without spines, pseudozygocarpic; female receptacles cylindrical to fusiform, up to 4 mm long, up to 0.5 mm in diameter, without spines, pseudozygocarpic.

Specimens From Vietnam

Specimens Dai 81174 and 81175. Collected April 24, 1981, from Ninh Thuan (Son Hai), Vietnam; drifted.

(Figs. 23–28)

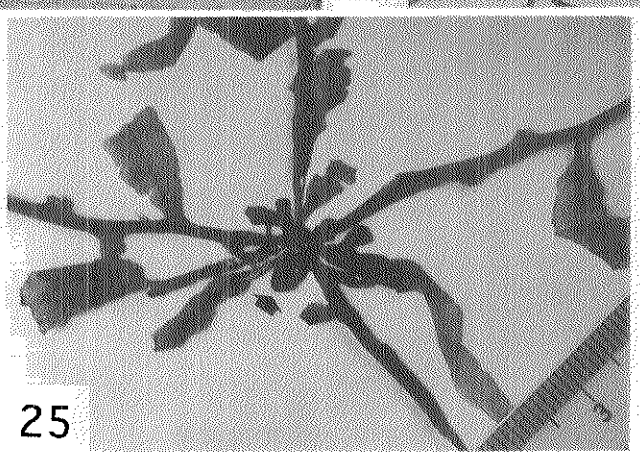
Holdfast lacking (drifted specimens). Stem cylindrical, 5 mm tall, 2 mm in diameter. Main branches arising radially from the apex of the stem, 40 cm or more long, slightly compressed, up to 2 mm wide in the basal part, cylindrical distally, 1 mm wide, smooth on the surface; secondary branches 10 cm or more long; short, thick bulbous structures formed from the stem, about 8 mm long, 3 mm in diameter on the surface. Leaves on the lower parts of main branches lanceolate, up to 7 cm long, 10 mm wide, entire or with sparse and small denticulations on the margin, papyraceous, midrib reaching the apex; leaves on the distal parts of main and secondary branches finer in texture, becoming narrower and shorter, 5.5 cm long, 7 mm wide; cryptostomata very small, scattered on the surface of leaves; vesicles spherical, with round apex, without appendages, 5 mm in diameter, with short cylindrical petioles up to 3 mm long.

Plants monoecious. Receptacles androgynous, slender, cylindrical to fusiform, up to 12 mm long, up to 1 mm in diameter, 1–2 times forked, without spines, holozygocarpic.

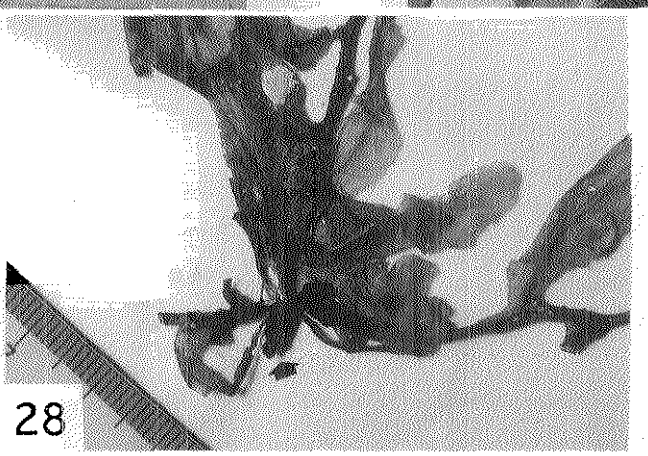
Specimens AJI 01–04 (4 sheets). Collected February 28, 1994, from Ganh Cao, Tien Yen Bay, Quang Ninh Province, Vietnam.

(Figs. 29–36)

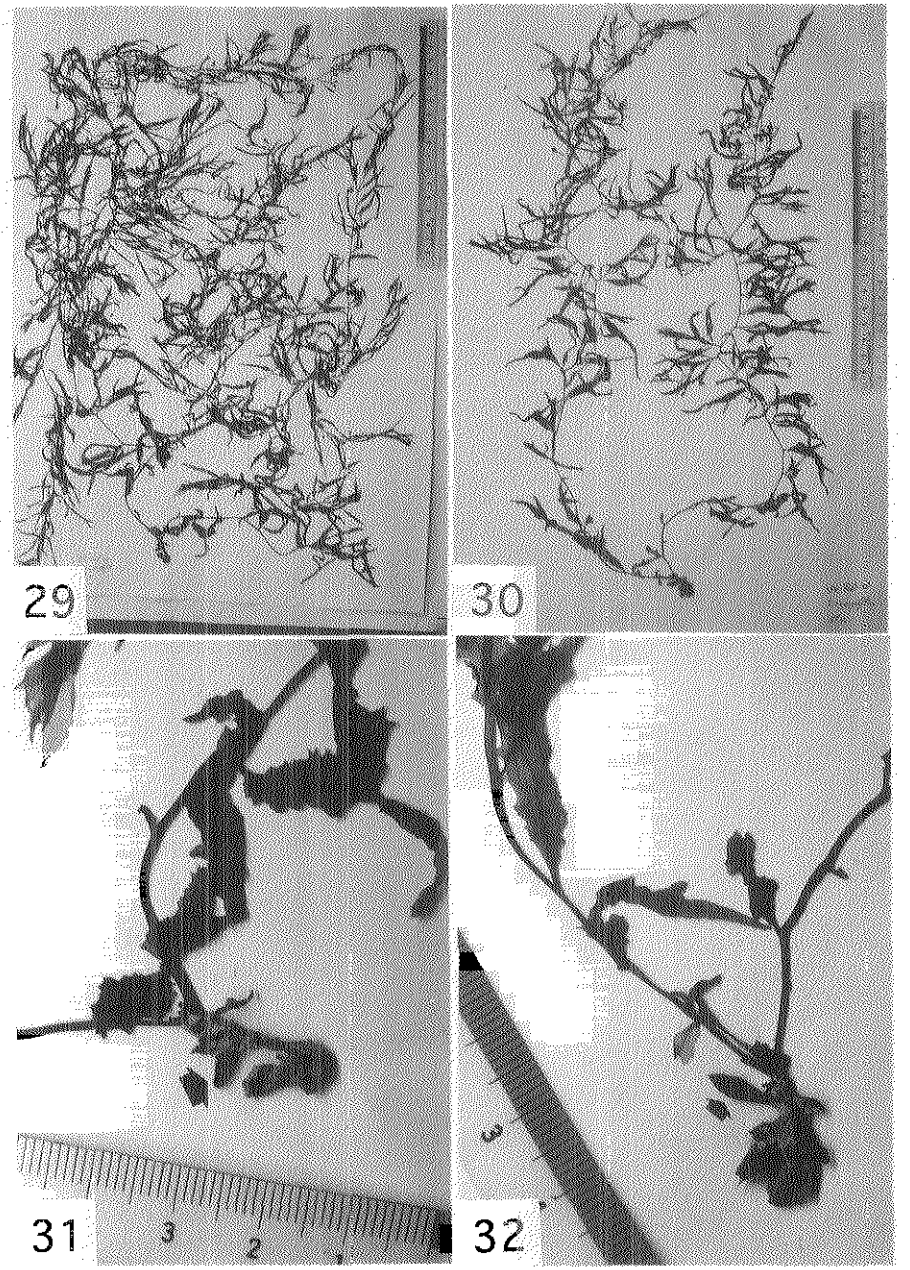
Holdfast discoid, up to 8 mm in diameter. Stem cylindrical, 1 cm tall, 2 mm in diameter. Main branches arising radially from the apex of the stem, 50 cm or more long, slightly compressed, up to 2 mm wide in the basal part, cylindrical distally, smooth on the surface, with alternate leaves; secondary branches 10 cm or more long; short, thick bulbous structures formed from the stem, about 5 mm long, 2 mm in diameter. Leaves on the lower parts of main branches linear to linear-lanceolate, up to 10 cm long, 10 mm wide, entire or with sparse and small denticulations on the margin, papyraceous, midrib reaching the apex; leaves on the distal parts of main and secondary branches finer in texture, becoming narrower and shorter; leaves often 3–4 times forked; cryptostomata very small, scattered on the surface of leaves; vesicles spherical to obovate, with round apex, without



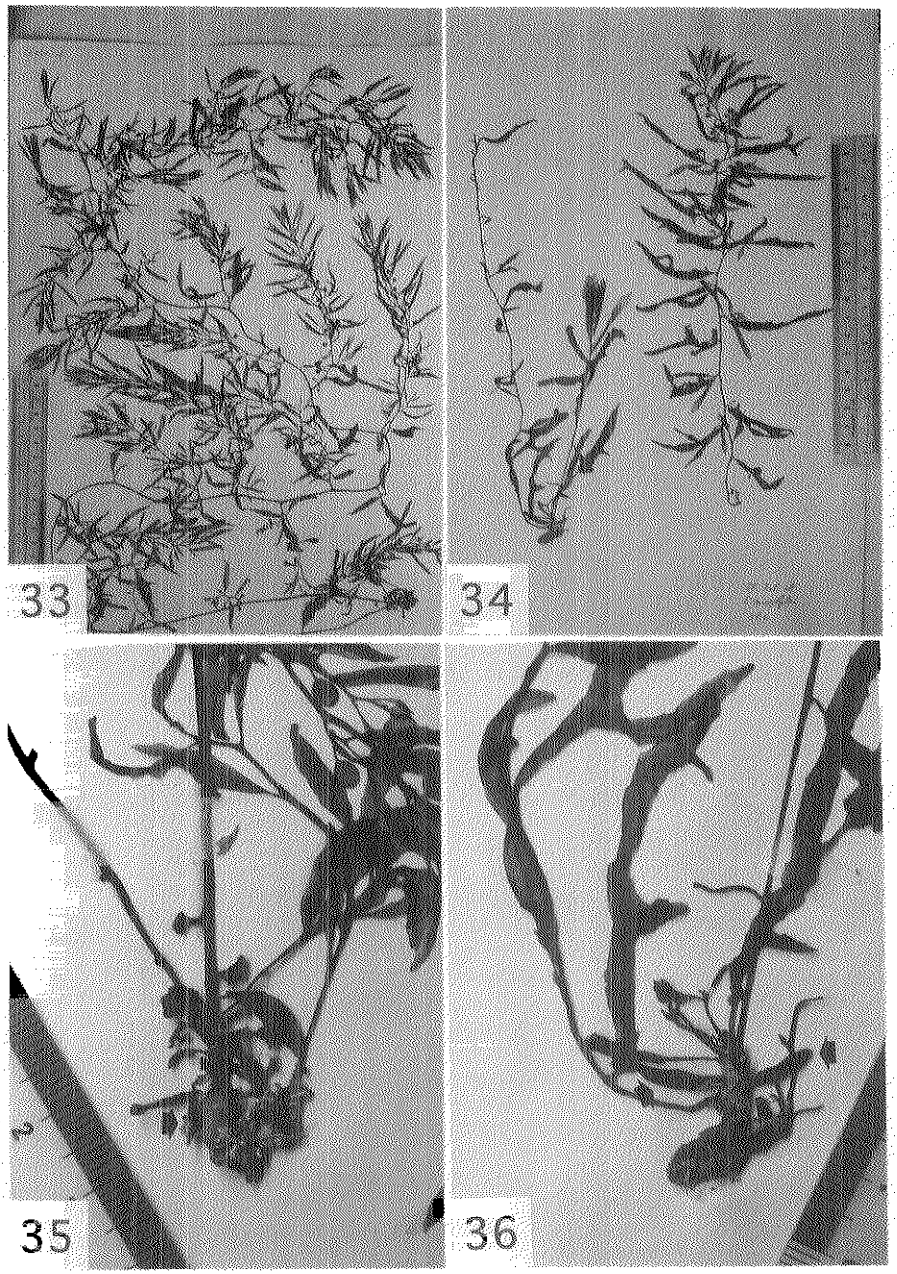
Figs. 23–25. ***Sargassum*** **specimen from Vietnam (Dai 81174). Fig. 23, Whole plant. Fig. 24, Upper branchlets with leaves and holozygocarpic receptacles. Figs. 25, Holdfast with bulbous structure (arrow).**



Figs. 26–28. ***Sargassum*** **specimen from Vietnam (Dai 81175). Fig. 26, Whole plant. Fig. 27, Upper branchlets with leaves, vesicles, and holozygocarpic receptacles. Fig. 28, Holdfast with bulbous structures (arrow).**



Figs. 29–32. ***Sargassum*** **specimens from Vietnam (Figs. 29 and 31, AJI 01; Figs. 30 and 32, AJI 02). Figs. 29 and 30, Whole plants. Figs. 31 and 32, Holdfasts with bulbous structures (arrows).**



Figs. 33–36. ***Sargassum*** **specimens from Vietnam (Figs. 33 and 35, AJI 03; Figs. 34 and 36, AJI 04). Figs. 33 and 34. Whole plants. Figs. 35 and 36, Holdfasts with bulbous structures (arrows).**

appendages, 3 mm in diameter, with cylindrical petioles up to 3 mm long.

Remarks: These plants with bulbous structures are immature plants without reproductive structures.

Specimens From Bahrain

Specimens ARAI 01–08 (8 sheets) and 09–12 (4 sheets). Collected February 6, 1999 (ARAI 01–08), and December 22, 1998 (ARAI 09–12), from Bahrain, Arabian Sea; drifted.

(Figs. 37–47)

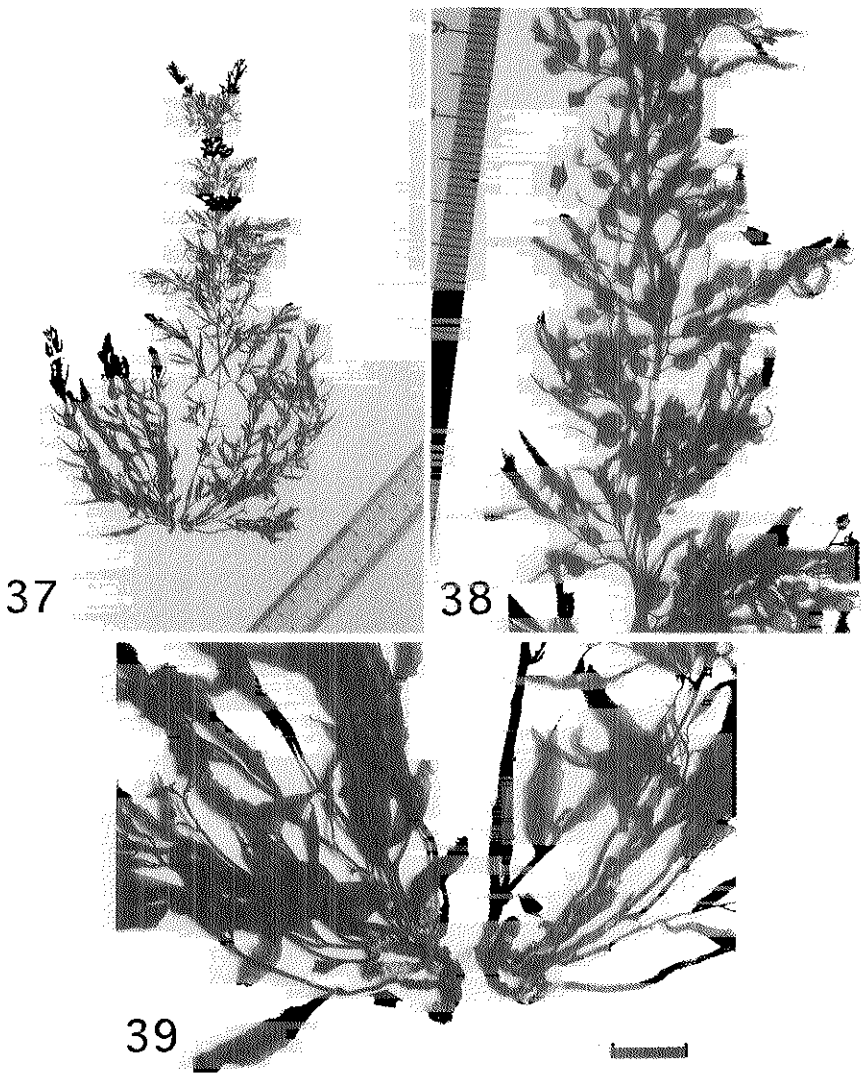
Holdfast discoid, up to 7 mm in diameter. Stem cylindrical, 5 mm tall, 1 mm in diameter. Main branches arising radially from the apex of the stem, 40 cm or more long, cylindrical, up to 1 mm wide, smooth on the surface, with alternate leaves; secondary branches 5 cm or more long; short, thick bulbous structures formed from the stem, about 6 mm long, 2 mm in diameter. Leaves on the lower parts of main branches lanceolate, up to 3.5 cm long, 4 mm wide, entire or with sparse and small denticulations on the margin, papyraceous, midrib reaching the apex; leaves on lower parts often 1–4 times forked; leaves on the distal parts of main and secondary branches finer in texture, becoming narrower and shorter; cryptostomata very small, scattered on the surface of leaves; vesicles spherical, 3 mm in diameter, usually with round apex, sometimes crowned with a linear leaf, 3 mm long; cylindrical petioles up to 5–8 mm long, sometimes longer, up to 10 mm, on secondary branches.

Plants monoecious. Receptacles androgynous, variable in shape and length, slender, cylindrical to short fusiform, up to 5–10 mm long, up to 0.8 mm in diameter, 1–2 times forked, without spines, sometimes holozygocarpic.

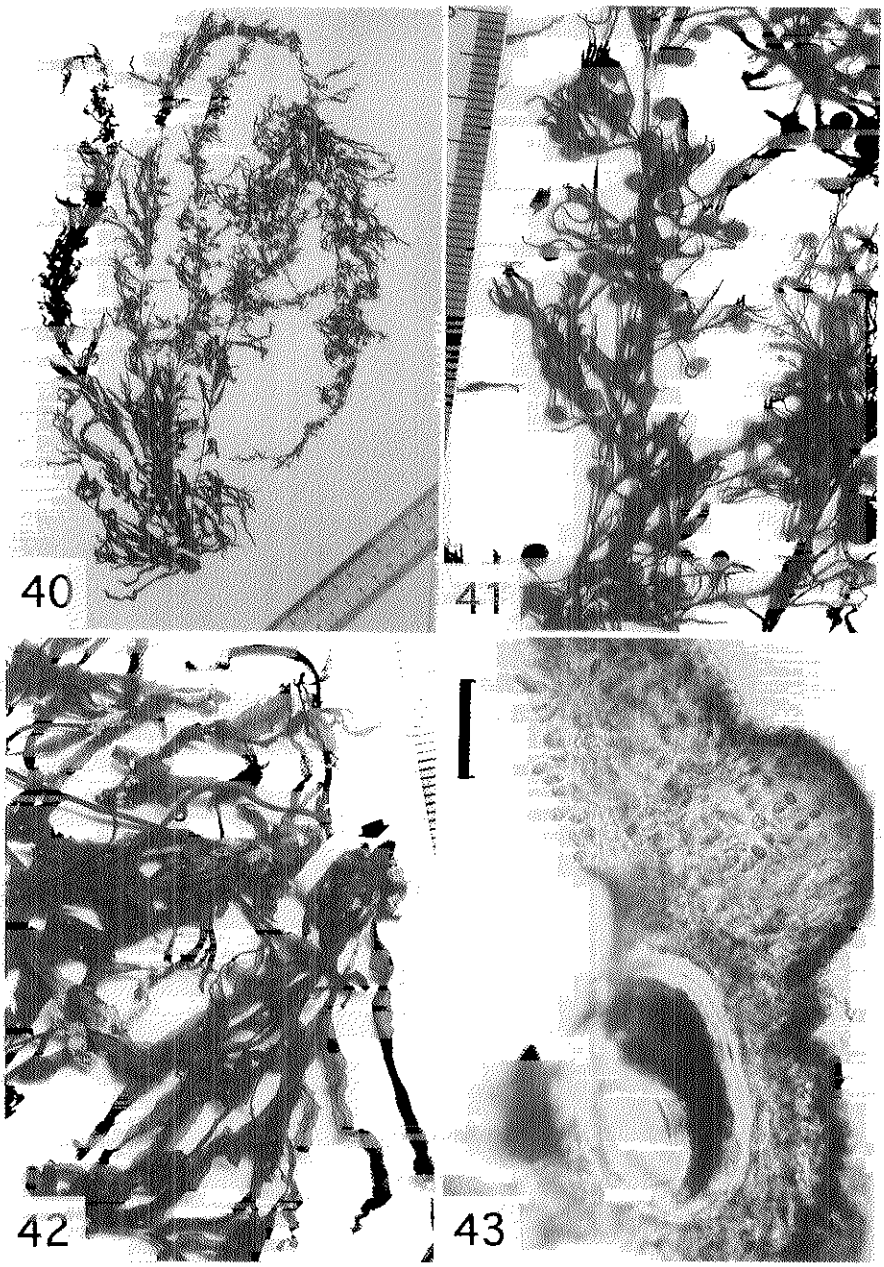
Discussion

Sargassum bulbiferum described by Yoshida (1994) can be easily distinguished from other *Sargassum* species by 2 characteristics: furcate leaves on the basal part of the plant and bulbous structures. The other morphological characters of *S. bulbiferum* are clearly similar to those of *S. carpophyllum* J. Agardh. However, Ajisaka et al. (1997) reported *S. carpophyllum* var. *nhatrangense* Ajisaka from Vietnam, which has furcate leaves on the basal parts of the plant. Nguyen and Huynh (1999) also reported a new variety from Vietnam, *S. carpophyllum* var. *honomense* Nguyen et Huynh, which also has furcate leaves on the basal part of the plant. The occurrence of these furcate leaves on the basal parts of the plant in *S. carpophyllum* may be common in Vietnamese populations. Sometimes basal furcate leaves are present even on the secondary branches of Vietnamese plants. On the other hand, basal furcate leaves have not been observed in Japanese specimens of *S. carpophyllum* (Ajisaka et al. 1995).

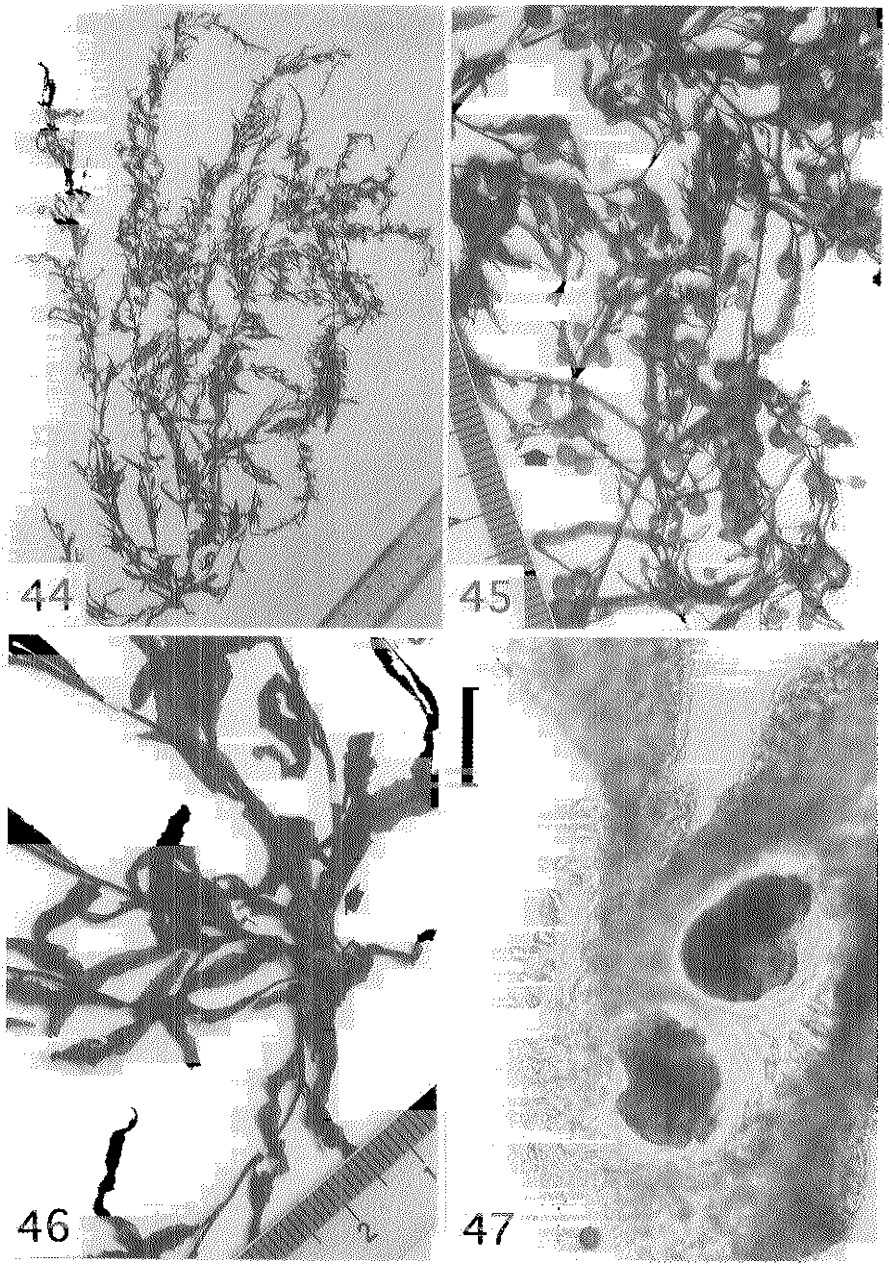
In her description of *C. nodicaulis* (Withering) M. Roberts, Roberts (1977)



Figs. 37–39: ***Sargassum*** **specimen from Bahrain (ARAI 09). Fig. 37, Whole plant. Fig. 38, Upper branchlets with leaves, vesicles with crown leaves (arrows). Fig. 39, Holdfast with bulbous structures (arrows); scale bar = 1 cm.**



Figs. 40–43. Sargassum specimen from Bahrain (ARAI 03). Fig. 40, Whole plant. Fig. 41, Upper branchlets with leaves, vesicles, and long holozygocarpic receptacles (arrow). Fig. 42, Holdfast with bulbous structures (arrow). Fig. 43, Transection of androgynous receptacle; scale bar = 100 µm.



Figs. 44–47. ***Sargassum*** **specimen from Bahrain (ARAI 06). Fig. 44, Whole plant. Fig. 45, Upper branchlets with leaves, vesicles, and holozygocarpic receptacles (arrow). Fig. 46, Holdfast with bulbous structures (arrow). Fig. 47, Transection of androgynous receptacle; scale bar = 100 μm.**

stated, "The basal tophules [the bulbous structures] form around the apex of the axis . . . and form a conspicuous feature of the denuded resting axis." She characterized the basal tophules of *Cystoseira nodicaulis* as "ovoid, about 1.5 cm long and the surface may be smooth or covered with tubercles." She reported that "after the period of dormancy, slender cylindrical outgrowths arise from the tips of the tophules, elongate rapidly, and divide to form the lateral branch system." After the plants were actively growing, these characteristic tophules disappeared. However, the morphological nature and the cause of their development are unknown. Yendo (1907) described similar structures of *C. hakodatensis* (Yendo) Fensholt as "fusiforme structures."

Bulbous structures of *Sargassum* and *Cystoseira* specimens have a similar morphology: ovoid to short, thick and fusiform, 5–10 mm long, 2–4 mm in diameter, with a very smooth surface. The bulbous structure may be an arrested stage of the main branch on the stem. After a period of dormancy, slender main branches may arise from the tip of bulbous structures, as with the tophules in *Cystoseira*. Bulbous structures may be produced on 1-year-old plants and may issue a new main branch for the next season in perennial specimens.

In North Vietnam (Quang Ninh Province), the *Sargassum* plants were growing in shallow coastal waters, only about 1 m deep. Juvenile plants with furcate leaves usually have no bulbous structures, but the juvenile and young main branches from the stout stem, which seems to be perennial, have bulbous structures (Figs. 29–36). These findings suggest that bulbous structures are formed only on perennial plants. At this time, mature plants with receptacles have not been collected from this location. When the juvenile and immature plants without bulbous structures are identified, they are easily recognized as *S. carpophyllum* J. Agardh because they have somewhat thin, papyraceous leaves and have furcate leaves on the basal parts of the plant, the same as does *S. carpophyllum.*

The Japanese specimens of *S. bulbiferum* were found in comparatively deeper water, about 15–18 m deep (Yoshida 1994). Because the type locality is located near the Tsushima Current (warm current, a branch of the Kuroshio Current), the deeper area may be warmer than the shallow/surface waters, even at the high latitude. On the other hand, in the tropical region, Vietnam, the plants were growing along a shallow coast, in water about 1 m deep. The plants of subgenus *Sargassum* usually grow in subtropical/tropical areas, so perhaps the plants of the Japanese population can survive only in deeper (warmer and calmer) conditions in the temperate region. The Japanese specimens have slightly larger holdfasts than do the specimens from other localities (Table 1). The larger holdfasts and bulbous structures may enable the population to persist in the deeper habitat.

Because the specimens from Bahrain and Ninh Thuan, Vietnam, were drifted specimens, we cannot discuss their habitats. However, the collector, Mr. Shogo Arai, observed that these plants were growing along the shallow coast (about 1 m deep) in Bahrain. We have no information about the habitats of the specimens from China.

A comparative study of the morphological characters among the type speci-

Table 1. A Comparative Study of Morphological Characters in *Sargassum bulbiferum* and Specimens With Bulbous Structures*

Character	Locality and Specimens						
	Japan *S. bulbiferum*	China AST 55-1830	China AST 55-1922	China AST 55-2041	Vietnam Dai 81174 and 81175	Vietnam AJ 101–04	Bahrain ARA 101–15
Holdfast							
Diameter, mm	20	8	5	5	(None)	8	7
Stem							
Height, mm	10	5	6	15	5	10	5
Diameter, mm	2	2	2	2	2	2	1
Bulbous structure							
Height, mm	8	6	5	10	8	5	6
Diameter, mm	3	3	2	4	3	2	2
Main branch							
Length, cm	40	40	37	40	40	50	40
Width, mm	2	2	2	3	2	2	1
Secondary branches							
Length, cm	10	8	14	5	10	10	5
Leaves							
Length, cm	10	3	5	7	7	10	3.5
Width, mm	10	5	5	9	10	10	4
Tines, forked	0–1	0–3	0–4	0–3	0	0–4	0–4
Vesicles							
Diameter, mm	3	4	3	4.5	5	3	3
Petioles							
Length, mm	3	8	8 (17)	6	3	3	8
Receptacles	Monoecious	Monoecious	Monoecious	Monoecious	Monoecious	NA	Monoecious
Length, mm	7	5	6	6	12	NA	10
Diameter, mm	0.8	0.8	0.8	0.8	1.0	NA	0.8
Tines, forked	1–2	1–2	1–3	1–4	1–2	NA	1–2
Zygocarpic	Pseudo-	Pseudo-	Pseudo-	Pseudo-	Holo-	NA	Holo-

*Data for *S. bulbiferum* are from the type description (Yoshida 1994). Values for diameters, heights, lengths, and widths are maximums. NA indicates not applicable.

mens of *S. bulbiferum* and other *Sargassum* specimens with bulbous structures from China, Vietnam, and Bahrain is shown in Table 1. From the morphological characters, we conclude that Vietnamese and Arabian specimens seem to belong to the same species, which may be temporarily included in the name of *S. carpophyllum* "*perennis*," because it is difficult to recognize the characteristics (furcate leaves on the basal parts of the plants and bulbous structures) as taxonomic criteria at the species level.

Some morphological characteristics of the leaves, vesicles, and receptacles differ among these specimens. For example, some specimens from Bahrain have vesicles with linear crown leaves and receptacles that vary in shape and length (Figs. 38, 41, and 45). Receptacles of the plants from Bahrain and Vietnam (Ninh Thuan) have holozygocarpic receptacles, but specimens from other localities have pseudozygocarpic receptacles. These morphological differences might be caused by some geographic, physical, and ecological factors. A DNA analysis of the 2 species, *S. bulbiferum* and *S. carpophyllum*, is required for a clear conclusion about the taxonomic distinction between them.

The Chinese specimens present a somewhat different case in terms of the morphological characters. Some of the Chinese specimens might be included in *S. carpophyllum* "*perennis*," but some might be included in other species. The specimen AST 87-1329 (given the temporary name "*S. weizhouense*" by Tseng and Lu) is similar in morphological characters to other specimens from China, but Chinese specimens sometimes have very long, leafy petioles of the vesicles (Fig. 13). We also found some specimens (e.g., AST 55-2112) from China that have the same characteristics as those of *S. carpophyllum* "*perennis*," but the specimens have dioecious receptacles (Figs. 18 and 22); Tseng and Lu gave these specimens the tentative herbarium name "*S. gemmipherum*" (unpublished). This situation calls for a more critical survey of the morphological variations in these Chinese specimens, especially at the population level.

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