Science Diliman (January-June 2013) 25:1, 29-50

Taxonomy of the Genus *Sargassum* (Fucales, Phaeophyceae) from Alabat Island, Quezon, Northeastern Philippines

Wilfred John E. Santiañez*
and Gavino C. Trono Jr.
University of the Philippines Diliman

ABSTRACT

Taxonomic observations on some *Sargassum* species in Alabat Island, Quezon are presented. These are based on collections made on the spot during an ecological survey on the *Sargassum*-dominated seaweed communities in the locality. Gross morphological characteristics of the species such as the type of holdfast, shape and nature of its branches, vesicles, leaves, nature and distribution of cryptostomata, and nature and form of receptacles were used to discriminate the different morphotypes. Free-hand sections of receptacles were made to ascertain the sex of the plant. Different morphotypes were identified up to species level when possible. Eight morphotypes were distinct, six of which were recognized, namely, *Sargassum crassifolium* J. Agardh, *S. cristaefolium* C. Agardh, *S. kushimotense* Yendo, *S. gracillimum* Reinbold, *S. myriocystum* J. Agardh, and *S. polycystum* C.A. Agardh. The two other remaining materials were unidentified and are described here in detail.

Keywords: *Sargassum*, brown seaweed, seaweed taxonomy, diversity, Philippines

INTRODUCTION

Sargassum species are conspicuous marine macrobenthic floral elements that form part of most rocky shores of the Philippines (Trono 1992). In addition, the Philippines is home to one of the most diverse *Sargassum* resources in the western Pacific basin (Phillips 1995, also in Phang and others 2008, and Ang and others 2008). Ganzon-Fortes (2012) listed 73 *Sargassum* species out of the total of 979 reported seaweed species (including Cyanophyta) in the country. However, because it only

**Corresponding Author*

ISSN 0115-7809 Print / ISSN 2012-0818 Online

covers the period year 1800-1999 and because "[t]he list is comprehensive rather than selective, in order to avoid the difficulty of having to assess each reported species for its worthiness of inclusion" (Ganzon-Fortes 2012, p 186), it did not account for the nomenclatural changes on some of the species listed in the compilation. For example, the list by Ganzon-Fortes (2012) still included *S. duplicatum* Bory de Saint-Vincent and *S. berberifolium* J. Agardh, which have been considered synonyms of *S. cristaefolium* C. Agardh; *S. sandei* Reinbold, which is a synonym of *S. ilicifolium* (Turner) C. Agardh; *S. binderi* Sonder, which is presently considered as *S. oligocystum* Montagne (Silva and others 1996); and *S. feldmannii* Pham, which has been considered synonymous with *S. crassifolium* J. Agardh by Ajisaka and others (1997). More recently, Mattio and others (2009) also proposed the synonymy of *S. cristaefolium* C. Agardh with *S. ilicifolium* (Turner) C. Agardh, *S. crassifolium* J. Agardh and *S. binderi* Sonder with *S. aquifolium* (Turner) C. Agardh, and *S. myriocystum* with *S. polycystum* C. Agardh.

Members of the genus *Sargassum* are also well known for their economically important natural products such as alginates, fucoidan, fucoxanthin, and lutein, among others. Alginates, which are found in the cell walls of *Sargassum* spp., are cheap sources of viscofiers and thickeners, and are the most widely used seaweed colloids. The compound has a wide range of food production applications such as emulsifying, stabilizing, gelling and thickening agent (Prud'homme van Reine 2001). They are also used in paint, textile, paper and plastic manufacturing industries (e.g. as ingredient in shoe polish (Brownlee and others 2005)); in the medical, pharmaceutical and dental industries (e.g. as gelling agents and as source of dietary fiber to protect against obesity and diabetes, among others (Brownlee and others 2005)); as well as in the in agriculture industry as feeds and fertilizers (Trono and Lluisma 1990, Prud'homme van Reine 2001). In the Philippines, Montaño and others (2005) reported on the utilization of *Sargassum* by coastal populations which include 1) as a cover for fishery products to prevent desiccation and/or maintain their freshness; 2) as food; 3) as fertilizer, insect repellant, flower inducer, and animal feed; and 4) as a therapeutic drink, among others. *Sargassum* biomass is also believed to have a great potential as feedstuff for alternative sources of energy, i.e. biofuel.

Despite their economic importance and significance to the lives of many coastal populations, not to mention their ecological role as community-structuring species, the *Sargassum* resources of the Philippines are among the poorly known and least studied genera (Trono 1992). This dilemma has been primarily attributed by Kilar and others (1992) to the highly variable morphology of the species. Trono (1992) emphasized the need to do more work on the taxonomy of the species noting that much of the more than 80 species and varieties listed by Silva and others (1987)

remain questionable. This proposition was supported by Phillips (1995), who suggested more detailed work on the other *Sargassum* subgenera from the Philippines.

The first major taxonomic treatment of the genus *Sargassum* in the country was done by Trono (1992) where he described 28 species, 12 of which were published as new species two years after (Trono 1994). In the subsequent comprehensive study on the taxa by Modelo and Umezaki (1995) based on the *Sargassum* specimens deposited in various herbaria in the country and elsewhere in the world, 20 species were recognized; six species were added as new records to the country (i.e., *S. acinaciforme* Montagne, *S. angustifolium* C. Agardh, *S. glaucescens* J. Agardh, *S. henslowianum* C. Agardh, *S. herporhizum* Setchell *et* Gardner, and *S. parvivesiculosum* Tseng *et* Lu), and the presence of six other *Sargassum* species listed in Silva and others (1987) were confirmed. It should also be noted that taxonomic studies on *Sargassum* were already conducted in other parts of the country prior to those conducted by Trono (1992, 1994) and Modelo and Umezaki (1995), albeit scanty. These include the studies conducted by Ang and Trono (1987) in Batangas where eight species were described, and by Noro (1989) where he also described eight species from Palawan, Zamboanga, and Cebu. Despite the many number of the specimens that were collected and examined from many areas in the country in the

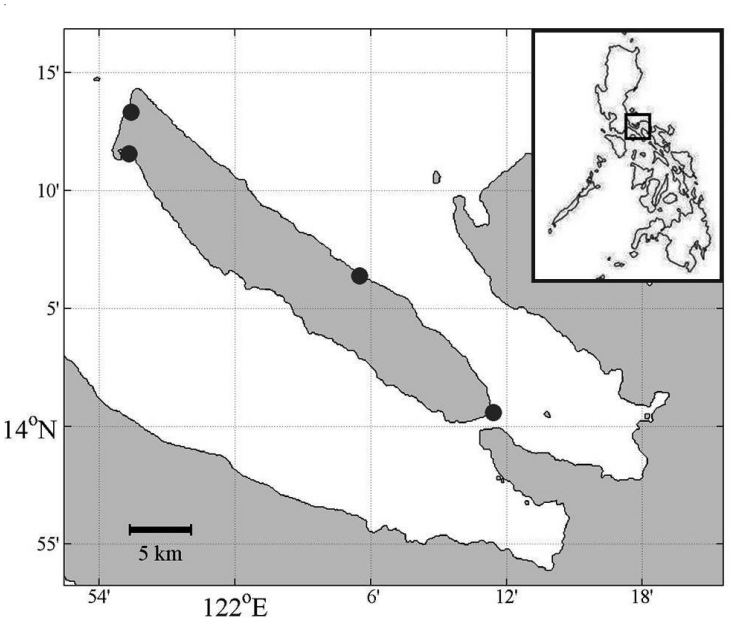

Figure 1. Map of Alabat Island, Quezon showing the different sampling areas

aforementioned studies, no specimens of *Sargassum* from Alabat Island, Quezon were included. Thus, we attempt herein to fill in the gap of information by conducting taxonomic studies on the *Sargassum* specimens collected in Alabat Island, Quezon Province.

MATERIALS AND METHODS

The specimens were collected from Alabat Island, Quezon Province (Figure 1) between 2009 and 2011 during the ecological survey conducted in the *Sargassum*-dominated communities of the locality. A total of seven collections were made throughout the three-year period (i.e. December 2009; May, September, November 2010; January, July, and October 2011) from four areas in the locality namely, Gerardo Pt. (14°13'20.35"N; 121°55'23.77"E), Perez (14°11'34.16"N; 121°55'19.39"E), Sabang (14° 6'22.88"N; 122° 5'30.60"E), and Silangan (14° 0'35.04"N; 122°11'25.57"E). Collections were made by the authors (WJES and GCT), together with Marilyn Dayao, Mon Hubilla and Napo Cayabyab.

All collected specimens were dried and mounted on herbarium sheets. Materials were deposited at the G.T. Velasquez Herbarium (T), The Marine Science Institute, University of the Philippines Diliman. Only fertile materials were selected and reported in this study except that of *S. polycystum* and *S. myriocystum*. This was due to the unreliability of the identification made from vegetative materials. Hence, the collections made during the periods of December to May-July (the reproductive period of *Sargassum* in the area) form the basis of this report. Different morphotypes were discriminated using morphological characters such as the type of holdfast, shape and nature of their branches, vesicles, leaves, nature and distribution of cryptostomata, and nature and form of receptacles. To determine the sex of the plant, free-hand cross-sections of the receptacles were made under the stereomicroscope, stained with 10% aniline blue, fixed with 1% HCl, and mounted on glass slides using corn syrup. Photographs of cross-sections were made using MoticCam 580 mounted on Motic BA410 Microscope.

Key references were consulted to identify the different species; particularly, the *Sargassum* monographs by Trono (1992, 1994), Modelo and Umezaki (1995) and Ang and Trono (1987). *Sargassum* monographs by Noiraksar and Ajisaka (2008) in Thailand, Wong and others (2008) in Malaysia, and those found in "Taxonomy of Economic Seaweeds" by Abbott and Norris (eds., 1985), Abbott (ed., 1988, 1992, 1994, 1995, 1997, 1999), Abbott and McDermid (eds., 2002, 2004), were also consulted. A taxonomic key based on the prominent morphological characteristics of each species is provided herein.

RESULTS

Key to the species of *Sargassum* of Alabat Island, Quezon

1. Thallus with secondary holdfast arising from the main axis ..... *S. polycystum*
1. Thallus without secondary holdfast arising from the main axis 2

2. Leaves with duplicated margins or portions of the blade 3
2. Leaves without duplicated margins or portions of the blade 4

3. Leaves duplicated on the margin; vertically attached .... *S. crassifolium*
3. Leaves duplicated especially at the tip, duplicated leaves at right angle with the plane of the blade; horizontally attached ..... *S. cristaefolium*

4. Branches strongly flattened ..... *S. kushimotense*
4. Branches terete to slightly compressed 5

5. Main axis smooth, percurrent ..... *Sargassum* sp. 1
5. Main axis lumpy, short and not percurrent 6

6. Primary and secondary branches with many short protuberances (muricate) ..... *Sargassum myriocystum*
6. Primary and secondary branches not as above 7

7. Female receptacles short, up to 3.5 mm in length, twisted towards the tip; leaves associated with receptacles filiform ..... *Sargassum* sp. 2
7. Female receptacles up to 5.5 mm long, sometimes triquetrous and/or twisted towards the tip; leaves associated with receptacles linear to linear-lanceolate ..... *S. gracillimum*

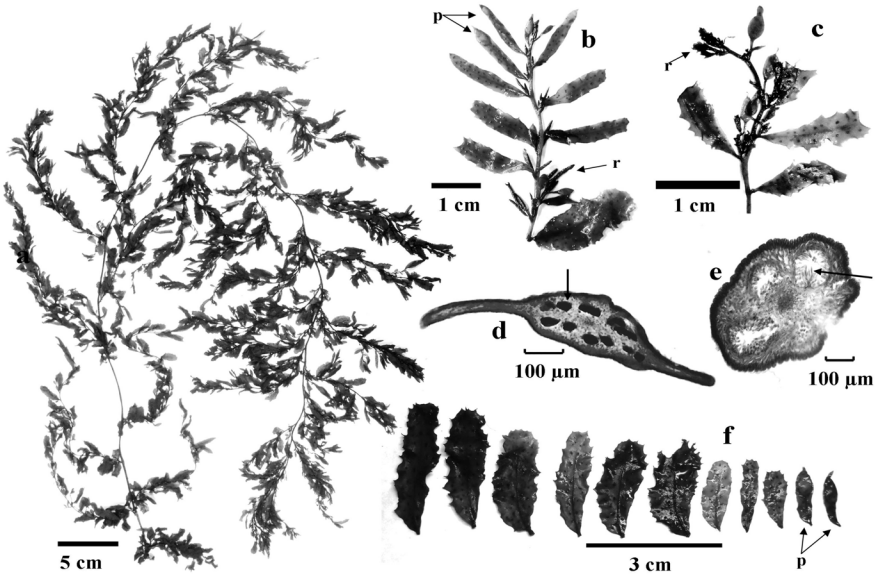

Figure 2. *Sargassum crassifolium* J. Agardh. a. Habit; b. Portion of branch showing terete male receptacles (r) and some phyllocystic leaves (p); c. Portion of the branch showing toothed female receptacles; d. Cross-section of female receptacles showing oogonium within the conceptacle (arrow); e. Cross-section of male receptacles showing antheridia (arrow); f. Leaves from different branch orders, with some phyllocystic leaves (p).

Species Description

Sargassum crassifolium J. Agardh (Fig. 2)

Ang and Trono 1987, p. 389, Fig. 1D; Trono 1992, p. 50, Figs. 9-11, 112; Trono 1997, p. 131, Figs. 88A-88B; Modelo and Umezaki 1995, p. 11, pl. 4A-4B, 9; Ajisaka and others 1997, p.34, Fig. 12; Tseng and Lu 1997, p. 23, Figs. 7, 14; Noiraksar and Ajisaka 2008, p. 967, Fig. 5.

Plants up to 101 cm long, holdfast incomplete (damaged) but appears to be discoid. Main axis rough, up to 10 mm long, 3 mm in diameter; up to four primary branches arise at the tip. Primary branches slightly compressed, smooth, up to 1 m long, up to 2 mm in diameter. Secondary branches smooth, slightly compressed, up to 23 cm long; attached almost always alternately along the primary branches at 3 to 6 cm interval at the lower portion, intervals becoming shorter at the upper portion (0.5cm to 2.5 cm). Leaves on primary branches linear-lanceolate to oblanceolate, up to 27 mm long, 9 mm wide, vertically attached; margin undulate, basal 1/3 especially at

the adaxial portion of the leaf entire, becoming serrate-dentate towards the tip; apex acute to rounded; base slightly asymmetrical, acute; midrib distinct, disappearing just below the tip; cryptostomata numerous, scattered. Leaves of secondary branches vertically attached, oblong, up to 30 mm long, 9 mm wide; margin entire at the basal 1/3 especially at the adaxial portion of the leaf, becoming serrate-dentate or sometimes duplicated towards the tip; apex rounded, sometimes obtuse; base slightly asymmetrical, acute; midrib apparent, disappearing towards the tip; cryptostomata present, numerous and scattered. Leaves of higher order branches highly variable in shape, generally linear-oblanceolate, up to 25 mm long, 5 mm wide; margins undulate, becoming serrate-dentate near the tip; apex rounded; midrib apparent, disappearing just below the tip; cryptostomata present, with tendency to be arranged in rows in narrow leaves. Vesicles oblong to elliptical, 8 mm long 4 mm wide; phyllocystic; apex sometimes round or mucronate.

Plants dioecious. Receptacles arranged racemosely; male receptacles terete and lumpy, up to 7 mm long, 1 mm wide; female receptacles lumpy, compressed to becoming flattened and toothed towards the tip; closely associated with vesicles and/or leaves.

Remarks: Ang and Trono (1987) noted the close similarity of *S. crassifolium* and *S. cristaefolium* because of the "double" margins of the leaves, but pointed out that the doubling of *S. crassifolium* is limited only to the leaf margins of some leaves, while that of *S. cristaefolium* involves doubling of the blade. Trono (1992) also pointed out the difference of nature of leaf attachment; i.e., *S. crassifolium* leaves are vertically attached while those of *S. cristaefolium* are horizontally attached. Moreover, *S. crassifolium* is characterized by an androgynous receptacle (Ajisaka and others 1997, Ang and Trono 1987, Yoshida 1988), as exhibited by those found in China (Tseng and Lu 1997), Thailand (Noiraksar and Ajisaka 2008), Malaysia (Wong and others 2008), and in Japan and Taiwan (Yoshida 1988). However, *S. crassifolium* from the Philippines appears to be dioecious.

The materials examined by Ang and Trono (1987) from Calatagan, Batangas and those by Modelo and Umezaki (1995) were reported to bear female receptacles. A female receptacle was also found after the examination of the specimen used in Trono (1992) collected from Bolinao, Pangasinan (T19951). Chou and Chiang (1981 in Yoshida 1988) also reported female materials from Taiwan. This appears to be the first report of an *S. crassifolium* bearing male receptacles in the country. Meanwhile, Ajisaka and others (1997) noted that *S. crassifolium* were similar to *S. cristaefolium* in having two rows of serrated teeth and distinguishes *S. cristaefolium* by being dioecious. Lastly, Ajisaka and others (1997) considered *S. feldmannii* Pham

as a synonym of *S. crassifolium*, and Mattio and others (2009) proposed the synonymy of *S. crassifolium* with *S. aquifolium* (Turner) C. Agardh on the basis of their examination of the type specimens.

Materials examined: T27536 (Male, 15.xii.2009), 27537 (Male, 15.xii.2009); 27538 (Female, 15.xii.2009).

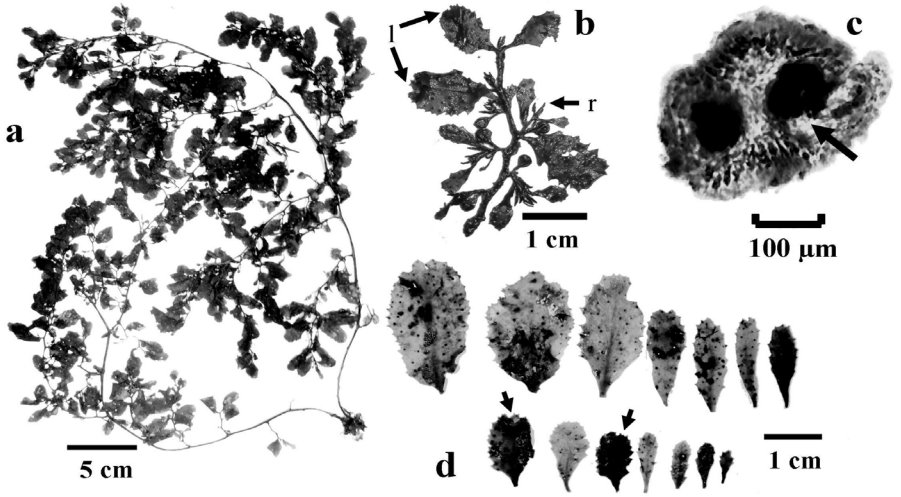

Figure 3. *Sargassum cristaefolium* C. Agardh. a. Habit; b. Portion of the branch showing duplicated leaves (l) and female receptacles (r) closely associated with leaves and vesicles; c. Cross-section of female receptacle showing oogonium (arrow); d. Leaves from different branch orders, one showing duplicated tips (arrows).

Sargassum cristaefolium C. Agardh (Fig. 3)

Trono 1992, p. 50, Figs. 12-15; 1997, p. 133, Fig. 89A-89B; Modelo and Umezaki 1995, p. 13, pl. 3A-3B, 8; Tseng and Lu 1997, p. 16, Figs. 3,10.

Plant up to 57 cm long; holdfast discoid; main axis smooth, terete up to 5 mm long, 3mm in diameter. Primary branches smooth, slightly compressed up to 56 cm long, up to 2 mm in diameter; basal portion with conspicuous branch scars. Secondary branches smooth, slightly compressed up to 20 cm long; almost always arising from the primary branches in an alternate manner. Leaves thick and coriaceous, horizontally attached; broadly oblong to obovate, up to 27.7 mm long, 15 mm wide, those associated with receptacles smaller; margins finely serrate-dentate; apex rounded, sometimes "duplicated", duplicated tips at right angle with the plane of

the blade; base symmetrical to slightly asymmetrical; midrib apparent, disappearing towards the tip; cryptostomata numerous, scattered; leaves of higher order branches generally smaller, variable in shape, broadly linear-oblanceolate to spatulate. Vesicles ovate to obovate, 4 mm long, 3 mm wide; apex round; cryptostomata absent; pedicels terete near base becoming flattened towards the tip, sometimes extended to vesicles creating a rib; pedicels smooth, often as long as vesicles.

Plant dioecious (?). Female receptacles racemosely arranged, terete near base, becoming compressed towards the blunt tip, up to 5 mm long, 0.5 mm wide.

Remarks: The material examined herein is similar to those examined by Trono (1992) except that our material has leaves that have smooth bases instead of being toothed; teeth were also absent in the terete-to-compressed pedicels of vesicles; and receptacles were smooth, lacking the teeth found at the margins and tips of those described by Trono (1992). It is also similar to those described by Modelo and Umezaki (1995) except that it is larger and has smaller receptacles, which also lacks teeth. As discussed earlier, this species is often lumped with and mistaken as *S. crassifolium* but is distinct from the latter because of the doubling of the blade and being horizontally attached (Ang and Trono 1987, Trono 1992). Moreover, Mattio and others (2009) proposed the synonymy of *S. cristaefolium* C. Agardh with *S. ilicifolium* (Turner) C. Agardh.

Material examined: T27535 (Female, 19.vii.2009)

Sargassum gracillimum Reinbold (Fig. 4)

Reinbold 1913, p. 172, Figs. 48-49; Trono 1992, p. 56, Figs. 23-27; 1997, p. 137, Fig. 91.

Plants up to 42 cm long; holdfast discoid; main axis short, up to 6 mm long, 1.5mm in diameter; terete and lumpy. Primary branches crowded at the distal portion of the main axis, up to 40 cm long, 1.5 mm in diameter; basal portion with short protuberances perhaps due to the old branches that were shed. Secondary branches filiform, up to 12 cm in length, with lumps at the basal portion due to leaf scars; branches arranged almost always alternately along the primary branches, characteristically decreasing in length towards the tip, giving a pine-tree-like appearance to the thallus; cryptostomata apparent, elevated, giving branches a lumpy appearance. Leaves on primary and secondary branches linear to linear-lanceolate, up to 27 mm long, 6 mm wide; base asymmetrical, highly oblique at the adaxial

portion giving the appearance of long-stalked leaves; margin serrate-dentate; apex acuminate or obtuse; midrib apparent, disappearing towards the tip, evanescent in narrow leaves; cryptostomata numerous, scattered, with a tendency to be arranged in rows in narrow leaves. Vesicles numerous, ovoid to obovoid, small, up to 3 mm long, 2.5 mm in diameter; cryptostomata present, scattered and elevated.

Plant dioecious. Receptacles racemosely arranged, closely associated with leaves and vesicles. Male receptacles up to 9 mm long, terete and lumpy; female receptacles up to 5.5 mm long, terete near base becoming compressed towards the tip, sometimes triquetrous and/or twisted, warty and toothed.

Remarks: The specimens are similar to those described by Reinbold (1913) especially on the characteristically pyramidal shape (pine-tree-like) of the thallus. Although this character is not mentioned in Trono (1992), examination of his materials confirmed this character. Moreover, the specimens described herein differ from that of Trono (1992) by having a relatively smaller thallus; have elevated cryptostomata along the branches giving them a lumpy appearance; receptacles are racemosely arranged (instead of being in dense panicles), and the sometimes triquetrous and/or twisted female receptacles.

Materials examined: T27513 (Female, 26.i.2011), 27524 (Female, 26.i.2011), 27517 (Female, 15.xii.2009), 27518 (Female, 15.xii.2009), 27519 (Male, 27.i.2011), 27520 (Male, 26.i.2011), 27527 (Female, 26.i.2011).

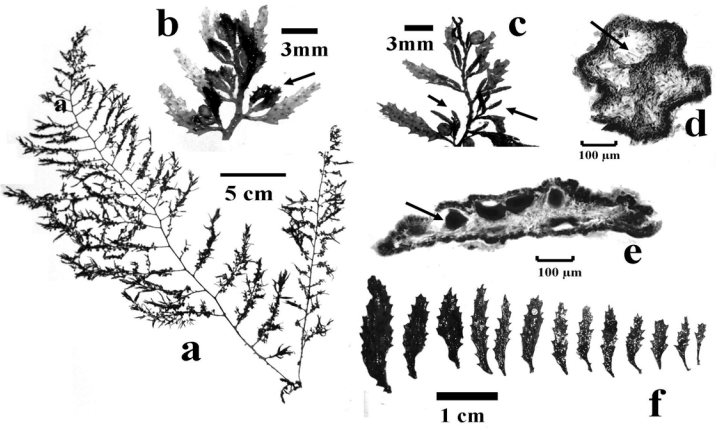

Figure 4. *Sargassum gracillimum* Reinbold. a. Habit; b. Portion of a branch showing toothed female receptacles (arrow); c. Portion of the branch showing terete male receptacle; d. Cross-section of male receptacles showing conceptacles (arrow); e. Cross-section of compressed female receptacles showing oogonia; f. Leaves from different branch orders.

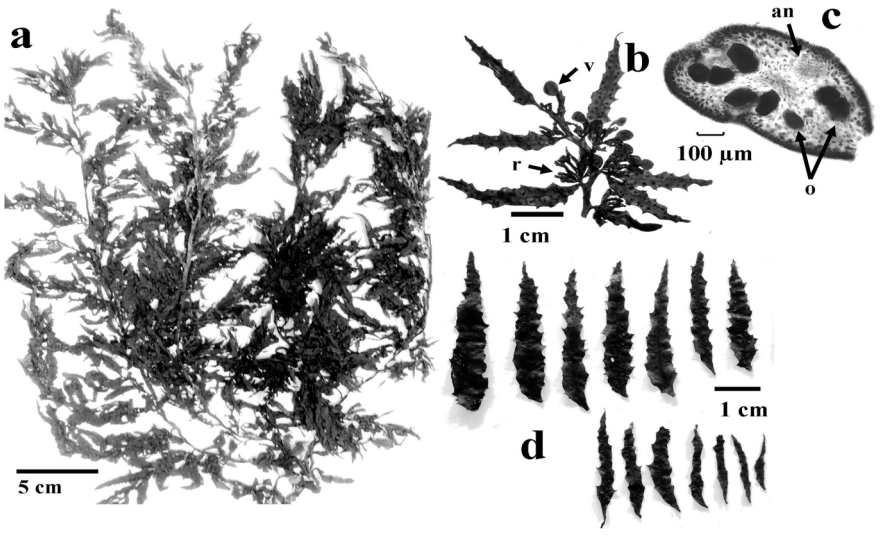

Figure 5. *Sargssasum kushimotense* Yendo. a. Habit; b. Portion of branch showing receptacles (r) and vesicles with distinctly flattened pedicels (v); c. Cross-section of androgynous receptacles showing antheridia (an) and oogonia (o); d. Leaves from different branch orders.

Sargassum kushimotense Yendo (Fig. 5)

Trono 1992, p. 60, Figs. 31-34, 115; 1997, p. 141, Fig. 93.

Plants up to 42 cm long; holdfast incomplete, perhaps due to damage during collection. Main axis short, up to 8.5 mm long, with up to seven primary branches crowding at its tip. Primary branches up to 41.5 cm long; strongly flattened throughout, up to 4 mm wide, becoming narrow towards the tip. Secondary branches strongly flattened, up to 25 cm long, 2.5 mm wide; arranged almost always alternately along the primary branches. Leaves of primary branches linear-lanceolate to linear-oblanceolate, up to 40 mm long, 9 mm wide; margins undulate with occasional teeth towards the tip; apex acute to rounded; stalk very short, leaves appearing sessile on branches; base assymetrical; midrib distinct, apparent towards the tip; cryptostomata present and scattered. Leaves of secondary branches linear-lanceolate to linear-oblanceolate, up to 40 mm long, 9 mm wide; margin sharply serrate; apex acute; based assymetrical; cryptostomata distinct and elevated, generally arranged in rows. Vesicles ovate to obovate, up to 5 mm long, 4.5 mm wide; cryptostomata few but distinct and elevated; pedicels flattened and winged, sometimes longer than vesicles; cryptostomata elevated and scattered.

Plant monoecious. Receptacles androgynous, lumpy and compressed becoming flattened towards the tip, up to 4 mm long, 1 mm wide; longer receptacle branches with tendency to be twisted towards the tip; margin with blunt teeth; in cymose arrangement.

Remarks: The specimens are similar to those described by Trono (1992), except that the materials reported herein have mature receptacles which are longer, characteristically toothed and compressed and/or flat towards the tip.

Materials examined: T27539 (Androgynous, 16.xii.2009), 27540 (Androgynous, 16.xii.2009)

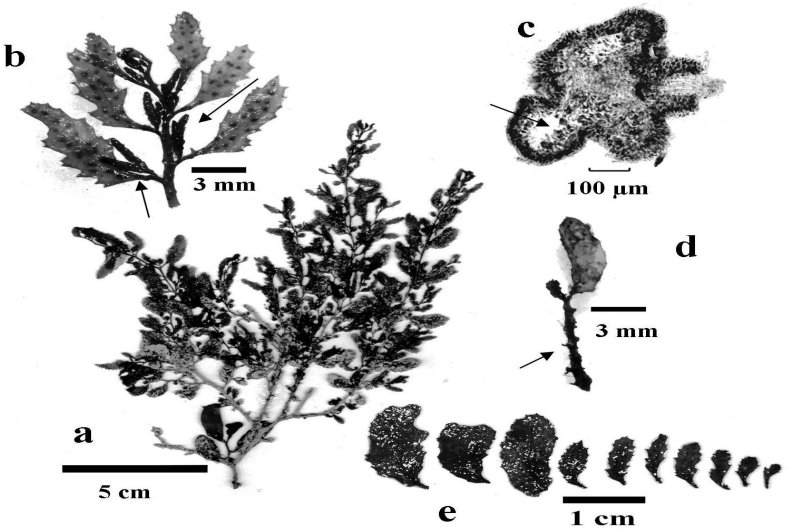

Figure 6. *Sargassum myriocystum* J. Agardh. a. Habit of fertile material; b. Portion of the branch showing terete male receptacles; c. Cross-section of male receptacle (conceptacles indicated by arrow); d. Portion of the branch showing protuberances (muricate); e. Leaves from different branch orders.

Sargassum myriocystum J. Agardh (Fig. 6)

Ajisaka and others 1995, p. 30, Figs. 16-18; Modelo and Umezaki 1995, p. 25, Plate 12A-12C, 22-23; Ajisaka and others 1999, p. 34, Fig. 5; Wong and others 2008, p. 125, Fig. 76-78.

Plant up to 18 cm long, holdfast lacking perhaps due to damage from collection. Main axis short, 8.5 mm long, terete and lumpy. Primary branches arising at the tip

of the stem, up to 16 cm long, 1.5 mm in diameter, terete; many simple protuberances found at the basal one-third of the branch, becoming few towards the tip. Secondary branches up to 14.5 cm long, 1.5 mm in diameter; muricate near the base, protuberances becoming lesser towards the tip. Leaves on primary branches horizontally attached, widely oblong to oblanceolate, up to 19 mm long, 8 mm wide; margin entire, sometimes wavy and with occasional teeth; apex rounded or obtuse; midrib distinct but disappearing towards the tip; base oblique, with spines arising perpendicular to the plane of the blade; cryptostomata numerous, elevated and scattered. Leaves of higher branches highly variable in shape, oblong to oblanceolate, linear to linear-lanceolate, up to 17 mm long, 1-6.5 mm wide; horizontally attached; base asymmetrical, adaxial part highly oblique, giving leaves a long-stalked appearance, with spines arising perpendicular to the plane of the blade; margin serrate-dentate; apex round to obtuse; midrib apparent, disappearing toward the tip, absent in some; cryptostomata elevated, numerous, scattered but with tendency to be arranged in rows in narrow leaves. Vesicles spherical to obovoid, 1-3 mm long, 1-2.5 mm wide; cryptostomata distinct and elevated; apex rounded; pedicel very short.

Plant dioecious (?). Receptacles closely associated with leaves and/or vesicles; up to 5 mm long, 1 mm wide; terete and lumpy; racemosely arranged.

Remarks: The materials are similar to those described by Modelo and Umezaki (1995) from the Philippines, Ajisaka and others (1995) from Japan, and Wong and others (2008) from Malaysia except that the material is shorter, and appears to have less muricate branches. The spines found arising perpendicular to the plane of the blade is similar to those observed in the line drawings of Ajisaka and others (1995), particularly in Figs. 18.7-8, but the authors did not mention this character. The same authors also reported on the highly variable shape of the male and female receptacles of the materials from Japan. Ajisaka and others (1999) reported the uniform shape of the receptacles of *S. myriocystum* from Malaysia. Meanwhile, the similarity of this species to *S. polycystum* is often pointed out because of its muricate branches but is discriminated from the latter due to the absence of rhizoidal holdfast (Ajisaka and others 1995, 1999, Modelo and Umezaki 1995, Wong and others 2008). Recently, this taxon is proposed by Mattio and others (2009) as a synonym of *S. polycystum* but the authors are also cautious in concluding this synonymy, noting that Grunow's type specimens must first be examined. Hence, we maintain and consider *S. myriocystum* and *S. polycystum* as distinct taxa.

Materials examined: T27530 (Male, 26.i.2011), 27532.

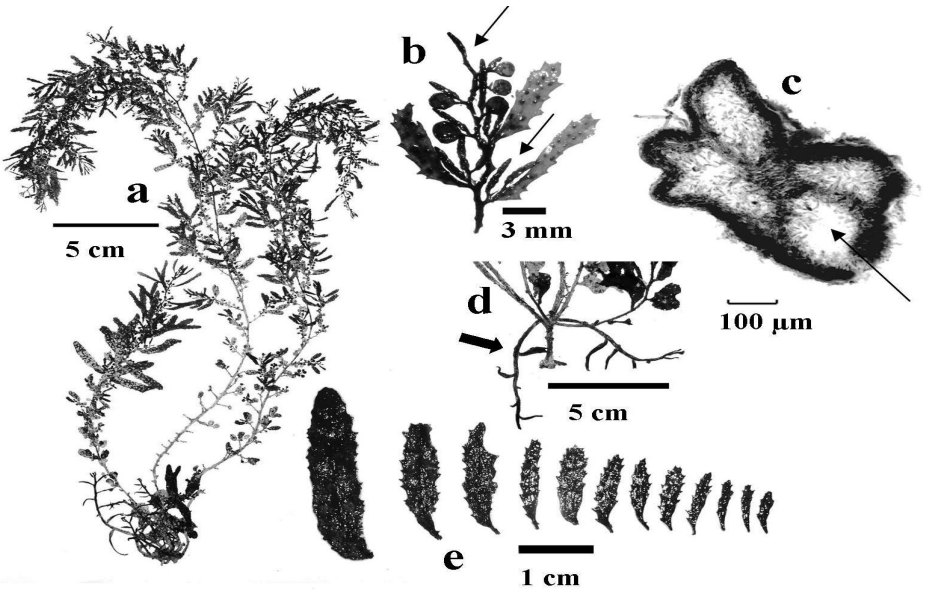

Figure 7. *Sargassum polycystum* C.A. Agardh. a. Habit; b. Portion of branch showing terete male receptacles; c. Cross-section of male receptacles showing conceptacles (arrow); d. Branched stolons arising from the tip of the main axis; e. Leaves from different branch orders.

Sargassum polycystum C.A. Agardh (Fig. 7)

Chiang and others 1992, p.36, Figs. 1-12; Trono 1992, p. 63; 1997, Figs. 96A-96B, p. 147; Modelo and Umezaki 1995, p. 34, pl. 27A-27D, 32, 33; Wong and others 2008, p. 126, Figs. 84-90.

Plants up to 75 cm long; holdfast discoid; main axis up to 16.5 mm long, 2.5 mm in diameter, lumpy. Primary branches up to 72.5 cm long, terete, with many simple or branched protuberances (muricate); crowded at the distal end of the main axis, some branches modified into branched stolons, branchlets often alternately arranged, with some tips modified into discs for attachment. Secondary branches terete, muricate. Leaves on primary branches of vegetative materials usually larger, oblong to oblanceolate, up to 30 mm long, and 10 mm wide; margin entire at the basal two-thirds of the leaves, sometimes wavy, becoming finely serrate-dentate towards the rounded or obtuse apex; base oblique; midrib apparent disappearing towards the tip; cryptostomata numerous and scattered. Leaves on secondary branches oblong to obovate, linear-lanceolate to oblanceolate, up to 13 mm long, 6 mm wide; base

asymmetrical, oblique, giving leaves a long-stalked appearance; margin serrate dentate; apex rounded or obtuse; midrib apparent, disappearing near the tip; cryptostomata numerous and scattered. Vesicles numerous, ovoid to obovoid, up to 3 mm long and 3 mm wide; lumpy due to scattered and elevated cryptostomata. Leaves on primary branches of fertile materials linear to linear-oblanceolate, up to 27 mm long, 5.5 mm wide; base asymmetrical; margin serrate-dentate; apex rounded or obtuse; midrib apparent, disappearing towards the tip; cryptostomata numerous, scattered. Leaves on secondary branches linear to linear oblanceolate, up to 13.5 mm long and 3.5 mm wide; base oblique, leaves having a long-stalked appearance; margin of leaves at the basal one-third entire becoming finely serrate-dentate towards the rounded or obtuse apex; midrib apparent but evanescent on narrow leaves; cryptostomata numerous, scattered but with tendency to be arranged in rows in narrow leaves. Vesicles numerous, ovoid to obovoid, 3 mm long to 3 mm wide; lumpy with few elevated cryptostomata.

Plants dioecious (?). Only male plants were available for examination. Male receptacles racemose, terete and lumpy, up to 5 mm long and 0.5 mm wide.

Remarks: Chiang and others (1992) reported that the diagnostic characteristics of *S. polycystum* include the presence of branched stolons, the highly muricate branches, and the abundance of small vesicles in mature plants. In the Philippines, Modelo and Umezaki (1995) reported *S. herporhizum* Setchell *et* Gardner as among the species that have branched stolons. This species is differentiated from *S. polycystum* by having smooth branches. Phang and Yoshida (1997) described another species, *S. stolonifolium* Phang *et* Yoshida from Malaysia, which is also characterized by the presence of stolons. However, this species was differentiated from *S. polycystum* and *S. herporhizum* by having stolons that "are derived from the cauline leaves, which are distinctly formed earlier on the lower part of the stem" (Phang and Yoshida 1997, pp 68 and 71). Noiraksar and Ajisaka (2008) noted the similarity of some specimens of *S. polycystum* (i.e. some have no branched stolons – perhaps because they are still immature – and have scattered or no spines) with *S. baccularia* (Mertens) C. Agardh from Malaysia, and the difficulty in distinguishing one from the other, especially when found growing together. Another species that closely resembles *S. polycystum* is *S. myriocystum*, which is characterized by highly muricate branches. *S. myriocystum* can be distinguished from *S. polycystum* primarily through the absence of the branched stolons. As mentioned earlier, Mattio and others (2009) proposed the synonymy of *S. myriocystum* with *S. polycystum* based on their diagnoses on the different varieties and forms of the two species as described by Grunow. However, Mattio and others (2009) noted that Grunow's specimens should be examined first to conclude this proposition, and, based on the distinct characteristics

outlined by Chiang and others (1992), particularly the branched horizontal stolons which are absent in mature specimens of *S. myriocystum*, we still consider these two taxa as distinct.

Materials examined: T27514, 27515 (Male, 15.xii.2009), 27523 (Male, 26.i.2011), 27531, 27533.

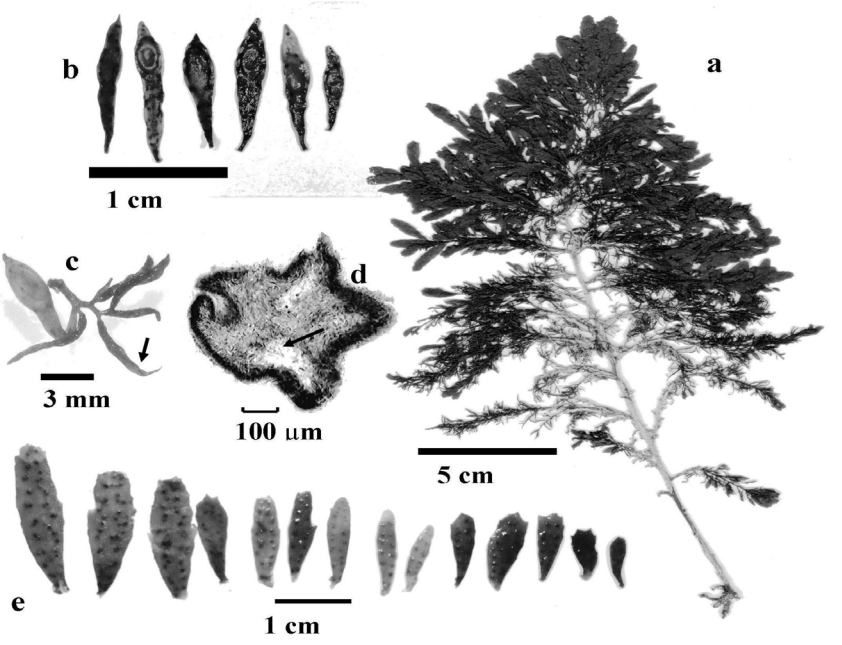

Figure 8. *Sargassum* sp. 1. a. Habit; b. Phyllocystic vesicles; c. Male receptacles (arrow) associated with vesicles; d. Cross-section of male receptacles showing antheridia (arrow); e. Leaves from different branch orders.

Sargassum sp. 1 (Fig. 8)

Plant up to 26 cm long; holdfast incomplete perhaps due to damage from collection. Main axis terete, smooth, up to 2.5 mm in diameter; percurrent. Primary branches terete, lumpy at the base; 1.5 mm in diameter, up to 9 cm long, becoming shorter towards the tip, creating the characteristic pine-tree like shape of the thallus. Leaves spatulate to linear-oblanceolate, up to 17 mm long and 7mm wide; margin wavy, entire at basal half, with several teeth towards the tip; base asymmetrical, adaxial part oblique, giving the leaves a long-stalked appearance; apex rounded to obtuse; midrib evanescent; cryptostomata distinct, elevated with a tendency to be

arranged in rows especially in narrow leaves. Leaves appear to be deciduous, especially near the basal portion of the thallus. Vesicles elliptical to oblong, 2-5 mm long, 0.5-2.0 mm wide, slightly compressed, mucronate; pedicels flattened, up to 4.5 mm long, sometimes longer than vesicles; cryptostomata distinct almost always arranged near the margin; mostly phyllocystic.

Plant dioecious (?). Male receptacles lumpy due to elevated cryptostomata, 7mm long, 0.5mm wide; slightly compressed near base, becoming flattened towards an acuminate tip; densely arranged in racemose clusters.

Remarks: Despite the review on the different *Sargassum* monographs mentioned earlier, no specific epithet can be assigned to this material. The pine-tree-like appearance of the thallus is similar to that of *S. gracillimum* but is different because of the leaf shape, the phyllocystic vesicles, and the receptacles of *Sargassum* sp.1 are terete near the base becoming flattened towards the tip. We believe that this species may be an undescribed and/or unreported species; however, more materials are needed to elucidate the range of morphological variations for the species and a more extensive review of literature on *Sargassum* is also needed to confirm this claim.

Material examined: T27534 (Male, 16.xii.2009)

Sargassum sp. 2 (Fig. 9)

Plants up to 21.5 cm long; holdfast discoid; main axis very short, up to 3.5 mm long, up to 1.25 mm in diameter. Primary branches slender, terete, and coarse near the base; up to 21 cm long. Secondary branches, which arise at the axil of the leaves on primary branches, shorter, terete, filiform, up to 4.5 cm long, decreasing in length towards the tip giving the thallus a pine-tree like appearance; base of the branches lumpy due to leaf scars. Leaves on primary branches linear to linear-lanceolate, almost always length is ten times more than the width, up to 30 mm long, 3.5 mm wide; margin entire at basal half, becoming occasionally serrated or dentate towards the blunt apex; stipe very short, giving leaves a sessile appearance; base asymmetrical; midrib apparent, disappearing just below the apex; cryptostomata scattered, becoming arranged in lines parallel to the margins in narrow leaves. Leaves on secondary branches linear to linear-lanceolate, almost always length is ten times more than the width, up to 22.5 mm long, 2.5 mm wide; highly oblique base gives the leaf a long-stalked appearance; margin entire at basal half, becoming serrate/dentate towards an acuminate tip; leaves found near the tip of the branches

and associated with the receptacles characteristically linear or filiform with an acuminate tip; midrib evanescent, absent in very narrow leaves; cryptostomata numerous, scattered, those in narrow leaves tends to be arranged in rows. Vesicles oblong to elliptical, up to 3 mm long and 2 mm wide; very few cryptostomata; apex rounded, sometimes apiculate or with a very short mucron; pedicels terete, up to 1 mm long.

Plant dioecious (?). Receptacles often associated with vesicles and/or leaves. Female receptacles cuneate, racemosely arranged, up to 3.5 mm long, 1 mm wide; flattened near base, becoming serrated, triquetrous and/or twisted, towards the tip.

Remarks: *Sargassum* sp. 2 is similar to the *S. gracillimum* described in this paper in terms of its pine-tree-like shape, its linear to linear-lanceolate leaf shape, its toothed and triquetrous receptacles that are closely associated with the vesicles and/or leaves. However, this species has distinctly filiform leaves especially near the tip of the secondary branches and the receptacles are shorter, cuneate and twisted towards the tip. The material is also similar to *Sargassum umezakii* Trono which has filiform leaves that are associated with the receptacles, but differs from the latter by having relatively longer and wider leaves, an apiculate or mucronate vesicles, and the cuneate female receptacles with flattened base becoming triquetrous towards the tip.

Material examined: T27526 (Female, 26.i.2011)

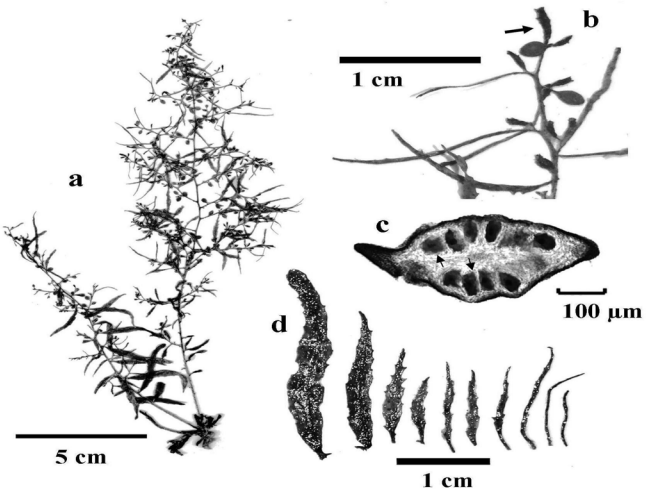

Figure 9. *Sargassum* sp. 2. a. Habit; b. Portion of branch showing cuneate female receptacles; c. Cross-section of female receptacles showing oogonia (arrow); d. Leaves from different branch orders.

SUMMARY

Eight *Sargassum* morphotypes are reported in this study. Six of these are identified as *Sargassum crassifolium* J. Agardh, *S. cristaefolium* C. Agardh, *S. kushimotense* Yendo, *S. gracillimum* Reinbold, *S. myriocystum* J. Agardh, and *S. polycystum* C.A. Agardh; while two remain unidentified and have not been assigned with specific epithets.

ACKNOWLEDGMENTS

An earlier version of this paper was presented as a poster titled "*Sargassum* (Sargassaceae, Phaeophyta) from Alabat Island, Quezon Province, Northeastern Philippines" at the 11th National Symposium in Marine Science and was published in its book of abstracts. This study was made possible through the funding of the Department of Science and Technology (DoST) under the climate change research program, "Resilient Seas". The two anonymous reviewers are also acknowledged for their invaluable comments/insights which have greatly improved the content of this manuscript. The authors are greatly indebted to Ms. Marilyn Dayao for the assistance in field collection; and to Mr. Christian Ace Guerta for processing voucher specimens. Mr. Napo M. Cayabyab and Dr. Olivia Cabrera are likewise acknowledged for collecting some of the interesting specimens described herein and for providing a line drawing of the map, respectively. Our thanks also go to the Marine Science Institute of the University of the Philippines (UP-MSI) and Dr. Laura T. David for the kind support in the conduct of this study. This is the Marine Science Institute Contribution No. 416.

REFERENCES

Abbott IA and Norris JN, editors. 1985. Taxonomy of economic seaweeds with reference to some Pacific and Caribbean species. California Sea Grant Program, La Jolla, CA, USA. 167 p.

Abbott IA, editor. 1988. Taxonomy of economic seaweeds with reference to some Pacific and Caribbean species. Vol. II, California Sea Grant Program, La Jolla, CA, USA. 264 p.

Abbott IA, editor. 1992. Taxonomy of economic seaweeds with reference to some Pacific and Western Atlantic species. Vol. III, California Sea Grant College, La Jolla, CA, USA. 241 p.

Abbott IA, editor. 1994. Taxonomy of economic seaweeds with reference to some Pacific species. Vol. IV, California Sea Grant College, La Jolla, CA, USA. 200 p.

Abbott IA, editor. 1995. Taxonomy of economic seaweeds with reference to some Pacific species. Vol. V, California Sea Grant College System, La Jolla, CA, USA. 254 p.

Abbott IA, editor. 1997. Taxonomy of economic seaweeds with reference to some Pacific species. Vol. VI, California Sea Grant College System, La Jolla, CA, USA. 212 p.

Abbott IA, editor. 1999. Taxonomy of economic seaweeds with reference to some Pacific species. Vol. VII, California Sea Grant College System, La Jolla, CA, USA. 181 p.

Abbott IA and McDermid K, editors. 2002. Taxonomy of economic seaweeds with reference to some Pacific species. Vol. VIII, California Sea Grant College System, La Jolla, CA, USA. 332 p.

Ajisaka T, Phang SM, Yoshida T. 1997. Taxonomic and nomenclatural study of *Sargassum duplicatum* Bory and related species. In: Abbott IA, editor. Taxonomy of economic seaweeds with reference to some Pacific species. Vol. VI, California Sea Grant College System, La Jolla, CA, USA. p 27–36.

Ajisaka T, Huyn QN, Nguyen HD, Lu B, Ang PO Jr, Phang SM, Noro T, Yoshida T. 1999. Preliminary report of *Sargassum* species collected from Malaysian coasts. In: Abbott IA, editor. Taxonomy of economic seaweeds with reference to some Pacific species. Vol. VII, California Sea Grant College System, La Jolla, CA, USA. p 23–41.

Ang PO Jr, Trono GC Jr. 1987. The genus *Sargassum* (Phaeophyta, Sargassaceae) from Balibago, Calatagan, Philippines. Bot. Mar 30: 387-397.

Ang PO Jr, Leung SM, Choi MM, Cheang CC. 2008. The genus *Sargassum* in the South China Sea region: A compilation list and preliminary biogeographical analysis. In Phang SM, Lewmanomont K, Lim PK, editors. Taxonomy of Southeast Asian Seaweeds. Institute of Ocean and Earth Sciences, University of Malaya, C308, IPS Building, 50603 Kuala Lumpur, Malaysia. p 147-158.

Brownlee IA, Allen A, Pearson JP, Dettmar PW, Havler ME, Atherton MR, Onsøyen E. 2005. Alginate as a source of dietary fiber. Crit Rev Food Sci Nutr 45: 497–510.

Chiang YM, Yoshida T, Ajisaka T, Trono GC Jr, Tseng CK, Lu B. 1992. Distribution and variation in *Sargassum polycystum* C.A. Agardh (Fucales, Phaeophyta). In: Abbott IA, editor. Taxonomy of economic seaweeds with reference to some Pacific and Western Atlantic species. Vol. III, California Sea Grant College, La Jolla, CA, USA. p 35–42.

Ganzon-Fortes ET. 2012. A historical account of biodiversity studies on Philippine seaweeds (1800-1999). Coastal Marine Science 35(1): 182-201.

Kilar JA, Hanisak D, Yoshida T. 1992. On the expression of phenotypic variability: Why is *Sargassum* so taxonomically difficult? In: Abbott IA, editor. Taxonomy of economic seaweeds with reference to some Pacific and Western Atlantic species. Vol. III, California Sea Grant College, La Jolla, CA, USA. p 95-117.

Mattio L, Payri CE, Verlaque M. 2009. Taxonomic revision and geographic distribution of the subgenus *Sargassum* (Fucales, Phaeophyceae) in the western and central Pacific Islands based on morphological and molecular analyses. J. Phycol 45: 1212-1227.

Modelo RB, Umezaki I. 1995. Contribution to the study of the genus *Sargassum* (Fucales, Phaeophyceae) of the Philippines. The Philippine Journal of Science Special Issue: 1-50.

Montaño MNE, Rodriguez MRC, Balitaan RL. 2006. Ethnobotany of Sargassum spp. in the Philippines. Coastal Marine Science 30 (1): 222-225.

Noiraksar T, Ajisaka T. 2008. Taxonomy and distribution of *Sargassum* (Phaeophyceae) in the Gulf of Thailand. J. Appl. Phycol. 20: 963-977.

Noro T. 1989. Preliminary taxonomic studies on the genus *Sargassum* (Sargassaceae, Fucales) in Palawan, Philippines. In: Umezaki I, editor. Scientific survey of marine algae and their resources in the Philippine Islands. p 41-51.

Phang SM, Wong CL, Ng WS, Sim MC. 2008. Checklist of Malaysian *Sargassum* species. In: Phang SM, Lewmanomont K, Lim PK, editors. Taxonomy of Southeast Asian Seaweeds. Institute of Ocean and Earth Sciences, University of Malaya, C308, IPS Building, 50603 Kuala Lumpur, Malaysia. p 83-103.

Phang SM, Yoshida T. 1997. *Sargassum stolonifolium* Phang *et* Yoshida *sp. nov.* from Penang Island, Peninsular Malaysia. In: Abbott IA, editor. Taxonomy of economic seaweeds with reference to some Pacific species. Vol. VI, California Sea Grant College System, La Jolla, CA, USA. p 61-71.

Phillips N. 1995. Biogeography of *Sargassum* (Phaeophyta) in the Pacific basin. In Abbott IA, editor. Taxonomy of economic seaweeds with reference to some Pacific species. Vol. V, California Sea Grant College System, La Jolla, CA, USA. p 107-144.

Prud'homme van Reine, WF. 2001. Introduction. In: Prud'homme van Reine WF, Trono GC, editors. Plant resources of South–East Asia No. 15(1). Cryptogams: Algae. Prosea Foundation, Bogor, Indonesia. p 15-74.

Reinbold T. 1913. *Sargassum*. In: Weber-van Bosse A, editor. Myxopyceae, Chlorophyceae, Phaeophyceae. Siboga Expeditie, Vol. 59a. Brill, Leiden, p 150-174.

Silva PC, Meñez EG, Moe RL. 1987. Catalogue of the benthic marine algae of the Philippines. Smithsonian Contributions to Marine Science No. 27. Smithsonian Institution Press, Washington, D.C. 179 p.

Silva PC, Basson PW, Moe RL. 1996. Catalogue of the benthic marine algae of the Indian Ocean. University of California Publication in Botany, Los Angeles, California.

Trono GC, Lluisma AO. 1990. Seasonality of standing crop of a *Sargassum* (Fucales, Phaeophyta) bed in Bolinao, Pangasinan, Philippines. Hydrobiologia 204/205: 331-338.

Trono GC Jr. 1992. The Genus *Sargassum* in the Philippines. In: Abbott IA, editor. Taxonomy of economic seaweeds with reference to some Pacific and Western Atlantic species. Vol. III, California Sea Grant College, La Jolla, CA, USA. p 43-94.

Trono GC Jr. 1994. New species of *Sargassum* form the Philippines. In: Abbott IA, editor. Taxonomy of economic seaweeds with reference to some Pacific species. Vol. IV, California Sea Grant College, La Jolla, CA, USA. p 3-7.

Trono GC Jr. 1997. Field guide and atlas of the seaweed resources of the Philippines. Bookmark, Philippines. 306 p.

Tseng CK, Lu B. 1997. Studies on the glomerulate *Sargassum* of China: IV. Series of *Platycarpae*. In: Abbott IA, editor. Taxonomy of economic seaweeds with reference to some Pacific species. Vol. VI, California Sea Grant College System, La Jolla, CA, USA. p 27–36.

Wong CL, Ng WS, Phang SM. 2008. Taxonomic notes on *Sargassum* species (Sargassaceae, Phaeophyta) from Malaysia. Checklist of Malaysian *Sargassum* species. In: Phang SM, Lewmanomont K, Lim PK, editors. Taxonomy of Southeast Asian Seaweeds. Institute of Ocean and Earth Sciences, University of Malaya, C308, IPS Building, 50603 Kuala Lumpur, Malaysia. p 105-145.

Yoshida T. 1988. Japanese and Taiwanese species of *Sargassum* subgenus *Sargassum*. In: Abbot IA, editor.Taxonomy of economic seaweeds with reference to some Pacific and Western Atlantic species. Vol. III, California Sea Grant College, La Jolla, CA, USA. p 5-21.

Wilfred John E. Santiañez <wjesantianez@gmail.com> is a Research Associate at the UP Marine Science Institute (UP-MSI) and a Master of Environment and Natural Resources Management (MENRM) student at the University of the Philippines Open University.

Gavino C. Trono, PhD is Professor Emeritus of Marine Science at UP-MSI and Academician at the National Academy of Science and Technology (NAST)-Philippines. Considered as the Father of Modern Philippine Phycology, Dr. Trono has more than 40 years of contribution to the studies on the diversity (taxonomy), ecology, and mariculture of seaweed resources of the Philippines.