



Research Article



The Morphotaxonomy and Distribution of the Genus *Sargassum* C. Agardh (Fucales, Phaeophyta) from Kampani Coastal Areas



Hsu Mon Oo¹, Chaw Thiri Pyae Phyo Aye², Mya Kyawt Wai^{3*}, Soe Pa Pa Kyaw³, U. Soe-Htun⁴

¹ MSc Candidate, Department of Marine Science, Mawlamyine University

² Demonstrator, Department of Marine Science, Mawlamyine University

³ Assistant Lecturer, Department of Marine Science, Mawlamyine University

⁴ Professor & Head, Department of Marine Science, Mawlamyine University

*Corresponding Author: Mya Kyawt Wai, Assistant Lecturer, Department of Marine Science, Mawlamyine University, Myanmar; E-mail: mrakyawtwai@gmail.com

Abstract

Three species of *Sargassum* belonging to the *Sargassum* subgenus *Sargassum* (Fucales, Phaeophyta) collected from the Kampani coastal areas- Thabawseik and southern Kampani from October 2012 to March 2013, had been identified as *Sargassum swartzii* (Turner) C. Agardh and *S. cervicorne* Greville under the section *Binderiana* and *S. plagiophyllum* C. Agardh (with or without stolons) under the section *Polycystae* based on a detailed account of morphologies of vegetative and reproductive structures of the plants. *Sargassum plagiophyllum* C. Agardh (with or without stolons) is the most common species occurring in the two study areas. The growth patterns in the development of furcate cauline leaf, dwarfs of main branch as well as different orders of branches, leaves, vesicles and receptacles of *Sargassum swartzii* (Turner) C. Agardh and *S. cervicorne* Greville under *Sargassum* section *Binderiana* was recorded. In addition, *S. cervicorne* Greville was firstly reported from Kampani coastal areas. Moreover, the simple cauline leaf, dwarfs of main branch or stolons as well as different orders of branches, leaves, vesicles and receptacles of *S. plagiophyllum* C. Agardh (with or without stolons) under *Sargassum* section *Polycystae* belonging to the *S.* subgenus *Sargassum* from Kampani coastal areas was also recorded.

Keywords: *Binderiana*; Fucales; Growth patterns; Morphology; Phaeophyta; Phytogeographic distribution; *Polycystae*; *Sargassum*, *S. cervicorne*, *S. plagiophyllum*, *S. swartzii*, taxonomy.

Introduction

The brown algal genus *Sargassum* which represents 929 species names of which 335 are currently accepted taxonomically, are the most abundant plants in various major marine geographical regions from Indo-Pacific to the Atlantic Oceans, covering temperate, sub-tropical and tropical regions of the world oceans^[1,2]. However, less than 40% are recognized as current, identifying a species is often a difficult task^[3]. Morphology and taxonomy of the genus *Sargassum* are still complex and variable due to many problems of phenotypic variations caused by polymorphisms and polyphenisms as well as genetic differences among populations^[4-8]. *Sargassum* species are economically important, especially in Asian countries where they are exploited by agro-food, textile, cosmetic and pharmaceutical industries. It can be utilized as a source of phycocolloids, in particular alginate, which is used in the textile industry in Indonesia and Vietnam. It is also used in vegetable soup. Young shoots also form a common ingredient of fish dishes in northern Philippines^[9]. Moreover,

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the genus *Sargassum* showed antibacterial or antiviral activity^[10-12] as well as antioxidant and antifungal activities^[13-15].

In Myanmar, the genus *Sargassum* known as “Leik-Sar-Phatt” or “Kyauk-Pann” in local name, grows luxuriantly along the Rakhine and Tanintharyi Coastal Regions and subjects to the lower intertidal and subtidal zones in winter and summer months. Kyaw Soe et al^[16] recorded a total of 22 species of *Sargassum*. Soe-Htun^[17] described fifteen species of *Sargassum*, namely *S. aff. trichophyllum* (Kützting) C. Kuntze, *S. aff. salicifoloides* Yamada, *S. aff. kasyotense* Yamada, *S. aff. tenerrimum* J. Agardh, *S. aff. carpophyllum* J. Agardh, *S. ilicifolium* (Turner) C. Agardh, *S. cristaeifolium* C. Agardh, *S. duplicatum* Bory, *S. swartzii* (Turner) C. Agardh, *S. plagiophyllum* (Mertens) C. Agardh, *S. polycystum* C. Agardh, *S. herporhi-*



zum Setchell and Gardner, *S. sp.1*, *S. sp.2* and *S. sp.3* in details. Recently, Soe-Htun *et al*^[18] reported the sequential processes of development of stolons and branches as well as leaves, vesicles, and receptacles of *Sargassum polycystum* C. Agardh and *S. plagiophyllum* (Mertens) C. Agardh (*Sargassum* section Polycystae) from Myanmar.

The purposes of this study are: 1) to know the morphotaxonomy of the genus *Sargassum* spp.; and 2) to elucidate the biodiversity and distribution of *Sargassum* spp. in Kampani coastal areas.

Materials and Methods

The specimens examined were collected from the intertidal and sub tidal zones of the Southern Kampani (Lat. 14° 02' N, Long. 98° 04' E) and Thabawseik (Lat. 14° 05' N, Long. 98° 05' E) coastal areas in Longlone Township of Taninthayi Region from 2012 to 2013 (Figure 1). All collected specimens were washed with seawater to remove the adhering other materials and contaminants and preserved in 5% formalin (40% formaldehyde) solution in seawater for a detailed investigation on external and internal morphologies of the materials. The herbarium sheets were prepared and deposited at the Herbarium of Department of Marine Science, Mawlamyine University (MMB). The external and internal characteristics of vegetative and reproductive structures used in the identification of the plants were also recorded and photographed by using digital camera, under the compound and dissecting microscopes. The sections of the samples were made by hand, using razor blades and were stained with 1% aniline blue or 1% acid fuchsin. Microscopic measurements of the specimens were recorded by using the calibrated ocular micrometer. Digital photographs were processing in Photoshop CS3. Identification of specimens was made, mainly based on the following taxonomic references: Soe-Htun^[17], Mattio *et al*^[8] Guiry *et al*^[2]. The local distribution of each taxon derived primarily from the reference collection of herbarium specimens examined. Phytogeography and potential uses of these algae were acknowledged from the worldwide literature records.

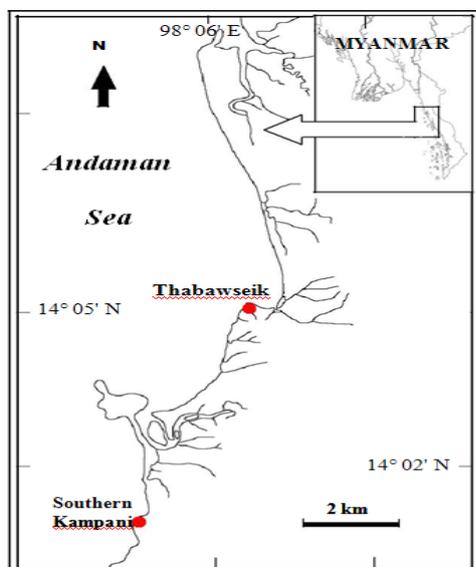


Figure 1: Map showing the two collection sites of the genus *Sargassum* from Kampani coastal areas.

Results

Three species of *Sargassum* belonging to the *Sargassum* subgenus *Sargassum* (Fucales, Phaeophyta) collected from the Kampani coastal areas- Thabawseik and southern Kampani from October 2012 to March 2013, had been identified as *Sargassum swartzii* (Turner) C. Agardh and *S. cervicornae* Greville under the section *Binderiana* and *S. plagiophyllum* C. Agardh (with and without stolons) under the section *Polycystae* based on a detailed account of morphologies of vegetative and reproductive structures of the plants.

A classification system of the genus *Sargassum* from Kampani coastal areas

Phylum: Phaeophyta (= Ochrophyta)

Class: Phaeophyceae

Orders: Fucales Family: Sargassaceae

Genus: *Sargassum* C. Agardh 1920

Subgenus: *Sargassum* J. Agardh

Section: *Binderiana* (Grunow) Mattio et Payri Species:

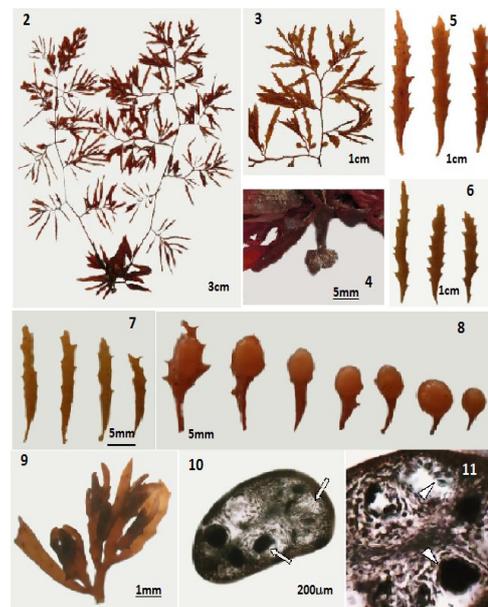
(1) *S. swartzii* (Turner) C. Agardh

(2) *S. cervicornae* Greville

Section: *Polycystae* Mattio et Payri.

Species: (1) *S. plagiophyllum* C. Agardh (with and without stolons)

Sargassum swartzii (Turner) C. Agardh^[19] 1824



Figures 2-11: *Sargassum swartzii* (Turner) C. Agardh from the Kampani coastal areas: 2) Habitat of plant; 3) Apical part; 4) Holdfast; 5) Leaves of lower part; 6) Leaves of middle part; 7) Leaves of upper part; 8) Various shapes of vesicles; 9) Androgynous receptacle; 10) Cross-section of androgynous receptacle with antheridia and oogonia; 11) Antheridia and oogonia within the separate conceptacle (arrow heads).^[16,19-36]

Type locality- 'Indian Ocean'^[37](Silva, Basson and Moe 1996: 693).

Description: Vegetative features Plants attach by means of discoidal or conical holdfast. The holdfast is usually 2.0 mm thick and 4.0 mm in diameter; The primary stem is terete, up to 5.0 mm long and 1.0-2.0 mm in diameter usually without branching; Two to four main branches on the middle parts of the stem are

flattened at the base to terete from middle part to upper portion, smooth, 15-20 cm in length and 1.0-1.5 mm in width without ridges and spinous processes; Leaves of main branches are simple, linear to linear-lanceolate in shape, 0.5-1.5 cm apart with a phyllotaxis of 1/3 in spiral or alternate order, thick, shortly stipitate with asymmetrical bases, midribs percurrent and acute to obtuse apices, 3.0-3.5 cm in length and 3.0-4.0 mm in width and slightly wavy or not. The margins of the leaves are sharply serrate.

Cryptostomata are small, 100-150 μm in diameter and scattered or aligned on each side of the midribs in one to several rows and spinous processes are absent on either sides of the stipe; Vesicles of secondary branches are large, mostly subspherical to ellipsoidal in shape, 7.0-17.0 mm in length and 3.0-5.0 mm in diameter, with lateral appendages and mucronate to rounded apices, sometimes foliar. The stipe of these vesicles are flattened in the lower part and compressed in the upper part generally slightly curved upwards with $\frac{1}{2}$ or $\frac{1}{3}$ length of vesicles; Reproductive features: The plant is monoecious. Receptacle branches are racemously to cymosely arranged, long, slightly flattened with a few spines on apical part, irregularly forked, 2.0-4.0 mm in length and 1.0-1.5 mm in diameter with tapering or obtuse apex and mostly formed in the axils of leaves and vesicles of tertiary branches with a short sterile stipe. Receptacle is androgynous (Figures 9-10).

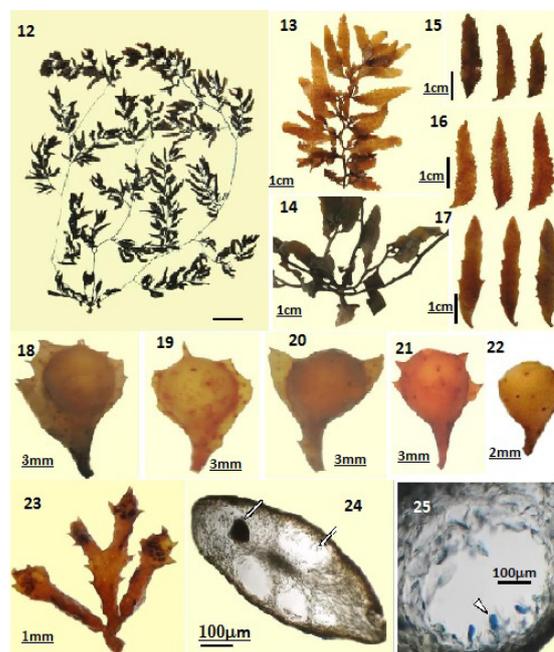
Specimens Examined in the Study Areas- Tanintharyi Coastal Region.- Southern Kampani (Hsu Mon Oo, 26.i.2013; MMB 11962-11963, Drift; Myo Min Tun^[36]7.i.2012; MMB 11463-11467); Thabawseik (Myo Min Tun, 10.i.2013; MMB 111134-37).

Other specimens examined- Tanintharyi Coastal Region- Maungmagun (Aung Myint, 25.xii.1971; MMB 02203); *Ayeyarwady Delta and Gulf of Mottama Coastal Region-* No data; *Rakhine Coastal Region.-* Gwa Aw (Soe-Htun, 13.iv.1983; MMB 02860); Mhaw Chye (Soe- Htun, 17.iv.1980; MMB 02665; Soe-Htun, 25.v.1980; MMB 02667); Maung Shwe Lay Gyaing (Soe-Htun, 15.iv.1980; MMB 02663); Kyaukme Taung (Soe-Htun, 13.iii.1983; MMB 02858); Kyauk Phone Gyi Mhaw (Phyo Zaya, 5.iv.2004; MMB 04650); Lonetha (Soe- Htun, 26.i.1983; MMB 02844); Mazin (Soe- Htun, 31.i.1983; MMB 02852); Ah-Le-Tha-Kyaw (Aung Myint, 25.iv.1970; MMB 02117);.

Myanmar Distribution: Tanintharyi Coastal Region.- Kampani, Thabawseik (Mwe Taung), Maungmagan^[38-40]; *Ayeyarwady Delta and Gulf of Mottama Coastal Region.-* No data; *Rakhine Coastal Region.-* Gwa Aw, Mhaw Chye, Maung Shwe Lay Gyaing, Kyaukme Taung, Kyauk Phone Gyi Mhaw, Lonetha, Mazin, Ah-Le-Tha-Kyaw^[38-40].

World Distribution: Africa.- Kenya^[37]; *Indian Ocean Islands.-* Andaman Islands^[37], Indian Ocean^[31], Nicobar Islands^[37]; *South-west Asia.-* Bahrain, India, Iran, Pakistan, Persian Gulf, Sri Lanka^[37]; *Asia.-* China (Tseng 1984), Hong Kong^[41,32,33], Japan^[1], Korea^[1], Taiwan^[30]; *South-east Asia.-* Indonesia^[1,37], Malaysia^[43], Singapore^[37,2], Myanmar^[42](This study), Thailand^[34,43], Vietnam^[28,1](Dai 2007); *Australia and New Zealand.-* Papua New Guinea(Mattio et al. 2009), Queensland^[31](Mattio et al. 2009); *Pacific Islands.-* New Caledonia^[2](Mattio et al. 2009).

Potential Utilization: *Sargassum swartzii* (Turner) C. Agardh is used as drugs^[11], human foods, fodder, fish meal, manure and alginates^[42,39,40]. It contains 17.23% of sodium alginate^[44].
Sargassum cervicorne Greville 1849



Figures 12-25: *Sargassum cervicorne* Greville from Kampani coastal areas: 12) Habitat of plant; 13) Apical part; 14) Holdfast; 15) Leaves of lower part (scale bar = 1.5cm); 16) Leaves of middle part (scale bar = 1.5cm); 17) Leaves of upper part (scale bar = 0.5mm); 18-22) Various shapes of vesicles; 23) Androgynous receptacle; 24) Cross-section of androgynous receptacle with antheridia and oogonia (arrows); 25) Antheridia attach on conceptacle wall (arrow head).^[16,26,32,33,35,45]

Type Locality- India^[2].

Description- Vegetative features: Plants attach by means of discoidal holdfast. The holdfast is usually 2.0-5.0 mm thick and 1.0 -1.5 mm in diameter; The primary stem is terete, up to 5.0 mm long and 1.0-2.0 mm in diameter usually without branching; Two to four main branches on the middle parts of the stem are flattened at the base to terete from middle part to upper portion, smooth, 25-55 cm in length and 1.0-2.0 cm in width without ridges and spinous processes; Leaves of main branches are simple, lanceolate to linear-lanceolate in shape, 0.5-1.5 cm apart with a phyllotaxis of 1/3 in spiral or alternate order, thick, shortly stipitate with asymmetrical bases, midribs percurrent and acute to obtuse apices, 1.0-5.0 cm in length and 0.5-1.0 cm in width and slightly wavy or not. The margins of the leaves are sharply serrate to dentate. Cryptostomata are small, 100-150 μm in diameter and scattered or aligned on each side of the midribs in one to several rows and spinous processes are absent on either sides of the stipe; Vesicles of secondary branches are large, mostly subspherical to ellipsoidal in shape, 2-6 mm in length and 0.5-2.5 mm in diameter, with or without lateral appendages and mucronate to rounded apices, or sometimes foliar. The stipe of these vesicles are terete in the lower part and compressed in the upper part generally slightly curved upwards with $\frac{1}{2}$ or $\frac{1}{3}$ length of vesicles; Reproductive features: The plant is monoecious. Receptacle branches are racemously to cymosely arranged, long, flattened, twisted with spines on apical

part, irregularly forked, 4.0-8.0 mm in length and 1.5-2.0 mm in diameter with tapering or obtuse apex and mostly formed in the axils of leaves and vesicles of tertiary branches with a short sterile stipe. Receptacle is androgynous and acanthocarpicae, or pseudozygocarpic (Figures 23-24).

Specimens Examined in the Study Areas: *Tanintharyi Coastal Region*- Thabawseik (Hsu Mon Oo, 6.xii.2012; MMB 11953, Drift; 26.i.2013; MMB 11954-11956, Drift); Southern Kampani (Myo Min Htike, 26.iii.2013; MMB 13030, Drift; Lin Lin Tun, 26.iii.2013; MMB 13031, Drift).

Other Specimens Examined: Co Co Island^[16] (Kyi Win, 14.i.1977; MMB 02508).

Myanmar Distribution: *Tanintharyi Coastal Region*.- Kampani, Thabawseik (Mwe Taung), Maungmagan^[16,39,40]; *Ayeyarwady Delta and Gulf of Mottama Coastal Region*.- No Data; *Rakhine Coastal Region*.- Co Co Island^[16].

World Distribution: India^[37](Sahoo et al. 2001), Pakistan, Sri Lanka^[37]; *Asia:* China^[32,33], Japan; *South-east Asia:* Indonesia^[37], Singapore^[37,2].

Potential Utilization: *Sargassum cervicorne* Greville is used as drugs^[11], human food, fodder, fish meal, manure and alginates^[42,39,40].

Sargassum plagiophyllum C. Agardh^[19] 1824



Figures 26-36: *Sargassum plagiophyllum* C. Agardh from Kampani coastal areas: 26) Habitat of plant; 27) Apical part; 28) Holdfast; 29) Leaves of basal part; 30) Leaves of middle part; 31) Leaves of apical part; 32) Various shapes of vesicles; 33) Female receptacle; 34) Male receptacle; 35) Cross-section of male receptacle with antheridia (arrow); 36) Cross-section of female receptacle with oogonia (arrow).
[17,19,20,22,23,25,26,30,36,46-49]

Type Locality– ‘In mari Indico’^[37] (Silva, Basson and Moe 1996: 693).

Description- Vegetative Features: Plants attach by means of discoidal holdfast. The holdfast is usually 2-5 mm thick and 5-7 mm in diameter; The primary stem is terete, 3-10 mm long and 1.5-2.0 mm in diameter usually without branching; Two to four

main branches on the middle parts of the stem are terete, smooth, 10-35 cm in length and 1-2 mm in width without ridges and spinous processes; Leaves of main branches are simple, oblong to linear-lanceolate in shape, 0.5-1.5 cm apart with a phyllotaxis of 1/3 in spiral order, somewhat thick or thin, shortly stipitate with asymmetrical bases, midribs percurrent to disappear near at the apex and obtuse apices, 1-4 cm in length and 0.3-0.7 cm in width and not wavy. The margins of the leaves are entire to slightly or irregularly serrate margins. Cryptostomata are small, 100-150 µm in diameter and scattered or aligned on each side of the midribs in one to several rows and spinous processes are absent on either sides of the stipe; sometimes foliar; Vesicles of secondary branches are mostly ellipsoidal in shape, 2-6 mm in length and 0.5-2.5 mm in diameter, without lateral appendages and mucronate to rounded apices, sometimes foliar. The stipes of these vesicles are generally straight with 1/2 or 1/3 length of vesicles. The stipes of these vesicles are generally straight with 1/2 or 1/3 length of vesicles; Reproductive features: The plant is dioecious. Male receptacle branches are racemously arranged, long, terete, smooth or verrucose, irregularly forked, 5-15 mm in length and 1-1.5 mm in diameter with tapering or obtuse apex and mostly formed in the axils of leaves and vesicles of tertiary branches with a

Vesicles- Vesicles of secondary branches are mostly ellipsoidal in shape, 2-6 mm in length and 0.5-2.5 mm in diameter, without lateral appendages and mucronate to rounded apices, short sterile stipe. Male receptacle is pseudozygocarpic (Figures 34-35); Female receptacle branches are racemously arranged, compressed or triquetrous, smooth at the base and spiny at the lower middle at upper parts, irregularly forked, 3-5 mm in length and 1-1.5 mm in width and mostly formed in the axils of leaves and vesicles of tertiary branches with a short sterile stipe. Female receptacle is pseudozygocarpic (Figures.33,36).

Specimens Examined in the Study Areas–*Tanintharyi Coastal Region*- Southern Kampani (Hsu Mon Oo, 6.xii.2012; MMB 11939-11949; Myo Min Tun^[36] 30.ix.2012; MMB 11210,11214,11216; Htet Ko Ko, 26.iii.2013; MMB 13001; Htet Paing Soe, 26.iii.2013; MMB 13002; Aung Myo Win, 26.iii.2013; MMB 13003; Chuu Zin Thu, 26.iii.2013; MMB 13004; Lin Thet San, 26.iii.2013; MMB 13005; Aung Ye Thu, 26.iii.2013; MMB 13006; Thura Hein, 26.iii.2013; MMB 13007; Htet Nay Lin, 26.iii.2013; MMB 13008; San Nang Phyo, 26.iii.2013; MMB 13009; Soe Htet Naing Lwin, 26.iii.2013; MMB 13010; Htet Myat Maw, 26.iii.2013; MMB 13011; Aye Chan Maung, 26.iii.2013; MMB 13012; Kyaw Thiha, 26.iii.2013; MMB 13013; Win Warso Aung, 26.iii.2013; MMB 13014; Hein Min Paing, 26.iii.2013; MMB 13015; Kyaw Zin Ko, 26.iii.2013; MMB 13016; Aung Myo Thu, 26.iii.2013; MMB 13017; Zin Moh Moh Tun, 26.iii.2013; MMB 13018; Chit Ar Poe, 26.iii.2013; MMB 13019; Min Janes Bond, 26.iii.2013; MMB 13020; Nyan Moe Naing, 26.iii.2013; MMB 13021; May Poe Oo, 26.iii.2013; MMB 13022; Min Aung, 26.iii.2013; MMB 13023; Pyae Phyo Kyaw, 26.iii.2013; MMB 13024; Aung Mon, 26.iii.2013; MMB 13025; Aung Ko Latt, 26.iii.2013; MMB 13026; Su Pyae Tun, 26.iii.2013; MMB 13027; Min Than Htike Oo, 26.iii.2013; MMB 13028; Yamong Phoo, 26.iii.2013; MMB 13029); Thabawseik (Hsu Mon Oo, 26.x.2012; MMB 11958-11961, 6.xii.2012; MMB 11922-11938, 27.i.2013; MMB 11950;

Myo Min Tun, 15.ii.2013; MMB 111138).

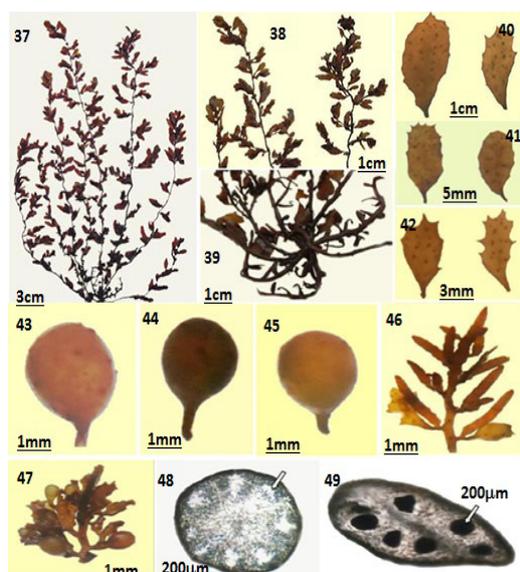
Other Specimens Examined– *Tanintharyi Coastal Region*-Maungmagun^[16]; Thabawseik (Mwe Taung) (4th year students, 15.iv.1980; MMB 02656; Myint Aung, 23.xii.1980; MMB 02657); *Ayeyarwady Coastal Region*- No data; *Rakhine Coastal Region*- Mawtin Point (Ne Aung Win, 2.xii.1976; MMB 02453; Murial Dwe Hla, 7.xii.1976; MMB 2457); Zeegyaing (Aung Myint, 5.i.1974; MMB 02342; Ohmar Kyi, 4.xii.1976; MMB 02454; Mu Mu Aye and Ma Myint Than, 17.ii.1980; MMB 02655); Cape Nagraris (Aung Myint, 22.ii.1978; MMB 02552); Gwa Aw (Aye Pyo, 23.i.1971; MMB 02201); Maung Shwe Lay Seaweed culture line (Soe Lwin, 15.vii.1983; MMB 02869).

Myanmar Distribution: *Tanintharyi Coastal Region*.- Kampani, Thabawseik (Mwe Taung), Maungmagan, San Hlann^[38-40]; *Ayeyarwady Delta and Gulf of Mottama Coastal Region*.- No Data; *Rakhine Coastal Region*.- Mawtin Point, Zeegyaing, Cape Nagraris, Gwa Aw,), Maung Shwe Lay Gyaing^[38-40].

World Distribution: *South-west Asia*.- India^[37], Sri Lanka^[37]; *Asia*.-China^[49], Taiwan^[30]; *South-east Asia*.- Myanmar^[42], Thailand^[50], Malaysia^[43], Indonesia^[37], Singapore^[37], Philippines^[51]; *Australia and New Zealand*.-Australia^[49], Queensland (Lewis 1985); *Pacific Ocean*: Federated States of Micronesia, Northern Gulf of California^[2].

Potential utilization- *Sargassum plagiophyllum* C. Agardh is used as drugs^[11], human food, fodder, fish meal, manure and alginates^[39,40,42]. It contains 15-19% of sodium alginate^[44].

Sargassum plagiophyllum C. Agardh sensu Mattio et Payri (= *S. stolonifolium* Phang et Yoshida^[55] 1997)



Figures 37-49: *Sargassum plagiophyllum* C. Agardh (= *S. stolonifolium* Phang et Yoshida) from Kampani coastal areas: A) Habitat of plant; B) Apical part; C) Holdfast; D) Leaves of basal part; E) Leaves of middle part; F) Leaves of apical part; G-I) Various shapes of vesicles; J) Male receptacle; K) Female receptacle; L) Cross-section of male receptacle with antheridia (arrow); M) Cross-section of female receptacle with oogonia (arrow).^[2,17,35,36,39,52-54]

Type locality– Penang, Malaysia^[52]

Description- Vegetative Features: Plants attach by means of discoidal holdfast. The holdfast is usually 1-3 mm thick and 2-5 mm in diameter; The primary stem is terete, 3.0-12.0 mm long and 1.5-2.0 mm in diameter usually without branching; Primordial branches located at the upper part of the primary stem are modified into stolons, compressed at the base and terete from lower middle to upper parts, 3.0-12 cm in length and 2-3 mm in width without ridges and spinous processes; Leaves of main branches are simple, oblong to ovoid in shape, 0.5-1.5 cm apart with a phyllotaxis of 1/3 in spiral order, somewhat thick or thin, shortly stipitate with asymmetrical bases, midribs petcurrent to disappear near at the apex and generally obtuse to rounded apices, 1-3 cm in length and 0.4-1.0 cm in width and slightly wavy. The margins of the leaves are entire to slightly or irregularly serrate margins. Cryptostomata are large, 100-250 µm in diameter and scattered or aligned on each side of the midribs in one to several rows and spinous processes are absent or present on either sides of the stipe; Vesicles of secondary branches are mostly spherical to ellipsoidal in shape, 1.5-4 mm in length and 1.0-3.0 mm in diameter, without lateral appendages and mucronate to rounded apices, sometimes foliar. The stipe of these vesicles are slightly compressed to terete and slightly curved with 1/2 or 1/3 length of vesicles;

Reproductive Features: The plant is dioecious. Male receptacle branches are racemosely arranged, long, terete, smooth or verrucose, irregularly forked, 6.0-8.0 mm in length and 0.5-1.0 mm in diameter with tapering or obtuse apex and mostly formed in the axils of leaves and vesicles of tertiary branches with a short sterile stipe. Male receptacle is pseudozygocarpic (Figures.46,48); Female receptacle branches are racemosely or cymosely arranged, compressed or triquetrous, smooth at the base and spiny at the lower middle at upper parts, irregularly forked, 2.5-4.0 mm in length and 0.5-1.0 mm in width and mostly formed in the axils of leaves and vesicles of tertiary branches with a short sterile stipe. Female receptacle is holozygocarpic (Figures 47,49).

Specimens Examined in the Study Areas– *Tanintharyi Coastal Region*- Thabawseik (Hsu Mon Oo, 6.xii.2012; MMB 11907-11919, 11926; 26.i.2013; MMB 11951-11952; Myo Min Tun, 15.ii.2013; MMB 111139-41).

Other Specimens Examined- *Tanintharyi Coastal Region*- St. Luke I.(Soe- Htun, 20.xii.1997; MMB 09937-09939); *Ayeyarwady Coastal Region*- No data; *Rakhine Coastal Region*- Zeegyaing (Mu Mu Aye and Ma Myint Than, 17.ii.1980; MMB 02653; Aye Thwin, 15.i.1984; MMB 02906); Makyeengu (Gwa Aw) (Soe Lwin, 13.iv.1983; MMB 02809); Yahaingkutoe (Aye Pyo, 8.iv.1971; MMB 02250); Maungshwelay Seaweed culture line (Soe Lwin, 10.v.1984; MMB 02957); Sin Gaung (Soe Nang, 18.iv.1981; MMB 2749); Kyauk La Yaine Gyaing (Mya Kyaw Wai, 14.xii.2008; MMB 11093, 10094-10097, 10241); Kyaukoomaw (Aung Myint, 7.iv.1974; MMB 02399); U Ba Saw's Pagoda(Aung Myint, 10.iv.1974; MMB 2400).

Myanmar Distribution: *Tanintharyi Coastal Region*- St. Luke I., Kampani, Thabawseik (Mwe Taung), Maungmagan^[38-40]; *Ayeyarwady Delta and Gulf of Mottama Region*- No Data; *Rakhine Coastal Region*- Mawtin Point, Zeegyaing, Shwe Ya Gyaing,

Makeyengu (Gaw Aw), Yahaingkutoe, Hlyaw Gaung Taung, Maw Shwe Gyaing, Maung Shwe Lay Gyaing, Kyauk La Yaine Gyaing, Lonetha, Ngapali, Mazin, Sing Gaung, Kyaukoomaw, U Ba Saw's Pagoda^[38-40].

World Distribution: *South-east Asia*.- Myanmar^[42], Malaysia^[53,34,35](Stiger et al.2004), Thailand^[34,54,50,21].

Potential Utilization: *Sargassum plagiophyllum* C. Agardh sensu Mattio et Payri (= *S. stolonifolium* Phang et Yoshida) is used as drugs^[11], human food, fodder, fish meal, manure and alginates^[42,39,40]. It contains 15-19% of sodium alginate^[44].

Discussion

In the present study, the three species of *Sargassum* subgenus *Sargassum*, namely *Sargassum swartzii* (Turner) C. Agardh, *S. cervicorne* Greville and *S. plagiophyllum* C. Agardh (with or without stolons) have been recorded from Kampani coastal areas. A comparison of the taxonomically reliable characteristics of vegetative and reproductive features for each species is shown in Table 1.

Table 1: A comparison of the morphological features in three species of *Sargassum* in Kampani coastal areas.

Sr. No	Charac-ters	Species			
		<i>S. swartzii</i>	<i>S. cervicorne</i>	<i>S. plagiophyllum</i>	
				without stolons <i>S. plagiophyllum</i>	with stolons <i>S. stolonifolium</i>
1.	H o l d - fast	Discoid	Discoid	Discoid	Discoid
2.	Stem	Terete	Terete	Terete	Terete
3.	P r i - m a r y branches	Compressed, smooth	Flattened into compressed, smooth	Terete smooth	Terete, smooth, twisted, transformed into stolons
4.	S e c - o n d a r y branches	Slightly compressed to terete, smooth	Slightly compressed to terete, smooth	Terete, smooth	Terete, smooth
5.	Leaves: (i) P r i m a r y leaves	Elongated lanceolate to linear lanceolate, asymmetrical base, acute or sometimes obtuse apices, detate margins, midribs percurrent or evanescent, cryptostomata less, one row or two rows on both sides of the midribs	Lanceolate to linear, asymmetrical bases, rounded to slightly acute apices, sharply serrate margins, percurrent midribs, cryptostomata randomly distributed on both sides of the midribs.	Oblong to linear lanceolate, asymmetrical base, obtuse to rounded apices, entire to slightly or irregularly serrate margins, midribs percurrent or disappear near the apices, cryptostomata small, scattered or aligned on each side of the midribs.	Oblong to ovoid, asymmetrical base, acute to rounded apices, entire to slightly or irregularly serrate margins, percurrent midribs, cryptostomata large, scattered on both sides of the midribs

	(ii) Secondary leaves	Linear-lanceolate, asymmetrical base, acute apices, dentate margins, midribs percurrent cryptostomata in one to two rows	Lanceolate to linear, asymmetrical base, acute to rounded apices, slightly serrate margins, midribs percurrent, cryptostomata randomly distributed on both sides of the midribs.	Lanceolate to linear, asymmetrical base, acute to rounded apices, slightly serrate margins, midribs percurrent or disappear near the apices, cryptostomata scattered on both sides of the midribs	Elliptical, asymmetrical base, acute to rounded, apices, slightly serrate to serrate margins, percurrent midribs, cryptostomata large, randomly distributed over the leaves' surface
6.	V e s i - c l e s	Ellipsoidal to spherical, apex pointed or with a short leafy crown	Spherical, rounded apices	Ellipsoidal, mucronate to rounded apices	Spherical to ellipsoidal, mucronate to rounded apices,
7.	Receptacles: Monoecious	Slightly terete, small spines at the apices and margins.	Flattened, twisted with spines, acanthocarpic		
	(i) Dioecious (male)	-	-	Long terete, simple or irregularly fork, pseudozygocarpic	Long, terete with wavy outlines and generally bifurcate tips, pseudozygocarpic.
	(ii) Dioecious (female)	-	-	Slightly compressed to triquetrous, sometimes bearing spines at the surface, pseudozygocarpic or holozygocarpic	Short, compressed with wavy outlines and bifurcate tips, pseudozygocarpic.

Soe-Htun^[17] firstly described the developmental process of vegetative and reproductive features in *Sargassum* spp. including the stoloniferous species as *Sargassum herporhizum* Setchell and Gardner with furcate cauline leaves under *S.* subgen. *Sargassum*.

Moreover, Soe-Htun and Yoshida^[4] also proposed the developmental process of vegetative and reproductive features in *S. cristaeifolium* C. Agardh. Likewise, Kilar *et al*^[6,7] again reported that the developmental process of *Sargassum* species with the modification of the previous report of Soe-Htun and Yoshida^[4].

Tseng and Lu^[32,33] reported five main characteristics of *Sargassum swartzii* that are flattened and compressed primary branches, cymosely arranged receptacles, ellipsoidal vesicles with long pedicels, leaves lanceolate with percurrent midribs, softening and dropping off of some parts when dried specimens are soak in water, thus damaging the appearance of the specimens. Ajisaka^[34] also reported that *S. swartzii* (Turner) C. Agardh can be differentiated from *S. binderi* Sonder and *S. oligocystum* Montagne on the basis of its slender leaves and smaller vesicles

with mucronate and closely clustered receptacles. However, Noiraksar and Ajisaka^[55] also reported Thai species of *Sargassum swartzii* (Turner) C. Agardh which shows some resemblance to *S. binderi* Sonder and *S. oligocystum* Montagne, but can be distinguished from those species by their linear-lanceolate leaves with shallow dentate to entire margins, small vesicles with terete stalks and entire margins and receptacles arranged in a cymose. By contrast, the present specimens is closely related to *S. swartzii* (Turner) C. Agardh from China^[32,33], Malaysia^[34] and Thailand^[55] in having those characters. Moreover, the present specimens also resemble to those from Australia^[31] which have linear leaves, subspherical vesicles and terete receptacles. Soe-Htun^[17] described the Myanmar species of *Sargassum swartzii* (Turner) C. Agardh are dioecious but the present specimens are monoecious, antheridia and oogonia occur in separate conceptacles or sometimes in same conceptacles.

Durairatnam^[45] reported *S. cervicorne* Greville with flattened branches, linear-lanceolate leaves equally attenuated at both ends, entire or rarely furnished with sharp teeth upwards and elliptical vesicles borne on dilated foliaceous petioles about the same length as the vesicles, among 13 species of *Sargassum* from Ceylon (Sri Lanka). He described receptacles were pedunculate more or less divided racemes compressed, irregular in shape and toothed and did not mention these as dioecious or monoecious. In this study, the receptacles of the plants are monoecious. In Myanmar, Kyaw Soe and Kyi Win^[16] firstly reported *S. cervicorne* Greville collected from Maungmagan. In general, the present specimens of *S. cervicorne* Greville are closely resembled to some characteristics such as the shapes and sizes of the leaves and vesicles of the Sri Lankan specimens^[45] and specimens of Maugmagan^[16].

Tseng and Lu^[33] studied the two subseries: the *Swartzia* and the *Binderia* of the series *Binderiana* under the section *Acanthocarpicae* in which the *Swartzia* group were consisting of 10 species: 8 species of these from China with each species of Hawaii and India. Among these, the Chinese species, *S. cervicorne* Greville is reduced to a variety of *S. binderi* in Grunow's monograph^[23]. However, they recovered the species status of *S. cervicorne* Greville after going through hundreds of specimens which are grouped under the *Swartzia*. They described differences in the vesicles and receptacles in this species as compared to *S. binderi* Sonder and also reported that this species was related to *S. dumosum* Greville. However, Wong *et al.*^[35] described the characters of *S. cervicorne* Greville along with flattened branches, ellipsoidal vesicles with long leafy pedicels, glomerulate receptacles which are dilated in the upper part and lanceolate leaves with serrate to double serrate margin and obtuse apices. Specimens of *S. cervicorne* Greville in the present study are closely related to the species from Malaysia^[35] based on the characters as mentioned above.

Noiraksar and Ajisaka^[55] stated that *Sargassum binderi* Sonder and *S. oligocystum* overlap in many morphological characters, particularly when they are immature but *S. oligocystum* is dioecious. *S. binderi* was placed as the synonym of *S. oligocystum* Montagne by Womersely and Bailey. However, Tseng and Lu^[33] and Ajisaka *et al.*^[53] argued that facts and supported the original description of *S. binderi* Sonder by J.G. Agardh^[20], retaining as a separated species by itself. Recently, this species had also been synonymised as *S. aquifolium* (Turner) C. Agardh by Mattio *et al.*^[3] based on morphological and molecular anal-

ysis. The species of *S. cervicorne* Greville is closely related to *S. binderi* Sonder from China, Malaysia and Thailand^[33,53,55] due to some vegetative structures such as branches and leaves, but different in vesicles and receptacles. Nevertheless, the growth pattern in the development of furcate cauline leaf and dwarfs of main branch as well as different orders of branches, leaves, vesicles and receptacles of *Sargassum* section *Binderiana* belonging to the *S. subgenus Sargassum* from the study areas is closely resemble to that of *Sargassum cristaeifolium* reported by Soe-Htun and Yoshida^[4] and *Sargassum polyceratium* described by Kilar and Hanisk^[5].

Recently, Soe-Htun *et al.*^[18] presented the growth pattern in the development of simple cauline leaf, the primordial branches or the dwarf or determinate branches or stolons modified from dwarfs of main branch and secondary branches as well as different orders of branches, leaves, vesicles and receptacles. They observed that the dwarf or determinate main branches issued on the uppermost parts of the primary stem were normally transformed into stolons. In other words, these determinate branches gradually changed into indeterminate branches which in turn lengthened together with tip of each branch issued tending to surface of the substrates. At the same time, the midribs of leaves of the dwarf branches also enlarged, reducing and disappearing foliar structures on both sides and then changed into stout branchlets with hapteras attached to the substrates at the tips, transforming as stolons. Because of the dwarf branches which were very close to the substrates, it was normally transformed into stolons in mature plants of *S. plagiophyllum* C. Agardh (with stolons) but not in *S. plagiophyllum* C. Agardh (without stolons). They proposed the presence of simple cauline leaves and specific developmental sequences of dwarf branches or stolons, if present, should be assigned as the main taxonomic criteria of the *Sargassum* sect. *Polycystae* designated by Mattio *et al.*^[8].

Recently, *S. stolonifolium* Phang *et al.* Yoshida characterized by the presence of stolons had also been synonymised as *S. plagiophyllum* C. Agardh in which the formation of stolons was entirely absent throughout the life span by Mattio *et al.*^[3] based on morphological and molecular analysis. Soe-Htun^[17] had previously identified this stoloniferous species without mucrication on branches as *S. herporhizum* Setchell *et al.* Gardner by in accordance with the description and illustration given by Setchell and Gardner^[56] and Dawson^[57] (p. 249, pl.40, figs. 1-12) for *S. herporhizum* Setchell *et al.* Gardner collected from California. However, this species (as *S. herporhizum* Setchell *et al.* Gardner *sensu* Soe-Htun^[17]) had been established as a new species, *S. stolonifolium* by Phang and Yoshida^[52] based on the specimens collected from Penang, Malaysia.

In the present study, there were two types of plants under the *Sargassum* sect. *Polycystae* designated by Mattio *et al.*^[8] 1) primordial branches or the dwarf or determinate branches which are transformed into stolons in adult plants; and 2) primordial branches or the dwarf or determinate branches which are not transformed into stolons in adult plants, as described by Soe-Htun *et al.*^[18]. It was noted that, in the first type of stoloniferous species, dwarfs of main branch on primary stem as well as the secondary branches formed at the lower part of main branches were able to be transformed into stoloniferous branches in some plants found exposed to heavy wave action in the lower intertidal zones of the Southern Kampani coastal areas (Figures.50-52).

The formation of newly propagated plantlets issued from the attached haptera of different orders branches in *Sargassum plagiophyllum* sensu Mattio et Payri (= *S. stolonifolium*) collected from the lower intertidal zone was diagrammatically shown in Figure 53. By contrast, Phang and Yoshida^[52] had described the stolons of this species were derived from the cauline leaves and produced secondary holdfast (haptera) on contact with the substratum and then new plantlets were formed. On the other hand, in the latter type species, i.e. *Sargassum plagiophyllum* C. Agardh (without stolons) collected from Kampani coastal areas, the growth pattern in the development of dwarfs of main branch on primary stem and secondary branches as well as different orders of branches, leaves, vesicles and receptacles is closely similar to those of *S. cristaefolium* C. Agardh described by Soe-Htun and Yoshida^[4], except for the formation of simple cauline leaves.

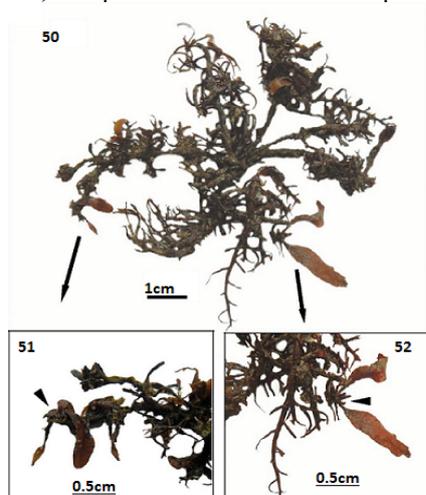


Figure 50-52: The formation of newly propagated plantlets from the attached haptera of *Sargassum plagiophyllum* sensu Mattio et Payri (= *S. stolonifolium*) collected from the lower intertidal zone of Southern Kampani coastal areas: 51) Habit of plant showing stoloniferous branches with young plantlet; 52) The newly propagated plantlet (arrow head) issued from the haptera of stoloniferous branch which was transformed from the secondary branch; 53) The newly propagated plantlet (arrow head) issued from the haptera of stoloniferous branch which was transformed from the dwarf of main branch.

Moreover, Ajisaka and Lewmanomount^[54] reported two type of morphology in cauline leaves on the stem, (i) elliptical cauline leaves from the upper portions and (ii) cylindrical stolons from the lower portions. By contrast, in the present study, elliptical cauline leaves were observed at the lower portions and cylindrical stolons from the upper portions. In addition, Ajisaka and Lewmanomount^[54] reported that among other two species with stolons, *S. polycystum* C. Agardh and *S. herporhizum* Setchell et Gardner produces branched stolons from the stem into attaching branches, haptera to new plantlets. The present study on *S. plagiophyllum* C. Agardh (with stolons) generally agrees well with their observations on the presence of stolons on the stem and the new plantlets which were regenerated from the stolons (haptera) in *Sargassum polycystum* C. Agardh and *S. herporhizum* Setchell et Gardner. They did not mention the location of stolons, as compared with the present study which emphasized the location of stolon derived from the primordial branches (dwarf branches) as well as the secondary branches in *S. plagiophyllum* C. Agardh (with stolons).

In the present study, the stolons branches are twist-

ing and forming net-work with each other in *S. plagiophyllum* C. Agardh (with stolons) growing in the lower intertidal zone due perhaps to heavy wave actions and other environmental factors (Figures.51-53). The findings on both species of *S. plagiophyllum* C. Agardh (with stolons) in heavily wave-exposed conditions and *S. plagiophyllum* C. Agardh (without stolons) in calm conditions in the present study sites also agreed with the observations of Ajisaka and Lewmanomount^[54] who reported that the formation of the stolons was not necessary for plants in stable environmental conditions on the calm coasts or when protected by rocks from strong waves but it might be necessary on wave-exposed coasts. Interestingly, *Sargassum plagiophyllum* sensu Mattio et Payri (= *S. stolonifolium* Phang et Yoshida) possess stolons formed from the modified dwarf main branches located at the top of the primary stem characterized by the formation of newly propagated plantlets from the tips of each and the secondary branches on the main branches, and is stoloniferous branch in wave-exposed lower intertidal zones. *Sargassum plagiophyllum* sensu Mattio et Payri (= *S. stolonifolium* Phang et Yoshida) which shows the formations of new plantlets can be utilized in mass cultivation of *Sargassum* by the method of vegetative propagation for the production of raw materials to produce the valuable product of alginates.

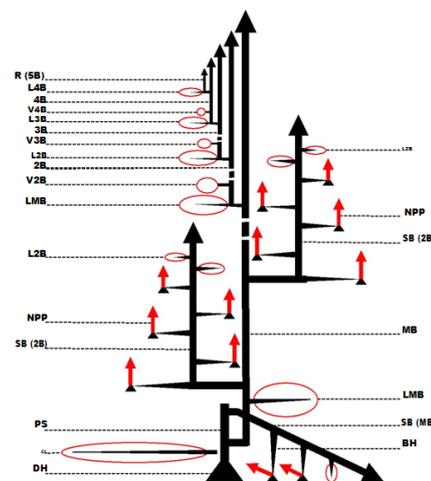


Figure 53: The schematic diagram of the development of newly propagated plantlets in *Sargassum* section *Polycystae* belonging to the *S.* subgenus *Sargassum* from Kampani coastal areas. Abbreviations: DH, discoid holdfast; CL, cauline leaf; PS, primary stem; MB, main branch; LMB, leaf of main branch; 2B, second branch; L2B, leaf of secondary branch; V2B, vesicle of secondary branch; 3B, tertiary branch; L3B, leaf of tertiary branch; V3B, vesicle of tertiary branch; 4B, fourth order branch; L4B, leaf of fourth order branch; V4B, vesicle of fourth order branch; R(SB), receptacle (modified from fifth order branch); SB (MB), stoloniferous branch modified from main branch, SB (2B), stoloniferous branch modified from secondary branch; BH, branchlet with haptera,  = Leafy blade,  = Transformed stoloniferous petiole along with midrib of the leaf,  = Newly propagated plantlet.

Branches of *Sargassum herporhizum* Setchell et Gardner and *S. plagiophyllum* C. Agardh sensu Mattio et Payri (= *S. stolonifolium*), in the present study, are normally smooth but these are covered with spines in *S. polycystum* C. Agardh. Morphological features of holdfast are not apparently different each other in *Sargassum* species observed in this study. Cauline leaves are found in some juvenile plants but these were lost in

adult plants. In *S. plagiophyllum* C. Agardh and *S. plagiophyllum* C. Agardh sensu Mattio et Payri (= *S. stolonifolium*) main branches are terete and smooth but these are compressed to flattened in another two species. The younger plants of *S. plagiophyllum* C. Agardh sensu Mattio et Payri (= *S. stolonifolium*) are very similar to *S. plagiophyllum* C. Agardh. In adult plants, this species is different from *S. plagiophyllum* C. Agardh in having stolons. In addition, branches of *S. plagiophyllum* C. Agardh sensu Mattio et Payri (= *S. stolonifolium*) are slightly twisted but not in *S. plagiophyllum* C. Agardh. Leaves are oblong to ovoid in shape, cryptostomata are large and scatter on both sides of the midribs in *S. plagiophyllum* C. Agardh sensu Mattio et Payri (= *S. stolonifolium*) whereas these are oblong to linear-lanceolate in shape and cryptostomata are small and scattered or aligned on each side of the midribs in *S. plagiophyllum* C. Agardh. Male receptacle branches of two species are closely similar but female receptacle branches are slightly different between these two species. Female receptacles are compressed to terete in the former but these are compressed to triquetrous in the latter and pseudozogocarpic or holozogocarpic receptacles in the two species.

In the present study, leaves and vesicles showed morphological variabilities caused by polymorphisms and polyphenisms among populations of Kampani coastal areas but not in the receptacles as mentioned by Soe-Htun et al.^[4], Kilar et al.^[5-7], Mattio et al.^[8]. Monoecious receptacle branches are observed in *S. swartzii* (Turner) C. Agardh and *S. cervicorne* Greville while dioecious receptacle branches are found in *S. plagiophyllum* C. Agardh and *S. plagiophyllum* C. Agardh sensu Mattio et Payri (= *S. stolonifolium*).

Monoecious receptacle branches are flattened to compressed, twisted with spines on *S. cervicorne* Greville but slightly terete with small spines in *S. swartzii* (Turner) C. Agardh. Female receptacle branches of dioecious species, compressed with wavy outline in *S. plagiophyllum* C. Agardh sensu Mattio et Payri (= *S. stolonifolium*) while these are compressed to triquetrous in *S. plagiophyllum* C. Agardh. Male receptacle branches of *S. plagiophyllum* C. Agardh sensu Mattio et Payri (= *S. stolonifolium*) are closely similar in morphology to that of *S. plagiophyllum* C. Agardh. Stolons occur only in *S. plagiophyllum* C. Agardh sensu Mattio et Payri (= *S. stolonifolium*).

In Myanmar, the occurrence and distribution of the species diversity of *Sargassum* spp. along Kampani coastal areas is presented in Table 2. The numbers of species of *Sargassum* spp. were high in southern Kampani whereas those were low in Maungmagan. The genus *Sargassum* subgen *Sargassum* occurs both along the Rakhine and Tanintharyi Coastal Regions (Figure 54). A comparison of the latitudinal distribution ranges of the three species of *Sargassum* (*S. swartzii* (Turner) C. Agardh, *S. cervicorne* Greville and *S. plagiophyllum* C. Agardh (with or without stolons) are shown in Table 3. In the present study, *Sargassum swartzii* (Turner) C. Agardh was found from Southern Kampani (Lat. 14° 02' N, Long. 98° 04' E) to Ah-Le-Than-Kyaw (Lat. 20° 50' N, Long. 93° 30' E) with an intermediate distribution range but *S. cervicorne* Greville was encountered from Southern Kampani (Lat. 14° 02' N, Long. 98° 04' E) to Co Co Island (Lat. 14° 10' N, Long. 93° 30' E) through Thabawseik (Mwe Taung)^[39,40] and Maungmagan^[16] with a narrowest distribution range. *S. plagiophyllum* C. Agardh (with or without stolons) distributed in nature from St.

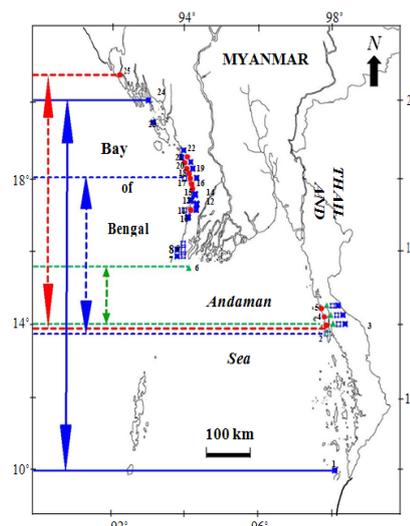


Figure 54: Map showing the distribution of *Sargassum* species along the coastal areas of Myanmar: 1. St. Luke I, 2. San Hlann, 3. Southern Kampani, 4. Thabawseik, 5. Maungmagan, 6. Co Co Island, 7. Mawtin Point, 8. Zee Gyaing, 9. Cape Nagraris, 10. Shwe Ya Gyaing, 11. Gwa Aw, 12. Yahaingkutoe, 13. Hlyaw Gaung Taung, 14. Maw Shwe Gyaing, 15. Mhaw Chye, 16. Kyaukme Taung, 17. Maung Shwe Lay Gyaing, 18. Kyauk Phone Gyi Mhaw, 19. Lonetha, 20. Ngapali, 21. Mazin, 22. Sing Gaung, 23. Yanbye I. (Kyaukoomaw and U Ba Saw's Pagoda), 24. Kyauk La Yaine Gyaing, 25. Ah-Le-Than-Kyaw. Symbols: ● *S. swartzii* (Turner) Agardh, ▲ *S. cervicorne* Greville, □ *S. plagiophyllum* Agardh, ■ *S. plagiophyllum* sensu Mattio et Payri (= *S. stolonifolium*); - - - - - Distribution range of *S. swartzii*, - - - - - Distribution range of *S. cervicorne*, - - - - - Distribution range of *S. plagiophyllum*, - - - - - Distribution range of *S. plagiophyllum* (= *S. stolonifolium*).

Table 2: The occurrence and distribution of the species diversity of *Sargassum* spp. along Kampani coastal areas.

Sr. No.	Species	Locality				
		Southern-Kampani ¹	Thabaw-seik ¹	Maung-magan ²	Thabaw-seik ³	Kam-pani ⁴
1.	<i>S. swartzii</i> (Turner) C. Agardh	+	-	-	-	+
2.	<i>S. cervicorne</i> Greville	+	+	+	+	-
3.	<i>S. plagiophyllum</i> C. Agardh	+	+	-	+	+
4.	<i>S. plagiophyllum</i> C. Agardh (= <i>S. stolonifolium</i> Phang et Yoshida)	+	+	-	+	+
Total		4	3	1	3	3

Symbols: (+) = present; (-) = absent. Sources: 1 = Present study (2013); 2 = Kyi Win and Kyaw Soe (1977); 3 = Soe- Htun et al. (2009); 4 = Myo Min Tun (2012)

Table 3: The latitudinal distribution range of the genus *Sargassum* subgen. *Sargassum* along three Coastal Regions of Myanmar.

Sr. No.	Species	TCR		ACR		RCR	
		From	To	From	To	From	To
1	<i>Sargassum swartzii</i> (Turner) C. Agardh	Southern Kampani (Lat. 14° 02' N, Long. 98° 04' E)	Maungmagan (Lat. 14° 30' N, Long. 98° 06' E)	No Data	No Data	Co Co Island (Lat. 14° 10' N, Long. 93° 30' E)	Ah-Le-Than-Kyaw (Lat. 20° 50' N, Long. 93° 30' E)
2	<i>Sargassum cervicorne</i> Greville	Southern Kampani (Lat. 14° 02' N, Long. 98° 04' E)	Maungmagan (Lat. 14° 30' N, Long. 98° 06' E)	No Data	No Data	Co Co Island (Lat. 14° 10' N, Long. 93° 30' E)	
3	<i>Sargassum plagiophyllum</i> C. Agardh (without stolons)	Southern Kampani (Lat. 14° 02' N, Long. 98° 04' E)	Maungmagan (Lat. 14° 30' N, Long. 98° 06' E)	No Data	No Data	Mawtin Point (Lat. 16° 04' N, Long. 94° 20' E)	Maung Shwe Lay Gyaing (Lat. 18° 21' N, Long. 94° 21' E)
4	<i>Sargassum plagiophyllum</i> C. Agardh sensu Mattio et Payri (= <i>S. stolonifolium</i>)	St. Luke Island. (Lat. 10° 10' N, Long. 98° 15' E)	Maungmagan (Lat. 14° 30' N, Long. 98° 06' E)	No Data	No Data	Mawtin Point (Lat. 16° 04' N, Long. 94° 20' E)	Kyauk La Yaine Gyaing (Lat. 19° 50' N, Long. 93° 25' E)

Abbreviations: RCR = The Rakhine Coastal Region; ACR = The Ayeyarwady Delta and the Gulf of Mottama (Martaban) Coastal Region; TCR = The Tanintharyi Coastal Region.

Luke I. (Lat. 10° 10' N, Long. 98° 15' E) to Kyauk La Yaine Gyaing (Lat. 19° 50' N, Long. 93° 25' E), showing the widest range of distribution among the genus *Sargassum* in this study.

With regard to world distribution of 3 species of the genus *Sargassum* subgen. *Sargassum* in the present study, there are no records for these species of *Sargassum* along the coastal regions of the Atlantic Ocean (Figure 55). *Sargassum swartzii* (Turner) C. Agardh and *S. cervicorne* Greville distribute mainly in the Indian Ocean Regions (IOR) and eastern parts of the Pacific Ocean. On the other hand, *S. plagiophyllum* C. Agardh (with or without stolons) uniquely predominate along the coastal areas of the eastern part of the Indian Ocean except for the plants encountered in northern Gulf of California. In general, the ranges of phytogeographical distribution of all species of *Sargassum* normally occur along the Indo-Pacific regions except for the coastal region of the Atlantic Ocean.

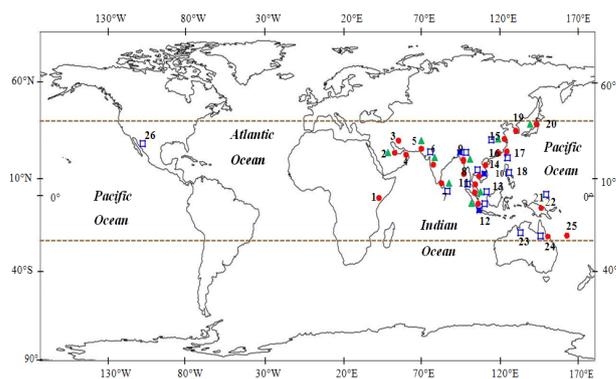


Figure 55: The phylogeographic distribution of *Sargassum* species: 1. Kenya, 2. Baharin, 3. Iran, 4. Persian Gulf, 5. Pakistan, 6. India, 7. Sri Lanka, 8. Andaman Islands and Nicobar Islands, 9. Myanmar, 10. Thailand, 11. Malaysia, 12. Indonesia, 13. Singapore, 14. Vietnam, 15. China, 16. Hong Kong, 17. Taiwan, 18. Philippines, 19. Korea, 20. Japan, 21. Federated States of Micronesia, 22. Papua New Guinea, 23. Australia, 24. Queensland, 25. New Caledonia, 26. Northern Gulf of California. Symbols: ● *S. swartzii* (Turner) C. Agardh, ▲ *S. cervicorne* Greville, □ *S. plagiophyllum* Agardh sensu Mattio et Payri (= *S. stolonifolium*); Potential distribution range and _____ Northernmost and southernmost recorded limits of *Sargassum* species.

Further studies on the cross fertilization, transplanting in different zones and the effects of ecological parameters such as wave actions, various substrates and habitats in different zones on the formations of stolons and newly propagated plantlets are still necessary to be worked out for the confirmation of species between *S. plagiophyllum* C. Agardh (without stolons) and *S. plagiophyllum* sensu Mattio et Payri (= *S. stolonifolium* Phang et Yoshida) (with stolons).

Conclusions

The three species of *Sargassum* have been identified as *Sargassum swartzii* (Turner) C. Agardh and *S. cervicorne* Greville under *Sargassum* section *Binderiana* and *S. plagiophyllum* C. Agardh (with or without stolons) under *Sargassum* section *Polycystae*, belonging to the Subgenus *Sargassum* from Kampani coastal areas, Longlone Township of Taninthayi Region from October 2012 to March 2013.

Sargassum swartzii (Turner) C. Agardh and *S. cervicorne* Greville (*Sargassum* sect. *Binderiana*) revealed no formation of stolons. In contrast, *S. plagiophyllum* C. Agardh showed two types of plants with stolons and without stolons under *Sargassum* section *Polycystae*: *S. plagiophyllum* C. Agardh (without stolons) and *S. plagiophyllum* C. Agardh sensu Mattio et Payri (= *S. stolonifolium* Phang et Yoshida) (without stolons). It was suggested that further studies on the alternative transplanting of this species (with or without stolons) in various environments were still needed to be worked out to confirm the taxonomic status between *S. plagiophyllum* C. Agardh (without stolons) and *S. plagiophyllum* C. Agardh sensu Mattio et Payri (= *S. stolonifolium* Phang et Yoshida) (without stolons). *S. cervicorne* Greville was firstly reported from Kampani coastal areas. Among these, the latitudinal distribution range of *S. plagiophyllum* sensu Mattio et Payri (= *S. stolonifolium* Phang et Yoshida) (with stolons) is wider than that of the remaining species. All these species of *Sargassum* mostly occur along the coastal regions of the Indian and eastern parts of the Pacific Ocean.

Keys to the Species of *Sargassum* from Kampani Coastal Areas

- 1a. Plants monoecious; branches are flattened to compressed without forming stolons2
- 1b. Plants dioecious; branches are terete with or without stolons3
- 2a. Vesicles are ellipsoidal to spherical with pointed or a short leafy crown; receptacles are compressed with small spines at the apex*S. swartzii*
- 2b. Vesicles are spherical with rounded apices; receptacles are flattened and twisted with spines.....*S. cervicorne*
- 3a. Plants without stolons; vesicles are ellipsoidal in shape; female receptacles are pseudozygocarpic.....*Sargassum plagiophyllum*
- 3b. Plants with stolons; vesicles are spherical to ellipsoidal in shape; female receptacles are pseudozygocarpic or holozygocarpic.....*S. plagiophyllum* C. Agardh sensu Mattio *et* Payri (= *S. stolonifolium* Phang *et* Yoshida)

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