The Morphology and Distribution of *Halymenia durvillei* Bory de Saint-Vincent (Halymeniales, Rhodophyta) from Myanmar

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**ABSTRACT**

The genus *Halymenia* collected from three coastal zones of Myanmar: Tanintharyi coastal zone, Ayeyawady Deltaic coastal zone and Rakhine coastal zone, and lodged in the herbarium of the Department of Marine Science, Mawlamyine University, has been identified as *Halymenia durvillei* Bory de Saint-Vincent, based on the external and internal morphologies of the vegetative and reproductive structures. The species of *H. durvillei* Bory de Saint-Vincent was encountered in the Rakhine and Tanintharyi coastal zones whereas not found in the Ayeyawady Delta and the Gulf of Mottama (Martaban) coastal zone. The photogeographical distribution range of *H. durvillei* Bory de Saint-Vincent is mostly dominates in India, Pacific Oceans and Indo-Pacific regions. But *H. durvillei* are rarely found in the Atlantic Ocean. Moreover, some ecological notes and potential uses of this species were briefly described.

**Keywords:** Halymeniales, *Halymenia durvillei*, Myanmar, Rhodophyta, morphology.

**INTRODUCTION**

The first description of the genus *Halymenia* was established by C. Agardh in 1817. Traditionally *Halymenia* has been classified in the family Halymeniaceae, one of several families belonging to the large order Cryptonemiales. And then the order of Cryptonemiales was transferred to the Halymeniales. The red algal genus *Halymenia* C. Agardh, comprising 69 currently accepted species, is one of the largest genera in terms of species within the family Halymeniaceae. It is mostly distributed in tropical and subtropical regions. The genus is mainly characterized by a lubricous texture, a lax medulla with predominantly anticlinally oriented filaments connecting cortex to cortex, the presence of refractive ganglionic cells, and somewhat flattened and expanded auxiliary cell ampullae with branched secondary filaments.

*Halymenia durvillei* is one of the commonest *Halymenia* species found along the Southeastern Asian Coasts. This alga was first described by Bory de Saint-Vincent (1828) from New Zealand, Papua New Guinea and has been reported from various locates around the Pacific and the Indian Oceans. *H. durvillei* is characterized by its comparatively dark red color, robust blades with non gelatinous texture, toothed margin besides repeatedly branched blades. Recently, based on the study of the type material and many other plants of *Halymenia durvillei* from the Philippines, De Smedt et al. reported that the type material of *H. microcarpa* and *H. venusta* had no differences that warrant recognition on the species level, and concluded that they are both conspecific with *H. durvillei*.

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Magyi, Rakhine coastal area. In this study, *H. durvillei* occurred in the distribution range of the Rakhine coastal area and Tanintharyi coastal area.

The objectives of this study are: 1) to know detailed morphological of vegetative and reproductive structures used for identification in the taxonomy, 2) to study potential used and some ecological features and 3) the distribution ranges of this species growing along both the three coastal zones of Myanmar and the coastal areas of the world.

**MATERIALS AND METHODS**

The algae of the genus *Halymenia* C. Agardh 1817 were collected from coastal zone of Myanmar, and deposited in the herbarium of Department of Marine Science, Mawlamyne University, Myanmar (MMB). The fresh specimens were preserved in 4% formaldehyde-seawater and mounted on the herbarium sheets. From this herbarium and liquid-preserved specimens were used for detailed investigations emphasized on the vegetative of external, internal structures and reproductive features. For anatomical studies, small portions of specimen dissected from the herbarium were prepared for microscopic observations. This study of taxonomic followed the classification system used by Silva Menez and Moe 18; Lewmonomont and Ogawa 19; Abbott 20; De Smedt et al.; Kawaguchi21 and Guiry and Guiry.22 Photogeographical distribution and potential uses of this species were recorded from the literature available.

**RESULTS**

**Classification System of the Genus Halymenia**

Phylum : Rhodophyta

Class : Florideophyceae

Order : Halymeniaceae G. W. Saunders & G. T. Kraft

Family : Halymeniaceae Bory

Genus : *Halymenia* C. Agardh

Species : *H. durvillei* Bory de Saint-Vincent

**Description of Halymenia durvillei Bory de Saint-Vincent**

*Halymenia durvillei* (Figures 2-23)
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**Reproductive structure.** Tetrasporangia are cut off from the cortical cells in the third or fourth layer from the surface. Tetrasporophytes tend to have more orders of branches. Mature tetrasporangia are broadly ellipsoidal in shape, 18 µm long and 13 µm wide, cruciatedly or decussately divided. Auxiliary cells are formed in the bottom of cup-shaped ampullae branched to the third order. Early post-fertilization events were not clarified, but connecting filaments in contact with auxiliary cells were frequently observed. Gametophyte and spermatangia plants are not occurred.

Ecological notes. Plants grow at the lower intertidal zone.
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**Figures 2-10.** The external and internal structures of *Halymenia durvillei* Bory de Saint-Vincent (Liquid specimen). 2) Habit of tetrasporophyte plant; 3) Flattened and bladelike erect blade of a plant; 4) Part of a plant; 5) Thallus showing repeatedly subdichotomous branching; 6) One of a small branch; 7) Apical portion of a plant gradually tapering towards the tips; 8) Lateral pinnate branchlets; 9) Short spines on the surface; 10) Contorted texture or supple cartilaginous structure.

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Figures 11-23. The external and internal structures of *Halymenia durvillei* Bory de Saint-Vincent (Liquid specimen). 11) Surface view of a branch; 12) Transverse section of thallus; 13) Cross section shows arrangement of cortical cells (arrow); 14) Highly elongated of the outermost cortical cells (like-rabbit ear) (arrow); 15) the inner cortex layer with polygonal to stellate cells connected to each other by secondary pit-connections (arrow); 16) Longitudinal section of a branch; 17) Cross-section showing predominant periclinally or obliquely arrangement of medullary filaments from cortex to cortex; 18) Refractive ganglionic cells irregularly shaped, arms branched (arrow); 19) Incoming connecting filament attached to auxiliary cell (arrow); 20) Auxiliary cell-ampulare with involucral auxiliary cell-filaments (arrow); 21) Gland cell in the cortex (arrow); 22) Tetrasporangia cut off from the cortical cells in the third or fourth layer from the surface (arrow); 23) Ellipsoidal in shape of mature tetrasporangia (arrow).

Hlaing, 3.iv.1996; MMB 03116; Mic Mie Tun, 3.iv.1996; MMB 03315; Than Aung, 3.iv.1996; MMB 07430; Hsan Htoon, 4.iv.1996; MMB 03150; Soe Myo Set, 4.iv.1996; MMB 07399; San Nyunt Tun, 4.iv.1996; MMB 07432), Maung Shwe Lay Gyaing (Dr. Min Thein, 8.v.1979; MMB 07438; S.T 45, 27.v.1980; MMB 07412; Soe Hun, 27.i.1983; MMB 07405, MMB 07406, MMB 07450, MMB 07452,
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Table 1. A comparison of main characteristics of *Halymenia durvillei* Bory de Saint-Vincent growing in different localities.

<table>
<thead>
<tr>
<th>Characters</th>
<th>Myanmar</th>
<th>Philippine</th>
<th>Western Pacific</th>
</tr>
</thead>
<tbody>
<tr>
<td>I: Vegetative Structures:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) External structures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blade shape</td>
<td>Branched</td>
<td>Branched</td>
<td>Branched</td>
</tr>
<tr>
<td>Orders of branching</td>
<td>Up to 7 orders</td>
<td>Up to 7 orders</td>
<td>3 to 4 orders</td>
</tr>
<tr>
<td>Texture</td>
<td>supple cartilaginous structure</td>
<td>Cartilaginous and mucilaginous</td>
<td>-</td>
</tr>
<tr>
<td>Margin</td>
<td>Dentate and laciniate</td>
<td>Dentate and laciniate</td>
<td>-</td>
</tr>
<tr>
<td>Spines or leaflets on margin</td>
<td>Present</td>
<td>Present</td>
<td>-</td>
</tr>
<tr>
<td>Maculae on surface</td>
<td>Present</td>
<td>Present</td>
<td>-</td>
</tr>
<tr>
<td>Spines on surface</td>
<td>Abundant</td>
<td>Abundant</td>
<td>Rarely</td>
</tr>
<tr>
<td>Axis shape</td>
<td>Tapering toward the apex</td>
<td>Tapering toward the apex</td>
<td>Abruptly at apices</td>
</tr>
<tr>
<td>Axis width (mm)</td>
<td>&gt; 15</td>
<td>15-20</td>
<td>-</td>
</tr>
<tr>
<td>Colour</td>
<td>Pink to dark</td>
<td>Dark pink</td>
<td>-</td>
</tr>
<tr>
<td>Stipe shape</td>
<td>Unbranched</td>
<td>Unbranched</td>
<td>-</td>
</tr>
<tr>
<td>Surface</td>
<td>Smooth</td>
<td>Smooth</td>
<td>Slippery</td>
</tr>
<tr>
<td>Stipe size (mm long)</td>
<td>7</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>(ii) Internal structures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shape of cells in outer cortex</td>
<td>subspherical to elongated</td>
<td>Elongated</td>
<td>Elongated</td>
</tr>
<tr>
<td>Shape of cells in inner cortex</td>
<td>rounded to stellate</td>
<td>Elongated parallel</td>
<td>-</td>
</tr>
<tr>
<td>Thickness of cortex (µm)</td>
<td>50-70</td>
<td>70-150</td>
<td>60-80</td>
</tr>
<tr>
<td>Number of cells in cortex</td>
<td>6-7</td>
<td>4-7</td>
<td>4-6</td>
</tr>
<tr>
<td>Medulla thickness</td>
<td>150</td>
<td>248-494</td>
<td>-</td>
</tr>
<tr>
<td>Refractive ganglionic cells</td>
<td>Present</td>
<td>Abundant</td>
<td>Present</td>
</tr>
<tr>
<td>Arms</td>
<td>6</td>
<td>6-7</td>
<td>4-6</td>
</tr>
<tr>
<td>II. Reproductive Structures:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tetrasporangia size (µm)</td>
<td>18±1/13w</td>
<td>17±1/14w</td>
<td>20±8w</td>
</tr>
<tr>
<td>Carpospore size (µm)</td>
<td>No Data</td>
<td>12</td>
<td>250-270w</td>
</tr>
<tr>
<td>Spermatangia (µm)</td>
<td>No Data</td>
<td>No Data</td>
<td>No Data</td>
</tr>
</tbody>
</table>

MMB 07458, MMB 07459, MMB 07463, MMB 07464, MMB 07468, MMB 07471, MMB 07472, MMB 07473, MMB 07474, MMB 07475, MMB 07454, MMB 07451, MMB 07456, MMB 07400; ST, KL & KM, 27.i.1983; MMB 07439, MMB 07447, MMB 07453, MMB 07457, MMB 07460; Soe Htun & Ko Lay, 27.i.1983; MMB 07462; Win Maw, 6.iv.2004; MMB 07480), Gwa (U.A.M, 28.x.1970; MMB 07460), Gyeik Taw (KKL, 18.i.1967; MMB 07414, MMB 07416, MMB 07418, MBB 07419, MMB 07433, MMB 07435), Ngapali (U.A.M, 14.iv.1969; MMB 07434, MMB 07444, MMB 0767; Botany Department, Mawlamyine University, 14.iv.1969; MBB 07445; Botany Department, Mawlamyine University, 20.iv.1970; MMB 07429, MMB 07413, MMB 07477; Dr. Kyaw Soe, 16.v.1970; MBB 07479; U.A.M, 25.x.1970; MBB 07425; U.A.M, 18.iii.1973; MBB 07455; Botany Department, Mawlamyine University, 18.iii.1973; MBB 07408, MBB 07424, MBB 07428; Aung Myint, 28.iii.1977; MBB 07478; Aung Myint, 28.i.1977; MBB 07481; MBB 07429, MBB 07430; San Tha Tun, 18.iii.1987; MBB 07417; Phyu Tun Aung, 22.ii.1975; MBB 07420; L.L.W, 25.ii.1987; MBB
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**Table 2.** The distributional range of *Halymenia durvillei* Bory de Saint-Vincent collected along the three coastal zones of Myanmar.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Species</th>
<th>RCZ</th>
<th>ACZ</th>
<th>TCZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Halymenia durvillei</em> Bory de Saint-Vincent</td>
<td>Leik Island</td>
<td>Kyauk Phyu</td>
<td>High Island</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lat. 15°51’ N and Long. 94° 17’ E</td>
<td>Lat. 19°43’ N and Long. 93° 55’ E</td>
<td>Lat. 11° 01’ N and Long. 98° 17’ E</td>
</tr>
<tr>
<td></td>
<td></td>
<td>07449)</td>
<td>No data</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>O7449)</td>
<td>No data</td>
<td>Wa Maw</td>
</tr>
</tbody>
</table>

Abbreviations: RCZ= Rakhine Coastal Zone; ACZ= Ayeyawady Coastal Zone; TCZ= Tanintharyi Coastal Zone.

07449): Ayeyawady Delta and Gulf of Martaban coastal zone - No data; Tanintharyi coastal zone - High I. (Botany Department, Mawlamyine University, 7.ii.1972; MMB 07446), Mali I. (Soe Htun, 18.i.2002; MMB 07387, MMB 07389, MMB 07390, MMB 07391, MMB 07393, MMB 07394, MMB 07397; 19.i.2002; MMB 07386, MMB 07392), Wa Maw (Htet Htar Hlaing, drift, 26.ii.2017; MMB 111917, 111918, 111919).

**Local distribution.** Rakhine coastal zone- Leik I., Phoe Kalar I., Chaungtha, Magyi, Wethey, Maungshwelay Gyaing, Gwa, Gyeik Taw, Ngapali, Mazin, Kyauk Phyu; Ayeyawady Delta and Gulf of Martaban coastal zone- No Data; Tanintharyi coastal zone- High I., Mali I., Wa Maw.

**World distribution.** Atlantic Ocean- Africa: Kenya, South Africa, Tanzania, Yemen; Indian Ocean- India, Sri Lanka, Myanmar (Present study), Andaman Islands; Pacific Ocean- American Samoa, Republic of Palau, Taiwan, South China Sea, Mariana Islands, Federated States of Micronesia, Papua New Guinea, Guam, Solomon Islands, Somoa, Central Polynesia, Western Australia, Queensland, Fiji, Samoan Archipologo, Western Pacific; Indo-pacific Region- Indonesia, Singapore, Malaysia, Thailand, Philippine, Japan.

**Potential Uses.** *Halymenia durvillei* can be used as human foods, fish meal, manure, drugs, fodder, organic fertilizer, alginates, agar and carrageenan. *Halymenia durvillei’* red or violet-red color is due to the accessory pigment phycoerythrin, used as a natural coloring in cosmetics, pharmaceuticals and food.

**DISCUSSION**

The first study addressing the diversity of *Halymenia* using gene sequence data (rbcL; Kawaguchi et al.) confirmed the conclusions from De Smedt et al. The analyses of Kawaguchi et al. confirmed specimens from Indonesia, Japan, Malaysia and Thailand that, based on morphological features, would be classified as *H. durvillei* sensu De Smedt et al. *H. durvillei* Bory de Saint-Vincent, is sometimes very variable (branching pattern, blade width or degree of dentation) and confusing the classification system of its morphology because no special differences were found in their vegetative and reproductive structures.

Normally, the characteristics of the *Halymenia durvillei* Bory de Saint-Vincent are erect blade, subdichotomously branched, lateral branchlets and short spines from the margins or on the surface. The blade consists of a comparatively dense medulla and a compact cortex; the medullary filaments are mainly running verticllay or obliquely from cortex to cortex. In Myanmar specimens of *H. durvillei* are thallus epilithic, erect, up to 11 cm long, 4 cm wide; dark pink to red in colour; branched up to 7 orders; central axis if present flattened and blade-like erect blades are repeatedly subdichotomously branched, gradually tapering towards the tips and stipe 7 mm long.

Branching is profuse and irregular, mostly occurring marginally, with secondary axes arising as proliferations on the surface of the primary axes. Numerous short lateral branchlets are formed from the margins of the branches. The branches and the branchlets are beset with spine-like proliferations along the margins and on the surfaces. *H. durvillei* has a very smooth and soft feel, contorted texture or supple cartilaginous structure and very slippery to the touch.
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Symbols; ▲ Present study; ● Data from the literature; ————Northernmost and Southernmost recorded limits.

The description of De Smedt et al.\textsuperscript{2} specifies the presence of a high branching pattern (up to seventh order) and a thick cortex (50-100 µm) for *H. durvillei*; these characteristics are shared with the specimens in the present study branching up to seventh order and 50-70 µm cortex thickness. The branched plants of *Halymenia durvillei* collected from Wa Maw showed that the branching varied greatly from plants having a percurrent axis with pinnately or distichously arranged laterals to those with repeatedly dichotomously or subdichotomously branched blades. On the contrary, no special differences were found in their vegetative and reproductive features. This fact suggests that these plants may all belong to a single species and that the wide external variations found among them be growth forms in different environmental conditions.

Additionally, Kawaguchi et al.\textsuperscript{21} reported that the morphological and molecular phylogenetic studies of *H. durvillei* from Indo-Pacific. The cortex consists of an outer layer of 3 or 4 rounded cells tightly packed in vertical rows and an inner layer of 3 or 4 larger, polygonal to stellate cells connected to each other by secondary pit-connections (measured from Japan, Philippines, Thailand and Indonesia). Since all previously and newly sequenced specimens share the same thickness of the cortex and characteristics of secondary pit-connection of *H. durvillei* in the present study. And then in this study, he clarified the range of morphological variations of *Halymenia durvillei* and its taxonomic relationships with the allied taxa.

In the present study, mature tetrasporangia are broadly ellipsoidal in shape, 18 µm long and 13 µm wide. According to De Smedt et al.\textsuperscript{2} the tetrasporangia are decussately divided, 17 µm long and 14 µm wide so that the comparison of the present study are nearly overlapped of the tetrasporangia shape. The Western Pacific specimens by Isabella A. Abbott\textsuperscript{20} described the blade bearing dense third- and fourth-order branches, outer cortex 2-celled, the outermost part 2-3 cells thick and without conspicuous stellate filaments joinging to outer medullary filaments. Tetrasporangia were about 20 µm long and 8 µm wide. There is a little
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differentiates occurring between the present study and in this result paper. The analysis to establish diagnostic characterisitics for morphological identification many of the measurements and features were studied by only one species and compared with the specimens of other countries such as Myanmar, Philippine and Western Pacific (Table 1).

In the present study of the genus from the Philippines, however, De Smedt et al. reduced *H. ceylanica*, *H. durvillei* var. *denudata* Weber-van Bosse, *H. durvillei* var. *edentata* Weber-van Bosse, *H. formosa*, *H. microcarpa* and *H. venusta* to synonyms of *H. durvillei*, based on comparisons of type material and vegetative and reproductive morphology. Their broad morphological species concept resulted in any tropical Indo-Pacific *Halymenia* specimens with a branched thallus and a margin and surface with branchlets and / or spines being referred to *H. durvillei*.

In the distributional range of the Rakhte coastal zone and the Tanintharyi coastal zone, *Halymenia durvillei* Bory de Saint-Vincent was occurred from Lampi Island (lat. 10° 57’ N, long 98° 09’ E) to Toung Pyo (lat. 21° 13’ N, long 92° 15’ E). Moreover, this species tend to move upwards at their northern limit of Alethankyaw (lat. 20° 50’ N, long 92° 20’ E) beyond Mazin coastal areas from Pine Tree Island (lat. 10° 20’ N, long 98° 15’ E), as recorded by Mya Kyawt Wai et al. Among the previously records of Soe-Htun described this species from High I. (lat. 11° 01’ N, long 98° 17’ E) of the Tanintharyi coastal zone to Kyauk Phyu (lat. 19° 26’ N, long 93° 33’ E) of the Rakhte coastal zone.

In the present study, table 2 gives the distribution range of the species of *H. durvillei* Bory de Saint-Vincent distributes in the Rakhte coastal zone, from Leik Island (Lat. 15° 51’ N and Long. 94° 17’ E) to Kyauk Phyu (Lat. 19° 43’ N and Long. 93° 55’ E) and in the Tanintharyi coastal zone, from High Island (Lat. 11° 01’ N and Long. 98° 17’ E) to Wa Naw (Lat. 13° 35’ N and Long. 98° 08’ E). The genus of *Halymenia* was not found in Ayeyawady Delta and Gulf of Martaban coastal zone.

According to the herbarium specimens, *H. durvillei* were also dominated in Wettey, Ngapali and Maung Shwe Lay Gyaing from Rakhte coastal zone. In January to April, at that time the species of *H. durvillei* are more abundant species than the other months. With respect to the world distribution, this species are encountered throughout warm temperate and tropical regions of the Atlantic, Indian, Pacific Ocean and Indo-Pacific regions. In general, *H. durvillei* is common in Indo-Pacific regions, including ASEAN countries of Philippine, Malaysia, Indonesia and Thailand including Myanmar.

*Halymenia*, a genus of red algae (Halymeniaceae), has been used as food in many countries. Anywhere that people like vegetable salads, or naturally thickened soups, *Halymenia* can be sold either fresh or dried. In Hawaii, Hawaiians love to eat *Halymenia* raw, especially with raw fish; Japanese and Koreans treat these plants “namasu style”; and others rehydrate dried pieces, adding the pieces to fresh salads or to “cream style” soup (without the calorie-rich cream). *Halymenia* species have a ready market in the United States and Japan. This *Halymenia* species is favoured as edible seaweed by several ethnic groups in Hawaii. It may have potential for domestication, especially if spores could be seeded onto coral rubble and outplanted into appropriate local habitats.

**CONCLUSION**

The order Halymeniaceae belonging to two families Halymeniaceae and Tsengiaceae was found in the world. But only one family of Halymeniaceae was found in Myanmar. Firstly, the taxonomic study of genus *Halymenia* collected from the three coastal zones of Myanmar was described. Detailed descriptions of *Halymenia durvillei* were studied in this result. Moreover, the distributions of this species along the three coastal zones of Myanmar and world were recorded based on the information from specimens examined and available literature. *H. durvillei* occurs along the Rakhte and Tanintharyi coastal zones and not occurs in Ayeyawady Delta and the Gulf of Martaban coastal zones. So, *H. durvillei* grow the lower intertidal zone and this species are widely distributed throughout the warm temperate and tropical Regions of the Atlantic, Indian, Pacific Oceans and Indo-Pacific regions. In ecological point of view, marine red algal beds support as natural habitats as well as feeding, spawning and nursery grounds for economically important marine living resources such as shrimps, clams, oysters and fishes. In Myanmar, the conservation of natural beds of marine red algae is still necessary to be worked out for the sustainable development of other marine living resources in the future.
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