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Morphology and distribution of *Laurencia sp.1* (Ceramiales, Rhodophyta) from Myanmar

Abstract

The plants of *Laurencia sp. 1* were collected from Nyaw Byin (Lat. 13˚40′N, Long. 98˚00′E) to Sittwe (Lat. 20˚08′ N, Long. 92˚54′E) of Myanmar from 1987 to 2019. *Laurencia sp.1* was characterized by the absence of *corps en cerise* within each superficial cortical cell, and lenticular thickenings in the walls of medullary cells, and the presence of secondary pit-connections between cortical cells, four pericentral cells per axial segment and tetrasporangia formed in the apical portion of the lateral axis with a parallel arrangement and cystocarps with one or more ostioles, based on the external and internal morphologies of both the vegetative and reproductive structures. The distribution and some ecological notes along with potential uses of this species were briefly described.

Keywords: ceramiales, distribution, *Laurencia sp.1*, morphology, Myanmar, Rhodophyta, taxonomy

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Introduction

The genus *Laurencia* was established by Lamouroux in 1813. According to Guiry and Guiry,[1] the genus *Laurencia* comprises about 145 species. This genus is widely distributed in temperate and tropical seas of the world.

In Myanmar, Kyi Win[2] and Kyaw Soe and Kyi Win[3] reported four species of *Laurencia*, such as *L. obtusa* Hudson, *L. platyclada* Boergesen, *L. penniculata* (Agardh) J. Agardh, and *L. papillosa* (Forsskal) Greville. Soe-Htun[4] accounted that three species of *Laurencia*, viz., *L. obtusa* Hudson, *L. papillosa* (Forsskal) Greville and *L. platyclada* Boergesen from three coastal regions of Myanmar. Subsequently, Soe-Htun et al.[5,6] recorded six species of *Laurencia*, viz., *L. composita* Yamada, *L. pinnata* Yamada, *L. intricata* Lamouroux, *Chondrophycus papillosa* (C. Agardh) Garbary and Harper (*L. papillosa* (C. Agardh) Greville), *C. intermedius* (Yamada) Garbary and Harper (*L. intermedia* Yamada), and *C. ceylanicus* (J. Agardh) Wynne, Serio, Cormaci and Funari (*L. ceylanica* J. Agardh). Very recently, Soe-Htun et al.[7] reported two species of *Laurencia*, viz., *C. intermedius* (Yamada) Garbary and Harper (*L.intermedia* Yamada), and *C. ceylanicus* (J. Agardh) Wynne, Serio, Cormaci and Funari (*L. ceylanica* J. Agardh) from Gwa coastal areas. Moreover, Mya Kyawt Wai et al.[8] also recorded three species of *Laurencia*, viz., *C. intermedius* (Yamada) Garbary and Harper (*L. intermedia* Yamada), *C. ceylanicus* (J. Agardh) Wynne, Serio, Cormaci and Funari (*L. ceylanica* J. Agardh), and *Chondrophycus papillosa* (C. Agardh) Garbary and Harper (*L. papillosa* (C. Agardh) Greville) from Mazin coastal areas of the Rakhine State.

Soe-Htun et al.[5,6], Hlaing Hlaing Htoon and Soe-Htun[9], Sein Moh Moh Khaing and Soe-Htun[10] and Thet Htwe Aung[11] identified the only one species of *Laurencia* as *L. intricata* Lamouroux. In the present study, *L. intricata* Lamouroux is designated as *Laurencia sp.1* according to the literature available at hand. *Laurencia sp. 1* has been identified in the present study, based on the specimens collected from the Myanmar Coastal Zones from 1978 to 2019. The objectives of this study are to investigate detailed morphological structures used for identification in the taxonomy, and to know distribution and some ecological features.

Materials and methods

Fresh and living plants of the genus *Laurencia* were collected from the mangrove swamps and rocky shores in the upper intertidal zone of three Coastal Zones of Myanmar, Taninthayi Coastal Zone, Deltaic Coastal Zone and Rakhine Coastal Zone (Figures 1-19) from 2009 to 2019, preserved with 4% formalin in seawater and then prepared as herbarium sheets. Furthermore, herbarium sheets and liquid-preserved specimens of the genus *Laurencia* collected from the upper intertidal zone along the Myanmar coastal areas during 1987-2019 and deposited in the Herbarium of Department of Marine Science, Mawlamyine University, Myanmar (MMB) were also used for detailed investigations emphasized on the vegetative and reproductive structures in the present study.

The fragments of plant were squashed on microscope slides, and stained with aniline blue (0.5g water soluble aniline blue in 100ml distilled water and 5ml conc. Acetic acid) and acid fuchsin (1% solution in distilled water and 70% alcohol) for detailed observations. The sections were prepared by hand using razor blades. Microscopic measurements were recorded in micrometer (µm) using the ocular meter. External and internal morphological structures were photographed with a Panasonic (Lumix) DMC-TZ 15 digital camera and processed using Adobe Photoshop CS. The distribution, ecological notes and associated algae of this species were also recorded. The classification system of *Laurencia sp. 1* basically follows that of Saito,[12,13] Saito and Womersley[14] and Guiry and Guiry.[1]

Results and Discussion

A classification system of the *Laurencia sp.1*

Phylum: Rhodophyta

Class: Florideophyceae

Order: Ceramiales

Family: Rhodomelaceae

Genus: *Laurencia* Lamouroux

Species: *Laurencia sp. 1*

Morphology of *Laurencia sp. 1*

Laurencia sp. 1 (Figures 1-19)

a. Vegetative Structures:

(i) External features: Fronds, caespitose and prostrate (Figure 1), 3-11cm in diameter, densely entangled with stoloniferous branches, reddish brown, rigid, and cartilaginous in texture, attached to the substratum by discoid holdfasts (Figure 5) formed on main axes and secondary branches, never adhere to paper when drying; main axes, terete with blunt tips terminate in a small depression (Figure 3), not percurrent; branches cylindrical (Figure 2), 2-12mm long, irregularly alternate at intervals of 0.5-2.0mm and at angles of 30-90°. In a surface view, the cortical cells in the main axis (Figure 4), slightly elongated, 16-60µm long and 12-40µm broad, while those in the secondary branch, nearly rounded or slightly elongated, 12-28µm long and 12-20µm broad. Trichoblasts (Figure 6) grow from a young pericentral cell near the growing apex of the apical depression; repeatedly dichotomously branched; trichoblast cells, 70-150µm long and 20-30µm broad, without *corps en cerise*. (ii) Internal features: In transverse section, main axes (Figure 7), 600-760µm in diameter in the lower portions, 550-830µm in the middle portions, and then gradually taper to 450-700µm at the tips; cortical cells (Figure 8), subquadrate, not protrude at the apex and not form a palisade-like layer, 16-36µm long and 16-40µm broad in the lower to upper portions, with secondary pit connections (Figure 8) between these cells, *corps en cerise* absent; medullary cells (Figure 8), rounded or more or less elongated, 32-100µm diameter in the lower to upper portions, with primary and secondary pit connections (Figure 8), but without intercellular spaces between these cells, lenticular thickenings in the walls of the medullary cells absent; four pericentral cells per axial cell (Figure 9); secondary branches, 520-640µm in diameter; cortical cells, subquadrate, 16-28µm long and 16-24µm broad; medullary cells, rounded or more or less elongated, 28-68µm in diameter; four pericentral cells per axial cell. In longitudinal section, main axes, 550-640µm broad; cortical cells, rounded or more or less elongated, 30-50µm in diameter; medullary cells, oblong, 128-300µm long and 44-80µm broad; axial cells, 300-470µm long and 40-50µm broad in the middle to upper portions.

b. Reproductive Structures

Tetrasporangial stichidia (Figure 10-11), formed on the apical portions of secondary branches and branchlets; simple or with 1-5 branches; cylindrical, 725-2000µm long and 500-700µm broad. Tetrasporangia, originate from a pericentral cell (Figure 12), and scatter over the branches by many reddish brown spots, and these spots become colourless after the shedding of spores; tetrahedrally divided; adaxially from the pericentral cell, and with parallel arrangement. Elongated tetraspores form in tetrasporangia, but liberated tetraspores spherical, 55-60µm in diameter. Plants, dioecious; spermatangial stichidia, formed on the apical portions of main axis; slightly turbinate (Figure 13), single or in clusters, 250-625µm in diameter when young; cylindrical with distinct stipe (Figure 14), simple or with 1-3 branches, 1.2-2.6mm long, and 0.7-1.1mm broad when mature; with apical cup-shaped spermatangial pits, 100-150µm broad and contain numerous fertile trichoblasts. Trichoblasts (Figure 15), arise from a young pericentral cell near the apical cell; consist of a repeatedly dichotomously branched; terminate in a single large sterile vesicular cell, 12-16µm in diameter. In the carpogonial plant (Figure 16-17), the secondary branches and branchlets cylindrical when sterile, but these become broad with the development of the cystocarps. Cystocarps, single or in clusters (1-5 lobes) with one or more apical ostiole, borne laterally on branches (except first to fourth-order branches), broadly ovoid, slightly pointed at these apices; 570-1100µm long and 670-1800µm broad at maturity. The gonimoblast filaments (Figure 18) develop from fusion cell. The terminal cells of the gonimoblast increase in size and become carpospores. Elongated carpospores (Figure 18) form in cystocarps, but liberated carpospores spherical, 64-88µm in diameter.

Specimens examined. - Tanintharyi coastal zone: Nyaw Byin (Yin Yin Htay, 24.v.2006; MMB 10737-10739: sterile); Sitaw (Third year (Hons) (group 1), 7.vii.2016; MMB 111575-111579: sterile); Kawdut (Lamine) (Soe Pa Pa Kyaw, 17.i.2014, MMB 111210-111212: sterile); Kalegoke (Nyo Nyo San, 29.ix.2010; MMB 10649-10651: sterile); Kalagoke I. (Apor Seik) (Thet Htwe Aung, 28.ix.2012, MMB 11850: sterile); Kalagoke I. (Auk Seik) (Thet Htwe Aung, 28.ix.2012, MMB 111071: sterile); Kalagoke I. (Alè Seik) (Thet Htwe Aung, 28.ix.2012, MMB 111072: sterile); Kalagoke I. (Pashyu Chaung) (Thet Htwe Aung, 28.ix.2012, MMB 111073: sterile); Kalagoke I. (Kyunn Pyet) (Thet Htwe Aung, 28.ix.2012, MMB 111074: sterile); Kalagoke I. (Chaytoryar pagoda) (Thet Htwe Aung, 28.ix.2012, MMB 111075: sterile); Kayinthaung (Soe Pa Pa Kyaw, 9.viii.2009; MMB 10323-10329: sterile; 6.ix.2009; MMB 10345-10346: sterile, ♀, ⊕; MMB 10347-10353: sterile, ⊕; 11.vii.2010; MMB 10564-10566: sterile, ⊕; 8.viii. 2010; MMB 10609, 10615: ♂; MMB 10610-10612, 10619: sterile, ⊕; MMB 10617-10618: ♂; 29.iii.2011; MMB 10727: sterile; 28.vii.2012; MMB 11700-11701: sterile; MMB 11702-11704: sterile, ⊕; MMB 11705-11706: sterile; Soe-Htun, 16.vii.2010; MMB 10606-10608: sterile, ⊕; Soe Pa Pa Kyaw, 8.viii.2013; MMB 111179, 111181: sterile); Setse (Myint Than, 31.vii.1978; MMB 07538: sterile; 14.ix.1980; MMB 07541: sterile; Soe-Htun, 21.ix.1982; MMB 07549-07550: sterile; Ma Thidar, 15.vii.1984; MMB 02962: sterile; San Tha Tun, 15.viii.1990; MMB 07532: sterile, ♀, ⊕; 27.ix.1990; MMB 07547-07548: sterile; 4.ix.1991; MMB 07533: ♀, ♂, ⊕; MMB 07534: sterile; Mya Soe Latt, 7.ii.1994; MMB 07537: sterile; Thein Zaw, 7.ii.1994; MMB 07530: sterile; Tan C.T, 7.ii.1994; MMB 07546: sterile; Group A&B, 19.xii.1994; MMB 07545: sterile; Phyo Haymar Hlaing, 4.iii.2006; MMB 05271: sterile; Soe Pa Pa Kyaw, 6.viii.2009; MMB 10317: sterile; 6.ix.2009; MMB 10343: sterile, ⊕; MMB 10344: sterile, ♀; 3.x.2009; MMB 10354-10356: sterile, ♀; MMB 10357-10361: sterile; 28.iv.2010; MMB 10563: sterile; 30.iii.2011: MMB 10728-10729: sterile; Moe Moe Khaing, 1.v.2012; MMB 11690-11691: sterile; Soe Pa Pa Kyaw, 8.viii.2013; MMB 111178: sterile; 8.ix.2013; MMB 111183, 111185: sterile); Yathaetaung (Tin Oo, 24.viii.1983; MMB 07539: sterile; G.3, 24.viii.1983; MMB 07540: sterile; Baby San, 24.viii.1983; MMB 07542: sterile; Lal Biak Dika, 24.viii.1983; MMB 07543: sterile; Nyi Nyi Htwe, 24.viii.1983; MMB 07544: sterile; Soe Pa Pa Kyaw, 4.x.2009; MMB 10330-10335: sterile, ♀, ⊕); Kyaikkhami (San Tha Tun, 14.viii.1990; MMB 07535: sterile, ♀; 15.viii.1990; MMB 07536: sterile, ⊕; Soe Pa Pa Kyaw, 8.viii.2009; MMB 10318-10322: sterile; 5.ix.2009; MMB 10336-10342: sterile; 30.iv.2010; MMB 10556-10560: sterile; 7.viii.2010; MMB 10613: ⊕; MMB 10614, 10616: ♂; 1.iv.2011; MMB 10730-10732: sterile; 7.iv.2011; MMB 10733-10735: sterile; 13.viii.2011; MMB 11693-11695: sterile; Khin Khin Gyi, 3.vii.2010; MMB 10561-10562: sterile; Khaing Myo Win, 17.ix.2010; MMB 10652: sterile; Khin Khin Gyi and Cho Cho Latt, 22.ix.2010; MMB 10647: ♂; MMB 10648: sterile, ♀; Jar San, 26.i.2012; MMB 11601-11602: sterile, ⊕; Sein Moh Moh Khaing, 31.i.2012; MMB 11502, 11314, 11316,

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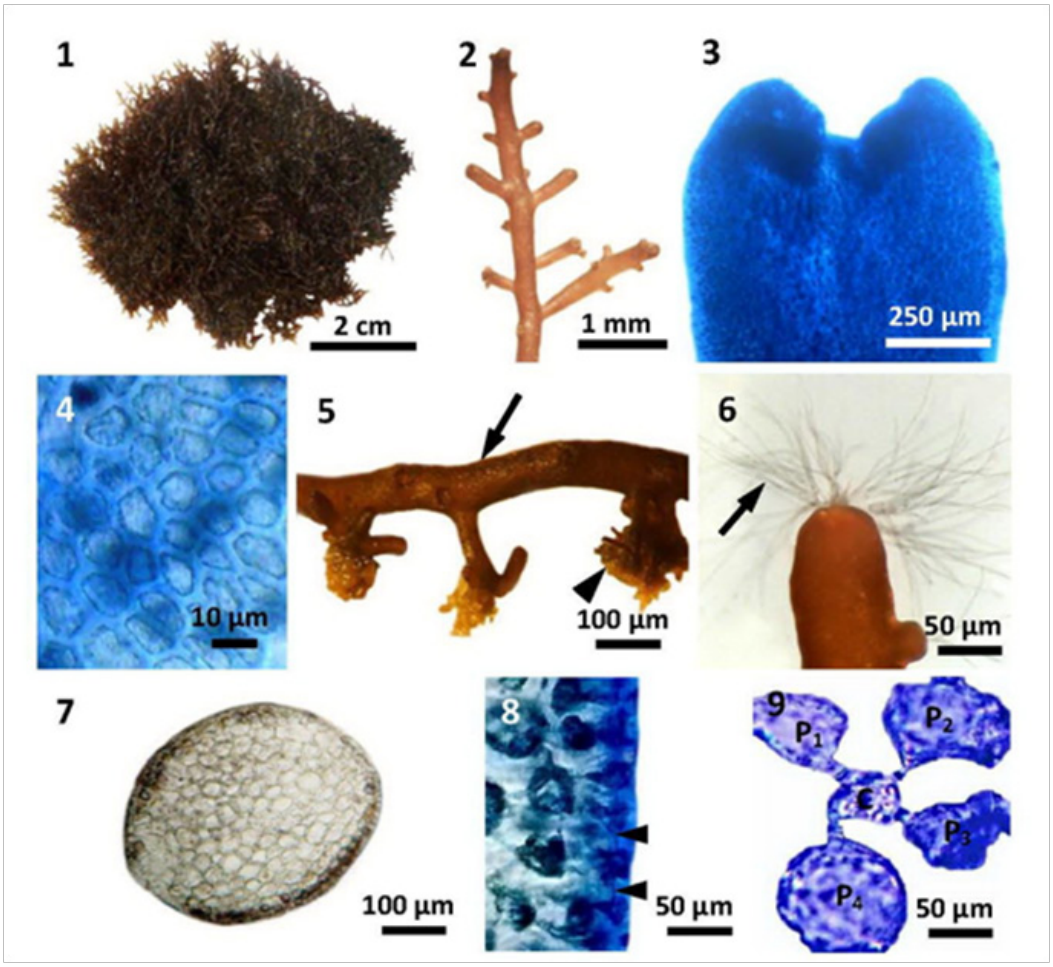
11318: sterile; Soe Pa Pa Kyaw, 7.viii.2013; MMB 111180: sterile; 7.ix.2013; MMB 111184, 111186-111187: sterile); Button I. (Wuit Yi Phyo, 3.viii.2019; MMB 112014: sterile; Htwe Yee Lin, 3.viii.2019; MMB 112025: sterile; Soe Pa Pa Kyaw, 3.viii.2019; MMB112034-112035: sterile); **Deltaic Coastal Zone:** No Data; **Rakhine Coastal Zone:** Mawtin Point (Mya Kyawt Wai et al., 17.xi.2009; MMB 10736: sterile; Soe Pa Pa Kyaw, 28.ix.2013; MMB 111188-111189: sterile, ⊕); Ngapali (Department of Botany, Mawlamyine College, 16.iv.1969; MMB 07518: sterile); Sittwe (San Tha Tun, 4.iii.1987; MMB 07512-07513: sterile; Mya Kyawt Wai, 4.vi.2012; MMB 11679-11682: sterile).



Figures 1-9 Morphology and anatomy of Laurencia sp.1 (Living material): (1) Habit of a plant (MMB 10330); (2) Part of a sterile plant (MMB 10556); (3) Apex of a branch with apical depression (MMB 10558); (4) Surface view of main branch, showing slightly elongated cortical cells (MMB 10559); (5) Secondary discoid holdfast (arrowhead) with stoloniferous branch (arrow) (MMB 10561); (6) Trichoblast (arrow) arising from growing apex (MMB 10562); (7) Cross section of main branch (MMB 10563); (8) Cross section of main branch showing a secondary pit connections (arrowheads) between cortical cells (MMB 10358); (9) Cross section of main branch showing central (c) and five pericentral (p) cells (MMB 10360).

Ecological notes: Plants grow on mud flat or on rocks covered with sand in the upper to lower intertidal zones. This species attached to the substratum by stoloniferous holdfast. The vegetative or reproductive plants can be found from February to November. The reproductive plants are abundantly found in August. Associated algal species are *Schizothrix sp.*, *Cladophora sp.*, *C. rupestris*, *C. vagabunda*, *Chaetomorpha gracilis*, *C. linum*, *Dictyota adnata*, *Gracilaria foliifera*, *Gelidium crinale*, *G. arenarium*, *Catenella nipae*, *Ceramium sp.*, *Centroceras clavulatum*, *Caloglossa bengalensis*, *Polysiphonia subtilissima*, *Acanthophora spicifera*, *Bostrychia tenella*, *B. binderi.*

Potential uses: *Laurencia sp. 1* (*L. intricata*) is one of the economically important seaweeds. It has many useful substances, such as protein, lipid, crude fibre, iodine, ash, moisture, sulphate and carbohydrate[15].

Distribution of *Laurencia sp. 1*

Myanmar distribution: Tanintharyi Coastal Zone: Nyaw Byin, Sitaw, Kawdut, Kalegoke, Kayinthaung, Setse, Yathaetaung, Kyaikkhami, Button I.; Deltaic Coastal Zone: No Data; Rakhine Coastal Zone: Mawtin Point, Ngapali, Sittwe (Present study) (, Figure 19).

Laurencia sp. 1 collected from Myanmar was seemingly related to *L. intricata* Lamouroux which had been reported from various localities in tropical to warm temperate regions in the world: Americas[16], Canary Islands[17], Mediterranean Sea,[18] Japan[12] and Philippines.[19] Its type locality was the Antilles and Cuba. Authentic material of *L. intricata* Lamouroux had not been available for comparison.

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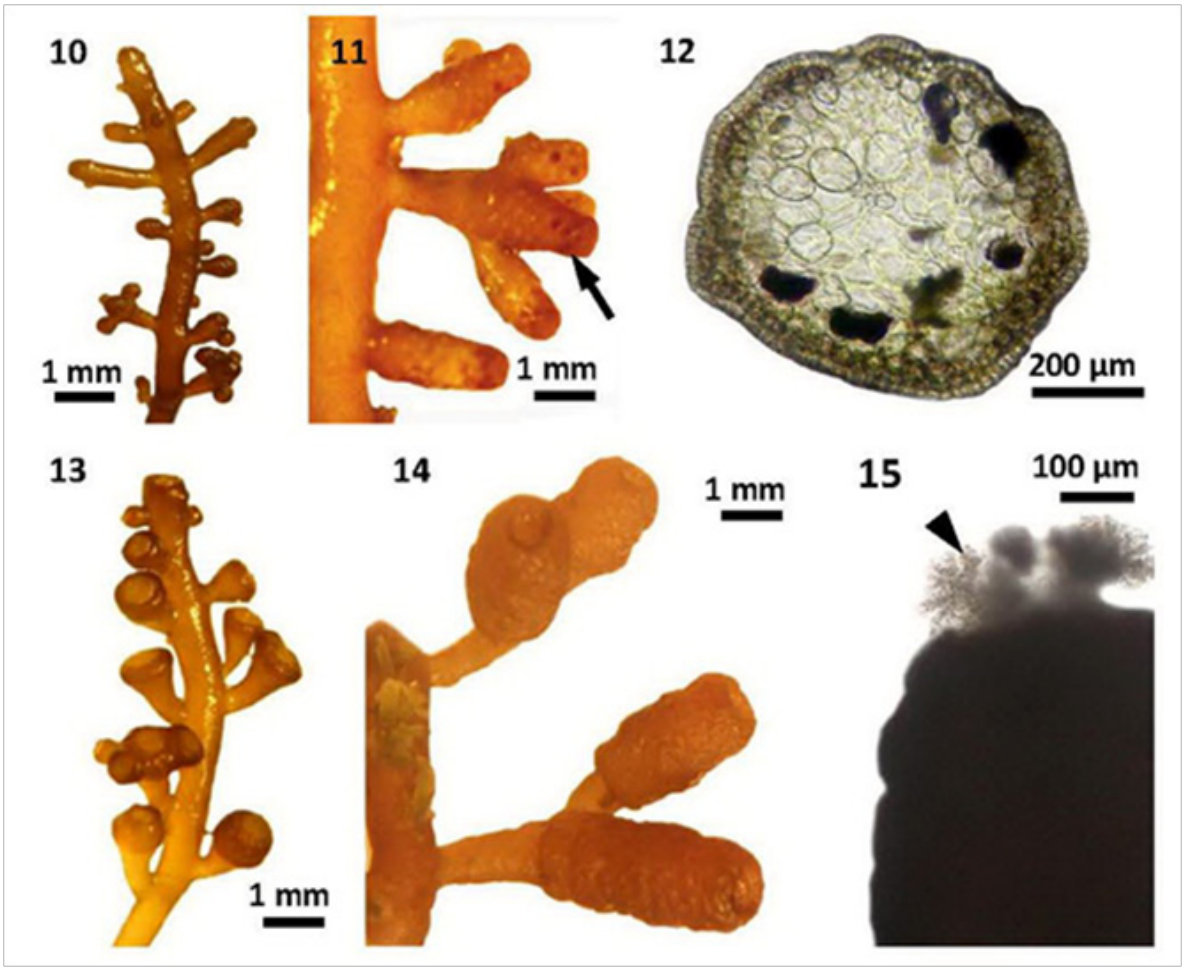
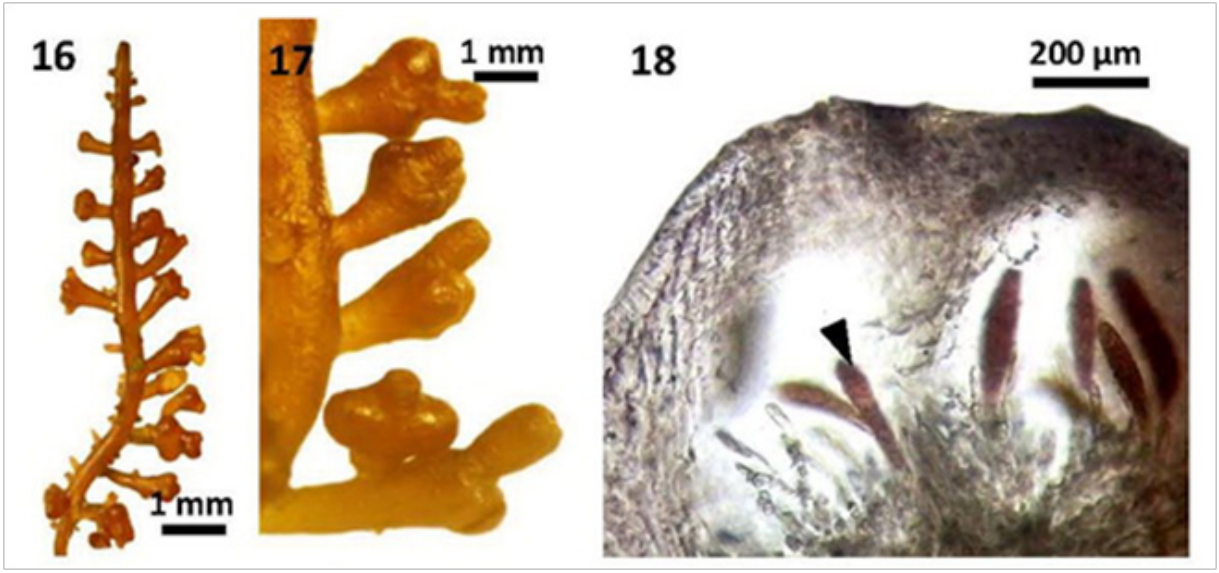


Figures 10-15 Morphology and anatomy of Laurencia sp.1 (Living material): (10) Part of a tetrasporangial plant (MMB 10606); (11) Tetrasporangial stichidia (arrow) on main branch (MMB 10607); (12) Cross section of tetrasporangial stichidium (MMB 10608); (13) Part of a young spermatangial plant (MMB 10614); (14) Part of a mature spermatangial plant (MMB 10616); (15) Spermatangial stichidia with fertile trichoblasts (arrowhead) (MMB 10609).



Figures 16-18 Morphology and anatomy of *Laurencia sp.1* (Living material): (16) Part of a young carpogonial plant (MMB 10344); (17) Part of a mature carpogonial plant (MMB 10354); (18) Longitudinal section of a mature cystocarp showing elongated carpospore (arrowhead) (MMB 10356).

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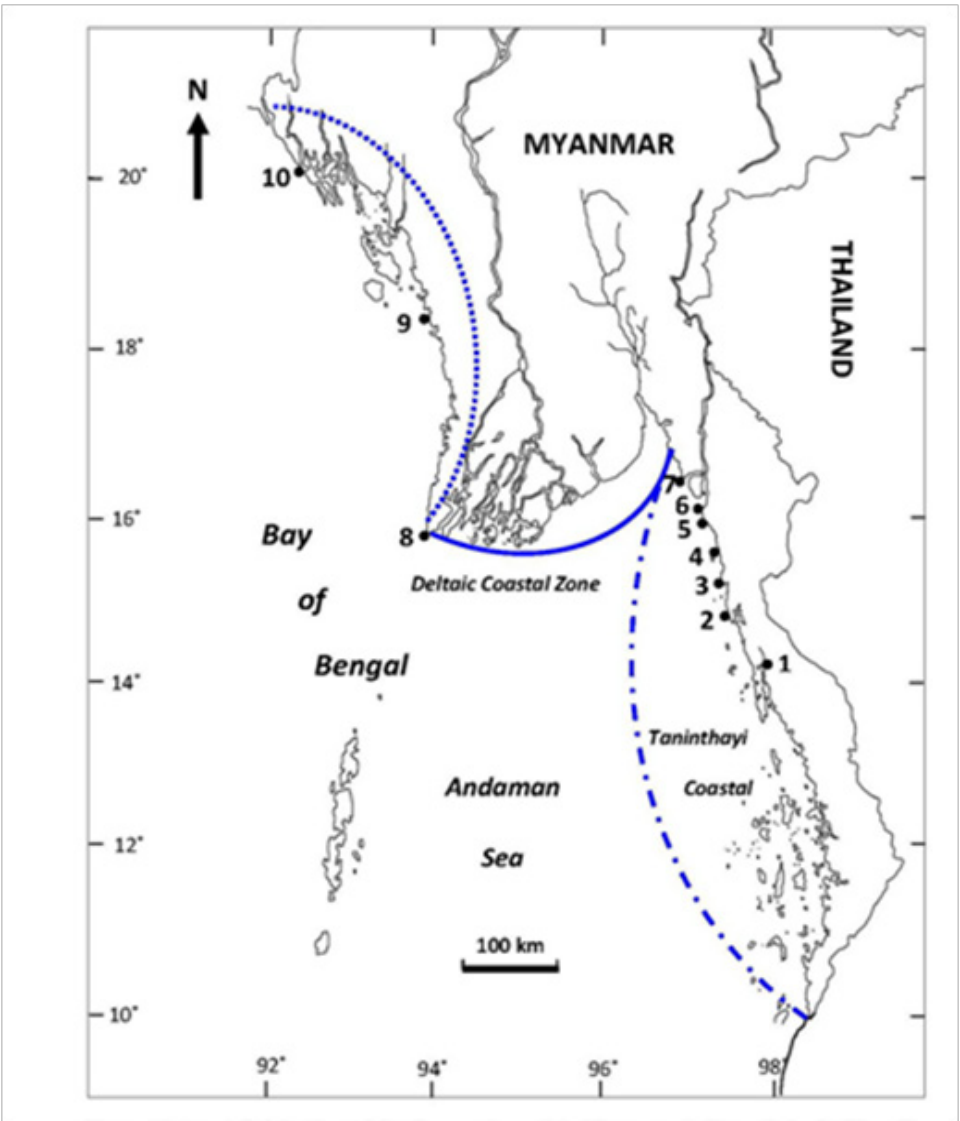

Figure 19 Local distribution of the *Laurencia sp. 1* in Myanmar. 1. Nyaw Byin, 2. Sitaw, 3. Kawdut, 4. Kalagoke, 5. Setse, 6. Kyaikkhami, 7. Button I, 8. Mawtin Point, 9. Ngapali, 10. Sittwe Taninthayi Coastal Zone; Deltaic Coastal Zone; Rakhine Coastal Zone.

Laurencia intricata Lamouroux had been characterized in having matted or tufted, freshly soft thalli with entangled and coalescing, lower branches, the presence of slightly projecting superficial cortical cells, and the absence of both percurrent main axes and lenticular thickenings among the species of the genus Laurencia.[12] Furthermore, the species was characterized by the production of four periaxial cells from each vegetative axial segment, and the occurrence of 2-3 *corps en cerise* per superficial cortical cell (Nam 1990) as cited in Masuda et al.[17] These features were based on material from the Pacific. All of these features were found in Myanmar specimens, although superficial cortical cells with single *corps en cerise* had not been found.

Specimens of *L. intricata* Lamouroux from Japan[12] and Mediterranean Sea,[18] having subverticillate or irregular spiral manner branched, were distinct from that of Myanmar specimens. In addition, two to four *corps en cerise* present within each superficial cortical cell in Mediterranean specimens[18] was also distinct from that of Myanmar specimens. The descriptions of male and female plants were not given in Japanese specimens.[12] The characters of loosely arranged medullary cells found in Philippines specimens[19] of *L. intricata* Lamouroux differed with those of Myanmar specimens of the present study. Canarian specimens[17] of *L. intricata* Lamouroux were somewhat similar in external appearance to *L. sp. 1*, but it was distinguished by the presence of two to four *corps en cerise* within each superficial cortical cell, tetrasporangia formed at the apical portions of main axes, and cystocarps with a single apical ostiole. Moreover, the specimens of *L. intricata* Lamouroux from Americas coasts[16] were closely similar to Myanmar specimens, but differ in their habitat, growing more ample and regular in deep water (to a depth of 36m). In comparison, *Laurencia sp. 1* from Myanmar, growing in upper intertidal zone exposed to air during low tide, was characterized in having the absence of *corps en cerise* within each superficial cortical cell, along with tetrasporangia formed apical portion of the lateral axis, and cystocarps with one or more ostioles (Table 2) (Figures 10-18).

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Table 1 The distributional range of *Laurencia sp.1* along the three Coastal Zones of Myanmar

Species	Coastal Zones					
	TCZ		DCZ		RCZ	
	From	To	From	To	From	To
Laurencia sp. 1	Nyaw Byin (Lat. 13˚40′N, Long. 98˚00′E)	Button I (Lat. 16˚01′N, Long. 97˚58′ E)	-	-	Mawtin Point (Lat. 15˚58′N, Long. 94˚14′ E)	Sittwe (Lat. 20˚08′N, Long. 92˚54′E)

Abbreviations: RCR, the rakhine coastal region; ACR, the Ayeyawady and the Gulf of Mottama (Martaban) Coastal Region; TCR, the tanintharyi coastal region.

Table 2 Comparison of the taxonomic features in *Laurencia sp. 1* and its other related species

Sr. no.	Characters	Species		
		Laurencia sp.1	*Laurencia intricata* Lamouroux	*Laurencia pygmaea* Weber-van Bosse
	Vegetative Structures			
1.	*corps en cerise*	absence	presence	presence
2.	lenticular thickenings	absence	-	presence
	Reproductive Structures			
3.	Formation of tetrasporangia	formed apical portion of the lateral axis	formed at the apical portions of main axes	-
4.	Cystocarps with number of ostioles	cystocarps with one or more ostioles	cystocarps with a single apical ostiole	-

The other closely related species of *Laurencia sp. 1* was *L. pygmaea* Weber-van Bosse (*L. decumbens* Kutzing). Specimens of *L. pygmaea* Weber-van Bosse (*L. decumbens* Kutzing) from Malaysia,[20] Australia,[21] and Tanzania[22] were somewhat similar in their habit, habitat, and diameter of decumbent thallus to *Laurencia sp. 1*, but it was distinguished by the presence of lenticular thickenings in the walls of medullary cells, single or two *corps en cerise* within each superficial cortical cell, form and structure of tetrasporangia stichidia and cystocarps. However, in the present specimen, there were no lenticular thickenings in the walls of medullary cells and *corps en cerise* within each superficial cortical cell, and different type of formation in the development of tetrasporangia stichidia and cystocarps (Table 2). Thus, *Laurencia sp. 1* appears to be distinguished from all known intricate species of *Laurencia*, from available literature in hand.

Laurencia sp. 1 distributes in the Tanintharyi Coastal Zone, from the southern limit of Nyaw Byin (Lat. 13˚40′ N, Long. 98˚00′E) to Button I. (Lat. 16˚01′N, Long. 97˚58′E), no data in Deltaic Coastal Zone, and in the Rakhine Coastal Zone, from the southern limit of Mawtin Point (Lat. 15˚58′ N, Long. 94˚14′E) to the northern limit of Sittwe (Lat. 20˚08′ N, Long. 92˚54′E). In general, local distribution range of *L. sp. 1* is widely distributed from the southern limit of Nyaw Byin (Lat. 13˚40′ N, Long. 98˚00′ E) of the Tanintharyi Coastal Zone to the northern limit of Sittwe (Lat. 20˚08′N, Long. 92˚54′ E) of the Rakhine Coastal Zone.

Conclusions

In the present study, the specimens were collected from the upper intertidal zone of muddy and rocky areas of Nyaw Byin (Lat. 13˚40′N, Long. 98˚00′E) to Sittwe (Lat. 20˚08′N, Long. 92˚54′E) of Myanmar. The collected specimens were identified as *Laurencia sp. 1* based on the morphologies of both vegetative and reproductive structures. Although *Laurencia sp.1* should be identified as a new species, it could not be described as of new species due to limited literature available at hand. For this reason, it is tentatively designated as *Laurencia sp.1* so far. Local distribution range of *L. sp. 1* is widely distributed from the southern limit of Nyaw Byin of the Tanintharyi Coastal Zone to the northern limit of Sittwe of the Rakhine Coastal Zone.

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