# **Taxonomic Notes on Marine Algae from Malaysia.** V. Five Species of Rhodymeniales (Rhodophyceae)

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Five species of the red algal order Rhodymeniales are reported from Malaysia for the first time and their characteristic features are described: *Chamaeborr s boergesenii* (Weber-van Bosse) Huisman (Rhodymeniaceae), *Coelarthr m* sp. (Rhodymeniaceae), two species of *Champia* (Champiaceae), *C. compressa* Harvey and *C. ieillardii* Kützing, and *Lomentaria monochlam dea* (J. Agardh) Kylin (Lomentariaceae). The alga with vegetative features similar to the *Chamaeborr s/Coelarthr m* group is new to science and is characterised by the presence of a conspicuously developed, solid, cartilaginous stipe. This alga seems to be more closely related to *Coelarthr m* on the basis of its upright habit rather than *Chamaeborr s*, which has decumbent or prostrate thalli. The production of slender branches in *Champia ieillardii* is an additional critical feature that distinguishes it from a closely related species, *C. compressa*.

## Introduction

In a series of papers dealing with noteworthy Malaysian marine algae we have reported on various groups of red algae (Masuda et al. 1999, 2000 a, 2000 b, Terada et al. 2000). In this paper we document species of the red algal order Rhodymeniales. Only seven members of the order have previously been reported from Malaysian waters: Botr ocladia leptopoda (J. Agardh) Kylin, Ceratodict on spongios m Zanardini, Champia compressa Harvey, Champia par la (C. Agardh) Harvey, Chr s menia sp., Gastrocloni m compress m (Hollenberg) Chang et Xia, and Gelidiopsis intricata (C. Agardh) Vickers (Phang and Wee 1991, Ismail 1995). The record of Champia compressa, however, should be excluded, as the description and illustrations given by Ismail (1995, p. 93, fig. 7.29) do not match the circumscription of the genus. This small number may be due to the scarcity of field surveys in the region, which is very important in assessing the relationship between the marine algal floras of the Pacific Ocean and the Indian Ocean. Our recent field survey of the entire coasts of Malaysia has revealed the presence of a further five species of the Rhodymeniales. Of the previously recorded species, only Ceratodict on spongios m, Champia par la and Gelidiopsis intricata have been re-collected.

#### **Materials and Methods**

Specimens examined were collected by us at various localities in Malaysia. The specimens were fixed in 10% Formalin in seawater, and later some were dried

as voucher herbarium specimens or mounted in 30% Karo® on microscope slides, both of which are deposited in the Herbarium of the Graduate School of Science, Hokkaido University (SAP) or in the Seaweed Herbarium, Institute of Biological Sciences, University of Malaya. These specimens are cited in the following sequence: state, locality (latitude and longitude and date in parentheses) (specific localities are not given for small islands) and island, town or city. The latitude and longitude of each locality was determined using a Panasonic GPS (Global Positioning System) Receiver [Model KX-G5500] (Matsushita-Denki-Sangyo, Oosaka, Japan) in 1998 and an Ensign XL GPS [Model P/N 17737-15] (Trimble Navigation Ltd., Sunnyvale, California, USA) in 1999.

Sections were made by hand using a razor blade and pith stick and stained with 0.5% (w/v) cotton blue in a lactic acid/phenol/glycerol/water (1:1:1:1) solution and mounted in 50% glycerol/seawater or 30% Karo<sup>®</sup> on microscope slides.

#### **Observations and Discussion**

*Chamaebotrys boergesenii* (Weber-van Bosse) Huisman 1996: 106, f. 35–38, 40–42

(Figs 1-6)

**Distribution:** Tropical to warm-temperate regions of the Pacific Ocean (Segawa 1936 as *Coelarthr m coact m* Okamura *et* Segawa, Abbott and Littler 1969 as *Coelarthr m boergesenii* Weber-van Bosse, present paper) and Indian Ocean (Silva *et al.* 1996 as *Coelarthr m boergesenii*, Huisman 1996).



Figs 1-6. Chamaebotr s boergesenii (Weber-van Bosse) Huisman.

Fig. 1. Portion of a Formalin/seawater-preserved cystocarpic specimen: arrowhead indicates a secondary anastomosis (scale bar = 1 mm). Fig. 2. Transverse section (TS) of a vegetative portion of a tetrasporophyte (scale bar =  $20 \,\mu$ m). Fig. 3. Three gland cells borne on a rhizoidal cell (TS of a female gametophyte) (scale bar =  $20 \,\mu$ m). Fig. 4. Tetrasporangium representing a lateral one-celled branch from one of the outer cortical cells (TS) (scale bar =  $20 \,\mu$ m). Fig. 5. Terminal spermatangia (TS) (scale bar =  $20 \,\mu$ m). Fig. 6. Cystocarp in TS (scale bar =  $200 \,\mu$ m).

**Specimens examined**: Terengganu: Teluk Gadung (5°54'32" N, 102°46'14" E; 20. v. 1999; SAP 072317), Pulau Perhentian Besar; Pasir Panjang Kecil (5°46'15" N, 103°02'03" E; 22. v. 1999; SAP 072318), Pulau Redang; Tanjung Pasir China (5°36'36" N, 103°03'44" E; 23. v. 1999; SAP 072319), Pulau Bidong Laut; Pulau Tenggol (4°48'57" N, 103°40'42" E; 28. v. 1999; SAP 072320). Pahang: Pulau Rengis (2°48'38" N, 104°08'12" E; 2. vi. 1999; SAP 072321); Kampung Genting (2°45'24" N, 104°07'13" E; 4. vi. 1999; SAP 072322), Pulau Tioman. Johor: Pulau Apil (2°16'39" N, 104°07'40" E; 8. vi. 1999; SAP 072323).

Plants grow solitarily in the upper subtidal zone of reef flats on various algae, such as *H pnea*, *Dict opteris* and *Dict osphaeria*, and on dead coral or rope. An individual plant possesses one or two decumbent or prostrate axes that develop from a discoid hold-fast. Axes are also attached to the substratum by sec-

ondary discoid holdfasts. The axes are pale red, softly fleshy, 2-4 cm in length. They are regularly segmented and are branched dichotomously to polychotomously at the distal end (sometimes at the lateral sides) of each segment (Fig. 1). Secondary anastomoses are frequently present between closelyplaced axes (Fig. 1). Joints between segments are up to 0.8-1.5 mm wide. Segments are ellipsoidal or obovate, 5-13 mm long by 7-11 mm wide, becoming spherical near the apices (0.5-1.0 mm in diameter). These segments consist of an outer cellular tissue and an inner mucilage-filled cavity. The cellular tissue consists of an inner layer (medulla) one cell thick of large  $(35-125 \,\mu\text{m}$  wide by  $35-65 \,\mu\text{m}$  thick in transverse section), hyaline cells and an outer layer (cortex) one or two cells thick of smaller  $(7-20 \,\mu m)$ wide by  $5-15 \,\mu\text{m}$  thick in transverse section), pigmented cells (Fig. 2).

Internal rhizoidal cells are sometimes formed from the medullary cells. Gland cells are borne on the inner surface of medullary cells or rhizoidal cells (Fig. 3). The gland cells are spherical,  $10-20 \,\mu\text{m}$  in diameter and stain deeply with cotton blue.

Tetrasporangia are formed in nemathecial sori. Each tetrasporangium represents a lateral one-celled branch from one of the outer cortical cells (Fig. 4). Tetrasporangia are ellipsoidal,  $22-35 \,\mu$ m long by  $20-27 \,\mu$ m wide, and are cruciately or decussately divided.

A spermatangium is produced terminally from each spermatangial parent cell that is cut off from an outer cortical cell in a sorus (Fig. 5). Spermatangia are spherical and  $3.0-3.5 \mu m$  in diameter. Spermatangial parent cells may produce secondary spermatangia.

Carpogonial branches and cystocarp development were not observed in cystocarpic plants. Well-developed cystocarps are protuberant and are covered with a thickened pericarp (Fig. 6).

Our Malaysian alga agrees well with the description and illustrations of *Chamaebotr s boergesenii* from Australia (Huisman 1996). This species was originally described from material collected at several localities in Indonesia as *Coelarthr m boergesenii* by Weber-van Bosse (1928). It was recently transferred to *Chamaebotr s* by Huisman (1996) because it has terminal tetrasporangia in contrast to the intercalary tetrasporangia in *Coelarthr m*.

Huisman (1996) mentioned that another species of Chamaebotr s, C. lomentariae (Tanaka et Nozawa) Huisman, is similar to the generitype C. boergesenii and may prove to be conspecific, although he proposed to maintain C. lomentariae until more collections become available and an assessment of its defining characters can be made. Mature segments of the holotype specimen of Chamaebotr slomentariae (SAP 052169 as Coelarthr m lomentariae Tanaka et Nozawa; Huisman 1996, fig. 39) are small, terete to elongated cask-shaped (1-4 mm long by 1-2 mm wide)(also see Tanaka 1964, fig. 6), whereas those of C. boergesenii are large, ellipsoidal or obovate (5-13 mm long by 7-11 mm wide). Huisman (1996) indicates that specimens from colder waters tend to have more elongated segments in the species of *Coelarthr* m. This is not applicable to Chamaebon s boergesenii and C. lomentariae. These two algae are distributed in tropical and warm-temperate regions of Japan as defined by Michanek (1979), and the geographical range of C. boergesenii extends to Miyake Island (Segawa 1936 as *Coelarthr m coact m*), which is colder than Mageshima Island, the type locality of C. lomentariae. We conclude that Chamaebotr s boergesenii and C. lomentariae are entirely different species.

#### Coelarthrum sp.

(Figs 7 - 13)

**Distribution:** Tropical region of the Pacific Ocean (present paper).

**Specimens examined**: Sabah: Pulau Bankawan (6°04′56″ N, 117°59′50″ E; 17. v. 1998; SAP 072324, 072325), Sandakan.

Plants are solitarily attached to bedrock in the upper subtidal zone on a reef flat. An individual plant possesses 6-10 upright axes arising from an expanded basal disc (up to 2 cm in diameter) and reaching 6-10 cm in height. The axes consist of a lower, non-segmented, rigidly cartilaginous, solid stipe that is dark red in colour and upper, segmented, softly fleshy, vesicular parts (Figs 7–10) that are pale red in colour.

The stipe is terete or subterete, 2-4 mm in diameter and grows to 3-6 cm in length. It is polychotomously or irregularly divided (Figs 8, 9) two or three times. It also produces proliferations. The stipe consists of tightly packed cells: its medulla is composed of non-pigmented, parallel filaments, and its cortex is composed of pigmented, anticlinally oriented filaments (Figs 11, 12). The medulla is 10-14 cells thick throughout the stipe. The medullary cells are elliptical (elongated in the direction of the axis) in longitudinal section, 300-450 µm long and 150-220 µm wide, circular to elliptical in transverse section, and  $100-220 \,\mu\text{m}$  wide at the centre of the lower portions of the stipe. These medullary cells become gradually shorter and more slender outwards and merge with anticlinal cortical cells. The cortex is 30-40 cells thick in the lower portion of the stipe, and 3 or 4 cells thick in the uppermost portion. The cortical cells are rectangular (superficial cells being hemispherical) in transverse section, and  $25-75 \,\mu m$  wide.

Each axis of the upper vesicular parts arises from the apex of a branch of the stipe (Fig. 9). The axis is dichotomously to polychotomously branched at the distal end of each segment (Fig. 10). Secondary anastomoses are not found between even closely-placed axes. Joints between segments are 400-700 µm in diameter and very short (up to 200 µm long) (Figs 9, 10). Segments are club-shaped, 6-11 mm long by 3-5 mm wide (at a distal widest portion) in the lower portion of axes and become ellipsoidal to spherical (0.5-2 mm long by 0.5-1 mm wide) upwards. These segments consist of an outer cellular tissue and an inner mucilage-filled cavity except for their nodes, which are solid. The cellular tissue consists of the inner layer (medulla) of one or two, large  $(45-65 \,\mu\text{m})$ wide by  $30-55\,\mu\text{m}$  thick in transverse section), hyaline cells and the outer layer (cortex) of one or two, small  $(5-25 \,\mu\text{m}$  wide by  $5-20 \,\mu\text{m}$  thick in transverse section), pigmented cells (Fig. 13). Some of the inner medullary cells cut off elongated rhizoidal cells or spherical to ellipsoidal cells towards the cavity. Gland cells are borne on medullary cells, rhizoidal cells, or spherical to ellipsoidal cells that develop from medullary cells. They are spherical,  $10-15 \,\mu m$ in diameter (Fig. 13), and stain deeply with cotton blue. Reproductive structures were not found in our collection.



Figs 7–13. Coelarthr m sp.

Fig. 7. Herbarium vegetative specimen (SAP 072324) (scale bar = 2 cm). Fig. 8. Apical portion of a solid, cartilaginous stipe before the production of a vesicular part (scale bar = 2 mm). Fig. 9. Transitional region from a stipe (arrowhead) to a vesicular part (scale bar = 2 mm). Fig. 10. Upper portion of the vesicular part showing the initiation of a new segment (arrowhead) (scale bar = 2 mm). Fig. 11. Longitudinal section (LS) of the lower portion of a stipe (scale bar = 200  $\mu$ m). Fig. 12. TS of the lower portion of a stipe (scale bar = 500  $\mu$ m). Fig. 13. TS of a vesicular part (g, gland cell) (scale bar = 50  $\mu$ m).

This alga seems to be new to science and may belong to either *Coelarthr* m or *Chamaebotr* s. It is clearly distinguished from all species of the two genera (three species in *Coelarthr m* and two in *Chamaebotr* s) by the presence of a conspicuously developed solid stipe; none of the species of these genera produces such a long stipe (Huisman 1996). Our Malaysian alga seems to be more closely related to Coelarthr m on the basis of its upright habit rather than *Chamaebotr* s that has decumbent or prostrate thalli. Coelarthr m op ntia (Endlicher) Børgesen is somewhat similar to our alga in having a cartilaginous stipe [Harvey 1860 as Ch clocladia m elleri (Sonder) Harvey, Huisman 1996]. However, Coelarthr m op nia differs from our Malaysian alga in having a short unbranched stipe and characteristically constricted joints between segments of the upper vesicular parts [Harvey 1860 as Ch clocladia m elleri, Kützing 1865 as Lomentaria alida Kützing, Børgesen 1931 as Coelarthr m m elleri (Sonder) Børgesen, 1937, Huisman 1996]. The generic position of our Malaysian alga cannot be precisely decided at present because of the absence of its reproductive structures, as the two genera are distinguished by the mode of the tetrasporangial production: terminal (Chamaeboers s intercalary (Coelarthr m) (Huisman Tr s) 1996). We hope that reproductive plants of this alga

will be found from somewhere in the Indo-Pacific region and the formal description published in the near future.

#### Champia compressa Harvey 1838:402 (Figs 14–17)

**Distribution:** Tropical regions of the Pacific Ocean (Millar 1990, present paper) and Indian Ocean (Silva *et al.* 1996).

**Specimens examined**: Terengganu: Mak Sinpain (5°48'02" N, 102°59'33" E; 22. v. 1999; SAP 072326), Pulau Redang; Hujung Tenggara (5°12'58" N, 103°16'14" E; 26. v. 1999; SAP 072327), Pulau Kapas; Pulau Nyireh (4°50'46" N, 103°39'55" E; 28. v. 1999; SAP 072328); Pulau Tenggol (4°48'24" N 103°41'13" E; 28. v. 1999; SAP 072329).

Plants grow solitarily in the upper subtidal zone of reef flats on dead coral or monofilament fishing line. Thalli are upright or decumbent and are attached to the substratum by a discoid holdfast. The thalli are pale brownish-red and softly fleshy and reach up to 1.5 cm high. Axes are terete near the base (0.4-0.6 mm in diameter) and become compressed upwards (Fig. 14), reaching up to 1.6 mm in width and 0.5 mm in thickness at the middle to upper third portions of fertile plants and having a blunt apex. Lateral branches are formed oppositely (sometimes

alternately) in a single plane: pairs of the laterals arise at intervals of 0.5-1.5 mm and at angles of  $50-70^{\circ}$ . These laterals are simple or bipinnate and reach up to 3 mm in length, tapering at both ends. Secondary anastomoses are sometimes present between closelyplaced branches of the same individual. Axes and branches are hollow and regularly segmented by single-layered cellular diaphragms that are 8-10 cells across (Fig. 15) between the dorsal and ventral surfaces. The diaphragms are associated with slight constrictions, which are evident even in young plants (Fig. 14).





Fig. 14. Apical portion of a young main axis (7 mm long): note diaphragms (arrowheads) being associated with slight constrictions (scale bar = 1 mm). Fig. 15. LS of a main axis (d, diaphragm; g, gland cell) (scale bar =  $100 \mu$ m). Fig. 16. Tetrasporangial sorus in LS (scale bar =  $200 \mu$ m). Fig. 17. Tetrasporangium connected with two cells (arrowheads) in LS (scale bar =  $50 \mu$ m).

#### Figs 18-20. Champia ieillardii Kützing.

Fig. 18. Apical portion of a main axis; note diaphragms (arrowheads) that are not associated with constrictions (scale bar = 1 mm). Fig. 19. First-order branch on the lower portion of the axis becoming broad distally and forming many second-order branches (scale bar = 2 mm). Fig. 20. LS of a main axis (d, diaphragm; g, gland cell) (scale bar =  $100 \,\mu$ m).

Internally the thallus consists of an outer cellular tissue and an inner mucilage-filled cavity. The cellular tissue consists of inner (medullary) and outer (cortical) layers (Fig. 15). The medullary layer consists of conspicuously elongated, hyaline cells. These cells are  $60-200 \ \mu m$  long by  $10-20 \ \mu m$  wide, and the majority of these produce one (Fig. 15) or two gland cells which are spherical, and  $7-15 \ \mu m$  in diameter. The cortical layer consists of inner, large rectangular cells ( $25-50 \ \mu m$  high by  $35-40 \ \mu m$  thick in longitudinal section), which are continuous and chiefly contribute to the pseudoparenchymatous organization, and outer, small cells ( $10-25 \ \mu m$  high by  $10-30 \ \mu m$  thick in longitudinal section), which are usually discontinuous.

Tetrasporangia are formed in sori (Fig. 16) and are intercalary (Fig. 17). Tetrasporangia grow towards the cavity (Figs 16, 17). Mature tetrasporangia have tetrahedrally arranged spores and are  $45-55 \,\mu\text{m}$  in diameter.

*Champia compressa* was originally described from South African material (Harvey 1838) and has been reported from various localities in the tropical regions of the Indian Ocean and the Pacific Ocean (Millar 1990, Silva *et al.* 1987, 1996). The distinction between this species and a closely related species, *C. ieillardii* Kützing, will be mentioned in the treatment of the next species. Ismail (1995) reported an alga under the name of *Champia compressa* from Malaysian waters. His description and illustrations, however, show that his alga is a member of the Gelidiaceae (Ismail 1995, p. 93, fig. 7.29).

## Champia vieillardii Kützing 1866: 14, pl. 37 e, f (Figs 18–20)

**Distribution:** Tropical regions of the Pacific Ocean (Millar 1990, present paper) and Indian Ocean (Silva *et al.* 1996).

**Specimens examined**: Johor: Kampung Penaga (2°27′06″ N 103°58′17″ E; 6. vi. 1999; SAP 072330), Pulau Babi Besar.

Plants grow solitarily or gregariously on dead coral in the upper subtidal zone of reef flats. Thalli are prostrate or decumbent and are attached to the substratum by one primary and several secondary discoid holdfasts. They are pale brownish-red and cartilaginous in texture and grow to 4.5 cm high. Axes are terete near the base (0.4-0.5 mm in diameter) and become flattened upwards (reaching up to 1.8 mm in width and 250 µm in thickness at the lower portion), having an acute apex (Fig. 18). Lateral branches arise oppositely (sometimes alternately) in a single plane at intervals of 2-3 mm and at angles of  $60-80^{\circ}$ , reaching up to 2.5 cm in length and tapering at both ends (Fig. 18). These branches are divided in a manner similar to the axis and bear up to four orders of branches. Eight to 10 first-order branches on the lower portion of the axis are slender  $(250-400 \,\mu\text{m})$  wide): half of these branches are simple, short  $(0.6-1.2 \,\text{cm})$  and completely prostrate; the rest become broad distally  $(1.2-1.5 \,\text{mm})$  wide) and form many second-order branches (Fig. 19). Secondary anastomoses are frequently present between closely-placed branches of the same or different individuals.

Axes and branches are hollow and regularly segmented by single-layered cellular diaphragms that are three or four cells across (Fig. 20) between the dorsal and ventral surfaces. Constrictions are not present (Figs 18, 19).

Internally the thallus consists of an outer cellular tissue and an inner mucilage-filled cavity. The cellular tissue (Fig. 20) is basically similar to that of *Champia compressa*: cells of the medullary layer are  $80-250 \,\mu\text{m}$  long by  $15-20 \,\mu\text{m}$  wide; those of the inner cortical layer are  $25-75 \,\mu\text{m}$  high by  $40-60 \,\mu\text{m}$  thick in longitudinal section; and those of the outer cortical layer are  $15-30 \,\mu\text{m}$  high by  $20-40 \,\mu\text{m}$  thick in longitudinal section. Spherical gland cells (Fig. 20)  $10-12 \,\mu\text{m}$  in diameter are borne on the majority of medullary cells. Reproductive structures were not found in our collection.

Dawson (1954) referred his Vietnamese material to Champia ieillardii, a species originally described from New Caledonia (Kützing 1866) but later reduced to synonymy with C. compressa by De Toni (1900). The differences between the two species are stated as follows by Dawson (1954, p. 443): 'Champia compressa differs in its more erect habit, less strongly compressed thallus, more remote and longer ultimate branches'. Millar (1990) confirmed Dawson's statement on the basis of the lectotype specimens of the two species, C. compressa and C. ieillardii and added two critical features distinguishing the species: (1) diaphragms of C. compressa are 10-18 cells across from dorsal to ventral surfaces, whereas those of C. ieillardii are 2 or 3 cells across; and (2) diaphragms are associated with constrictions in C. compressa, but constrictions are absent in C. ieillardii. Our observations of Malaysian specimens of C. compressa and C. ieillardii support the conclusion of Dawson (1954) and Millar (1990). The production of slender branches in *Champia ieillardii* is an additional critical feature that distinguishes it from C. compressa.

## Lomentaria monochlamydea (J. Agardh) Kylin 1931: 27, f. 30 (Figs 21-24)

**Distribution:** Tropical regions of the Pacific Ocean (Millar 1990, present paper) and Indian Ocean (Huisman 1997).

**Specimens examined**: Pahang: Pulau Rengis (2°48′38″ N, 104°08′12″ E; 2. vi. 1999; SAP 072331).

Plants grow solitarily on dead coral in the lower intertidal zone of reef flats. Thalli are brownish-red,



Figs 21-24. Lomentaria monochlam dea (J. Agardh) Kylin.

Fig. 21. Portion of a plant (scale bar = 2 mm). Fig. 22. LS of a main axis: note a medullary cell bearing a gland cell (g) (scale bar =  $20 \mu$ m). Fig. 23. Fertile branch bearing tetrasporangial sori (scale bar =  $500 \mu$ m). Fig. 24. TS of a tetrasporangial sorus (scale bar =  $100 \mu$ m).

softly fleshy, 1.5-2.2 cm long. Axes are arcuate and form secondary holdfasts when they are attached to the substratum. The axes produce secundly arranged first-order branches on the dorsal side (Fig. 21). Some axes bear attachment discs at the tips, from which 1-5 secondary axes develop. The axes are terete,  $150-250 \,\mu\text{m}$  in diameter near the primary disc and become subterete to compressed,  $400-750 \,\mu m$ wide at the middle portion and then become terete apically. The majority of first-order branches are terete and become arcuate, each forming secund branches which may produce third-order branches on the dorsal side and an attachment disc at the tip; others, however, are unbranched, compressed to flattened, 2-6 mm long by  $500-700 \text{ }\mu\text{m}$  wide and form reproductive structures.

Internally the thallus consists of an outer cellular tissue and an inner mucilage-filled cavity. The cellular tissue consists of a single medullary layer and 2-4 cortical layers (Fig. 22). The medullary layer consists of conspicuously elongated, hyaline cells, which are  $85-125 \,\mu$ m long by  $7-10 \,\mu$ m wide. The cortex consists interiorly of one or two layers of elongated, large, lightly pigmented cells ( $25-75 \,\mu$ m high by  $15-35 \,\mu$ m thick in longitudinal section), and exteriorly of small, deeply pigmented cells ( $5-20 \,\mu$ m high by  $4-20 \,\mu$ m thick in longitudinal section). Gland cells are borne on the majority of medullary cells (Fig. 22) and are spherical or ellipsoidal, and  $6-10 \,\mu$ m in diameter. Diaphragms are absent except at branch bases.

Tetrasporangia are formed in a relatively wide region of the fertile branches (Fig. 23). The tetrasporangia are produced terminally on cortical cells in isolated, sunken sori (Fig. 24). Mature tetrasporangia have tetrahedrally arranged spores and are  $35-50 \mu m$  in diameter.

This species was originally described from material collected from Australia as *Ch locladia monochlam* - *dea* J. Agardh (1890). Its type locality is Port Philip Heads, Victoria (Kylin 1931, Millar 1990). It was transferred to *Lomentaria* by Kylin (1931) and has been reported from several Australian localities in addition to the type locality (Millar 1990, Huisman 1997). Our material from the east coast of Malaysia agrees well with the description and illustrations of the Australian alga, which has small (up to 2 cm long and 700  $\mu$ m wide), strongly arcuate axes with arcuate branches (Millar 1990). This is the first report of *Lomentaria monochlam dea* outside Australian waters.

Wynne (1998) described a new species of Lomentaria, L. str mosa Wynne from Oman, the northern Arabian Sea. It is similar to L. monochlam dea but distinguished by the production of tetrasporangial sori in a single conspicuously swollen subapical region of each fertile branch (Wynne 1998). Our Malaysian alga produces tetrasporangial sori that are scattered over each fertile branch, as does the Australian alga (Millar 1990). The production of the same type of tetrasporangial sori in these geographically distant populations of L. monochlam dea suggests that it is a constant character and supports the distinction between L. str mosa and L. monochlam dea.

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