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Balliella richardsii sp. nov. (Ceramiaceae, Rhodophyta) from the Sultanate of Oman, northern Arabian Sea

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Abstract — The red algal species *Balliella richardsii* (Ceramiaceae, Ceramiales) is newly described from the Sultanate of Oman, the Arabian Peninsula. Its distinctive features include its small stature (to only 18 mm in height), straight apices, and the close positioning of its branching, resulting in a very dense appearance. Gland cells are produced exclusively in an adaxial position and are very abundant. Tetrasporangia are relatively small compared to those in other species of the genus.

Arabian Sea / *Balliella* / *B. richardsii* sp. nov. / Ceramiaceae / Rhodophyceae / Sultanate of Oman / taxonomy

Résumé — ***Balliella richardsii* sp. nov. (Ceramiaceae, Rhodophyta), du Sultanat d'Oman, nord de la mer d'Arabie**. L'algue rouge, *Balliella richardsii* (Ceramiaceae, Ceramiales), est décrite du sultanat d'Oman, Péninsule arabique. Cette nouvelle espèce est caractérisée par : une petite taille (jusqu'à seulement 18 mm de hauteur), des apex étroits, et un positionnement rapproché de ses ramifications, lui donnant une apparence très dense. Les cellules glanduleuses sont produites exclusivement dans une position adaxiale et sont très abondantes. Les tétraspocystes sont relativement petits comparés à ceux des autres espèces du genre.

***Balliella* / *B. richardsii* sp. nov. / Ceramiaceae / Rhodophyceae / Mer d'Arabie / Sultanat d'Oman / taxinomie**

INTRODUCTION

The genus *Balliella* is currently regarded as being composed of seven species (Athanasiadis, 1996). Species in the genus have a straight or sinusoidal axial row with opposite, distichous determinate whorl branches and produce obvious spherical gland cells from cells of the whorl branches. In particular, these gland cells differentiate *Balliella* from other members of the Ceramiaceae.

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The presence of two opposite carposporophytes supported from the same axial cell, a loose but obvious cortical envelopment of the axial row, and spermatangia produced in successive whorls on determinate branches caused Itono & Tanaka (1973) to place the genus in their new tribe, the Delesseriopseae. *Balliella crouanioides* (Itono) Itono *et* T. Tanaka, the type species, is known from Japan (Itono, 1971; Itono & Tanaka, 1973) and Korea (Lee *et al*., 1988). Young (1981) transferred *Antithamnion pseudocorticatum* Dawson (1962) to *Balliella* and proposed that the genus *Bakothamnion*, described by van den Hoek (1978) from the eastern Caribbean, be treated as congeneric with *Balliella*. Huisman & Kraft (1984) subsequently treated *Bakothamnon curassavicum* C. Hoek as synonymous with *Balliella pseudocorticata*. That assessment was followed by Ballantine & Wynne (1986) and Schneider & Searles (1997). *Balliella pseudocorticata* was also reported from the Maldives (Hackett, 1977) and New Zealand (Adams, 1994).

Three new species of *Balliella* were described from eastern Australia by Huisman and Kraft (1984): *B. amphiglanda*, *B. grandis*, and *B. repens*. The range of *B. repens* was later extended to include the Hawaiian Islands (Abbott, 1999). Huisman (1988) described the new species *B. hirsuta* from western Australia. Another species was added to the genus when Athanasiadis (1987) transferred the Mediterranean-based species *Callithamnion cladodermum* Zanardini (1846), a taxon that had also been known as *Antithamnion cladodermum* (Zanardini) Hauck (1883), to *Balliella*, as *B. cladoderma* (Zanardini) Athanas. In addition to many records within the Mediterranean, *B. cladoderma* has been reported to occur in the Azores (Neto, 1994). Although Itono & Tanaka (1973) also assigned *Antithamnion subcorticata* Itono (1969) to their new genus *Balliella*, Athanasiadis (1996) pointed out that that species name was not validated with a Latin diagnosis. Athanasiadis (1996) suggested that Itono's material identified as "*Antithamnion subcorticatum*" may be the same as *Balliella repens* Huisman & Kraft.

Records of the genus *Balliella* from the broad expanse of the Indian Ocean include *B. hirsuta* from western Australia (Huisman, 1988; Huisman & Walker, 1990; Huisman, 2000), *B. pseudocorticata* from the Maldive Islands (Hackett, 1977), *B. crouanioides* from Natal, South Africa (De Clerck *et al*., 2002), *B. repens* from Socotra Island, Yemen (Schils & Coppejans, 2003), and an unnamed species from Masirah Island, Oman (Schils & Coppejans, 2003). *Balliella subcorticata* nom. nud. was reported from Mozambique by Wollaston (1984), the Dampier Archipelago, Western Australia (Huisman & Borowitzka, 2003), and from Socotra Island by Schils & Coppejans (2003). On the basis of the branching pattern, size of the gland cells, and the arrangement of the tetrasporangia, Huisman (1988) suggested that Wollaston's Mozambique material is probably *B. crouanioides*.

MATERIALS AND METHODS

The material was collected from coral rubble in a sublittoral habitat (6-8 m deep) in September 2001 in Dhofar, Oman. Material was processed as herbarium mounts soon after collecting. Some specimens were preserved in 5% Formalin/sea-water. Wet-preserved parts of thalli were mounted on glass slides for observation with a standard Zeiss research microscope. Line-drawings were made with a camera lucida. Specimens for photomicrography were stained with aniline

blue. Photomicrographs were taken using a Zeiss microscope equipped with a model 11.2 Spot InSight 2 digital camera. Digital images were composed in Adobe Photoshop™ 6.0.1. Co-ordinates were obtained in the field by using a GPS model made by Garmin eTrex Summit (Garmin International Inc., Olathe, KS 66062, USA). Herbarium abbreviations follow Holmgren *et al*. (1990), and initials for authorities' given names are from Brummitt & Powell (1992).

RESULTS

Balliella richardsii **M.J. Wynne *et* C.W. Schneid.** Figs 1-5

Thallus erectus ad 18 mm altum; apex rectus vel leviter sinusoidalis indeterminatorum axium; rami determinati binati et in serialis distichis dispositi; rami determinati et indeterminati ad ramos adjacentes proxime prodientes, apprime in partibus junioribus; rami determinati distale arcuati, irregulariter ramosi, caespes tridimensiones circa axem ferentem efferentes; rami indeterminati a segmento secundo axis parientalis plerumque exorientes. Cellulae glandulosae in magnis numeris prodientes, cellulae glandulosae singulae adaxiales formati, primo a cellulis pluribus proximalibus ramuli verticillati et postea a revera cellulis ullis ramuli verticillati; cellulae glandulosae sphaericae, ad 6 µm diametro, adaxiales portatae. Axes plerumque ecorticati, aliquando cum filis pauci corticalibus a cellula basali ramulorum verticillatorum. Tetrasporangia ovoidea, 20-24 a 16-20 µm, unum ad multum cellulis ramulorum verticillatorum adaxialia portata, sessilia. Thalli sexuales ignoti.

Holotype: Raaha (= Alto) Bay (16.95116º N, 54.81650º E), east of Mirbat, Dhofar, Sultanate of Oman: 12.ix.2001, *leg. Glenn Richards 12092001-07-20*; on coral rubble, sublittoral, 6-8 m deep. Deposited in MICH.

Isotypes: Deposited in BM, ON, and Herbarium CWS (= the personal herbarium of the second author).

Etymology: Named for the collector, Mr Glenn Richards of Yorkshire, England, who provided much-appreciated logistical help to the first author during the tenure of this research project (1999-2002) on the marine algal flora of the Sultanate of Oman.

Diagnosis: Thallus erect, to 18 mm high; apex of indeterminate axes straight, or slightly sinusoidal; pairs of determinate branches distichously arranged; determinate and indeterminate branches produced in close proximity to adjacent branches, especially in the younger portions; determinate branches arching distally, irregularly re-branched, resulting in a 3-dimensional tuft wrapped around the bearing axis; indeterminate branches usually arising from every second segment of parent axis. Gland cells produced in great abundance, individual gland cells formed adaxially, at first from the more proximal cells of the whorl branchlets and later from essentially any cell of the whorl branchlets; gland cells spherical, up to 6 µm in diameter, borne adaxially. Cortication mostly absent, occasionally with a slight development of cortical filaments from the basal cell of whorl branchlets. Tetrasporangia ovoid, 20-24 × 16-20 µm, 1-several borne adaxially on cells of whorl branchlets, sessile. Sexual thalli not seen.

Detailed Description: Thalli are erect, to 18 mm high. The tips of indeterminate axes (Figs 1, 2) are straight, or slightly sinusoidal. Each cell of

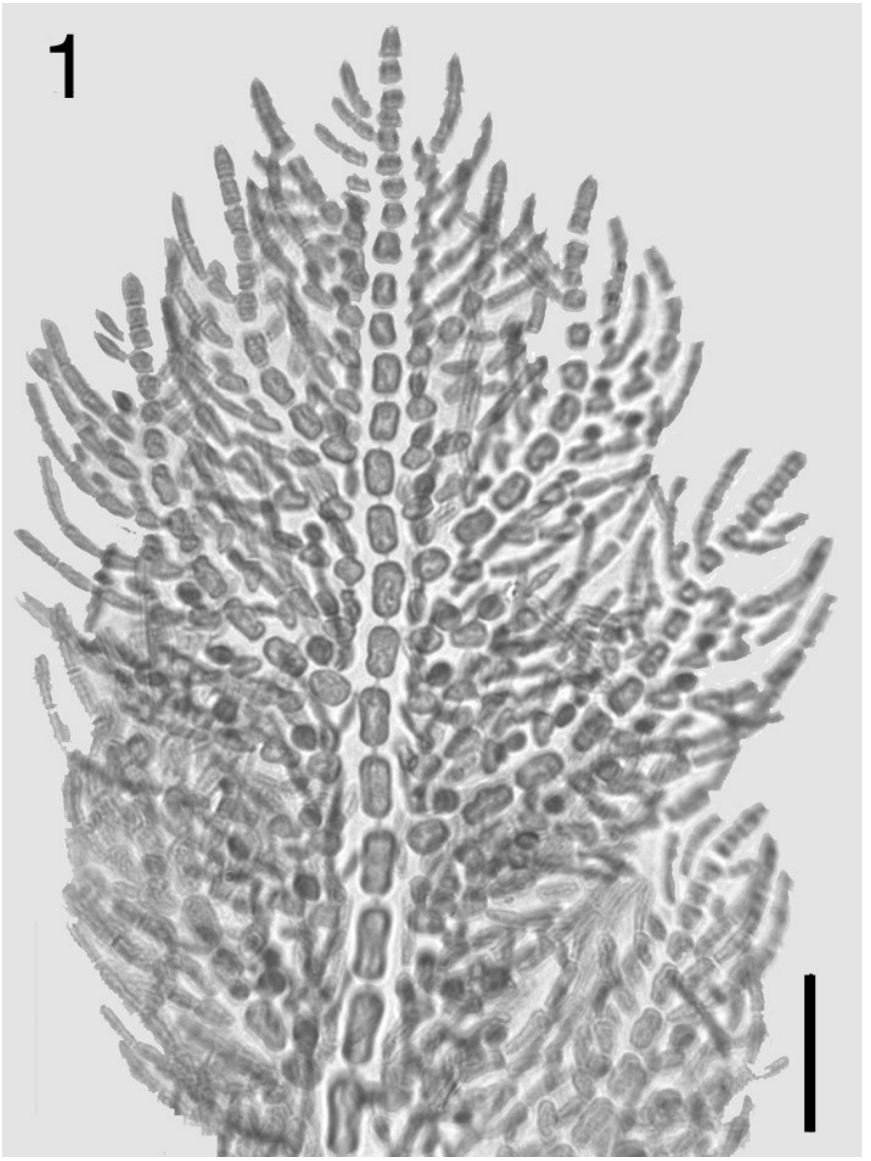
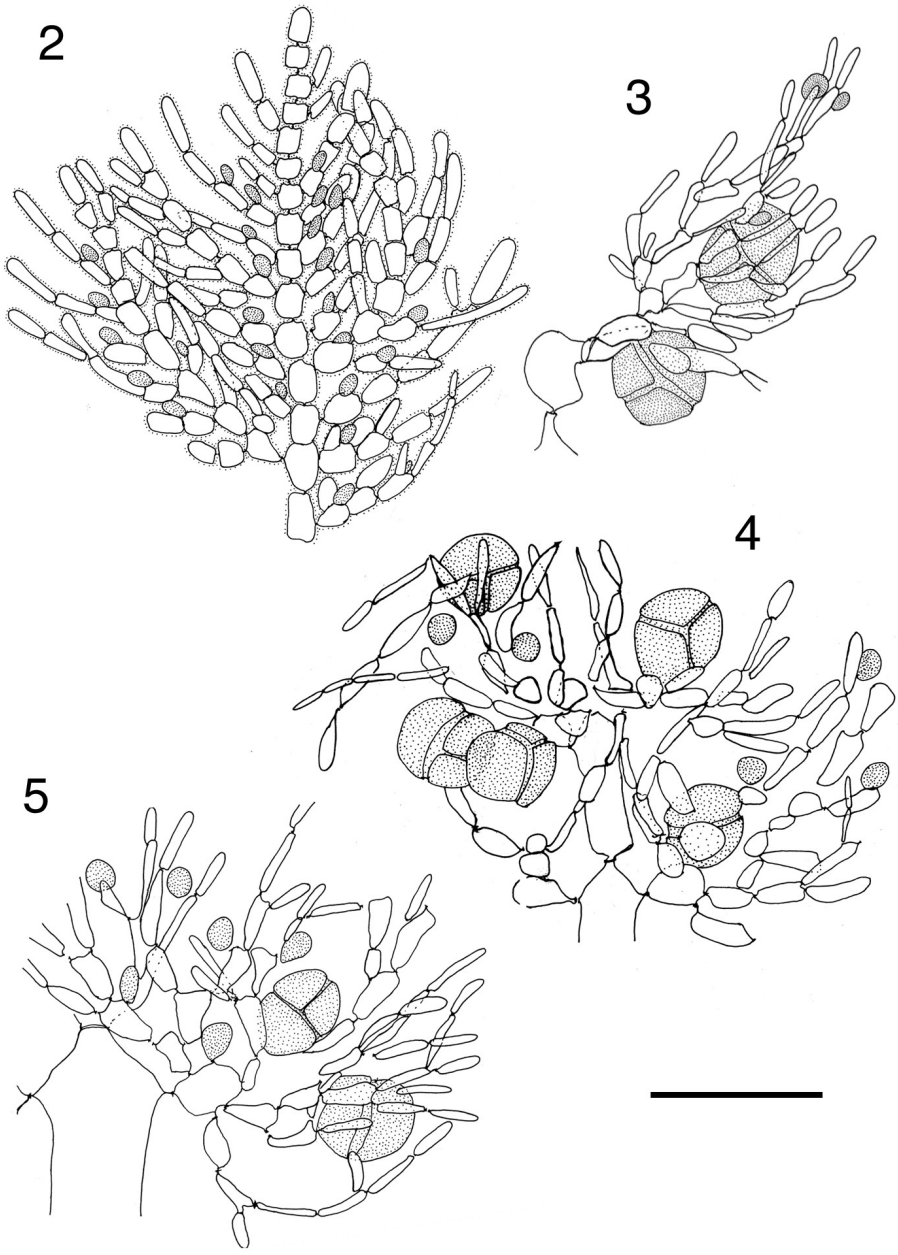


Fig. 1. *Balliella richardsii* sp. nov. Apical region of an indeterminate axis, with close proximation of laterals. Scale bar: 50 μm [from slide in Holotype collection, MICH].

indeterminate axes gives rise to a pair of lateral branches that develop unequally. Pairs of determinate branches (= whorl branchlets) are distichously arranged. Branches (both determinate and indeterminate types) lie in close proximity to adjacent branches such that little "space", or gaps, between them is evident, especially in the younger stages (Figs 1, 2). With elongation of axial cells below, more space between branches becomes apparent, but the extremely dense nature of the branching is one of the distinctive characteristics of this species.



Figs 2-5. *Balliella richardsii* sp. nov. **2.** Apex of axis, showing straight orientation and formation of [stippled] gland cells on adaxial sides of bearing cells. **3.** A pair of tetrasporangia formed from determinate branch. **4, 5.** Formation of tetrasporangia and gland cells in the densely branched determinate branches. Scale bar: 50 μm [from slide in Holotype collection, MICH].

Lateral determinate branches arch distally and irregularly re-branch, resulting in a 3-dimensional tuft wrapping around the axis that bears it. Basal cells of older whorl branches are 14-16 μm long and 10-12 μm wide. Mature axes are 250-284 μm in diameter, including the fully developed determinate whorl branchlets. Indeterminate branches usually arise from every second (occasionally third) segment of a parent indeterminate axis, alternately to right and then to left, arising in place of whorl branchlet. Axial cells of the oldest axes are 340-375 μm in length and 125-156 μm in width. Gland cells are produced in great abundance, often 20-30 gland cells formed per whorl branchlet. Individual gland cells are formed adaxially, at first from the more proximal cells of the whorl branchlet and later from many other cells of the whorl branchlet. The gland cells are spherical, to 6 μm in diameter, and are borne adaxially (Figs 1, 2). Cortication is mostly absent, but occasionally some loose cortical filaments are produced from the basal cell of whorl branchlets forming multicellular filaments acropetally and basipetally, appressed to the large cells of the parent axis. Tetrasporangia (Fig. 3) are ovoid and borne sessilely, 20-24 × 16-20 μm, 1-several adaxially arranged on cells of whorl branchlets (Figs 4, 5).

DISCUSSION

The diagnostic features that allow us to assign this Omani alga to the genus *Balliella* are the following: uniaxial organization with distichously arranged opposite whorl branches from every segment of the determinate axes, a regular pattern of indeterminate branches replacing some determinate branches, the production of a great abundance of globose gland cells on the whorl branches, the presence of cruciately divided terasporangia, and the production of loose cortication from the whorl branches to encircle the older axes. The table provided by Huisman (1988), comparing his new species *Balliella hirsuta* with the other species in the genus, can be employed in our own delineation of the Omani species. The only species in *Balliella* that shares straight upper axes with *B. richardsii* is *B. hirsuta*. Nevertheless, that species has a greater stature (up to 90 mm), much larger gland cells (to 17 mm in diameter), and significantly larger tetrasporangia, while lacking the very closely positioned branchlets that are such a conspicuous feature of *B. richardsii* [see Huisman's (1988) figs 2 and 5 for the loose/open arrangement in *B. hirsuta*]. In fact, all of the known species of *Balliella* have tetrasporangia that are relatively large compared with their size in *B. richardsii*. The exclusively adaxial position of the gland cells in *B. richardsii* conforms to that for *B. hirsuta*, whereas in other species the gland cells are either known to be produced only abaxially or both adaxially and abaxially (Huisman, 1988).

Because apices in the new species are occasionally slightly sinusoidal, it should be compared with those species in the genus that are reported to have such apices and also have indeterminate lateral branches arising at intervals of two segments. One such species, *Balliella repens*, has gland cells that are produced abaxially and only on the basal cells of whorl branches (Huisman & Kraft, 1984), and its gland cells are larger than those in *B. richardsii* (to 10 μm in diameter *vs* to 6 μm). The distance between indeterminate lateral branches in *B. cladoderma* is 2-3 cells (Huisman, 1988), and although its gland cells are produced adaxially as

in *B. richardsii*, they are restricted to the basal cell of the whorl branches and to the corticating filaments (Athanasiadis, 1987). The tetrasporangia in *B. cladoderma* (45 × 27 µm, Athanasiadis, 1996) are significantly larger than those in *B. richardsii*.

When Itono & Tanaka (1973) described the genus *Balliella*, they assigned it to their newly described tribe Delesseriopseae of the Ceramiaceae. Moe & Silva (1979) disagreed with that assignment, stating that the genus had strong affinities with the Antithamnieae. This taxonomic opinion was supported by Huisman & Kraft (1984) and Huisman (1988). While retaining its position provisionally in the tribe Delesseriopsdeae, Athanasiadis (1996) excluded the tribe from the subfamily Ceramioideae, based on, among other things, branching relationships among the genera. In the Delesseriopseae, genera do not have transversely borne filaments or single cells on main axes, rather they have strictly distichous organizations (Athanasiadis, 2002).

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