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An Account of *Delesseria aemula* sp. nov. (Delesseriaceae, Rhodophyta) from New South Wales, Australia

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Delesseria aemula sp. nov. is described from sublittoral habitats on the shores of New South Wales, eastern Australia. Distinctive characters of this new species include its habit, in which spathulate to lanceolate blades radiate out from a centrally placed rhizoidal holdfast; its small size at maturity, blades reaching heights of only 10 mm and widths of 2 mm; its spermatangial sori, which form discrete islands separated by sterile veins made up of secondary and tertiary cell rows; and its branching, in which the majority arise from a centrally placed rhizoidal holdfast. Less frequently branches arise from the midrib or from the margins as outgrowths of secondary initials. In the field, plants are indistinguishable from the diminutive alga *Apoglossum unguiculescens* Millar which shares the same habitat, habit, blade size and shape. Characters serving to separate this pair of species are the following: 1) lateral pericentral cells transversely dividing in *D. aemula* but remaining undivided in *A. unguiculescens*; 2) cells of the sterile-cell groups dividing in *D. aemula* but remaining undivided in *A. unguiculescens*; and 3) differences in the arrangements of the spermatangial sori. With the discovery of *D. aemula*, Australia now hosts three genera of the Delesseria group (*viz.*, *Delesseria*, *Apoglossum* and *Patulophycus*).

Key Index Words: Apoglossum—*Australia*—Delesseria—D. aemula—*Delesseriaceae*—*New South Wales*.

Australia is host to a large variety of genera belonging to the family Delesseriaceae (Kraft and Woelkerling 1990, Millar 1990). Of the 38 or so genera represented, some 15 are endemic, although these are known mostly from the southern Australian coast. New South Wales has 16 genera of which two (*Patulophycus* and *Valeriemaya*) are endemic (Millar and Wynne 1992a, 1992b). Although several species of *Delesseria* are known from New Zealand (Adams 1972, Adams *et al.* 1974) and the subantarctic islands of both New Zealand and Australia (Hay *et al.* 1985, Ricker 1987), current floristic treatments (Huisman and Walker 1990, Millar 1990, Price and Scott 1992) have not recognized this genus as occurring on Australian shores. Up to now five species have represented the Delesseria group in Australia: *Apoglossum spathulatum* (Sonder) Womersley and Shepley, *A. tasmanicum* (F. Mueller ex Harvey) J. Agardh, *A. unguiculescens* Millar, *Patulophycus eclipes* Millar & Wynne, and the poorly known *Delesseria lacepedeana* Reinbold. *Apoglossum unguiculescens* was recently described as a common epiphyte along most of the New South Wales coastline (Millar 1990), but closer examination reveals that some of these records actually represent an undescribed species of the closely related genus *Delesseria*, which we describe here as *D. aemula*.

Materials and Methods

Collections using SCUBA were preserved in 4% formalin/seawater. Slide material, stained in a mixture of approximately 1 ml aniline blue/7 ml acetic acid/50 ml Karo syrup/50 ml millepore-filtered, distilled water, is on file at the National Herbarium of New South Wales (NSW) and the University of Michigan (MICH). The following speci-

mens of *Apoglossum unguiculescens* were examined: Coffs Harbour, *A. Millar and J. Huisman*, 8. vii. 1981, MELU AM 1093=holotype; *A. Millar and R. Millar*, 22. ii. 1989, NSW-A006379; Macauleys Reef, between Muttonbird Island and Split Solitary Island, *A. Millar, A. Wright and R. Medhurst*, 22. viii. 1991, NSW-A010531; Twofold Bay, Honeysuckle Point, *A. Millar and P. Richards*, 7. vii. 1991, NSW-A010532. Whole-plant photographs were taken on a Wild Photomakroscope M400, and photomicrographs on a Wild Leitz MPS51 Ortholux II system. Kodak Techpan Film was used following the methods of Millar (1990).

Observations

Delesseria aemula Millar et Wynne sp. nov.

Thalli 10 mm altos, laminae pro parte maxima ovatae ad spathulatas vel lanceolatas ad 2 mm latas; laminae alteruter singulatim vel turmas radiatim ad decem ab centralibus fasciculatis rhizoideorum exorientes; costa prominens, vulgo opacam; alae nitentes, paginae reflectivae; rami ab seriebus endogenis primis cellularum exorientes, gemmis adventitiis in costas corticatas vel initiis serierum secundariarum cellularum margines; venae microscopicae praesentes sed indistincate in axibus vegetativis; spermatangia in soris insulas discretas facientia, nervis microscopicis sterilibus secundariarum et tertiarum cellularum serierum separata, aream integram paginarum ambo laminarum praeter costam corticatam tegentia; cystocarpia hemispherica vel urceolata cum colla prominentia lata; pagina pericarporum laevis; tetrasporangia ad 52 μm diametro, in stratis multis in soris longis tenuibus continuis ad 3 mm longo et 300 μm lato portata, in ambo lateribus costarum.

Thalli to 10 mm high, of simple, mostly unbranched ovate to spathulate or lanceolate blades to 10 mm in length and 2 mm in width; blades arising either singly or in radiating groups of up to ten from centrally placed pad-like aggregations of rhizoids; midrib prominent, generally opaque; wings shiny, surface reflective; branches arise endogenously from primary cell rows, adventitiously from corticated midribs or from margins as outgrowths of secondary cell row initials; microscopic veins present, not distinct in vegetative axes; spermatangia in sori forming discrete islands, separated by sterile microscopic nerves made up of secondary and tertiary cell rows, covering entire surface (except corticated midrib) of both blade sides; cystocarps either hemispherical or urceolate with prominent, broad necks; pericarp surface smooth; tetrasporangia to 52 μm diameter, borne in multiple layers in long, slender, uninterrupted sori to 3 mm long and 300 μm wide, flanking both sides of midribs.

Holotype: NSW-A010529, just east of Honeysuckle Point, Twofold Bay, Eden, New South Wales, Australia (37°05′55″S.; 149°56′10″E.), 7. vii. 1991, *A. J. K. Millar and P. G. Richards*.

Isotypes: AD, GALW, MEL, MICH, US, WELT.

Etymology: L. *aemulus*, vying with, rivalling in, alluding to its vying with *Apoglossum unguiculescens* both in habit and habitat.

Distribution: From Jervis Bay to Twofold Bay, New South Wales, Australia.

Specimens examined: **Jervis Bay**; Plantation Point, on crustose coralline in 3 m depth, 4. vi. 1990, *A. Millar and P. Richards*, NSW-A010530; 'The Docks', on crustose coralline in 22 m depth, 9.x.1989, *A. Millar and P. Richards*, NSW-A010533.

Twofold Bay, Honeysuckle Point, 6-20 m deep growing in turf algal community, 7. vii. 1991, *A. Millar and P. Richards*.

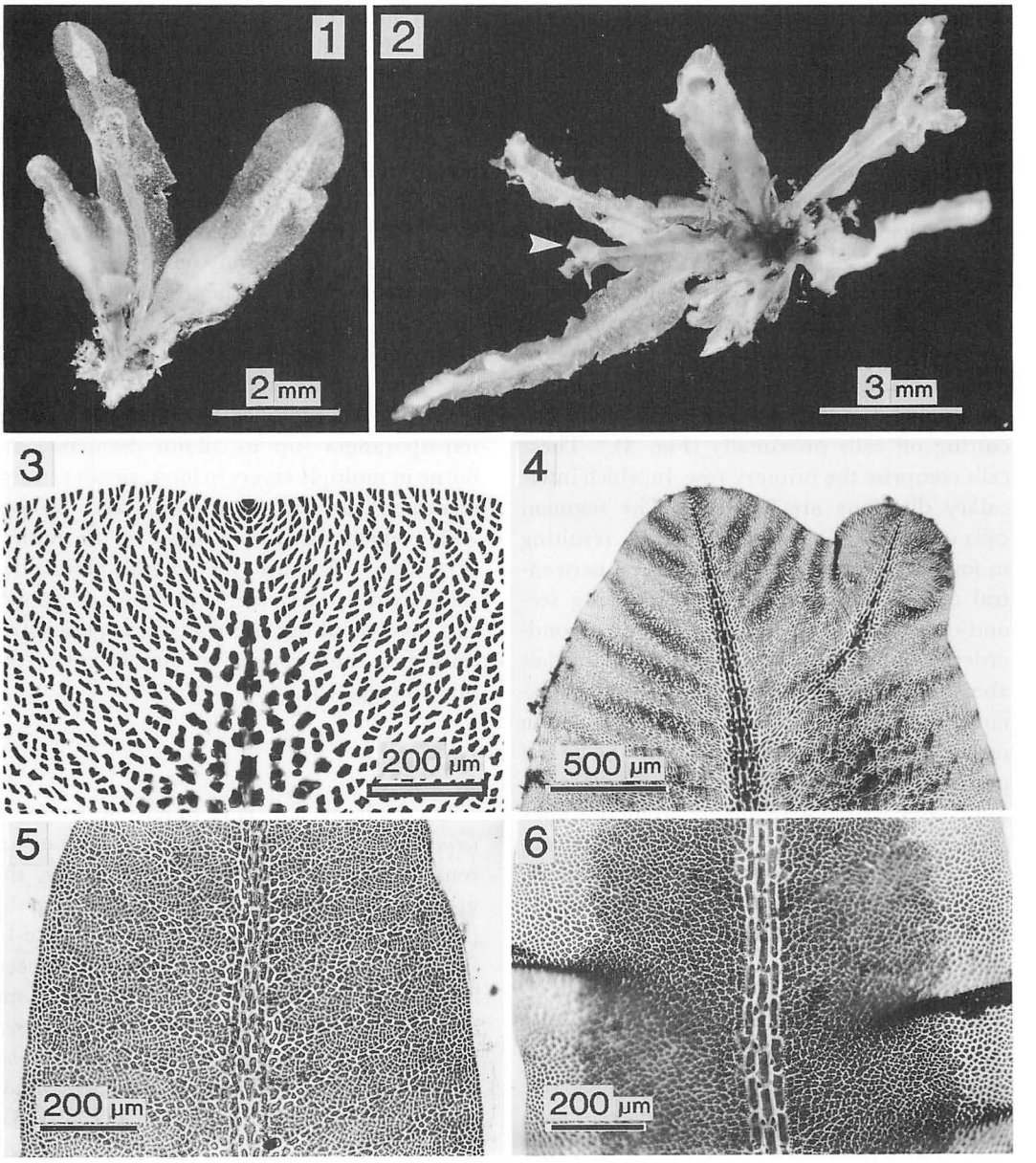
Habitat and Seasonality

Plants grow on a range of substrata such as other algae (especially crustose and articulat-

ed corallines), bryozoans, hydrozoans, sponges, and rocks in depths from 3-22 m. Collections thus far have been during June and July (austral winter) and all reproductive stages occur simultaneously on the same substratum.

Vegetative structure

Simple, mostly unbranched ovate to spathulate (Fig. 1) or lanceolate (Fig. 2) blades (reaching lengths of 8-10 mm and widths of 2 mm) arise either singly or in radiating groups of up to ten from a centrally placed



Figs. 1–5. *Delesseria aemula* sp. nov. Fig. 6. *Apoglossum unguiculescens*. Fig. 1. Habit of tetrasporophyte. Fig. 2. Habit of female gametophyte. Note cystocarp (arrow). Fig. 3. Detail of blade apex. Fig. 4. Male blade showing marginal branch where second order initial is converted into primary initial. Fig. 5. Spermatangial blade of showing islands of spermatangial sori separated by sterile veins. Fig. 6. Spermatangial blade of showing confluent spermatangial sori forming cushions on either side of the midrib. Note undivided lateral pericentral cells.

disk-like holdfast. Blades have a prominent midrib (Figs. 1, 2), the cortication of the central axial row beginning very close to the apex of the blade and becoming thick and obvious in proximal parts. The midrib is generally opaque and the wings have a shiny, reflective surface. Often the monostromatic wings erode or are lost altogether leaving only the cylindrical midrib behind which eventually becomes a substantial branched stipe with new blades arising adventitiously (Fig. 2). Microscopic nerves or veins are present but not distinct in vegetative axes. Branches may arise endogenously from the primary cell row, adventitiously from the corticated midrib and, on several occasions, from the margins (Fig. 4) as continued outgrowths of the secondary cell row initials being converted into primary initials.

Each blade is terminated by a single apical cell, which undergoes transverse divisions, cutting off cells proximally (Fig. 3). These cells comprise the primary row, in which intercalary divisions are lacking. The segment cells undergo longitudinal divisions, resulting in four pericentral cells. The lateral pericentral cells continue to divide, producing second-order cell rows. Cells of these second-order rows in turn cut off third-order initials abaxially. Fourth-order rows are cut off adaxially (Fig. 7). Intercalary divisions occur in second and higher order rows, and the lateral pericentral cells generally divide transversely some seven to ten segments from the apex (Fig. 7). In rare instances, the lateral pericentral cells do not divide, but in such instances, they are surrounded proximally and distally by divided pericentral cells (Fig. 8).

Reproductive structures

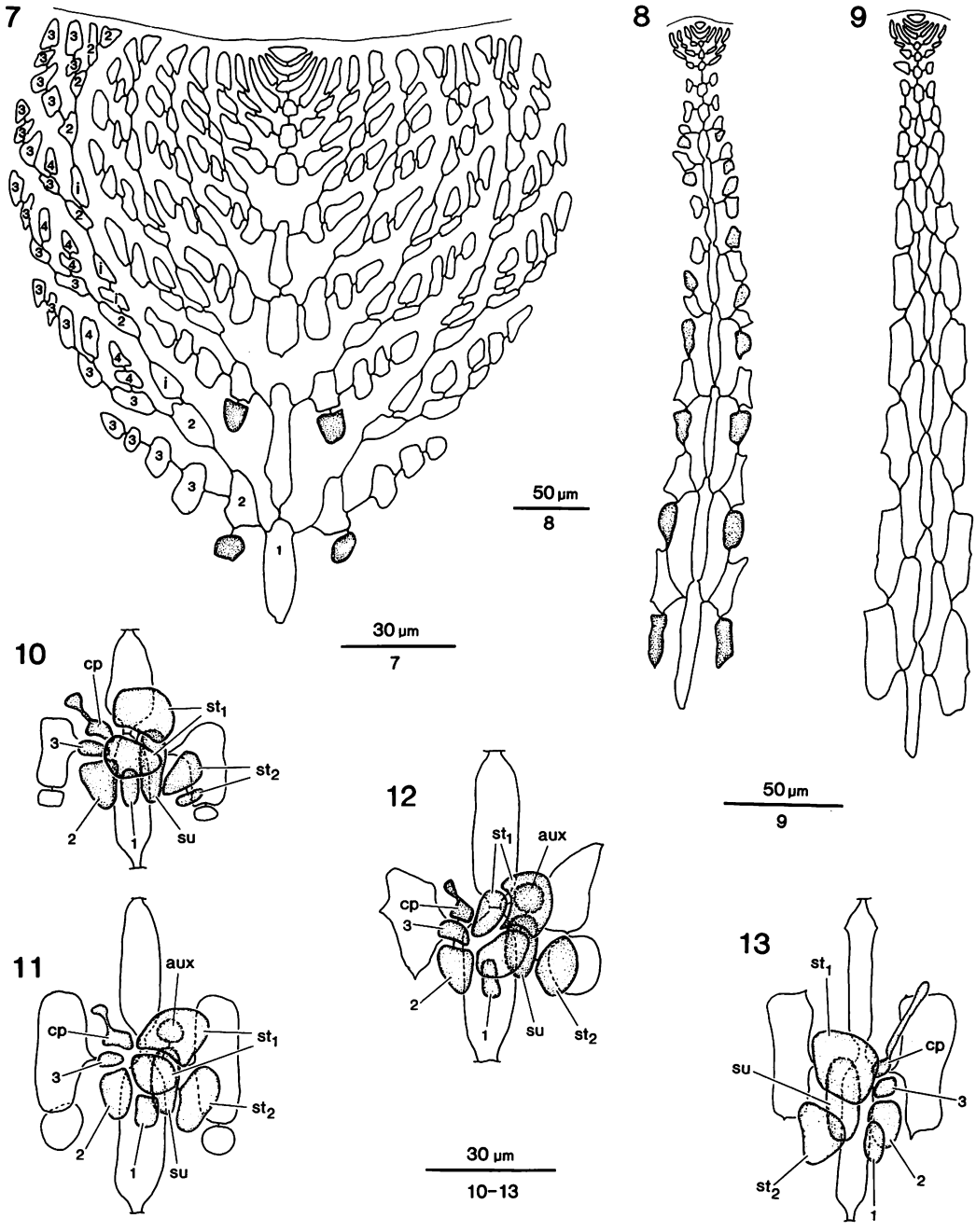
Male, female, and tetrasporic plants are isomorphic, and the gametophytes are unisexual. In male plants the spermatangial sori form discrete bands radiating out from each side of the midrib in chevron-like patterns (Fig. 5). These islands of sori are separated by sterile microscopic nerves made up of second- and third-order cell rows (Figs. 5, 17). At maturity, most of the blade surface (except the corticated midrib) bears spermatangial sori.

Female plants bear procarps on the primary cell row, the transverse pericentral cells acting as supporting cells of the carpogonial branches. The supporting cell cuts off two sterile-cell groups (one proximally and one distally) and a four-celled carpogonial branch (Fig. 10). The cell of the first, distally placed sterile-cell group divides once (Fig. 11) or twice (Fig. 12) after it is cut off by the supporting cell. The cell of the second, proximally placed sterile-cell group, however, may divide once (Fig. 10) or remain undivided (Figs. 11, 12). One (Fig. 14) to three cystocarps develop sequentially on any one blade, often on alternate surfaces. The ostiolate pericarps are either hemispherical or urceolate with a prominent, broad neck (Fig. 2), but in either case their surface is smooth.

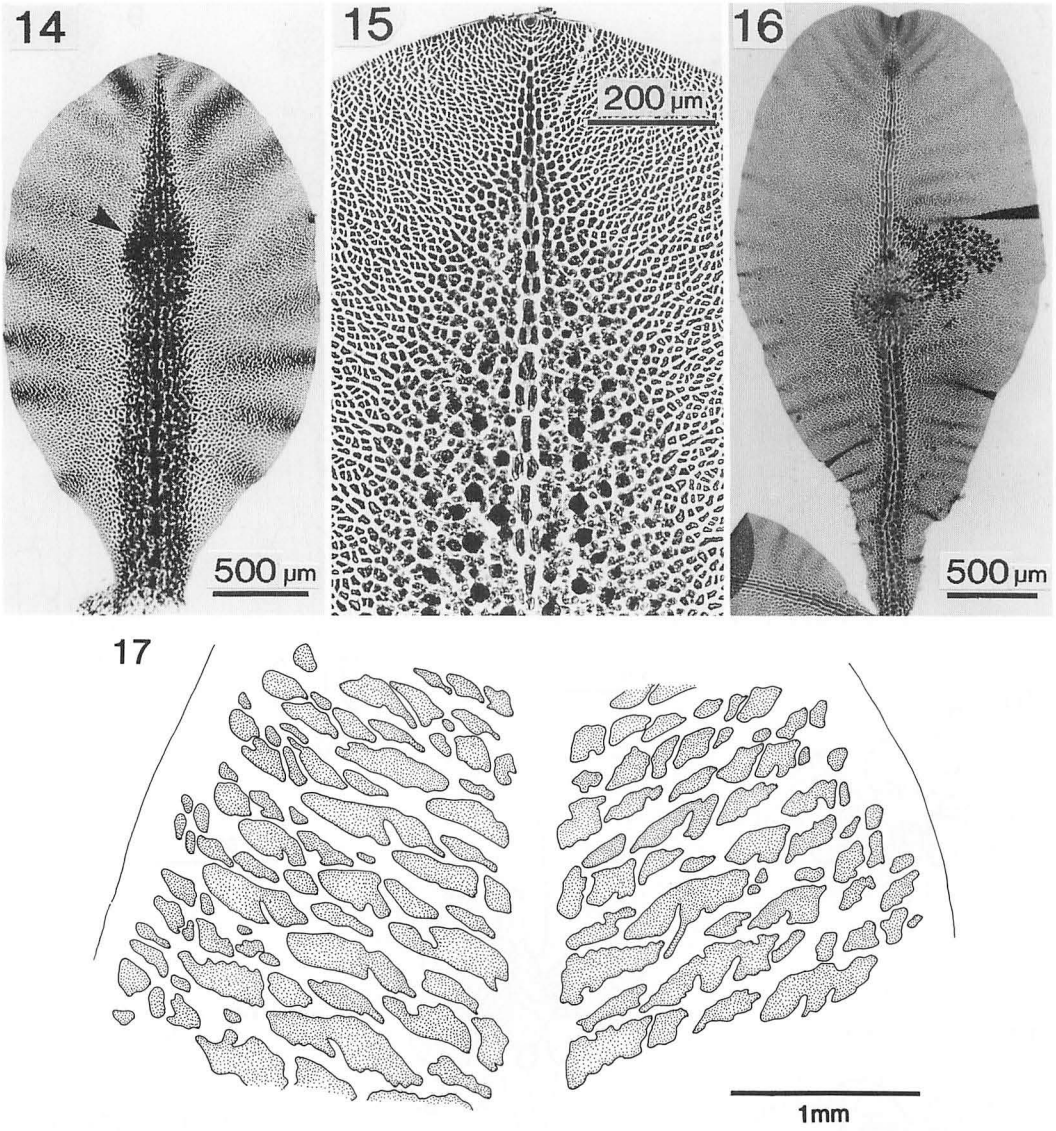
On the sporophytes tetrahedrally divided tetrasporangia (up to 52 μm diameter) are borne in multiple layers in long, slender, uninterrupted sori (to 3 mm long and 300 μm wide) which flank both sides of the midrib (Fig. 15). Because the lateral pericentral cells divide transversely, the tetrasporangial sori involve all but the transverse pericentral cells and thus appear to almost cover the midrib (Fig. 15).

Discussion

On the basis of its very small stature, *Delesseria aemula* is distinguishable from all the currently recognized species in the genus, the great majority of its species tending to be robust, relatively large-sized algae. Some 15 species based on Australian types have been assigned to *Delesseria* in the past. All but one of these, however, have subsequently been transferred to other genera, including *Branchioglossum, Hypoglossum, Apoglossum, Heterodoxia*, and *Crassilingua* (Agardh 1872, 1885, 1894, 1898, Kylin 1924, May 1965, Womersley and Shepley 1982). *Delesseria lacepedeana* Reinbold, described from southern Australia, remains an ill-known taxon. Reinbold (1898) remarked that his alga in its habit



Figs. 7–8, 10–12. *Delesseria aemula* sp. nov. Fig. 9, 13. *Apoglossum unguiculescens*. Fig. 7. Blade apex: 1, cells of first-order row; 2, cells of second-order row; 3, cells of third-order row; 4, cells of fourth-order row; i, cells resulting from intercalary divisions; stippled cells are those resulting from transverse division of lateral pericentral cells. Fig. 8. Dissected view of midrib showing cells resulting from transverse divisions of lateral pericentral cells (stippled). Note that not all lateral pericentral cells have divided. Fig. 9. Dissected view of midrib showing lateral pericentral cells remaining undivided. Fig. 10. Procarp before fertilization in which the cells of both sterile-cell groups (st_1 and st_2) have divided. cp, carpogonium; su, supporting cell; 1, 2, 3, cells of carpogonial branch. Fig. 11. Procarp after presumed fertilization in which cell of sterile-cell group 1 (st_1) has divided, but cell of sterile-cell group 2 (st_2) remains undivided. aux, auxilary cell. Fig. 12. Procarp in which cell of sterile-cell group 1 has divided twice to form 3 cells, but sterile-cell group 2 remains undivided. Fig. 13. Procarp showing both sterile-cell groups remaining undivided.



Figs. 14, 15, 17. *Delesseria aemula* sp. nov. Fig. 16. *Apoglossum unguiculescens*. Fig. 14. Female blade showing corticated midrib and immature cystocarp (arrow). Fig. 15. Tetrasporic blade with sorus. Fig. 16. Female blade showing ecorticate midrib with undivided lateral pericentral cells remaining obvious in proximal parts. Fig. 17. Camera-lucida of blade with discrete spermatangial sori.

resembled "*Delesseria denticulata*" of Harvey (1855a), currently known as *Heterodoxia denticulata* J. Agardh. De Toni (1924) reiterated this relationship. Lucas (1929) placed it in *Hypoglossum*, but according to Reinbold's description, the species does not appear to belong in that genus either. The type specimen has not been located in the Munchen Herbarium or the Rijksherbarium, Leiden, and no specimens identifiable as this taxon have been recently collected from southern Australia (H. B. S. Womersley, pers. comm.). Reinbold described *D. lacepedeana* as having thalli 15 cm tall and with blade surfaces giving rise to scattered proliferations; these features permit us to disallow *D. lacepedeana* from further consideration.

Several species of *Delesseria* are known from

New Zealand and environs (Adams 1972, Adams *et al.* 1974, Hay *et al.* 1985). These include *D. lancifolia* J. Ag., which according to Ricker (1987) is a morphologically variable entity, typically represented by robust, erect fronds reaching heights up to 50 cm. Similarly, plants of *D. crassinervia* Mont. reach substantial sizes and are branched to several orders (Montagne 1852, Kylin 1929), making this taxon clearly separable from *D. aemula*. Blades of *D. nereifolia* Harv. [=*D. laurifolia* (J. Ag.) Kyl.] are broad and with lateral veins, and plants are branched to a few orders (Harvey 1855b, Kylin 1929).

Looking beyond New Zealand waters, we can consider other species that have been assigned to *Delesseria*. Baardseth (1941) described *D. minor* from Tristan da Cunha in the South Atlantic to be a plant growing to 5 cm high and with branching from the stipe, midrib, margins or from the flat surface of the blades. Although its size immediately suggests that there is little in common between *D. minor* and *D. aemula*, the branches arising from the flat surface of the blade would appear to be unusual within the genus and quite different from the more typical branching seen in *D. aemula*. Levring (1944) described *D. crozetii* as a species growing to heights of 8 cm and with individual blades reaching lengths of 1-2 cm, sizes exceeding those in *D. aemula*.

Wynne (1984) characterized *Delesseria papenfussii* from South Africa as having thalli of moderate stature, from 4 to 6, rarely up to 9, cm tall, densely branched (to 5 orders), and with more or less cartilaginous basal stipes, features distinguishing it from *D. aemula*.

Apoglossum is a genus closely related to *Delesseria* and with which it might be confused. First established by J. Agardh (1876) as a subgenus of *Delesseria, Apoglossum* was later delineated as a distinct genus (J. Agardh 1898). Wynne (1984) summarized the six characters which had earlier been offered by Kylin (1923) to separate these genera. Wynne (1984) pointed out that one of these criteria, microscopic lateral nerves in *Apoglossum* vs. microscopic or macroscopic veins in *Delesseria*, was not a completely exclusive characteristic. *Delesseria aemula* conforms to *Delesseria* rather than to *Apoglossum* in respect to the following generic criteria: 1) lateral pericentral cells undergoing transverse divisions; 2) cross-sections of stipes showing a mixture of large cells intermingled with rhizoidal cells; 3) cells of the sterile-cell groups becoming divided; and 4) new cells from intercalary division may be cut off distally or proximally [NB: stippled cells in Fig. 7], unlike in *Apoglossum* where new cells from an intercalary division are cut off only distally. One difference from the generitype, *Delesseria sanguinea* (Hudson) Lamouroux, is that in *D. aemula* fourth-order rows are cut off adaxially rather than "usually abaxially". But this discrepancy with the generitype was also noted for *D. papenfussii* by Wynne (1984).

The problems involved in separating the two genera are not only at the morphological level. At the type locality (Twofold Bay, Australia) of *Delesseria aemula*, the diminutive alga *Apoglossum unguiculescens* grows right along side the new species on the same hosts and substrata. The two species are essentially indistinguishable to the naked eye, and only under microscopic examination can they be separated. In *A. unguiculescens*, the lateral pericentral cells remain clearly undivided (Fig. 9) and visible throughout the entire length of the midrib region (Fig. 16) of all life stages except mature cystocarp-bearing females, in which they are lightly to heavily corticated. This feature contrasts with the situation in *D. aemula*, in which the lateral pericentral cells are either obscured by heavy cortication of the midrib on spermatangial (Fig. 5) and female (Fig. 14) blades or involved in tetrasporangial production (Fig. 15). Spermatangial sori in *A. unguiculescens* are continuous and confluent from the early stages, occupying about one half to one third the blade width (Fig. 6). In *D. aemula*, however, spermatangial sori are discrete islets separated by some second- and third-order cells that remain sterile (Figs. 5, 17). Another useful difference between these two superficially similar species is their procarps. In *D. aemula* the cells of the sterile-

cell groups divide once (Fig. 10) or twice (Fig. 12) before fertilization takes place, whereas in *A. unguiculescens*, the cells of both sterile-cell groups remain undivided, at least before fertilization (Fig. 13).

Other species of *Apoglossum* with thalli of small-stature deserve mention. *Apoglossum spathulatum* (Sond.) Womersley and Shepley occurs in Western Australia (Sonder 1945) and South Africa (Wynne 1984). Sonder (1845) described this species as having dwarf fronds, and he later noted that the blades were 3.0 mm wide and marked by pellucide transverse striae, i.e., microscopic veins (Sonder 1848). Wynne (1984) reported South African plants of *A. spathulatum* to range from 5 to 11 mm in height and to have well developed midribs and ovate tetrasporangial sori overlying the midrib. *Apoglossum minimum* Yamada (Mikami 1985) and *A. gregarium* (Dawson) Wynne (Wynne 1985, Wynne and Norris 1991) are other examples of small-sized Apoglossums. In these species the lateral pericentral cells do not divide transversely, and thus these taxa clearly belong to the genus *Apoglossum* and cannot be confused with *Delesseria aemula*.

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A. J. K. Millar*・M. J. Wynne**：オーストラリア，ニューサウスウェールズ産の一新種 *Delesseria aemula* sp. nov.（紅藻，コノハノリ目）について

東オーストラリア，ニューサウスウェールズ産の亜潮間帯に生育する新種 *Delesseria aemula* sp. nov. を記載した。本新種は以下のような特徴を持つ：中央部の仮根状の付着器から放射状に生じるへら形または披針形の葉状部：成熟時においても高さ 10 mm, 幅 2 mm にしか達しない小さな藻体；二次及び三次の細胞列からなる不稔の葉脈により隔てられた不連続の細胞群からなる造精子嚢斑；大部分の枝が中央部の仮根状の付着器から生じる分枝の様式。一部の枝は中肋または縁辺部から二次的な成長により生じることもある。野外では本種は同じ場所に生育し，同様の外観，大きさと形を持つ *Apoglossum unguiculescens* Millar と区別が困難である。両種は以下の点で区別される：1）周心細胞が *D. aemula* では横方向に分裂するのに対し *A. unguiculescens* では分裂しない：2）不稔細胞群の細胞が *D. aemula* では分裂するのに対し *A. unguiculescens* では分裂しない：3）造精子嚢斑の配列が異なる。*D. aemula* の発見によりオーストラリアには 3 属（*Delesseria, Apoglossum* 及び *Patulophycus*）のコノハノリ類が生育することになる。
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