**Two *Peyssonella* species (Peyssoneliaceae, Rhodophyta) from Puerto Rico including *Peyssonella flavescens* sp. nov.**

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Two highly colourful encrusting red algal species from deep and shallow coral reef habitats in Puerto Rico are reported. *Peyssonella boergesenii* Weber Bosse is characterized by its multicoloured appearance, polythallate arrangement of hypothallial cells and multicellular holdfasts. *Peyssonella flavescens* sp. nov. is variably bi- to tri-coloured, with the principal background colour bright yellow to tan. It forms large crusts, to 30 cm in diameter, which are variably thick, measuring 310–640 μm in thickness. The new species differs from other known *Peyssonella* species by cutting off elongate, 12–17 μm long, spermatangial initials that cut off seriate chains of spermatangia distally and by its production of very large tetrasporangia, to 170 μm long.

### INTRODUCTION

A quantitative and qualitative examination of the benthic marine algae of coral reef habitats in southwestern Puerto Rico was begun in 2002 as part of a NOAA Coral Reef Ecosystem study. A large and highly conspicuous *Peyssonella* species was regularly encountered and is shown here to be an undescribed species.

*Peyssonella* is a large genus with a principally warm temperate to tropical distribution (Denizot 1968; Kato & Masuda 2003). Presently 64 species are recognized (Guiry & Nic Dhoumcha 2004; Ballantine & Aponte 2005). In the tropical western Atlantic, Wynne (1998) listed 13 *Peyssonella* species, including the listing of *P. polymorpha* (Zanardini) F. Schmitz cited as a questionable record. Inclusion of *Peyssonella armorica* (P. Crouan & H. Crouan) Weber Bosse and the recently described deep-water species, *P. abyssica* D.L. Ballantine & Aponte (2005) from the Bahamas, brings to 14, the total *Peyssonella* species from the region. Only four of these are currently known from Puerto Rico (Ballantine & Aponte 2002). *Peyssonella* species are separated from one another by a variety of morphological and reproductive characters including whether rhizoids are unicellular or multicellular, the degree of adherence to the substratum, disposition of the hypothallus filaments (whether they are in straight or fan-shaped arrangements), perithallus anatomy (angle of perithallial filaments, whether or not proximal perithallial cells are cut off from the entire surface of hypothallial cells, number of erect perithallial filaments from the proximal perithallial cell), presence or absence of cystoliths, whether nemathecia are immersed or superficial, position and size of the tetrasporangia in the nemathecia, and development of spermatangia (Boudouresque & Denizot 1975; Maggs & Irvine 1983; Schneider & Reading 1987; Guimarães & Fujii 1999).

### MATERIAL AND METHODS

Plants were collected utilizing SCUBA or by snorkelling. Specimens were preserved in 10% formalin–seawater. Prior to sectioning, pieces of *Peyssonella* were decalcified in 5% HCl. Transsections (50 μm thick) were made with an American Optical Cryo-Cut freezing microtome. Microscopic preparations were stained in acidified 1% aniline blue and mounted in 60% Karo® corn syrup on glass slides. Photomicrographs using Kodak Technical Pan black and white film were taken through an Olympus BMAX light microscope. The holotype is deposited in US and isotypes in MICH and MSM. Herbarium abbreviations follow Holmgren et al. (1990) and initials for given names of authorities are according to Brummitt & Powell (1992).

### RESULTS

**Peyssonella boergesenii** Weber Bosse 1916: 137

Figs 1, 5–7

Puerto Rican plants were collected at two highly differing locales in the southwestern part of the island on limestone substrata. At the Cabo Rojo Lighthouse, the alga was collected in a high-energy environment at 0.5 m depth, and at the edge of the insular shelf the alga was collected at 22 m. *Peyssonella boergesenii* typically possesses a greenish-yellow base colour with maroon or red radial streaks and maroon (Fig. 1) or red margins. Crusts are closely appressed to the substratum, and crust thickness is highly variable, ranging from 100 to 500 μm. Hypothallus filaments radiate in fan-shaped arrangements. The hypothallial cells are variable in size and shape measuring to 38 μm long and to 39 μm high. Multicellular rhizoids (Figs 5, 6) are occasionally branched and are abundantly produced from the ventral surface. The rhizoids measure to a maximum of 1.0 mm in length and to 23 μm in diameter. In radial vertical section (RVS), the basal cell of the perithallus is normally the same length as the supporting hypothallial cell, is boot-shaped and typically gives rise to two ascending files of perithallial cells (Fig. 5). Cells of the perithallus measure 25–35 μm in diameter and decrease to 10–13 μm distally. Distal cells of the perithallus frequently branch to give rise to two files of cells. The proximal per-
**Figs 1–4.**

Fig. 1. *Peyssonnelia boergesenii*. Photo of living plant (*DLB 5884*) overgrowing *P. flavescens*. Scale bar = 1.0 cm.

Figs 2–4. *Peyssonnelia flavescens*.

Fig. 2. Habit of living plant *in situ* showing bright yellow colouration. Scale bar = approximately 2.0 cm.

Fig. 3. The holotype, live, showing yellow-orange colouration (*DLB 6069*). *Peyssonnelia boergesenii* is overgrowing from bottom. Scale bar = 1.0 cm.

Fig. 4. Living plant showing tan colouration (*DLB 5869*). Scale bar = 5.0 mm.

**Figs 5–7. *Peyssonnelia boergesenii*.**

Fig. 5. A RVS showing dense multicellular rhizoids (*DLB 5884*). Scale bar = 50 μm.

Fig. 6. Tangential cross section (*DLB 5884*). Scale bar = 50 μm.

Fig. 7. A RVS through nemathecium showing an undivided sporangium (*DLB 5868*). Scale bar = 100 μm.
Figs 8–12. *Peyssonnelia flavescens* sp. nov.

**Fig. 8.** A RVS showing pairs of filaments branching from the proximal perithallial cells (arrowheads) as well as from a perithallial cell in a median position in the perithallus (arrow). Note rhizoids originating from the anterior ends of hypothallus cells (*DLB* 5883). Scale bar = 50 mm.

**Fig. 9.** Tangential cross section (*DLB* 5883). Scale bar = 50 μm.

**Fig. 10.** Hyothallus cells in regular parallel arrangement (*DLB* 5869). Scale bar = 25 μm.

**Fig. 11.** Perithallial surface in section with elongate spermatangial mother cells (arrows) which give rise to seriate series of spermatangia (*DLB* 5920). Scale bar = 10 μm.

**Fig. 12.** Elongate spermatangial mother cells (arrows) (*DLB* 5920). Scale bar = 10 μm.

Perithallial cells and the ascending filaments are either deflected at an angle to 60° or are nearly perpendicular. Only tetrasporophytic plants were collected. Tetrasporangia (Fig. 7) are cut off laterally from basal paraphysal cells in nemathecia which measured to 260 μm above the crust surface. Tetrasporangia measure to 160 μm long and to 50 μm wide. The crusts agree in all respects with the accounts provided by Taylor (1960), Guimaraës and Fujii (1999) and Littler and Littler (2000).

**TYPE LOCALITY:** White Bay, St Croix, US Virgin Islands (Weber Bosse 1916).

**KNOWN DISTRIBUTION:** Western Atlantic: Belize (Littler & Littler 1997); Venezuela, Guadeloupe, Panama, Mexico and Brazil (Guimaraës & Fujii 1999). Pacific Islands: Fiji (South & Skelton 2003).

**SPECIMENS EXAMINED:** Cabo Rojo Lighthouse (17°55.878'N, 67°11.301'W), 0.1–0.5 m (*H. Ruiz*, 21 March 2003, *DLB* 5868);
**Peyssonnelia flavescens** sp. nov.

Figs 2–4, 8–15

Crustae luteae clarae, bruneo-aurantiaceae, aut rubellae; maculae fuscae et irregularae in plantis vivis, arcte adhaerentes ad substratum; crustae 310–640 μm crassae; cellularae hypothallial parallele dispositae, 25–40 μm longae × 18–25 μm altae et rhiizoidea simplicia ventraliter producentes, usque ad 450 μm longa; cellularae perithalli proximales longitudinem cellularum in hypothallo aequantes, et duo filamenta ascendentes planamque abscondentes; cellularae filamentorum 15–18 μm latae × 25–30 μm altae; spermatangia in soris usque ad 70 μm alta; cellularae triangulares, a cellulis distalibus perithalli abscessae, fasciculos cellularum matricularum elongatarum 12–17 μm longarum efficiunt; spermatangia in catenis seriatis distaliter abscindentes; tetrasporangia ovata, lateraliter abscissa e filamentis basaliibus paraphysalibusque, usque ad 170 μm longa × 80 μm lata.

Crusts bright yellow, brownish orange or reddish with irregular dark spotting on living plants, closely adhering to substratum; crusts 310–640 μm in thickness; hypothallus cells in parallel arrangement, 25–40 μm in length × 18–25 μm in height, producing simple rhizoids ventrally, to 450 μm in length; proximal perithallial cells the same length as the hypothallial cells, normally cut off two ascending filaments, cells of these filaments measure 15–18 μm in breadth × 25–30 μm in height; spermatangia occur in sori to 70 μm high; triangular cells cut off terminally from distal perithallial cells give rise to clusters of elongate spermatangial mother cells, 12–17 μm in length, which cut off spermatangia distally in seriate chains; ovate tetrasporangia cut off laterally from basal paraphysal filaments, measure to 170 μm long × 80 μm broad.

**Holotype:** DLB 6069, Edge of Insular Shelf, La Parguera, Puerto Rico (17° 53.423′ N, 66° 59.320′ W), 24 m, 12 September 2003 (Alg. Coll. US#-204256).

**Isootypes:** MICH, MSM, US.

**Other specimens examined (all in MSM):** Media Luna Reef (17° 56.096′ N, 67° 02.911′ W), 12 m (HR, 5 August 2003, DLB 5920); Edge of Insular Shelf, 22 m (DLB, HR, 3 October 2003, DLB 5944; 23 m, 22 November 2003, DLB 6045); (HR, 27 March 2003 DLB 5883; 18 m, 4 June 2004, DLB 6189); Cabo Rojo Lighthouse (17° 55.878′ N, 67° 11.301′ W), 0.5 m (HR, Ivan Lopez, 21 March 2003, DLB 5869).

**Etymology:** The specific epithet is in reference to the yellow colour of the crusts, particularly when found in deeper water.

**Remarks:** *Peyssonnelia flavescens* was found in the same habitats as *P. boergesenii* as well as at intermediate depths at a mid-shelf coral reef site. Although never abundant, the new species is conspicuous due to its colouration and large size. Deeper-water crusts when living are bright yellow, orange-yellow or reddish yellow in colour with irregular reddish or dark lines and spotting (Figs 2, 3). The shallow-water crusts are brownish orange in colour with irregular yellowish portions and with dark maroon lines and spotting (Fig. 4). Radial lines may be distinct or may not be apparent. Crusts are frequently large, to 30 cm across, and are closely adherent to the substratum. Calciﬁcation is limited to the hypothallial region, and the crusts are variable in thickness, 310–640 μm. When viewed in RVS (Fig. 8), hypothallial cells measure 25–40 μm in length and 18–25 μm in height. In tangential cross section (Fig. 9), the hypothallial cells and perithallial cells measure to 10–12.5 μm across. The hypothallus forms straight ﬁles of cells (Fig. 10). Simple rhizoids, cut off from the anterior ends of the hypothallial cells, are unicellular and measure to 450 μm in length. A high frequency of hypothallial cells cut off rhizoids resulting in a dense profusion of rhizoids ventrally. The proximal perithallial cells are nearly square to rectangular and measure 30–35 μm in length and 25–35 μm in height, being nearly as long as the hypothallial cells which produce them. They are cut off at angles from 60° to nearly perpendicular to the plane of the hypothallus. The angle at which the perithallial cells originates appears to be, at least in part, related to the microtopography of the substratum. The proximal perithallial cell regularly gives rise to two ascending ﬁles of perithallial cells (Fig. 8). Immediately above the proximal perithallial cell, perithallial cells measure 15–18 μm in breadth and 25–30 μm in height. Cells of the ascending ﬁlaments may rebranch once (Fig. 8) and become progressively narrower and shorter distally. The perithallial ﬁlaments possess a hemispherical apical cell, measuring an average of 10 μm in diameter. In total, the crust may reach 6–12 cells in length.

Spermatangia occur in expanded sori to 40 μm high (Fig. 11). Terminal perithallial cells cut off small squarish or triangular cells distally, 6–8 μm broad, which give rise to clusters of elongate, 12–17 μm long, spermatangial mother cells (Fig. 12). The mother cells cut off spermatangia distally in seriate chains. As male plants were commonly encountered and female gametophytes were not seen, *Peyssonnelia flavescens* is considered to be dioecious. Tetrasporangia are cut off laterally from an enlarged basal paraphysal cell (Fig. 14). The ovate tetrasporangia measure to 170 μm long and to 80 μm broad. Division of the tetrasporangia is not obvious, and these sporangia were
Table 1. Comparison of *Peyssonnelia* species of the western Atlantic.

| Species         | Concentric rings/ radial lines | Crust margin | Vegetative crust thickness (µm) | Anatomy type | No. uprights from first perithalial cell | Hypothallus orientation | Rhizoids (µm) | Nemathecia | Tetrasporangia diameter × length (µm) | Spermatangial sorus type | References  |
|-----------------|---------------------------------|--------------|---------------------------------|--------------|----------------------------------------|-------------------------|---------------|------------|---------------------------------------|---------------------------|-------------|
| *P. abyssica*   | lacking/lacking                 | appressed    | 70–75                           | *P. rubra*-type | 2                                      | polyflabellate          | uncellular to 100 | superficial | to 90 × to 150                         | ?                         | 1           |
| *P. armorica*   | lacking/lacking                 | appressed    | 60–100                          | *P. rubra*-type | 1–2                                    | polyflabellate          | uncellular to 20   | superficial | 18–20 × 60–70                         | ?                         | 2           |
| *P. boergesennii* | lacking/present                | appressed    | 100–500                         | *P. rubra*-type | 1–2                                    | polyflabellate          | multicellular to 1000 | superficial | 30–52 × 110–170                       | ?                         | 2, 3        |
| *P. boudouresquei* | lacking/lacking               | appressed    | 80–220                          | *P. rubra*-type | 2–3                                    | parallel                | uncellular to 43   | immersed   | 12–25 × 40–70                         | *P. dubyi*-type            | 2, 4 (as *P. atlantica*) |
| *P. capensis*   | conspicuous/lacking             | free         | 140–310                         | *P. atropurpurea*-type | 1                                    | parallel                | multicellular to 1000 | superficial | 14–24 × 60–70                         | *P. dubyi*-type            | 2           |
| *P. conchicola* | lacking/lacking                 | appressed    | 220                             | *P. rubra*-type | (2–)3                                   | parallel                | uncellular to 60   | immersed   | 15–25 × 32–53                         | *P. dubyi*-type            | 4           |
| *P. inamoena*   | faint/faint                     | free         | 57–215                          | *P. rubra*-type | 2                                      | parallel                | uncellular to 160  | superficial | 27–57 × 70–100                        | *P. harvey-ana*-type       | 2, 4        |
| *P. nordstedtii* | ?/!                              | appressed    | ?                               | *P. rubra*-type | 2                                      | polyflabellate          | uncellular to 96   | superficial | ? × to 80                              | ?                         | 2           |
| *P. rosa-marina* | conspicuous/conspicuous        | free         | 160–3565                        | *P. rubra*-type | 1–2                                    | parallel                | uncellular & multicellular, to 330 | superficial | ?                                      | ?                         | 2, 5        |
| *P. rosenvingii* | ?/faint                         | appressed    | to 500 or more                  | ?             | ?                                      | polyflabellate          | ?                      | ?                      | ?                                      | ?                         | 6           |
| *P. rubra*      | ?/                             | ?            | 90–145                          | *P. rubra*-type | 2(–)3                                   | parallel                | multicellular       | ?                      | to 30 × to 80                          | ?                         | 5, 7        |
| *P. simulans*   | lacking/lacking                 | loose        | 200                             | *P. rubra*-type | 2                                      | parallel                | uncellular to 65   | superficial | 12–30 × 40–80                         | ?                         | 4           |
| *P. stoechas*   | conspicuous/lacking             | free         | 150                             | *P. rubra*-type | 2                                      | parallel                | uncellular to 230  | unknown    | unknown                               | ?                         | 4           |
| *P. valentinii* | lacking/lacking                 | free         | 50–150                          | *P. rubra*-type | 2–3                                    | parallel                | uncellular to 200  | superficial | 21–43 × 66–85                         | *P. harvey-ana*-type       | 2, 8        |
| *P. flavescens* | lacking/faint to conspicuous    | appressed    | 310–640                         | *P. rubra*-type | 2(–)3                                   | parallel                | uncellular to 450  | superficial | to 80 × to 170                        | *P. flavescens*-type       | 3           |

References: 1, Ballantine & Aponte (2005); 2, Guimaraes & Fujii (1999); 3, this paper; 4, Schneider & Reading (1987); 5, Boudouresque & Denizot (1975); 6, Taylor (1960); 7, Denizot (1968); 8, Schneider & Searles (1998).
initially confused with being monosporangia. The paraphyses are simple and are very slender, measuring approximately 2 μm in diameter. The distal two to three paraphysal cells, however, become enlarged (Fig. 15), 8–10 (13) μm broad (subapical) and 13–15 μm broad (apical). The enlargement of these cells results in a pellicle which completely covers the nemathecium (Figs 13–15).

DISCUSSION

Comparative features of western Atlantic Peyssonnelia species are given in Table 1. Peyssonnelia flavescens appears to be unique in the genus with its production of spermatangia distally from elongate spermatangial mother cells. Maggs & Irvine (1983) discussed the three types of spermatangial development previously known for Peyssonnelia: (1) P. atropurpurea-type with series of apical and intercalary divisions in all planes resulting in dense clusters of spermatangia; (2) P. harveyana-type with spermatangial initials borne in simple chains and cells dividing at first periclinally and then anticularly resulting in pairs of spermatangia; and (3) P. dubyi-type with each cell in a chain of initials cutting off cells by anticlinal divisions prior to each lateral product dividing periclinally to produce pairs of spermatangia.

The new species is also unusual in the genus due to its multi-coloured habit and production of very large tetrasporangia. Both of the species in this account are conspicuous due to their highly multi-coloured habit. Peyssonnelia boergesenii is perhaps the only species in the genus with tetrasporangia that approach the size known for the new species. However, P. boergesenii differs from the new species in a number of respects, including having hypothallial filaments in fan-shaped arrangements and in possessing multicellular rhizoids.

Among Caribbean species, Peyssonnelia flavescens also differs from P. abyssica, P. armorica, P. nordstedtii Weber Bosse, and P. rosenvingii F. Schmitz, all of which have a polyflabellate arrangement of hypothallial cells as opposed to having the hypothallus cells arranged in straight files (Guimaraes & Fujii 1999; Ballantine & Aponte 2005). Among other Caribbean species, the new species differs from P. capensis Montagne, P. inamoena Pilger, P. simulans Weber Bosse, in having thalli which are either loosely attached or free at the margin (Schneider & Reading 1987; Guimaraes & Fujii 1999). All but one western Atlantic Peyssonnelia species possess the Peyssonnelia rubra-type anatomy in which the proximal perithallial cells are the same length as the hypothallial cells which produce them (Denizot 1968). This feature additionally distinguishes the new species from P. capensis, which possesses the Peyssonnelia atropurpurea-type anatomy, in which the proximal perithallial cells are cut off from the distal end of hypothallial cells (Denizot 1968). The new species differs from P. boudouresquei Yoneshigue and P. conchicola Piccone & Grunow and P. valentini Yoneshigue & Boudouresque in having the proximal perithallial cell giving rise to two or three perithallial filaments (Schneider & Reading 1987; Guimaraes & Fujii 1999). Peyssonnelia rubra (Greville) J. Agardh, the presence of which in the western Atlantic has only been confirmed for Bermuda (Schneider & Reading 1987), differs from the new species in possessing multicellular rhizoids, much smaller tetrasporangia (to 80 μm in length) and in possessing cystoliths (Boudouresque & Denizot 1975). Peyssonnelia rosa-marina Boudouresque & Denizot differs from the new species in possessing conspicuous rings and radial lines and in having margins free from the substratum (Boudouresque & Denizot 1975; Guimaraes & Fujii 1999).

A living specimen of Peyssonnelia stoechas Boudouresque & Denizot is figured by Littler & Littler (2000) as having several shades of orange-yellow and is thus the only Caribbean species of Peyssonnelia that could be confused with the new species on the basis of colour. Nevertheless, P. stoechas forms a much thinner crust, to 150 μm, and grows largely free from the substratum (Schneider & Reading 1987; Littler & Littler 2000).

With the exception of Peyssonnelia harveyana J. Agardh and P. immersa Maggs & L.M. Irvine, the new species differs from all eastern Atlantic (including Mediterranean) species of the genus by nature of possessing unicellular rhizoids and possessing a parallel arrangement of hypothallial cells. The former species differs from P. flavescens in becoming free from the substratum and in having smaller (100–130 × 30–45 μm) tetrasporangia (Irvine & Maggs 1983). Peyssonnelia immersa, which may also be yellowish in colour, differs from the new species in having smaller (89–100 μm long) tetrasporangia which are immersed in the perithallus.

Among other Peyssonnelia species, P. mexicana E.Y. Dawson from Pacific Mexico, shares with the new species the characters of possessing hypothallial cells in parallel arrangement, unicellular rhizoids and in being firmly adherent to the substratum. Peyssonnelia mexicana differs, however, in possessing smaller (60–100 × 22–30 μm) tetrasporangia (Dawson 1952). Dawson (1952) was perhaps the first to utilize paraphysal filament morphology as a taxonomic character. In P. mexicana, the paraphysal filaments gradually increase in diameter towards the apex with the terminal cell being pointed. In the new species, the ultimate two to three cells are abruptly inflated and are shorter than broad. Finally, Peyssonnelia bicolor (Borgesen) Denizot, an Indian Ocean species, derives its name from the fact that the margin of the thallus is a less dark ‘purplish violet colour’ or due to the fact that in transverse section, the ‘lower-most layer is bluish violet’ and the ‘uppermost reddish purple’ (Borgesen 1935). Peyssonnelia bicolor differs from the new species by nature of its much thinner thallus (50–130 μm) and in possessing hypothallial cells in fan-shaped arrangements.

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REFERENCES

Ballantine D.L. & Aponte N.E. 2002. A checklist of the benthic marine algae known to Puerto Rico, second revision. Constancea. 83: http://ucjeps.berkeley.edu/constancea/83/ballantine.aponte/checklist.html.

Ballantine D.L. & Aponte N.E. 2005. An annotated checklist of
