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The marine algal (seaweed) flora of the Azores: additions and amendments 3

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Abstract

Thirteen species of benthic marine algae are reported as new to the mid Atlantic Azores archipelago, and the status is confirmed for five other species. Some of the new records fall within their overall distributional range. The discovery of seven species (*Codium taylorii*, *Digenea simplex*, *Gelidiella tinerfensis*, *Gelidiopsis intricata*, *Laurencia microcladia*, *Papenfussiella kuromo*, *Phyllophora gelidioides*) represents a northern extension in their Atlantic distributional range. The archipelago is the western limit of *Papenfussiella kuromo* and *Phyllophora gelidioides* in the Atlantic Ocean. *Ascophyllum nodosum*, common as drift, was found for the first time attached to rocks on Graciosa Island and *Caulerpa webbiana* is confirmed as a recent immigrant to the archipelago. Four species are removed from the flora.

Keywords: Azores; benthic marine macroalgae; biogeography; morphology; taxonomy.

Introduction

The isolated mid Atlantic Azores archipelago of nine islands, the Formigas islets and nearby sublittoral banks and sea-mounts are located (from the nearest point in the archipelago) approximately 1200 km from Europe and 1900 km from Newfoundland. It has a moderately rich benthic marine algal flora with 368 species thus far recorded (Tittley and Neto 2005). Intensive fieldwork at locations not previously studied and taxonomic review of difficult groups continue to add new records to the flora (e.g., Afonso-Carrillo et al. 2006, Parente et al. 2006). The present paper adds 12 species new to the Azores marine algal flora and the status of 5 other species records is reviewed. Four species are removed from the flora.

Materials and methods

The algae referred to in this paper were collected during field studies at eulittoral and sublittoral levels down to 30 m on many of the islands of the archipelago. Fieldwork was undertaken during all seasons of the year. Material collected was either fixed in 5% formalin seawater or was pressed and dried and when necessary prepared as microscope slides by staining with aniline blue and permanently mounted using Karo® corn syrup (Best Foods, Englewood Cliffs, NJ, USA). Dried specimens from earlier collections were re-hydrated and prepared for microscopic examination as above. All specimens were given an individual registration number and deposited in the herbaria of the University of the Azores (UA) and Natural History Museum (BM). Nomenclatural and taxonomic status and some distributional information used here follow *AlgaeBase* (January 2008; Guiry and Guiry 2008). For information on distribution, we refer to published floras and checklists (e.g., South and Tittley 1986, Maggs and Hommersand 1993, Afonso-Carillo and Sansón 2000, Neto et al. 2001).

Results

Systematic account, new species records

Chlorophyta, Ulvophyceae, Cladophorales, Cladophoraceae: *Cladophora pellucida* (Hudson) Kützing
Described and illustrated by van den Hoek (1963, pp. 215–218, figures 696, 697, 702); Brodie et al. (2007, pp. 164–166, figure 77); Cabioc'h et al. (2006, p. 75, figure 10).

Azores specimens are stiff, 32–96 mm tall, grass to dark green attached by a complex system of rhizoids from which erect, uniseriate, branched filaments (163–173 μm in width) arise. Basal cells are 143 μm in width and to 620 μm in length (longer elsewhere). Growth is by apical divisions giving an acropetal organization of branches with single-celled internodes. The apical cell is 41–61 μm wide and 255–520 μm long. Branches are cut off apically on cells at acute angles by oblique cross walls. Branching is pseudodichotomous on upper parts but appearing verticillate lower down the axis. Fertile material has not been observed in the Azores. *Cladophora pellucida* grows at eulittoral levels on open rocks and in pools. Never abundant, this species was only found mostly in late spring (June) and once in autumn.

Cladophora pellucida is widely distributed in the Atlantic Ocean (Ireland to Cape Verde Islands and Brazil), Mediterranean Sea, Indian and Pacific Oceans.

Specimens examined: Azores: Graciosa, Santa Cruz, 21.06.2006, GRW-06-23 (UA); Graciosa, Praia, 24.06. 2006, GRW-06-205 (UA); Graciosa, Carapacho,

26.06.2006, GRW-06-260 (UA); São Miguel, Mosteiros, 05.06.2004, SMG-04-134 (UA); São Miguel, Mosteiros, 19.09.2005, SMG-05-263 (UA); Santa Maria, Ponta do Castelo, 10.06.2005, SMA-05-104 (UA); Santa Maria, Baía da Boca da Ribeira Seca, 10.06.2005, SMA-05-148 (UA).

Bryopsidophyceae, Bryopsidales, Codiaceae: *Codium taylorii* P.C. Silva Described and illustrated by Silva (1960, pp. 510–513, plates 112, 118–120); Littler and Littler (2000, pp. 354, 355); John et al. (2003, p. 38, figure 7A,B).

Plants erect, spongy, green, more or less terete, to 55 mm tall and arising from a prostrate base. The thallus is irregularly dichotomously branched to 4 orders; branches are somewhat flattened at the dichotomies and measure (2)–3–(4) mm wide and have blunt tips. Utricles are cylindrical and not constricted, (140)–250–(350) μm wide, (400)–585–(700) μm long. Hair scars present, 2 per utricle, variously placed usually (100)–145–(200) μm below the utricle tip. The thickness of the utricle walls [(5)–10–(12.5) μm] distinguishes this species from other erect *Codium* species in the Azores. Filaments varied in width from 15 to 50 μm. Fertile material was not observed in the Azores. Plants were found in rock pools at lower mid-littoral levels on moderately wave-exposed shores and also at shallow sublittoral levels (5 m depth).

Codium taylorii occurs elsewhere in Macaronesia (Canary Islands and Madeira) and widely in the tropical and subtropical Atlantic (Bermuda and North Carolina) and Indian Oceans.

Specimens examined: Azores: São Miguel, São Roque, 15.09.1999, SMG-99-931 (UA); Pico, São Mateus, 09.07.2007, PIX-07-503 (UA); Pico, Fonte, 10.07.2007, PIX-07-549 (UA); Pico, São Roque, 28.07.2007, PIX-07-1377 (UA); Pico, Porto do Calhau, 01.08.2007, PIX-07-1503 (UA).

Ochrophyta, Phaeophyceae, Ectocarpales, Chordariaceae: *Myriactula rivulariae* (Suhr) Feldmann Described and illustrated by Feldmann (1937, pp. 268–274, figures 1, 2); Fletcher (1987, pp. 156–158, figure 31).

The thallus comprises epiphytic, minute cushions or tufts to 800 μm high. The lower part of the thallus is pseudoparenchymatous and composed of densely packed filaments, di- or trichotomously branched, comprising colorless cells (10–26×8–15 μm) containing a few discoid chloroplasts (Figure 1). These cells become smaller above and give rise terminally to slightly curved or straight multicellular pigmented paraphyses, reproductive organs, and/or hyaline hairs 8–13 μm wide. The paraphyses are closely packed and gelatinous, comprising a basal layer of rectangular or quadrate, barrel-shaped cells, but terminally less swollen and smaller (10–26×5–13 μm). Unilocular sporangia (36–102×15–28 μm) are pyriform, sessile or on 1-celled pedicels. Plurilocular sporangia (485–640×5–8 μm) are uniseriate on 1–2-celled pedicels. *Myriactula rivulariae* grows in pools, where it is epiphytic on *Cystoseira* and *Sargassum* species.

Myriactula rivulariae is widely distributed in cold and warm-temperate Atlantic Ocean waters southwards from

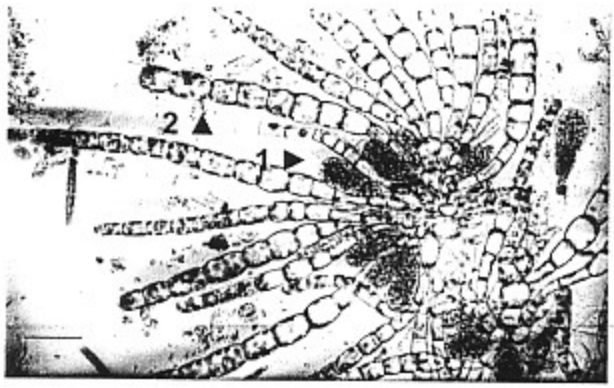

Figure 1 *Myriactula rivulariae*: unilocular sporangia (1) and pigmented paraphyses (2).
Scale bar=100 μm.

Scotland and the western Baltic, and in the Mediterranean Sea.

Specimens examined: Azores: São Miguel, São Vicente, 08.07.1996, SMG-05-57 (UA); São Miguel, São Vicente, 16.06.1998, SMG-98-749; São Miguel, Mosteiros, 06.07.1998, SMG-98-907/8/10 (UA); São Miguel, Mosteiros, 17.08.1998, SMG-98-1024/5/6 (UA); São Miguel, Mosteiros, 21.04.1999, SMG-99-793/4 (UA); São Miguel, Maia, 08.04.1999, SMG-99-732 (UA).

***Papenfussiella kuromo* (Yendo) Inagaki** Described and illustrated by Inagaki (1958, p. 128, figures 35–39); Martin et al. (1996, p. 165, figures 1–8).

Plants are light to dark brown, solitary, arising from small discoid holdfasts, branched, solid, cord-shaped, mucilaginous and tomentose, to 135 mm long. The thallus has a multiaxial structure with a medulla composed of longitudinal, parallel filaments surrounded by a cortex of long and short assimilatory filaments (Figure 2). Shorter filaments are determinate to 10 cells long, slightly curved and measure 10–20×5–8 μm; longer indeterminate filaments are up to 64 cells long and cells measure 12–35×10–15 μm. Cells contain several discoid chloro-

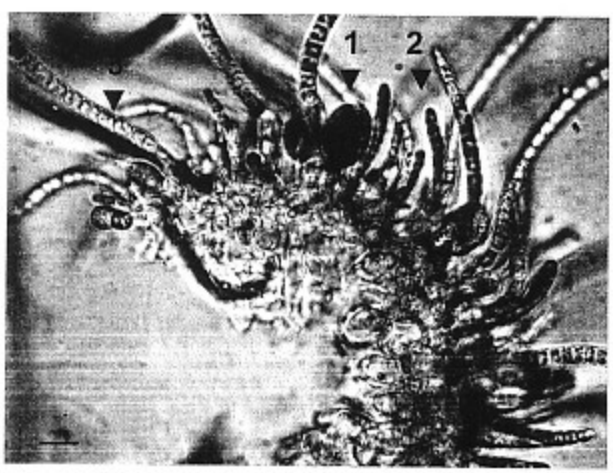

Figure 2 *Papenfussiella kuromo*: transverse section showing unilocular sporangia (1), short (2) and long (3) assimilatory filaments.
Scale bar=100 μm.

plasts each with a pyrenoid. Unilocular sporangia are formed on the basal part of assimilatory filaments and are clavate to ovoid measuring 38–100×15–33 μm [larger than those described from specimens from the Canary Islands that measured (35)–62–68×10–25 μm; Martin et al. 1996]; plurilocular sporangia have not been observed on the erect thallus. *Papenfussiella kuromo* grows at eulittoral levels epilithically, and epiphytically on *Cystoseira* spp.

Papenfussiella kuromo is known from the Canary and Salvage Islands, Japan, and China.

Specimens examined: Azores: Faial, Porto Eira, 11.02.2006, BM000769311 (BM); Graciosa, Baia de Santa Catarina, 30.06.2006, GRW-06-485 (UA); Graciosa, Baia das Caldeirinhas, 04.07.2006, GRW-06-649 (UA); Graciosa, Baía das Caldeirinhas, 04.07.2006, GRW-06-669 (UA); Graciosa, Porto Afonso, 05.07.2006, GRW-06-587 (UA); Graciosa, Porto Afonso, 07.07.2006, GRW-06-731; São Miguel, Pópulo, 25.04.1990, SMG-90-95d (UA); São Miguel, Maia, 08.04.1999, SMG-99-728 (UA); São Miguel, Maia, 09.03.2005, SMG-05-87 (UA); São Miguel, São Vicente, 20.03.2002, SMG-02-73 (UA).

Fucales, Fucaceae: *Ascophyllum nodosum* (Linnaeus) Le Jolis Described and illustrated by Baardseth (1970, pp. 1:1–1:5, figures 1–3); Cabioc'h et al. (2006, p. 100, figure 49).

Plants comprise strap-shaped thalli to 0.5 m long (in the Azores) with bladders along the main axis and branches; primary branching is dichotomous, secondary branching bilateral. Globular receptacles are formed on small lateral branchlets and contain mature male and female conceptacles; plants dioecious. *Ascophyllum nodosum* occurs commonly in the Azores as drift plants with a single attached record for the island of Graciosa.

Ascophyllum nodosum is widespread in the northern North Atlantic Ocean.

Specimens examined: Azores: Faial, 04.07.1965, BM000633041 (BM); Faial, 06.08.1965, BM000633040 (BM); Faial, Cais de Santa Cruz, 25.09.1971, BM0006-12939 (BM); Corvo, Porto da Areia, BM000633042 (BM); Faial, Monte de Guia, 20.07.1989, BM000054147; Flores, Ponta Delgada, 04.08.1995, BM000044469 (BM); Graciosa, Porto Afonso, 14.06.2004, GRW-04-148 (UA); Graciosa, Porto Afonso, 14.06.2004, GRW-04-149 (UA); Graciosa, Porto Afonso,14.06.2006, BM000804907 (BM); São Miguel, Praia do Pópulo, 05.05.1990, SMG-90-98 (UA), 31.05.2003, SMG-03-131 (UA).

Rhodophyta, Florideophycideae, Gelidiales, Gelidiellaceae: *Gelidiella tinerfensis* Seoane-Camba Described and illustrated by Seoane-Camba (1977, pp. 127–134, figures 1–4).

Small blackish-red, wiry, turf-forming plants that grow to 19 mm tall. Erect and prostrate filiform axes are attached to the substratum by rhizoidal filaments. Axes are branched and measure 1 mm in diameter. Axes have a distinct apical cell, are pseudoparenchymatous with an obvious cortex and medulla; rhizines are absent in the medulla and surface cortical cells are irregularly arranged. Tetrasporangial specimens were collected in March 2004; tetrasporangia develop in slightly swollen terminal sori, are tetrahedrally divided and measure 30 μm in diameter. *Gelidiella tinerfensis* grew on eulittoral rocks and among other species in lower eulittoral multispecific turfs.

The species was formerly known only from the Canary Islands and the new Azores record extends its known distributional range.

Specimens examined: Azores: Flores, Cedros, 03.2004, FLO-99-25 (UA); Graciosa, Lagoa, 22.06.2006, GRW-06-135 (UA); Graciosa, Carapacho, 26.06.2006, GRW-06-254, HIS-08-69 (UA); Graciosa, Carapacho, 26.06.2006, GRW-06-279 (UA); Santa Maria, São Lourenço, 06.06.2005, SMA-05-59 (UA).

Gigartinales, Phyllophoraceae: *Phyllophora gelidioides* P. Crouan *et* H. Crouan *ex* Karsakoff Described by Karsakoff (1896, pp. 290–291); Afonso-Carrillo and Sansón (2000, p. 76).

Plants grow to 20 mm in height and consist of flattened, subdichotomously divided blades borne on cylindrical stipes arising singly or in clusters from a discoid base. In section, the thallus, 179 μm across, has a multiaxial structure with a medulla of large cells (30–40 μm in diameter) surrounded by a cortex of smaller pigmented cells that measure 4×6 or 6×6 μm in surface view. Our specimens were sterile. Plants grew at low eulittoral levels in crevices on open rock often among other algae.

Phyllophora gelidioides was formerly known only from the Canary Islands and the new Azores records extend its distributional range.

Specimens examined: Azores: Graciosa, Praia, 24.06.2006, GRW-06-198; São Miguel, Lagoa, 19.02.2003, SMG-03-62 (UA).

Rhodymeniales, Lomentariaceae: *Gelidiopsis intricata* (C. Agardh) Vickers Described and illustrated by Norris (1987, p. 240, figures 10, 11); Afonso-Carrillo and Sansón (2000, p. 96).

Erect thalli arise from a stoloniferous base and form mat-like growths to 10 mm high of subcylindrical to compressed, subdichotomous to irregularly branched intertwining fronds that anastomose occasionally. Fronds are 255 μm across in transverse section and have a multiaxial structure with a cortex composed of an outer layer of cuboidal cells surrounding progressively larger, increasingly elongate cells and a medulla composed of loosely aggregated elongated filaments in a thin gelatinous matrix. Rhizoids to 214 μm wide are laterally inserted on the thallus. *Gelidiopsis intricata* grew in the algal turf at lower eulittoral levels.

Gelidiopsis intricata has been recorded in the Atlantic Ocean from Madeira, the Canary Islands, Bermuda, the Caribbean Basin, and Brazil; it also occurs in the Indian and Pacific Oceans.

Specimens examined: Azores: Flores, Ponta Delgada, 06.07.1999, FLO-99-113 (UA); São Miguel, Faial da Terra, 18.04.2003, SMG-03-77 (UA).

Ceramiales, Ceramiaceae: *Halurus equisetifolius* (Lightfoot) Kützing Described and illustrated by Maggs and Hommersand (1993, pp. 172–175, figure 56); Cabioc'h et al. (2006, p. 118, figure 78).

Thalli to 20 mm long, formed of a somewhat cartilaginous main axis that bears whorls of uniseriate, ecorticate, dark red filaments measuring 38 μm in width. The thallus is irregularly and repeatedly branched and the whorled ramuli are short, incurved and di-trichotomously branched. Cells of whorled ramuli are narrow (5 μm wide) at the apical region and gradually increase and double their size towards the base (basal cells to 10 μm wide). An uncommon alga in the Azores, found only once on rock at sublittoral levels.

This species occurs in the Atlantic Ocean from the British Isles to the Canaries, and in the Mediterranean Sea.

Specimen examined: Azores: Formigas, western side, 02.07.1991, FOR-91-48 (UA).

***Monosporus pedicellatus* (J.E. Smith) Solier** Described and illustrated by Maggs and Hommersand (1993, pp. 190–192, figure 62).

Thalli of uniseriate filaments that grow in dense tufts and consisting of fastigiately to divaricately branched erect axes 35 mm high, attached to the substratum by tangled rhizoidal holdfasts. The cells of the main axes are cylindrical or inflated at both ends, the basal ones to 433 μm in diameter; apical cells are mucronate. Branching is irregularly alternate or pseudodichotomous. Rhizoidal cells, 38–71 μm across, emerge from lower ends of basal cells. Unicellular propagules are ovoid to pyriforme measuring 51–112×31–92 μm and developed on the upper ends of laterals on pedicels formed by a single obconical cell (Figure 3). Gametangia and tetrasporangia have not been observed in the Azores. Never abundant, this species was only found in early summer growing in pools and at shallow subtidal levels.

Monosporus pedicellatus is widely distributed in Europe from southern Norway to the Canaries and in the Mediterranean Sea.

Specimens examined: Azores: São Miguel, Mosteiros, 05.06.2004, SMG-04-137 (UA); São Miguel, Lagoa 18.07.1997, SMG-97-204 (UA).

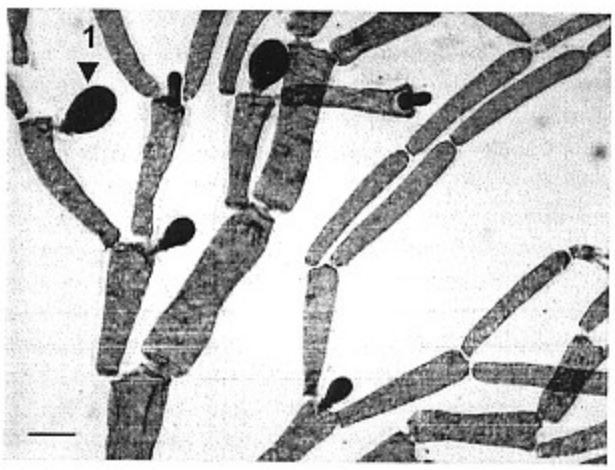

Figure 3 *Monosporus pedicellatus*: branched filaments with propagules (1).
Scale bar=100 μm.

Dasyaceae: *Eupogodon planus* (C. Agardh) Kützing Described and illustrated by de Jong et al. (1997, pp. 435–439, figures 25–40).

Azores plants are erect (elsewhere subprostrate), 23–55 mm high, dichotomously to irregularly branched, consisting of several irregular and entangled, branched main axes up to 765 μm in width arising from a central holdfast. Axes bear short spine-like branches, are terete to slightly flattened, and randomly produce determinate ramelli from each polysiphonous segment of an indeterminate axis. Pseudolaterals are pigmented, monosiphonous except at the extreme base. Four to five periaxial cells surround the axial cell row, but are obscured in the lower region by dense cortication. Tetrahedral sporangia, 61×82 to 61×102 μm, are formed in successive whorls on short adventitious branches. A single specimen was collected in June in a pool on the west coast of São Miguel Island.

Eupogodon planus is known from the Canary Islands, Mediterranean Sea, and, doubtfully, the Pacific Ocean.

Specimen examined: Azores: São Miguel, Mosteiros, 05.06.2004, SMG-04-125 (UA).

Rhodomelaceae: *Digenea simplex* (Wulfen) C. Agardh Described and illustrated by John et al. (2003, pp. 93–94, figure 26C, plate 6E).

Plants comprised erect polysiphonous cylindrical thalli, 15–40 mm high, axes 163 μm in diameter with few indeterminate branches and clothed with short determinate laterals. The thallus has a parenchymatous cortex with spirally arranged branchlets 0.8–2 mm long and sometimes lacking cortication. Pericentral cells 7–8, obscured in primary axes by a cortex. This is a rare species in the Azores and was only found on the Formigas Islets in rock pools in early summer (June).

Digenea simplex is known from the tropical and warm temperate Atlantic Ocean (the Canaries, West Africa, Cape Verde Islands, Brazil, Bermuda, Caribbean Sea), Mediterranean Sea, Indian and Pacific Oceans.

Specimens examined: Azores: Formigas Islets, Ponta Norte, 05.06.1990, FOR-90-46 (UA); Formigas Islets, Ponta Oeste, 06.06.1990, FOR-90-104 (UA); Formigas Islets, Baía Este, 08.06.1990, FOR-90-160 (UA).

***Laurencia microcladia* Kützing** Described and illustrated by Furnari et al. (2001, pp. 353–356, figures 35–39).

Erect, sparingly branched plants 15–45 mm high are pyramidal in shape and arise from a stoloniferous base. Branches are 0.5–1 mm wide, cylindrical to slightly compressed. The ultimate branchlets are truncate, slightly narrower than other branches and with blunt apices. The thallus is composed of 2–3 layers of small cortical cells (26×30 to 31×36 μm in surface view) surrounding larger medullary cells that measure 61×133 μm; the cortical cells have secondary pit connections and the medullary cells have lenticular thickenings. The species was recorded once in late spring at lower eulittoral levels.

Laurencia microcladia is known in the Macaronesian region of the Atlantic Ocean (Madeira to Cape Verde Islands), also West Africa, Brazil, Bermuda, and the Car-

ibbean Sea. Elsewhere, it occurs in the Mediterranean Sea, Southeast Asia and Samoa in the Pacific Ocean.

Specimen examined: Azores: Santa Maria, Baía de São Lourenço, 06.06.2005, SMA-05-49 (UA).

Confirmed records

Chlorophyta, Bryopsidophyceae, Bryopsidales, Caulerpaceae: *Caulerpa webbiana* Montagne Described and illustrated by Littler and Littler (2000, pp. 378–379); Afonso-Carillo and Sansón (2000, p. 134). *Caulerpa webbiana* grows at infralittoral levels to 10 m depth in Horta Harbor and the nearby Monte de Guia caldeira on the island of Faial. For distributional information, see Guiry and Guiry (2008).

Specimens examined: Azores: Faial, Horta Harbor – Ponte dos Radares, 10.10.2002, BM000804908 (BM); Faial, Horta Harbor – Ponta da Doca, 09.02.2006, BM000804900 (BM).

Rhodophyta, Florideophycideae, Gigartinales, Phyllophoraceae: *Ahnfeltiopsis devoniensis* (Greville) Silva *et* DeCew Described and illustrated by Cabioc'h et al. (2006, p. 144, figure 119); Maggs et al. (1992, pp. 214–232, figures 5–57). The species grows on rocks at lower eulittoral and sublittoral fringe levels as occasional tufts. For distributional information, see Guiry and Guiry (2008).

Specimens examined: Azores: Graciosa, Fenais, 08.07.2006, GRW-06-760 (UA); São Miguel, Pópulo, 10.06.1989, SMG-89-06 (UA); São Miguel, Pópulo, 10.06.1989, SMG-89-24 (UA); São Miguel, São Roque, 15.09.1999, BM000769428 (BM); São Miguel, São Vicente, 21.07.1997, SMG-97-244; São Miguel, Vila Franca, 22.07.1997, SMG-97-293; São Miguel, São Roque, 29.05.2003, SMG-03-130 (UA).

Ceramiales, Ceramiaceae: *Halurus flosculosus* (J. Ellis) Maggs *et* Hommersand Described and illustrated by Maggs and Hommersand (1993, pp. 175–178, figure 57); Cabioc'h et al. (2006, p. 113, figure 69). *Halurus flosculosus* grew on shaded rocks and in pools. For distributional information, see Guiry and Guiry (2008).

Specimens examined: Azores: Graciosa, Fenais, 29.06.2006, GRW-06-738 (UA); Graciosa, Porto Afonso, 07.07.2006, GRW-06-738 (UA); São Miguel, Mosteiros, 05.06.2004, SMG-04-130 (UA); São Miguel, Maia, 09.03.2005, SMG-05-77 (UA). These confirm a record from Flores in 1995 (Tittley et al., 1998) not vouched by specimens.

Delesseriaceae: *Drachiella minuta* (Kylin) Maggs *et* Hommersand Described and illustrated by Kylin (1924, p. 56, figure 44a); Maggs and Hommersand (1993, pp. 236–238, figure 74). Plants grew at low eulittoral levels epiphytic on larger algae and epilithic. For distributional information, see Guiry and Guiry (2008).

Specimens examined: Azores: São Miguel, Caloura, 05.02.2003, SMG-03-10 (UA); São Miguel, Caloura, 25.02.2003, SMG-03-48 (UA); São Miguel, São Antonio, 21.03.2002, SMG-02-119 (UA). These confirm a record by Ardré et al. (1973) for which voucher specimens are not available.

Rhodomelaceae: *Erythrocystis montagnei* (Derbès *et* Solier) P.C. Silva Described and illustrated by De Masi and Gargiulo (1982, pp. 113–117, figures 1–5); John et al. (2003, p. 94). Not uncommonly hemiparasitic on *Osmundea*, *Chondrophycus* and *Laurencia* spp. at low eulittoral levels. For distributional information, see Guiry and Guiry (2008).

Specimens examined: Azores: Graciosa, Santa Cruz, 21.06.2006, GRW-06-13 (UA); Graciosa, São Mateus (Praia), 13.06.2004, GRW-04-142 (UA); Graciosa, Baía das Calderinhas, 04.07.2006, GRW-06-655 (UA); São Miguel, Mosteiros, 05.06.2004, SMG-04-126 (UA); Santa Maria, Emissores, 20.06.2005, SMA-05-183 (UA); Santa Maria, Ilhéu da Vila, 28.06.2005, SMA-05-211 (UA).

Excluded species

The filamentous red alga and obligate epiphyte on *Ascophyllum nodosum*, *Polysiphonia lanosa* (Linnaeus) Tandy, has been incorrectly referred to the Azores (John 1974, Neto 1994), although drift *A. nodosum* occurs commonly. The non-native brown alga *Colpomenia peregrina* Sauvageau introduced to European waters in the early 20th century has also not been confirmed for the Azores and *Colpomenia sinuosa* (Endlicher) Derbès *et* Solier (distinguished by a different shape of the sporangial sori) is locally common; the *C. peregrina* records are probably misidentifications. There is also no evidence that the green alga *Cladophora rupestris* (Linnaeus) Kützing occurs in the Azores and previous records unconfirmed by specimens are probably *Cladophora prolifera* (Roth) Kützing that is widespread and common (cf. Neto et al. 2006). All bullate forms of *Codium* have proved to be *Codium elisabethiae* O.C. Schmidt (cf. Neto et al. 2006); records of the superficially similar *Codium bursa* are probably misidentifications.

Discussion and conclusion

The new records and confirmations comprise 12 Rhodophyceae, 3 Phaeophyceae, 2 Bryopsidophyceae, and 1 Ulvophyceae, continuing the predominance of Rhodophyceae in the flora as elsewhere in Macaronesia. The determination of *Phyllophora gelidioides* is provisional as the species is poorly known in Macaronesia. The strong warm-water floristic and ecological affinity with the algal flora of the nearer Macaronesian islands (cf. Tittley and Neto 2006) is supported by the new records discussed here and also by a new species described from the Azores and other Macaronesian islands, *Botryocladia macaronesica* Afonso-Carrillo, Sobrino, Tittley *et* Neto (Afonso-Carrillo et al. 2006).

Of the 13 species recorded new to the Azores and the 4 confirmed, 7 show extensions in distributional range. The discovery of *Codium taylorii*, *Digenia simplex*, *Gelidiopsis intricata*, *Gelidium tinerfensis*, *Laurencia microcladia*, *Papenfussiella kuromo*, and *Phyllophora gelidioides* in the Azores extends northward their distributional ranges in the Macaronesian region and the Atlantic Ocean. The record of *Eupogodon planus* represents a western extension in its distributional range. The Azores records of other species (*Cladophora pellucida*,

Erythrocystis montagnei, *Halurus equisetifolius*, *Halurus flosculosus*, *Monosporus pedicellatus*, and *Myriactula rivulariae*) are within their distributional ranges.

The species considered in this study show three main global distribution patterns; none are endemic to the Azores. The distributions of *Ahnfeltiopsis devoniensis*, *Ascophyllum nodosum*, *Drachiella minuta*, *Erythrocystis montagnei*, *Gelidiella tinerfensis*, *Halurus equisetifolius*, *Halurus flosculosus*, *Myriactula rivulariae*, *Monosporus pedicellatus*, and *Phyllophora gelidioides* are mostly restricted to the Atlantic Ocean and Mediterranean Sea. Of these, *Gelidiella tinerfensis* and *Phyllophora gelidioides* are known only from Macaronesia. *Caulerpa webbiana*, *Cladophora pellucida*, *Codium taylori*, *Digenea simplex*, *Eupogodon planus*, *Gelidiopsis intricata*, and *Laurencia microcladia* are more widespread and many occur in the Atlantic, Indian, and Pacific Oceans. *Papenfussiella kuromo* has a disjunct distribution (Macaronesia and Japan).

Cardigos et al. (2006) reported the occurrence of the pan-tropical *Caulerpa webbiana* on Faial in 2002 and it is likely that its appearance there was relatively recent (cf. Tittley and Neto 1994). Cardigos et al. (2006) suggested that its appearance in Horta harbor may have involved an anthropogenic vector, although its presence on Madeira and in the Canary Islands suggests the possibility of natural dispersal to Faial. The tropical *Halimeda tuna* (J. Ellis *et* Solander) J.V. Lamouroux was recorded by Fralick and Hehre (1990) once in the 1980s in a tide pool on the island of Flores in the Azores, but has not been found since then and may have been a natural ephemeral occurrence since it occurs in the Canary Isles. Unlike *H. tuna* and like *Caulerpa* species elsewhere, *C. webbiana* has become a permanent component of the local flora; its native or non-native status remains uncertain.

The record of *Ascophyllum nodosum* on Graciosa confirmed the surmise by Baardseth (1970) that it grew attached in the Azores. *Ascophyllum* occurs only in the North Atlantic Ocean, northward to the Arctic region and southward to northern Portugal (Ardré 1970) and to Delaware (Humm 1979) where it is common. Schneider and Searles (1991) found it in North Carolina just north of Cape Hatteras where it occurred rarely as typical plants and also as a form that resembled the ecad *mackayi* (Turner) Holmes *et* Batters. Further south, *A. nodosum* has been reported only as drift from Madeira (Neto et al. 2001), the Canary Islands (Haroun et al. 2001), south of the equator (John 1974), Bermuda, the Sargasso Sea (Humm 1979), Venezuela and Brazil north of the equator (John 1974). Drift material has also been found in the Pacific Ocean (San Francisco Bay) probably derived from discarded seafood packing and a population of ecad *mackayi* became established there; it was subsequently eradicated (Miller et al. 2004). In July 2004, *A. nodosum* was collected attached in the Azores for the first time at Porto Afonso on the island of Graciosa at mid-eulittoral levels, in a deep sheltered cleft between large boulders on a moderately wave-exposed shore. A reinvestigation of the site in July 2006 failed to re-locate the population.

The small North Carolina population of typical *Ascophyllum nodosum* at latitude 35.5° N is south of its southern limit in northern Portugal at 41.75° N and the Azores at 39° N. The mean summer surface sea temperatures at these locations are 25°C, 18°C, and 20°C, respectively (Morton et al. 1998). *A. nodosum* has a wide temperature tolerance of 0°C–28°C with optimal growth at around 15°C (Lüning 1990). The Azores mean annual temperature range of 13°C–20°C is within the temperature tolerance of *Ascophyllum* and close to the optimum growth temperature. Its absence in the Azores is unlikely to be caused by temperature but by factors, such as wave-exposure, grazing, and propagule input. The sheltered habitat requirements for variety *mackayi* are absent in the Azores. The origin of drift *A. nodosum* in the Azores is uncertain. Drift material of *A. nodosum* reaching the Azores often has fertile male and female conceptacles, and thus there is the possibility of sexual reproduction and the formation of a small population. Tittley (1986) and Bartsch and Kuhlenkamp (2000) showed its successful spread over short distances in the southern North Sea, including the island of Helgoland 60 km from the continental mainland following the creation of suitable habitats and probably involving drift material which is common there. *Ascophyllum* grows on the isolated Faroe islands 350 km from Scotland and 450 km from Iceland where it is also present (Tittley et al. 2005).

Reference to *Gymnogongrus crenulatus* by Schmidt (1931) may have been *Ahnfeltiopsis devoniensis* as cystocarps are referred to rather than carpotetrasporangia. The two species were recorded as occupying similar habitats in the Azores and the species were not always recognized as separate entities (cf. Dixon and Irvine 1977). The Azores occurrence is within the overall distributional range of *A. devoniensis*.

The present study raises questions as to the dispersal of species to the mid Atlantic Azores archipelago; it suggests natural and anthropogenic vectors involving propagule spread, rafting, and perhaps ship fouling. Our records show a considerable natural ephemeral component of the flora, as some of the species discussed have been found on a single occasion only. The current total of species recorded from the Azores stands at 54 Chlorophyta, 72 Ochrophyta (Phaeophyceae), and 243 Rhodophyta, 368 in total, and will increase with future taxonomic and floristic studies.

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