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New foliose and gelatinous red macroalgae (Rhodophycota) from the Azores: morphological and geographical observations

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Abstract

The following four species of foliose and gelatinous red algae (Rhodophycota) are newly recorded for the Azores archipelago (North Atlantic Ocean): *Gracilaria multipartita* (Clemente) Harvey, *Meristotheca decumbens* Grunow (Solieriaceae), *Asteromenia peltata* (W.R. Taylor) Huisman and A.J.K. Millar (Rhodymeniaceae), and *Agardhinula browneae* (J. Agardh) De Toni (Faucheaceae). The species are described, and information on reproductive status, ecology and biogeographical relationships is provided. © 2002 Published by Elsevier Science B.V.

Keywords: Rhodophycota; Atlantic Ocean; Azores; New records; *Gracilaria multipartita*; *Meristotheca decumbens*; *Asteromenia peltata*; *Agardhinula browneae*

1. Introduction

In recent years, there has been much research on the marine flora of the Azores archipelago, but relatively little attention has been given to the gelatinous and foliose red macroalgae. Prud'homme van Reine (1988) reported 114 red algal species and described the marine flora of these islands as dominated by long-dispersal range species. Of the 193 species of Rhodophycota from the Azores listed by Neto (1994), *Dumontia contorta* (S.G. Gmelin) Rupr., *Nemastoma confusum* Kraft and John, *Itonoa marginifera* (J. Agardh) Masuda and Guiry, *Platoma cyclocolpum* (Montagne) F. Schmitz and *Schizymenia dubyi* (Chauvin)

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J. Agardh were the only fleshy red algae reported for the islands. Since then (Neto, 1994), many other species have been recorded and described for the archipelago, but mainly filamentous red, and filamentous and crustose brown algae (Tittley et al., 1998, 2001; Parente and Neto, 2000; Parente et al., 2000). Since 1996, we have searched carefully around the São Miguel Island for foliose gelatinous species of red algae. As a result of this survey, four new species are established, along with data on their morphology, distribution and ecology.

2. Materials and methods

Between 1996 and 1999, specimens were collected from the intertidal and subtidal zones of São Vicente on the north coast of the São Miguel Island (Azores, Fig. 1).

In the laboratory, algae were identified using a combination of stereo and compound microscopes. For anatomical studies, permanent slides were prepared of all specimens collected. Thin sections and/or squash preparations of the thallus were mounted in 50% aqueous "Karo" corn syrup, after staining in aniline blue. For all specimens, camera lucida drawings of cross-sections of the thallus were made using a WILD M5 drawing system. Where appropriate, measurements were made of cells and other structures using a calibrated micrometer eyepiece. For each specimen, a drawing of the habit was made. A reference collection was made by giving each specimen a herbarium code number and storing algae

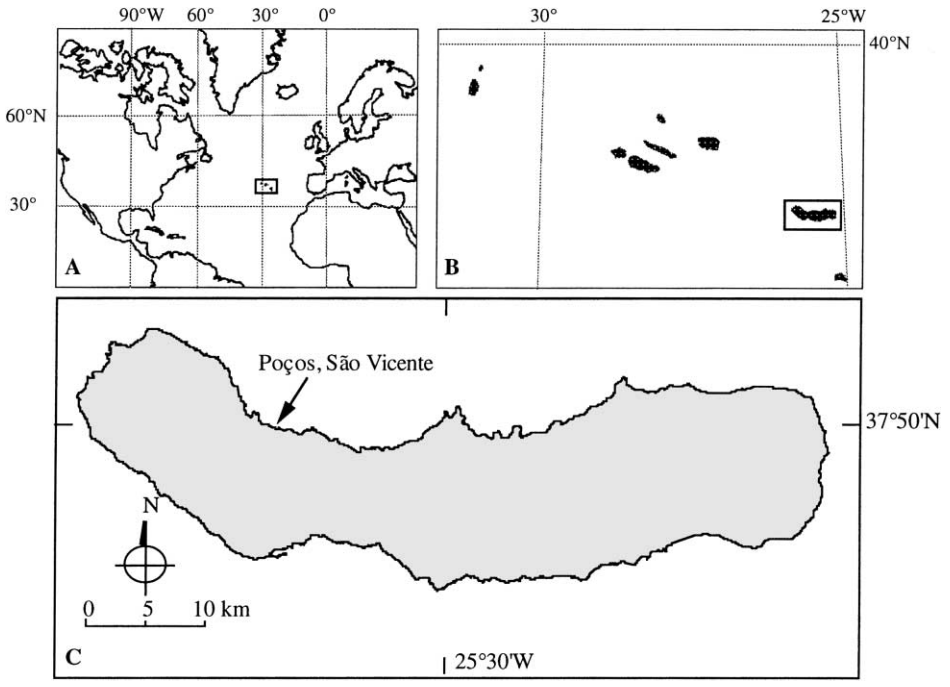

Fig. 1. (A) Location of the Azores archipelago in the North Atlantic; (B) position of the São Miguel Island in the archipelago; (C) location of the study site on São Miguel.

in 5% buffered formaldehyde seawater solution. These code numbers are provided in the results under each species name. All specimens are deposited at the Departamento de Biologia da Universidade dos Açores (DB/UA). The systematic arrangement, including the ordinal and lower classification schemes, follows mainly Silva et al. (1996). Nomenclatural authorities, in accordance to Brummitt and Powell (1992), are given in full, mainly to avoid confusion due to different abbreviation systems.

3. Results

3.1. Gracilaria multipartita (Clemente) Harvey (Gracilariaceae) (SMG-97-58)

Epilithic thallus attached by a small disc which gives rise to an erect frond up to 7.1 cm long (Fig. 2). Light red in colour, this translucid and cartilaginous plant had a compressed stipe, expanding gradually into a cuniate laciniate blade up to 415 μm thick. Branching was irregularly dichotomous in the plane of the blade, with some marginal proliferations (Fig. 2a). The medulla was composed of large cells (60 μm × 65 μm–132 μm × 180 μm), surrounded by a cortical layer of two to three cells deep (Fig. 2b), the outermost measuring 4 μm × 8 μm–8 μm × 16 μm, the inner layer being composed of slightly larger cells (8 μm × 12 μm–29 μm × 43 μm).

The plant was fertile, bearing cruciately-arranged tetraspores, 23 μm × 29 μm–34 μm × 60 μm (Fig. 2b), scattered in the younger parts of the blade.

This species is known from the British Isles to Senegal, Mediterranean, Nova Scotia to Uruguay, Red Sea, Indian Ocean (see Dixon and Irvine, 1977) and southwest Pacific (Silva et al., 1987) (Fig. 3). It occurs from the upper sublittoral down to several metres depth, tolerating a wide degree of exposure to wave action and sand and mud cover (Dixon and Irvine, 1977). In the Macaronesian region, it was reported from subtidal habitats in Lanzarote Island (Canaries) by Piccone (1884) as *G. corallicola* (see Prud'homme van Reine et al., 1994, p. 91). More recently, it was found on a sandy bottom at 35 m depth (Reyes et al., 1993). In the Azores, it was collected at 25 m depth in July 1997 where large boulders are interspaced with sand. This record extends the distribution of this species further north into Macaronesia.

3.2. Meristotheca decumbens Grunow (Solieriaceae) (SMG-96-341)

Thallus epilithic, up to 4.3 cm total length, attached by a discoid holdfast, which gives rise to a short stipe from which originates a dichotomous to trichotomous branched blade 650–1660 μm thick, saxicolous, firm, gelatinous and light rose in colour (Fig. 4a). The medulla was composed of loosely-arranged filaments (7–14 μm diameter), interspaced by stellate cells, 26–46 μm diameter. The four-layered cortex is composed of outer elliptical cells (4 μm × 7.5 μm–5 μm × 12.5 μm), intermediate and inner elongated cells (7.5 μm × 10 μm–9 μm × 15 μm, 14.5 μm × 29 μm–24 μm × 45 μm, respectively; Fig. 4b). The specimen was fertile bearing irregularly cruciate tetraspores, 23.5–31 μm diameter, scattered in the outer cortex.

This species is known from subtidal stations in all the other islands of Macaronesia (Fig. 3), including Madeira (Piccone, 1884; Prud'homme van Reine et al., 1994), the

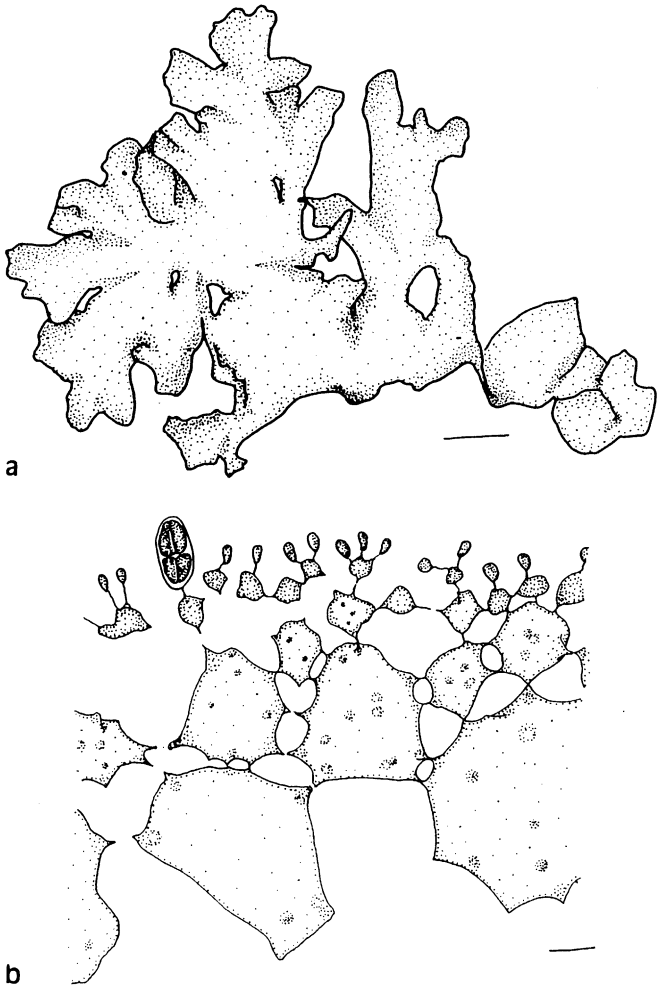

Fig. 2. *G. multipartita*: (a) habit of plant, bar = 1 cm; (b) cross-section of thallus showing the cortical cells, the outer medullary cells and the cruciately-arranged tetraspores, bar = 20 μm.

Canaries and Cape Verde (Prud'homme van Reine et al., 1994). In the Azores, it was collected at 15 m depth in July 1996 from a rocky bottom. This new record increases its distribution further north into Macaronesia and the central North Atlantic Ocean.

3.3. Asteromenia peltata (W.R. Taylor) Huisman and A.J.K. Millar (Rhodymeniaceae) (SMG-96-327)

Epilithic, saxicolous, firm gelatinous and rose red in colour, the plant measuring 6.2 cm total length (Fig. 5a) was attached by a discoid holdfast, which gives rise to a short stalk. Secondary attachment was provided by haptera tissue from the downturned margins of the

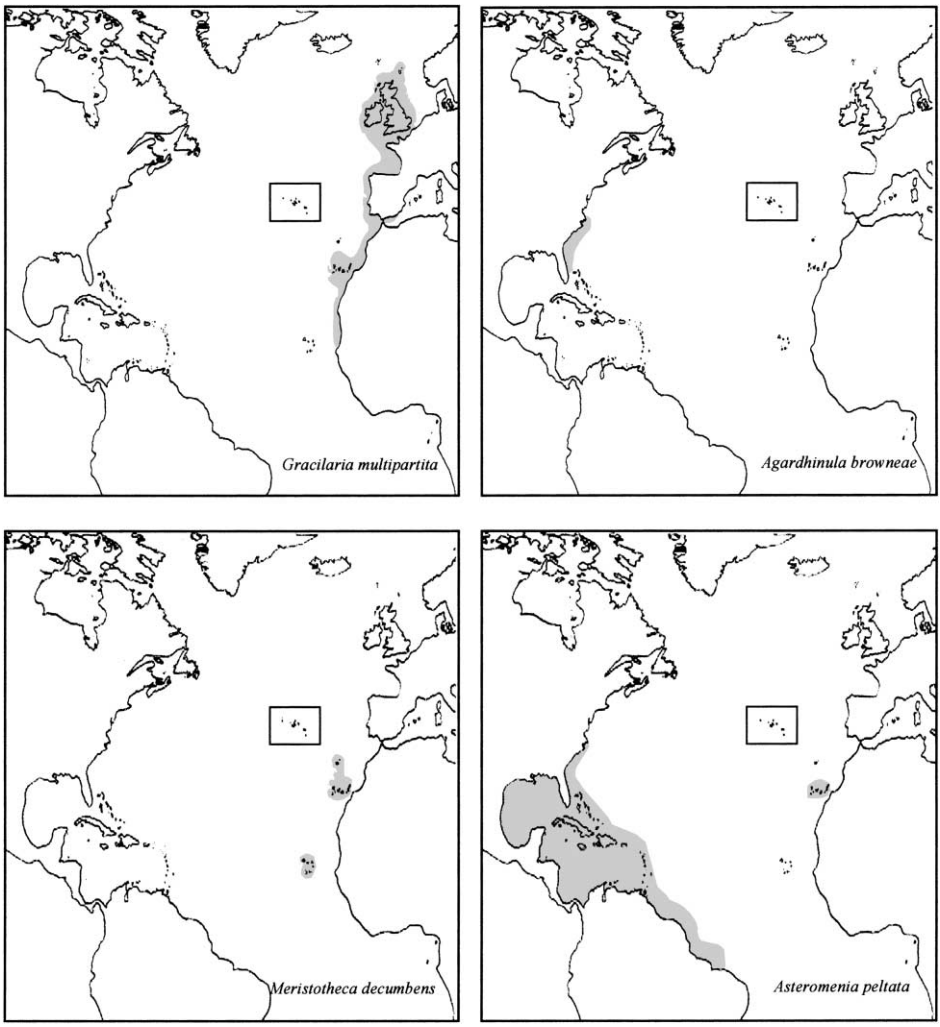

Fig. 3. Geographic distribution of the studied species.

ventral surfaces of the blade. This, initially lobate, became subdichotomously branched, branches overlapping and fusing with one another. Margins of blade were undulate and, occasionally, proliferous. Blade had obtuse apices, 270–368 μm thick. The thick medulla, comprising much of the blade thickness, was composed of large cells (41 μm × 100 μm–132 μm × 180 μm) and gives rise to a three-layered cortex of subglobose, irregularly-rounded cells, the outer ones measuring 4 μm × 6.5 μm–5 μm × 10.5 μm, the inner ones 12 μm × 14.5 μm–17 μm × 21.5 μm (Fig. 5b). The specimen was sterile.

The Azorean plant was collected in July 1996 in the lower intertidal zone, whereas in other locations *A. peltata* appeared always in the subtidal.

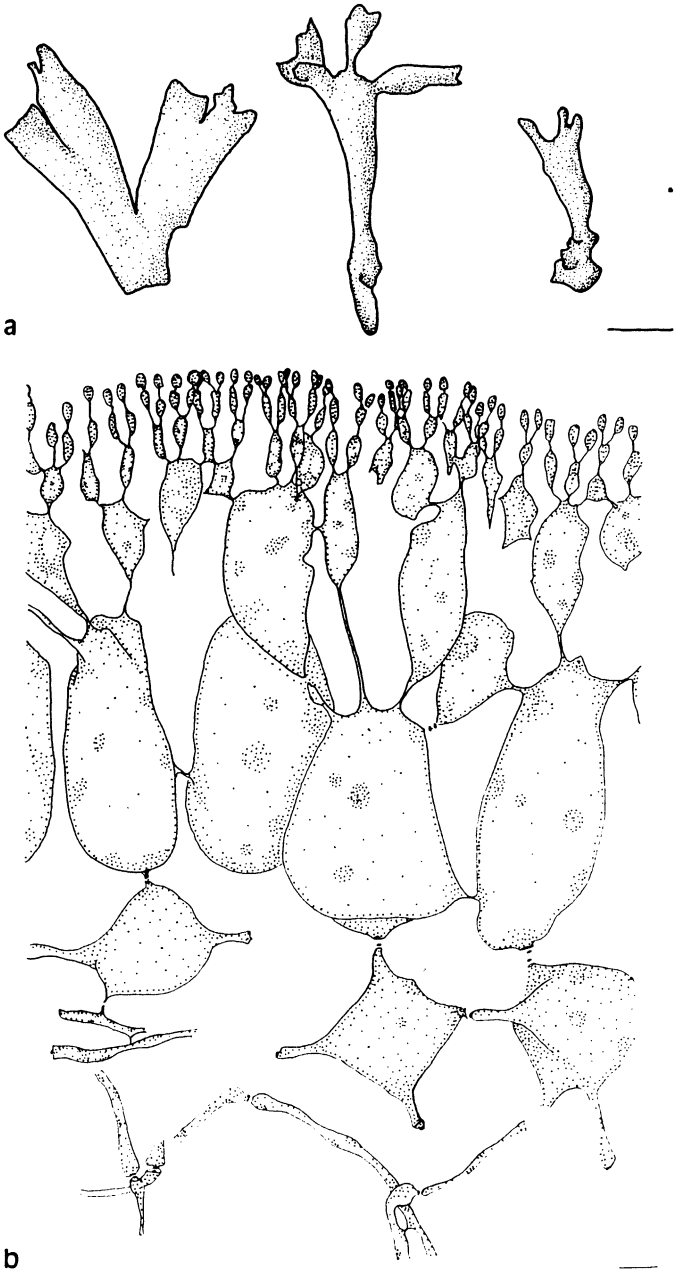

Fig. 4. *M. decumbens*: (a) habit of plant, bar = 1 cm; (b) cross-section of thallus showing the cortical and medullary cells, bar = 20 μm.

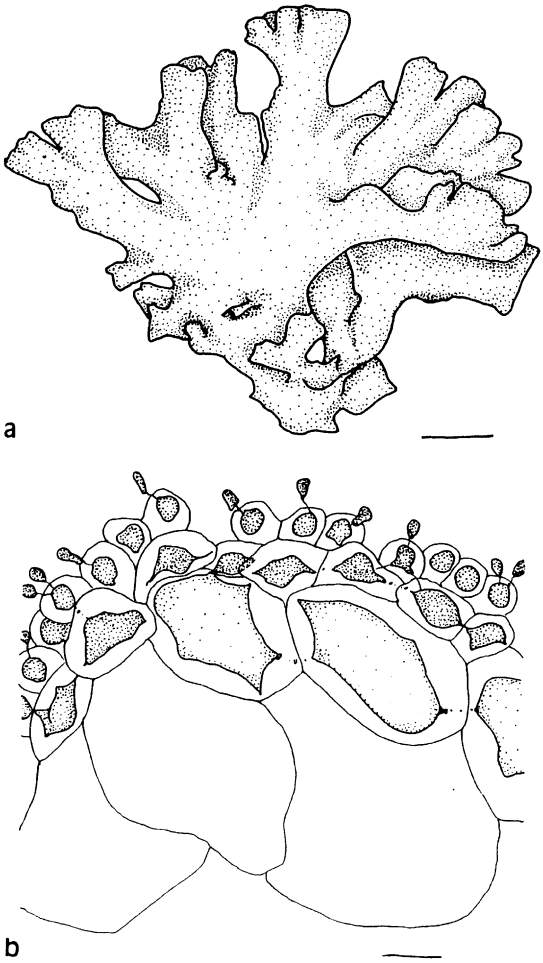

Fig. 5. *A. peltata*: (a) habit of plant, bar = 1 cm; (b) cross-section of thallus showing the cortical and medullary cells, bar = 20 μm.

This species is known from the Western Atlantic Ocean from North Carolina to Brazil (Schneider and Searles, 1991; Wynne, 1998), the Canary Islands (Eastern Atlantic Ocean) where it was reported also as a subtidal species (Haroun et al., 1993), and from the Indian Ocean (Silva et al., 1996). Its presence in the Azores fills the gap between the known populations of this species in both sides of the Atlantic Ocean (Fig. 3), extending further north its limit of distribution in the Macaronesia region.

3.4. Agardhinula browneae (J. Agardh) De Toni (Faucheaceae) (SMG-99-869)

With 10.3 cm total length, this epilithic, saxicolous, firm gelatinous, rose red algae was attached by a discoid holdfast, which gives rise to one palmate erect blade, irregularly

dichotomously to trichotomously branched (Fig. 6a). Lower axes are broader than above and have occasionally proliferous margins. Apices are rounded acute. Blades are 672–758 μm thick, the medulla comprising much of the blade thickness and being composed of large and intermixed smaller cells (Fig. 6b). In cross-section, the large medullary cells greatest

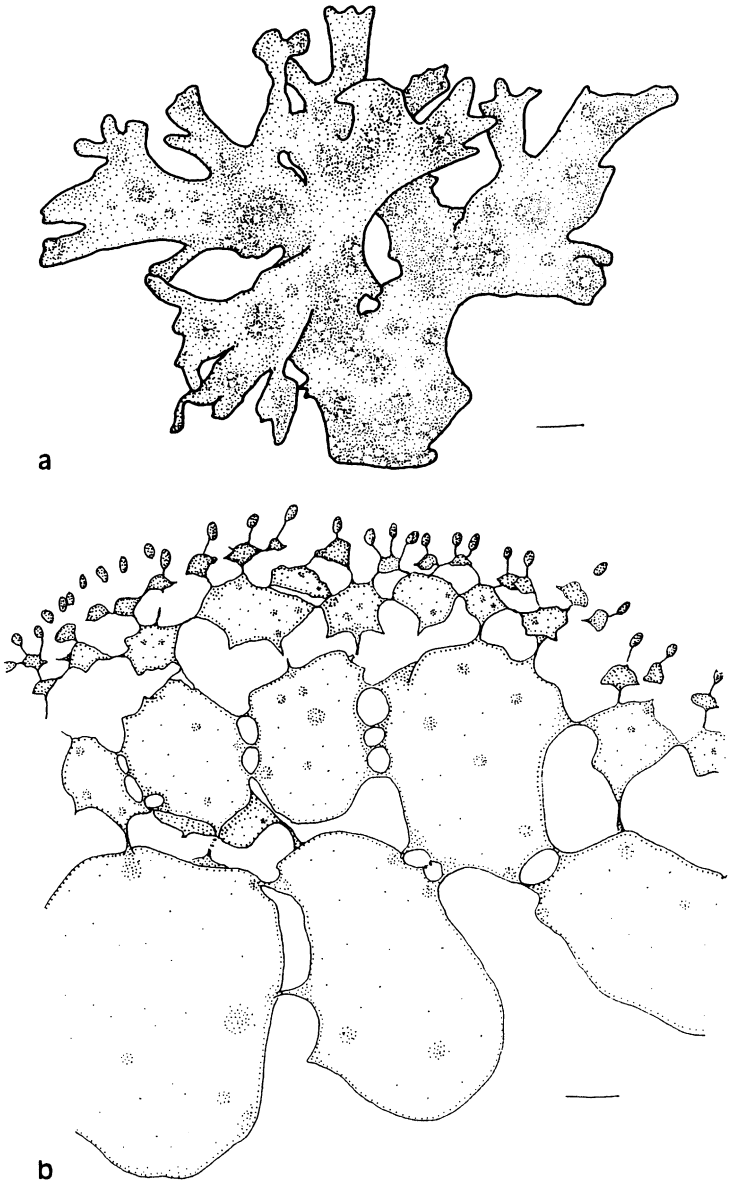

Fig. 6. *A. browneae*: (a) habit of plant, bar = 1 cm; (b) cross-section of thallus showing the cortical and medullary cells, bar = 20 μm.

dimension is 270 μm × 343 μm. The three-layered cortex (Fig. 6b) comprises an outer layer of elliptical cells (3.5 μm × 5 μm–5 μm × 9.5 μm), an intermediate layer of globose cells (9.5–19 μm in diameter) and an inner layer of more elongated cells (19 μm × 43 μm–45.5 μm × 72 μm). Only one specimen was found and it was sterile.

Frequent in the southeastern coasts of the United States from North Carolina to southern Florida (Fig. 3), where it can be occasionally abundant in localised offshore populations (Schneider and Searles, 1973, 1991). In the Azores, this macroalgae was also collected in the sublittoral zone at 12 m depth where large cobbles were interspaced with sand. This record represents its first record in the Macaronesian region and enlarges its distributional range further east in the North Atlantic Ocean.

4. Discussion

These four new records increase the number of foliose and gelatinous red algae from the Azores to 11, the Azorean algal flora counting now 220 species of Rhodophycota.

With the exception of *A. peltata*, the new records were found in subtidal habitats of São Miguel Island. Further subtidal studies along the Azorean coasts should provide other new records for the archipelago. Fredericq et al. (1992) reported 10 new subtidal macroalgae from the Azores resulting from the Harbor Branch Oceanographic Institution Expedition with the R/V "Sea Diver". Haroun et al. (1993) and Prud'homme van Reine (1998) added many subtidal macroalgae to the marine flora of the Canary Islands from the same expedition. Most of the recent additions to the Canarian marine flora result from detailed studies of subtidal habitats (Haroun et al., 2002).

The Azorean record of *G. multipartita* fits the known habitat and distributional range of this species in the North Atlantic Ocean (Dixon and Irvine, 1977; Guiry and Freamhainn, 1985).

From the present distributional records, it may be assumed that *M. decumbens* is an endemic species of the Macaronesian archipelagos of the North Atlantic Ocean and can be considered, probably as a sister species of the Caribbean *M. tobagensis* W.R. Taylor (Wynne, 1998). Apart from *M. decumbens*, other species of Solieriaceae have been identified from subtidal habitats in the southern archipelagos; these include *Sarcodiotheca divaricata* W.R. Taylor in the Canary Islands (Haroun et al., 1993) and *Meristiella gelidium* (J. Agardh) Cheney and Gabrielson (cited as *M. echinocarpa* (Areschoug) Cheney and Gabrielson by Prud'homme van Reine et al. (1994, pp. 99–101, Figs. 7 and 8) from Cape Verde. Guimarães and Oliveira (1996) reviewed the taxonomic status of flattened members of the genera *Agardhiella* and *Meristiella* from the Brazilian coasts, but this tropical-to-subtropical family deserves a more comprehensive study of the taxonomic relationships between the different genera and species reported on both sides of the Atlantic Ocean.

The presence of *A. peltata* in the Azores confirms the extension of this species towards the eastern side of the Atlantic Ocean. Prior to this record for the Azores, this common species on the American coasts was only known from the Canary Islands (Haroun et al., 1993, 2002).

A. browneae is considered as an endemic species from the warm temperate region of America and has a restricted distribution range (Schneider and Searles, 1991).

The presence of *A. browneae* and *A. peltata* on the Azores signals the relatedness of the Azores with the warm temperate region of America, in contrast to the data assembled by Prud'homme van Reine (1988) and Prud'homme van Reine and van den Hoek (1990), who argued that the absence of these species from the Azores was due to differences in temperature regimes. The numerical analysis of Tittley et al. (1990) suggested a closer affinities of the Azorean marine flora with that of North America. Ecocladistics analysis conducted by Tittley and Neto (1995) pointed to strong links between the Azorean and Iberian flora, and also affinities with the temperate American flora.

Further studies of the Azorean coasts, including collections from other islands, will probably support this suggested link between the Azorean and the temperate American floras.

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