

New records of benthic marine algae from the Canary Islands (eastern Atlantic Ocean): morphology, taxonomy and distribution

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Abstract

Four species of marine algae are reported from the Canary Islands for the first time. Our report of the western Atlantic *Gelidiella setacea* (Gelidiales, Rhodophyta) is the first from the eastern Atlantic Ocean. *Pseudotetraspora marina* (Tetrasporales, Chlorophyta) previously known on the eastern side of the Atlantic Ocean from temperate saltmarshes only, is now reported growing in the shallow sublittoral zone, the habitat in which tropical western Atlantic populations also occur. The presence of *Lomentaria chylocladiella* (Rhodymeniales, Rhodophyta) represents the first report in the Atlantic Ocean of a species previously thought to be endemic to the Mediterranean Sea. The record of the widely distributed *Acrochaetium hallandicum* (Acrochaetiales, Rhodophyta) was not unexpected. Specimens of *A. hallandicum* have vegetative cells with a single lobate parietal chloroplast with a single pyrenoid, a feature that among acrochaetoid algae occurs exclusively in the genus *Colaconema* (Colaconeatales), and consequently the species is transferred to this genus. Fertile sporophytes are described for *Gelidiella setacea*, a species previously known only in its vegetative condition. Crucially to irregularly divided sporangia are regularly arranged in transverse rows in stichidia laterally formed on the axes. The species is transferred to the genus *Parviphycus* on the basis of the morphology of the stichidia and the distichous pattern of apical division exhibited by the axes, both exclusive features of this genus.

Keywords: *Acrochaetium*; Canary Islands; *Colaconema hallandicum*; *Gelidiella*; *Lomentaria chylocladiella*; *Parviphycus setaceus*; *Pseudotetraspora marina*.

Introduction

According to the most recent list (Gil-Rodríguez et al. 2003), the marine algal flora of the Canary Islands comprises about 700 species of seaweeds, and is one of the richest and most diverse in the eastern Atlantic Ocean (John et al. 2004). Although the flora is considered to be well-documented, cataloguing marine algal richness is not yet complete in a region with a very varied littoral

zone and great diversity of habitats and environmental conditions (Afonso-Carrillo and Sansón 1999). Later studies on the coasts of the Canary Islands have added many species to the catalogue. Several new species have been described, and significant range extensions of taxa already known in other regions have been reported (Sansón et al. 2002, 2006, Afonso-Carrillo and Sobrino 2003, 2004, Afonso-Carrillo et al. 2003, 2006a,b, Afonso-Carrillo and Rojas-González 2004, Afonso-Carrillo and Tabares 2004, Díaz-Villa et al. 2004, 2005, Verlaque et al. 2004).

The aim of the present account is to add four species [*Pseudotetraspora marina* Wille, *Acrochaetium hallandicum* (Kylin) Hamel, *Gelidiella setacea* (J. Feldmann) J. Feldmann et Hamel and *Lomentaria chylocladiella* Funk] to the marine algal flora of the Canary Islands. Habitat information and morphological peculiarities of the Canarian specimens are provided. New generic placements for *Acrochaetium hallandicum* and *Gelidiella setacea* are proposed.

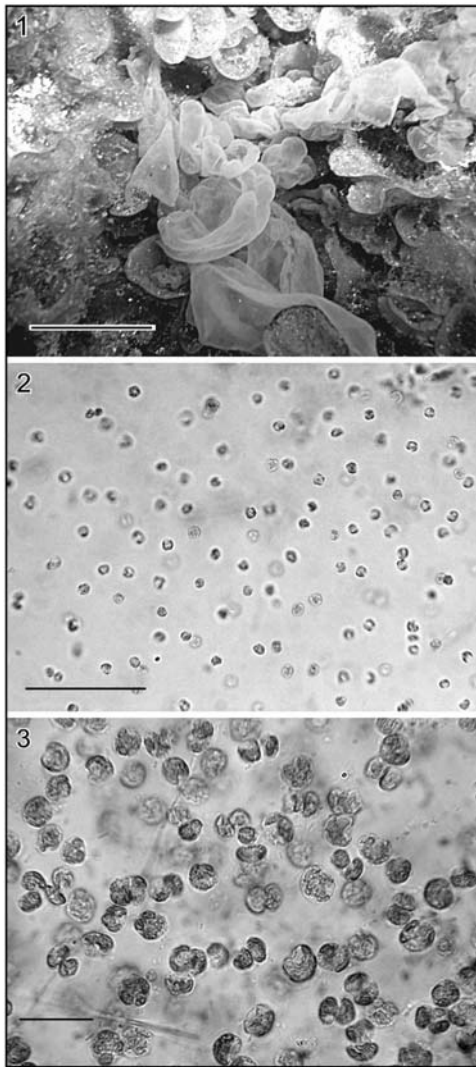
Materials and methods

Specimens were collected between 2000 and 2005 at several localities from La Palma, El Hierro and Tenerife (Canary Islands). Collections of sublittoral specimens were made by SCUBA diving and selected specimens were sorted and preserved separately in 4% formaldehyde in seawater. Permanent slides were prepared from selected fragments stained in 1% aniline blue in distilled water and mounted in a 50% Karo (Best Foods, Englewood Cliffs, USA) corn syrup solution. Sections were made by hand with a razor blade. Camera lucida drawings were made with the aid of a Zeiss standard microscope (Zeiss, Berlin, Germany). Micrographs were taken using a Nikon Coolpix 4600 digital camera (Nikon, Tokyo, Japan) attached to a Zeiss compound microscope. Voucher herbarium specimens and slides have been lodged at TFC (Departamento de Biología Vegetal, Universidad de La Laguna, Canary Islands).

Results and discussion

Pseudotetraspora marina Wille (Palmellopsidaceae, Tetrasporales, Chlorophyta) (Figures 1–3)

Selected specimens Canary Islands: Tenerife: Agua Dulce, 29.06.2004, leg. T. Díaz-Villa and C. Sangil, TFC Phyc 13093; La Palma: Puerto Trigo, 25.07.2004, leg. C. Sangil, TFC Phyc 13094; Punta del Moro, 31.08.2004, leg. C. Sangil, TFC Phyc 13095; El Hierro: Laja de Orchilla, 05.10.2005, leg. C. Sangil, TFC Phyc 13096.



Figures 1–3 *Pseudotetraspora marina* (TFC Phyc 13096). (1) Habit of several specimens growing as epiphytes on *Lobophora variegata* in its natural habitat. (2) Cells randomly scattered in gelatinous matrix. (3) Detail of coccoid cells. Scale bars: Figure 1=10 mm, Figure 2=100 μm , Figure 3=20 μm .

Distribution Western Atlantic Ocean: Florida, The Bahamas and Puerto Rico (Ballantine and Aponte 1997, Littler and Littler 2000, Wynne 2005). Eastern Atlantic Ocean: Europe and the western Mediterranean Sea (Polderman 1979, Cambra 1993).

Habitat Specimens were collected in the sublittoral zone (5–25 m) growing as epiphytes on *Lobophora variegata* (J.V. Lamouroux) Womersley ex E.C. Oliveira on bottoms dominated by small stones and sand, and epilithic on bare rocky bottoms colonized by the sea urchin *Diadema antillarum* Philippi.

Remarks The Tetrasporales includes mainly freshwater species, with only four genera that have marine representatives (*Pseudotetraspora* Wille, *Palmophyllum* Kützinger, *Palmoclathrus* Womersley and *Verdigellas* Ballantine et J.N. Norris), which are currently placed in the Palmellopsidaceae, a family assignment that is provisional until flagellated stages and reproductive morphology

have been studied (Nelson and Ryan 1986). Most marine Tetrasporales are deep-water algae occurring in tropical and subtropical waters, with palmelloid organization consisting of minute coccoid cells embedded in a gelatinous matrix, they are among the most simply organised benthic macroalgae (Ballantine and Norris 1994). Cells are uninucleate and possess a single chloroplast. *Pseudotetraspora* has a chloroplast with a central pyrenoid and cells frequently aggregated together in groups of 2–4, but cells in the other genera lack pyrenoids and are embedded randomly in the gelatinous matrix. Presently, genera are differentiated mainly by the shape of the habit: gelatinous-cartilaginous and crustose-lobate in *Palmophyllum* (Feldmann 1937), solid disc expanded into a cup-shaped clathrate membrane in *Palmoclathrus* (Womersley 1971), gelatinous, irregularly to uniformly compressed and broadly expanded in *Verdigellas* (Ballantine and Norris 1994), and gelatinous, very irregular from spherical to wrinkled and contorted in *Pseudotetraspora* (Wille 1906).

Pseudotetraspora marina was described by Wille (1906) from a cold-temperate site (type locality Trondheim, Norway), and later it was reported in saltmarsh communities from Atlantic Europe (Polderman 1979) and the western Mediterranean Sea (Cambra 1993). A second marine species, *P. antillarum* M. Howe (1920), was described as a sublittoral species in the tropical western Atlantic Ocean (type locality: The Bahamas). However, Woelkerling (1975) provided evidence that *P. antillarum* was conspecific with *P. marina*. These chlorophytes are particularly well represented in the tropical and subtropical western Atlantic Ocean (Wynne 2005), with only *Pseudotetraspora marina* and *Palmophyllum crassum* (Naccari) Rabenhorst exhibiting ampho-Atlantic distributions (John et al. 2004).

The Canarian specimens agree with the descriptions given by Wille (1906), Taylor (1960, as *Pseudotetraspora antillarum*) and Littler and Littler (2000). Specimens are yellowish-brown, very soft and gelatinous, initially subglobose and later constricted and wrinkled, ranging from 2 mm in diameter in young specimens to 30 mm long in senescent specimens, which are flattened, contorted and frequently with tears and holes (Figure 1). Although cells are randomly scattered in the homogeneous, non-stratified, soft gelatinous matrix, near the surface of the frond they are denser and often aggregated together in groups of 2–4. Cells are coccoid, subglobose to ellipsoid, 6–10 μm in diameter, with a lobate parietal chloroplast and a central pyrenoid (Figures 2 and 3).

In the Canary Islands, *Pseudotetraspora marina* grows as an ephemeral species in sublittoral habitats in areas with moderate water turbulence. The species can be locally abundant covering the perennial vegetation in extensive zones. On barren grounds occupied by sea urchins, *P. marina* is also common growing epilithically in places protected by the irregularities of the rocky surface. Conversely, *Palmophyllum crassum*, the other palmelloid chlorophyte previously reported from the Canarian coasts (Prud'homme van Reine 1998), seems to be an uncommon species. It is distinguished morphologically by its prostrate, closely adherent habit and gelatinous-cartilaginous texture.

***Colaçonema hallandicum* (Kylin) comb. nov.**
(Colaçonemataceae, Colaçonematales, Rhodophyta)
(Figures 4–6)

Basionym *Chantransia hallandica* Kylin, Zur Kenntnis einiger schwedischen *Chantransia*-Arten, in: *Botaniska Studier tillägnade F.R. Kjellman* (1906): 123, Figure 8.

Homotypic synonyms *Acrochaetium hallandicum* (Kylin) Hamel (1927): 20, *Rhodochorton hallandicum* (Kylin) Drew (1928): 151, *Kylinia hallandica* (Kylin) Kylin (1944): 13, *Chromastrum hallandicum* (Kylin) Papenfuss (1945): 321, *Audouinella hallandica* (Kylin) Woelkerling (1973): 123.

Heterotypic synonyms *Acrochaetium sargassi* Børgesen (1915): 7. For a detailed account of synonyms see Garbary (1978).

Selected specimens Canary Islands, La Palma: Barranco Herradura, 23.03.2002, leg. C. Sangil, TFC Phyc 13092.

Distribution Eastern Atlantic Ocean, from Greenland to France, Mediterranean Sea, Mauritania and Sierra Leone. Western Atlantic Ocean, from North Carolina to

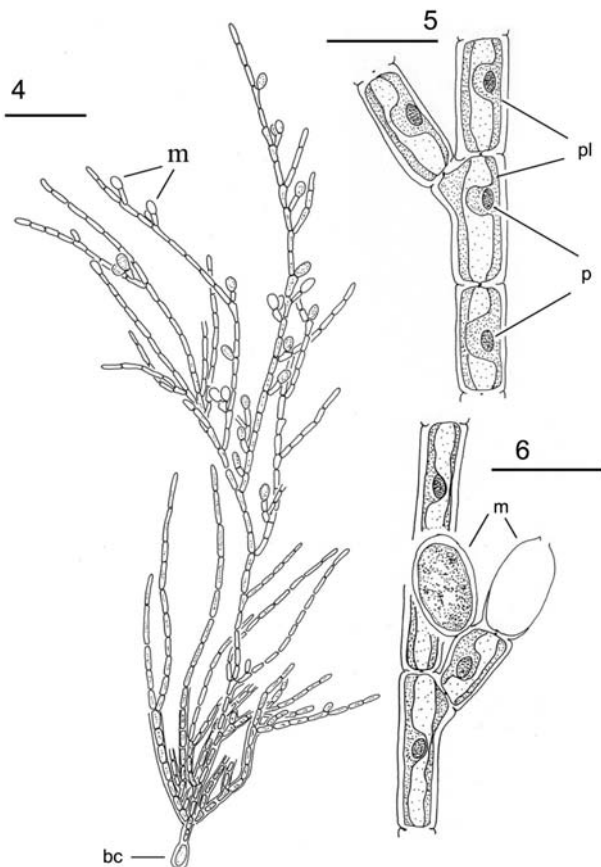
Florida, Caribbean Sea and Brazil. South Pacific Ocean: Philippines (Silva et al. 1987, Schneider and Searles 1991, Athanasiadis 1996, Stegenga et al. 1997, Furnari et al. 2003, John et al. 2004).

Habitat Epiphytic on old blades of *Sargassum* sp. collected in an upper eulittoral tidepool densely colonized by *Cystoseira humilis* Kützling.

Remarks The Canarian specimens are in agreement with the descriptions given by Børgesen (1915, as *Acrochaetium sargassi*), Taylor (1928, as *A. sargassi*) and Schneider and Searles (1991, as *Audouinella hallandica*). Specimens are erect up to 1 mm tall, arising from an ovoid, obvious single basal cell of the same size or bigger than cells of the filaments it produces; attached to the host by a broad disc of cell wall materials (Figure 4). Filaments are irregularly branched, mainly in the lowermost portions of the specimen, whereas they are long and simple in distal portions (Figure 4). Hairs were not observed. Vegetative cells are cylindrical, 6–10 µm in diameter and 18–30 µm long in proximal portions, and progressively tapering toward the apices. Each cell contains a single lobate parietal chloroplast with a single pyrenoid (Figure 5). Sessile or one-celled pedicellate, obovate to ovoid monosporangia, 8–12 µm in diameter and 15–18 µm long, were observed singly or in pairs on specimens lacking gametangia (Figures 4, 6). The monosporangial wall is retained after spore release (Figure 4).

Based on molecular data, Harper and Saunders (2002) showed that in the acrochaetoid algae two different lineages occur (Acrochaetiales and Colaçonematales), and they considered the differences in chloroplast morphology as important diagnostic features at the generic level. In the scheme of Harper and Saunders (2002), the Acrochaetiales includes the genera *Rhodochorton* Nägeli (multiple parietal discoid to band-shaped chloroplasts, lacking pyrenoids), *Audouinella* Bory de Saint-Vincent (multiple parietal lobed to discoid chloroplasts, lacking pyrenoids) and *Acrochaetium* Nägeli (single stellate chloroplast, each with a simple central pyrenoid). The Colaçonematales, with the single genus *Colaçonema* Batters, includes specimens with vegetative cells containing one to several parietal chloroplasts of varying shapes but never stellate, with or without pyrenoids. Among the acrochaetoid algae the only genus with species having single lobate parietal chloroplasts with single pyrenoids is *Colaçonema*.

Colaçonema hallandicum is the third species of the genus *Colaçonema* reported from the Canary Islands. The previously identified *C. daviesii* (Dillwyn) Stegenga and *C. ophioglossum* (C.W. Schneider) Afonso-Carrillo, Sansón et Sangil have clear differences in habitat and host attachment (Afonso-Carrillo and Sansón 1999, Afonso-Carrillo et al. 2003). Specimens of *C. daviesii* grow as epiphytes and have a distinctive base of compacted filaments where the original spore is not detectable, whereas specimens of *C. ophioglossum* grow as epi-endophytes and have endophytic scattered contorted filaments with persistent large and globose spore detectable. Among the acrochaetoid algae growing in the Canary Islands, only *Acrochaetium microscopicum*



Figures 4–6 *Colaçonema hallandicum* (TFC Phyc 13092). (4) Habit; bc: basal cell, m: monosporangium. (5) Detail of a filament with each cell containing a single lobate parietal chloroplast (pl) with a single pyrenoid (p). (6) Detail of two monosporangia (m) on a one-celled pedicel, one of them with monosporangial wall retained after spore release. Scale bars: Figure 4=100 µm, Figures 5, 6=20 µm.

(Kützing) Nägeli also exhibits a completely epiphytic habitat with host attachment exclusively by means of a single undivided basal cell (Afonso-Carrillo and Sansón 1999). However, *A. microscopicum* has a more diminutive habit with isodiametric vegetative cells, each containing a single stellate chloroplast.

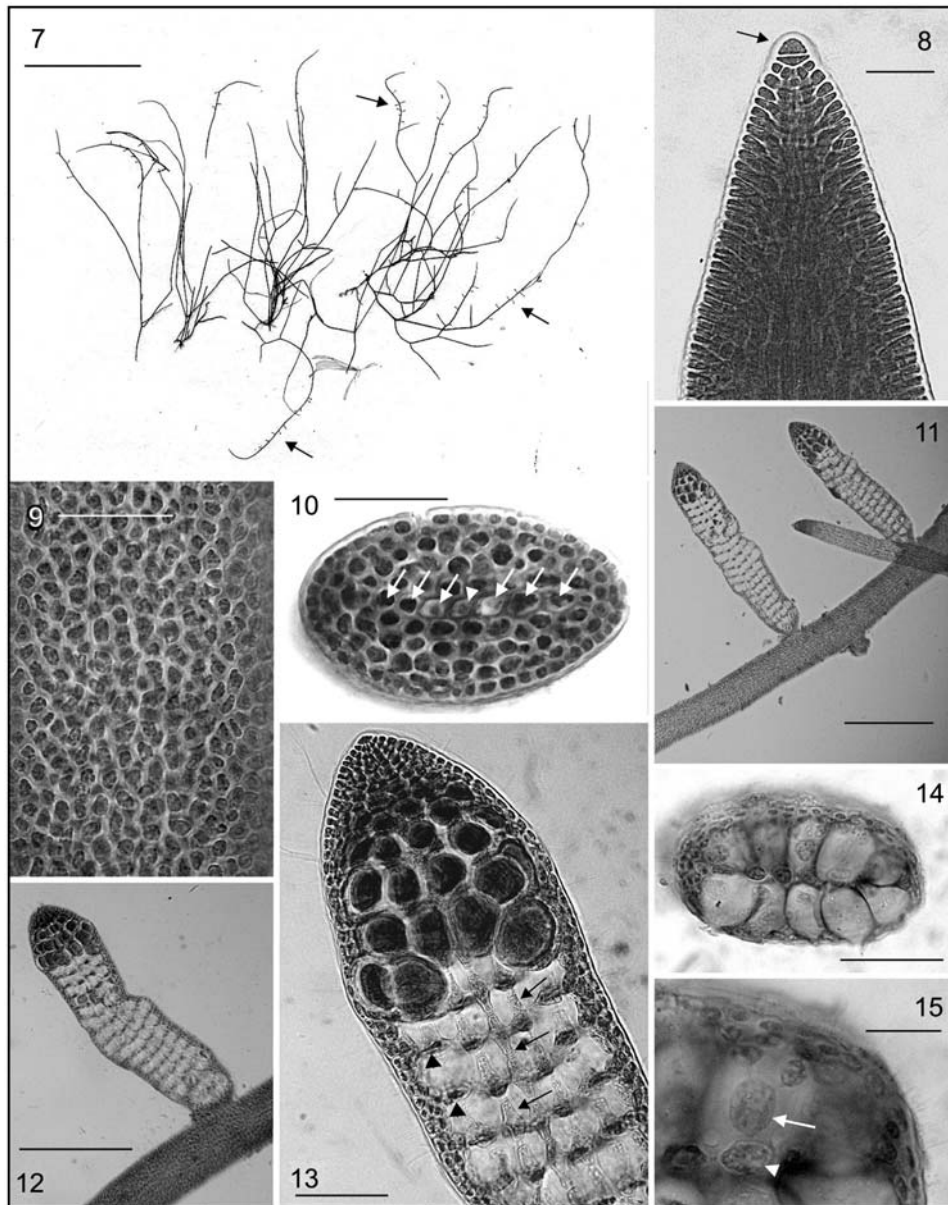
***Parviphycus setaceus* (J. Feldmann) comb. nov.**
(Gelidiellaceae, Gelidiales, Rhodophyta) (Figures 7–15)

Basionym *Echinocaulon setaceum* J. Feldmann, *Travaux cryptogamiques dédiés à Louis Mangin, Laboratoire*

de Cryptogamie, Muséum National d'Histoire Naturelle, Paris (1931): 163.

Homotypic synonym *Gelidiella setacea* (J. Feldmann) J. Feldmann et Hamel, *Revue Générale de Botanique* 46 (1934): 533.

Selected specimens Canary Islands, La Palma: Punta Cumplida, leg. C. Sangil, 30.12.2000, TFC Phyc 13101; 26.02.2001, TFC Phyc 13102; 30.05.2001, TFC Phyc 13103; 09.07.2001, TFC Phyc 13104; 22.07.2001, TFC Phyc 13105; 11.09.2001, TFC Phyc 13106;



Figures 7–15 *Parviphycus setaceus* (TFC Phyc 13107).

(7) Habit of tetrasporophyte with stichidia (arrows) arising perpendicularly on two sides of erect branches. (8) Detail of apex of an erect axis showing the pattern of division of the apical (arrow) and subapical cells. (9) Surface view of cortical cells of axes. (10) Transverse section of an axis showing medullary and cortical cells. The axial cell (arrowhead) is flanked by the periaxial cells (arrows) forming the axial row. (11, 12) Surface views of tetrasporangial stichidia. (13) Detail of tetrasporangial stichidium in surface view with regularly arranged sporangia. Note in empty parts the inner longitudinal network of periaxial cells (arrows), and tetrasporangial stalk-cells (arrowheads). (14) Transverse section of a stichidium showing empty sporangia arranged on both sides of the axial row. (15) Detail of transverse section of a stichidium showing a sporangial stalk-cell (arrow) arising perpendicularly from a periaxial cell (arrowhead). Scale bars: Figure 7=10 mm, Figures 8, 15=20 μm , Figures 9, 10, 13, 14=50 μm , Figures 11, 12=300 μm .

22.10.2001, TFC Phyc 13107; 24.11.2001, TFC Phyc 13108; 13.04.2002, TFC Phyc 13109.

Distribution Western Atlantic Ocean: Guadeloupe, Trinidad, Cuba, Belize and Guyana (Littler and Littler 1997, 2000, Suárez 2005).

Habitat Specimens grew epiphytically on the nongeniculate coralline *Neogoniolithon orotavicum* (Foslie) Lemoine in shaded sites in an upper eulittoral tidepool densely colonized by *Cystoseira humilis* Kützinger. Other red algae occurring in the same habitat were *Gelidiopsis intricata* (C. Agardh) Vickers, *Wurdemannia miniata* (Sprengel) J. Feldmann et Hamel, *Anotrichium tenue* (C. Agardh) Nägeli and *Jania adhaerens* Lamouroux. Minute nongeniculate Corallinaceae such as *Hydrolithon farinosum* (Lamouroux) Penrose et Chamberlain and *Titanoderma* species grow frequently as epiphytes on proximal portions of older axes. Fertile specimens were collected from September to April.

Remarks When the genus *Echinocaulon* Kützinger was emended by Feldmann (1931) to group species characterized by the presence of an apical cell and the lack of thick-walled rhizoid-like internal cells (rhizines) in the cortex or medulla, he presented the concise diagnosis of *Echinocaulon setaceum*. Its very thin (setaceous) axes and the black color of dry specimens were used as the diagnostic features of the new species, which was based on two collections from the Thuret herbarium deposited in PC (Herbarium of Cryptogamie of the Muséum National d'Histoire Naturelle, Paris). These collections consist of a single specimen from Guadeloupe collected by Mazé and Schramm and reported as *Acrocarpus spinescens* Kützinger or *Gelidium spinescens* Croauan (Mazé and Schramm 1878), and two specimens from Guyana collected by Mazé and misidentified as *Acrocarpus gracilis* Croauan (Mazé 1868). Later, Feldmann and Hamel (1934) proposed the combination *Gelidiella setacea*, when they established the genus *Gelidiella* to replace *Echinocaulon* Kützinger, which was determined later to be a homonym of an angiosperm genus. Sterile specimens referred to as *Gelidiella setacea* have been reported occasionally in few localities in the central western Atlantic Ocean, with a very concise description (Taylor 1960, Littler and Littler 1997, 2000). Reproductive structures were unknown until now. The finding of fertile specimens in the Canary Islands has allowed us to prepare a much-needed detailed description of this species.

Specimens from the Canary Islands belong to a single population that was revisited successively. They are in good agreement with previous accounts of the vegetative structure of the species (Taylor 1960, Littler and Littler 1997, 2000), and with the fragment examined from the original collection in PC. In addition, some specimens are fertile, bearing sporangia in stichidia. Specimens form entangled tufts (Figure 7) and consist of prostrate cylindrical branched axes up to 150 μm in diameter, attached by fascicles of rhizoids. Several erect axes arise dorsally from prostrate axes. Erect axes are up to 3 cm long and 170 μm in diameter, unconstricted or slightly constricted

basally, simple to sparsely and irregularly branched (Figure 7), nearly terete at their bases, while compressed and tapering towards the apices. The anatomy is uniaxial, with protruding hemispherical apical cells that divide transversally (Figure 8). Subapical cells divide longitudinally and distichously to form the periaxial cells, which cut off further medullary cells laterally. Several parallel medullary filaments are apparent next to the apices (Figure 8), consisting of longitudinally elongate cylindrical cells, to 50 μm long. Cortical cells are transversely elongate close to the apices (Figure 8), becoming rounded to angular below, more or less isodiametric, up to 7–9 μm , in vague rows to irregularly arranged (Figure 9), each with several small rhodoplasts. In transverse sections, axial and periaxial cells form an apparently axial row, with the axial cell and 2–4 periaxial derivatives to each side (Figure 10). Perpendicularly to the axial row, each periaxial cell forms two opposite filaments, which branch dichotomously to form hyaline medullary cells and 1–2 layers of pigmented cortical cells. First-derived cells from periaxial cells appear aligned parallel to the axial row and parallel to the surface (Figure 10). Cortical cells are slightly elongate parallel to surface, up to 7 μm in diameter.

Only tetrasporophytes were observed. Tetrasporangial stichidia arise perpendicularly on two sides along erect branches (Figures 7, 11) they are sessile or with a short stalk, basally constricted, lanceolate, 300–680 μm long and up to 135 μm wide, with whorls of 8–10 tetrasporangia (Figures 12, 13). Tetrasporangia are ovoid, up to 35 μm in diameter, irregularly decussately to tetrahedrally divided (Figure 13). Each tetrasporangium is formed upwards from the first-derived cell from the periaxial cell, which divides transversely to form a plate-like stalk-cell and a sporangium (Figure 13). In empty parts of tetrasporangial stichidia, numerous secondary pit-connections are evident between periaxial cells constituting an inner network surrounded by successive layers of tetrasporangial stalk-cells, with an outer network of cortical cells surrounding gaps through which the tetraspores are released (Figure 13). In transverse sections, empty sporangia are arranged at both sides of the axial row (Figure 14). A discoid hyaline stalk-cell, to 24–26 μm in diameter, occupies the bottom of each sporangium gap arranged perpendicularly to the periaxial cell (Figure 15).

Feldmann and Hamel (1934) used the morphology of stichidia to separate *Gelidiella* species into two groups: one for species [including the type species *G. acerosa* (Forsskål) J. Feldmann et Hamel] having conical stichidia with unordered compactly arranged tetrasporangia (the so-called “*acerosa*-type” stichidia), and the other for species forming elongate-compressed stichidia with tetrasporangia arranged in transverse rows (“*pannosa*-type” stichidia). Recently, Santelices (2004) established the genus *Parviphycus* to accommodate species previously assigned to *Gelidiella* that show the following features: distichous pattern of apical division, axial and periaxial cells in distinctive transverse rows and stichidia with few and regularly arranged rows of sporangia (“*pannosa*-type” stichidia). *Gelidiella adnata* E.Y. Dawson, *G. antipae* Celan, *G. tenuissima* J. Feldmann et Hamel and *G. womersleyana* Kraft et I.A. Abbott were transferred to *Parviphycus* by Santelices (2004), and more recently, a

new Mediterranean species, *Parviphycus felicinii* Perrone et Delle Foglie (Perrone and Delle Foglie 2006), was added to the genus. The suite of features that characterize *Parviphycus* is found in the specimens of *G. setacea* examined in this work, and consequently the species is transferred to the genus *Parviphycus*. Three *Gelidiella* species had been reported from the Canaries (Afonso-Carrillo and Sansón 1999). Two of them now belong to *Parviphycus* [*P. antipae* (Celan) Santelices and *P. tenuissimus* (J. Feldmann et Hamel) Santelices]. A remaining species, the endemic *Gelidiella tinertensis* Seoane-Camba (1977), need to be studied further to confirm its generic placement.

***Lomentaria chylocladiella* Funk (Lomentariaceae, Rhodymeniales, Rhodophyta) (Figures 16–20)**

Selected specimens Canary Islands, La Palma: Playa del Burro, 26.04.2004, leg. C. Sangil, TFC Phyc 13097.

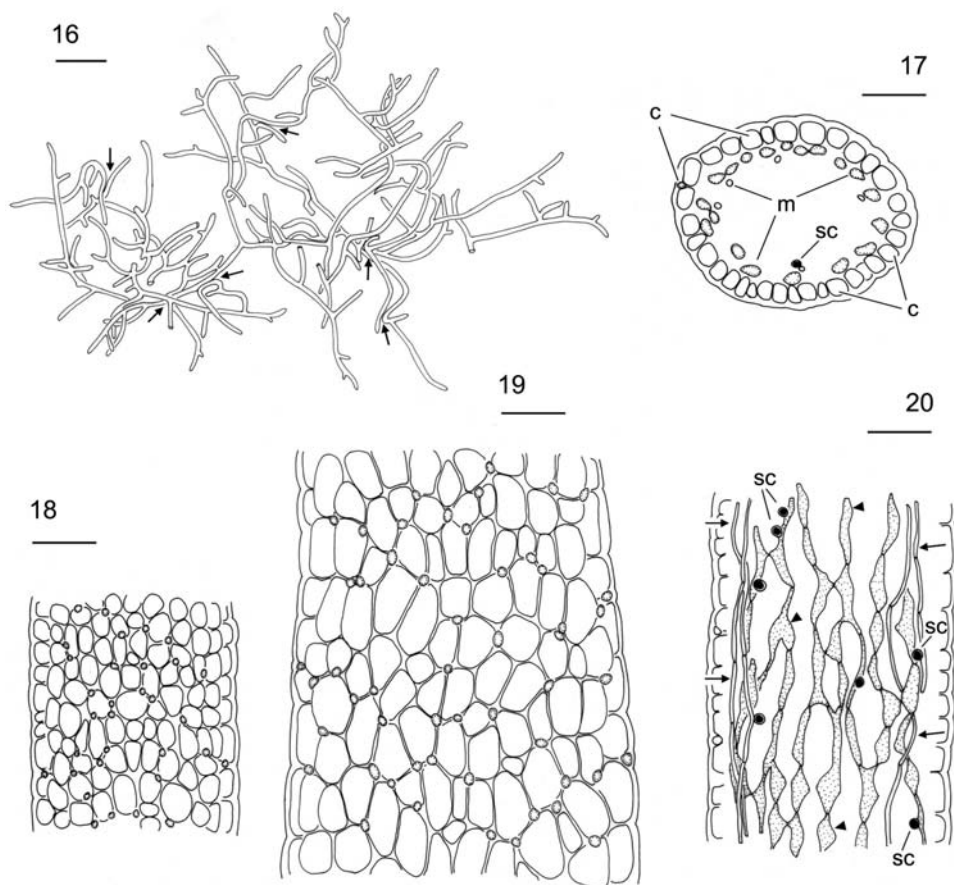
Distribution Northwestern Mediterranean Sea, Adriatic Sea and Greece (Boudouresque 1974, Athanasiadis 1987).

Habitat Specimens were collected at a depth of 10 m, entangled with *Jania adhaerens* J.V. Lamouroux, *Lopho-*

cladia trichocladus (C. Agardh) F. Schmitz, *Cottoniella filamentosa* (M. Howe) Børgesen and *Spyridia hypnoides* (Bory) Papenfuss, growing on small rocks on sandy bottoms where *Lobophora variegata* (J.V. Lamouroux) E.C. Oliveira was the dominant perennial species.

Remarks The brief original description of this species based on specimens from the Gulf of Naples made by Funk (1955) is apparently inexact because Boudouresque (1974) studying specimens from Corsica observed characters that had not been mentioned by Funk (i.e., the few pigmented small cortical cells and the elaborate network of medullary filaments). Boudouresque and Perret-Boudouresque (1987) stated that they were unable to locate any type specimens of the Funk species of *Lomentaria* in his herbarium in the Stazione Zoologica di Napoli, and consequently the species characterization made by Boudouresque (1974) has been accepted (Copejans 1983, Athanasiadis 1987).

Although only vegetative material was examined, the Canarian specimens are in good agreement with the previous observations made by Boudouresque (1974), Copejans (1983) and Athanasiadis (1987). They are red-yellow to pinkish, to 20 mm long, composed of fili-form irregularly and sparsely branched axes to forming



Figures 16–20 *Lomentaria chylocladiella* (TFC Phyc 13097).

(16) Habit; arrows indicate anastomoses. (17) Transverse section of an axis showing cortical cells (c), medullary cells (m) and a secretory cell (sc). (18) Surface view of cortex near the apex of an axis. (19) Surface view of mature cortex with the innermost layer of large cells surmounted by few scattered small cells. (20) Longitudinal section of an axis showing the peripheral network of narrow (arrows) and broader (arrowhead) medullary filaments, with some projecting globose secretory cells (sc). Scale bars: Figure 16=3 mm, Figures 17–20=50 μ m.

indefinite entangled masses (Figure 16). Axes are terete, 180–300 μm in diameter, lacking constrictions and attached to other algae by means of many small adherent lateral discs. Anastomoses and adherent secondary discs are numerous between adjacent axes and old axes appear frequently broken. The two processes result from a resumption of growth from the external cortical cells in contact with a foreign body. The anastomoses occur between axes of the same specimen and between axes of neighbouring specimens.

Axes are hollow and filled with watery mucilage (Figure 17), except for branch bases where the hollow interior of younger axes is separated by horizontal monostromatic diaphragms. The cortex is two-layered, with the innermost layer composed of lightly pigmented, large, sub-polygonal cells up to 35 μm broad and 60 μm long (Figures 17–19). The outermost layer consists of few, pigmented, small, rounded cells, 5–10 μm in diameter, which only occasionally occur on the adjacent walls of the large subpolygonal cells (Figures 18, 19). Two distinctive types of longitudinal filaments constitute the medullary region in the hollow periphery (Figure 20), viz. filaments composed of narrow, elongate cylindrical cells, 3–5 μm broad and up to 100 μm long, and filaments formed of obovoid, irregularly elongate cells, 7–20 μm broad and 30–80 μm long (Figure 20). Cells in both types of filaments are laterally connected by pit-connections, forming an irregular elaborate network next to the cortical wall and they bear irregularly scattered rounded secretory cells, 7–10 μm in diameter, which project into the cavity (Figure 20).

Cystocarpic and tetrasporangial specimens have been reported only occasionally from the Mediterranean specimens, whereas spermatangial specimens remain unknown (Funk 1955, Boudouresque 1974). The numerous broken axes and the branch ability for adhesion to other algae by means of lateral adhesive discs suggest that axis fragments could represent a vegetative mechanism of multiplication.

With the species newly reported in this work, there are now five species of *Lomentaria* recognized to grow on the coasts of the Canary Islands. The structure of the cortex as it is observed in surface view appears to be a useful character to separate species (Afonso-Carrillo and Sansón 1999). In *Lomentaria articulata* (Hudson) Lyngbye and *L. linearis* (Zanardini) Zanardini, the small pigmented outer cortical cells form an almost continuous layer, whereas in *L. baileyana* (Harvey) Farlow and *L. subdichotoma* Ercegovic they are arranged in rosettes. Finally, in *L. chylocladiella* the small pigmented outer cortical cells are very rare and scattered.

Conclusion

Recent studies have concluded that the present knowledge on the marine flora of the Canary Islands is still incomplete, since the findings of new records and undescribed species are relatively frequent (Afonso-Carrillo and Tabares 2004). This surprising floristic richness is a result of the geographical location of the Canaries in the central eastern Atlantic Ocean where conditions are suitable for settlement of seaweed species with different bio-

geographical affinities (Sansón et al. 2002). This is evident in the four marine algae documented in this paper. *Parviphycus setaceus* is reported for the first time from the eastern Atlantic Ocean. The species was previously known from a few localities in the western Atlantic Ocean, and now joins other ampho-Atlantic species that have in the Canary Islands their only known populations in the eastern Atlantic Ocean (Afonso-Carrillo et al. 2003, Afonso-Carrillo and Sobrino 2004). *Pseudotetraspora marina* was known as a saltmarsh temperate species in the eastern Atlantic Ocean and the western Mediterranean Sea (Polderman 1979, Cambra 1993). The Canaries constitute a new southernmost limit of distribution of the species and the first report in the eastern Atlantic Ocean for the shallow sublittoral zone, the habitat in which tropical western Atlantic populations occur (Littler and Littler 2000).

In the case of *Lomentaria chylocladiella*, this is the first report for the Atlantic Ocean. The species was known only from a few localities in the western Mediterranean Sea, with a single report from the Aegean Sea (Athanasiadis 1987). With the present finding, *L. chylocladiella* joins other species previously considered as endemic to the Mediterranean Sea [i.e., *Rissoella verruculosa* (Bertholini) J. Agardh, *Predaea pusilla* (Berthold) J. Feldmann, *Lomentaria subdichotoma* Ercegovic, *Sebdenia rodrigueziana* (J. Feldmann) P.G. Parkinson] that are at present known in the Atlantic Ocean from the Canaries (Sansón et al. 1991, Ballesteros et al. 1992). Finally, the remaining newly reported alga (*Colaconema hallandicum*) has been found previously in other localities from the eastern Atlantic Ocean, and its presence in the Canary Islands was not unexpected.

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