On Some Ceramiaceae (Rhodophyta) from California[1]

ISABELLA A. ABBOTT[2]

ABSTRACT: Morphological features in the red algal family Ceramiaceae are described for four taxa from California. One of them, *Bornetia californica,* is described as new to science and is distinguished from other known species by the method of branching in the tetrasporangial and spermatangial laterals. *Ptilothamnion codicolum* is a transfer from *Pleonosporium* and is placed in this genus because of the number of cells of the fertile axis and the development of the gonimoblast. *Spermothamnion snyderae,* widely distributed on the Pacific coast, is transferred to *Tiffaniella* because of the structure of the gonimoblast and the lack of an involucre. Two species of *Callithamnion, C. rigidum* Dawson and *C. uncinatum* Dawson, are placed in synonymy with *Callithamnion rupicolum* Anderson.

NEW SPECIES, new combinations, and new records of marine algae continue to be added to the already rich flora of California and the Pacific coast of North America. As more collections and more studies are made, a better understanding of the structure, morphology, and reproduction is gained, and as the geographical and depth limits are explored, a more adequate assessment of species limits becomes possible.

The following species are rather inconspicuous members of the intertidal flora, compared to the large bladelike red algae recently studied by Abbott (1967*a,* 1967*b,* 1968), and of other algae studied by Hollenberg and Abbott (1968) and Hollenberg (1969). The species reported upon in this paper have all been known previously, but in limited fashion. Some were never collected with adequate reproductive structures. These have now been found. Others were never studied in sufficient numbers to assist in a reasonable interpretation. The Ceramiaceae (Rhodophyta) are not conspicuously represented in California, there being 10 genera recognized by Smith (1969) while a similar coastline in Japan supports a flora of 22 genera as recognized by Okamura (1936). The following species add two genera to the California flora (one of them previously reported by Setchell (1901) but overlooked by Smith).

I have been helped in this study by the collections of Robert Setzer, Nancy Nicholson, James Norris, and Eric Barham to whom I extend thanks, and further by the use of herbarium materials of the University of California at Berkeley (UC), Allan Hancock Foundation of the University of Southern California (AHF), Adelaide University (ADU) through the courtesy of H. B. S. Womersley, and Maxwell S. Doty (MSD) of the University of Hawaii. I am grateful for continued loans from these sources. The Gilbert M. Smith herbarium (GMS) at Hopkins Marine Station is the repository of my collections. For a generous and profitable exchange of opinions, I am also grateful to Dr. Elizabeth Gordon, University of Adelaide. I am indebted, as always, to Dr. Hannah Croasdale for the Latin diagnosis. For illustrations, I acknowledge the financial aid of the U.S. Office of Naval Research through contract N-0014-67-A-0112.

Bornetia californica Abbott, new species

B. secundiflora of Setchell (1901, p. 125)

Fig. 1*a–d.*

Diagnosis Holotypi

Thalli caespitosi, saxicoli aut epixoici, cellulae infimae horizontales necnon in stratum basale repens aliquantulum mutatae. E hoc strato filamenta recta multinucleata usque ad 10 cm alt., paucas dichotomias praebentia, enascuntur; cellulae 250–500 μ lat. (plerumque 0.5 mm) in sectionibus mediis, duplo vel plus longiores quam latae. Dichotomiae plerumque Y-formes.

[1] Manuscript received September 25, 1970.

[2] Hopkins Marine Station of Stanford University, Pacific Grove, California 93950.

Totae structurae reproductivae in ramis abbreviatis mutatisque lateraliter portatae. Fasciculi tetrasporangiales spermatangialesque dendroidei, saltem tres ordines ramificationis e cellula basali fasciculi praebentes. Tetrasporangia sessilia in superficiebus omnibus quattour ramulorum patentium sita, omni ramulo in 1 vel 2 cellulas involucrales cernuas desinente. Tetrasporangia matura fere sphaerica 78–104 μ diam. Capitula spermatangialia oblonga, conferte ramosa, cellulis axialibus celatis, omni spermatangio 2.0–3.5 μ lat., 2.5–6 μ long. Cystocarpi magni, cellulis involucralibus includentibus plus quam 0.6 mm lat. aut alt. antequam carposporae maturae formantur.

Diagnosis of Holotype

Thalli tufted, saxicolous or epizooic, lowest cells horizontal and slightly modified as a creeping basal layer (Fig. 1*b*) from which arise erect, straight filaments up to 10 cm high, with few dichotomies, the cells 250–500 μ (mostly 500 μ) in diameter through the midsections, two or more times longer; 2–3 mm long toward the base. Dichotomies (Fig. 1*a*) frequently Y-shaped. All reproductive structures borne laterally on shortened, modified branches. Tetrasporangial (Fig. 1*c*) and spermatangial (Fig. 1*d*) clusters dendroid, of at least three orders of branching from the basal cell of the cluster. Tetrasporangia sessile, on all four surfaces of the spreading branchlets, each branchlet terminated by one or two nodding involucral cells. Mature tetrasporangia nearly spherical, 78–100 μ in diameter. Spermatangial heads (Fig. 1*d*) oblong, densely branched, the axial cells obscure, each spermatangium 2.0–3.5 μ wide by 2.5–6.0 μ long. Cystocarps large, with enclosing involucral cells over 0.6 mm wide or tall before mature carpospores are formed.

Type Specimen

(Holotype, GMS): Setzer, 1899, in sea-urchin holes behind protecting rocks, Pescadero Beach, San Mateo County, central California, March 15, 1969 (tetrasporangial, male and female).

OTHER SPECIMENS: From San Mateo County —Gardner 4912, 6651, (UC), Moss Beach, no date and April 5, 1931, respectively; J. Norris 405*b*, 405*c*, (GMS), Pillar Point, March 4, 1966; Setzer 3078 (GMS) Pillar Point, May 6, 1966; Setzer *s. n.*, Pillar Point, April 23, 1967; Setzer 3339 (GMS) Pillar Point, July 16, 1969; W. W. Jordan *s. n.*, Frenchman's Reef, May 1966; Setzer 3808 (GMS) Frenchman's Reef, December 6, 1969; Setzer 2171 (GMS) Pescadero Beach, March 28, 1969; Setzer 507, Pigeon Point, July 26, 1968. Monterey County —Pacific Grove, J. M. Weeks 118 (UC), March 1897; M. S. Doty 5674 (MSD), cast ashore at foot of 7th St., June 26, 1943; J. Jensen 198 (GMS), Asilomar Point, March 19, 1961; Abbott 6847 (GMS), Pebble Beach, May 21, 1970.

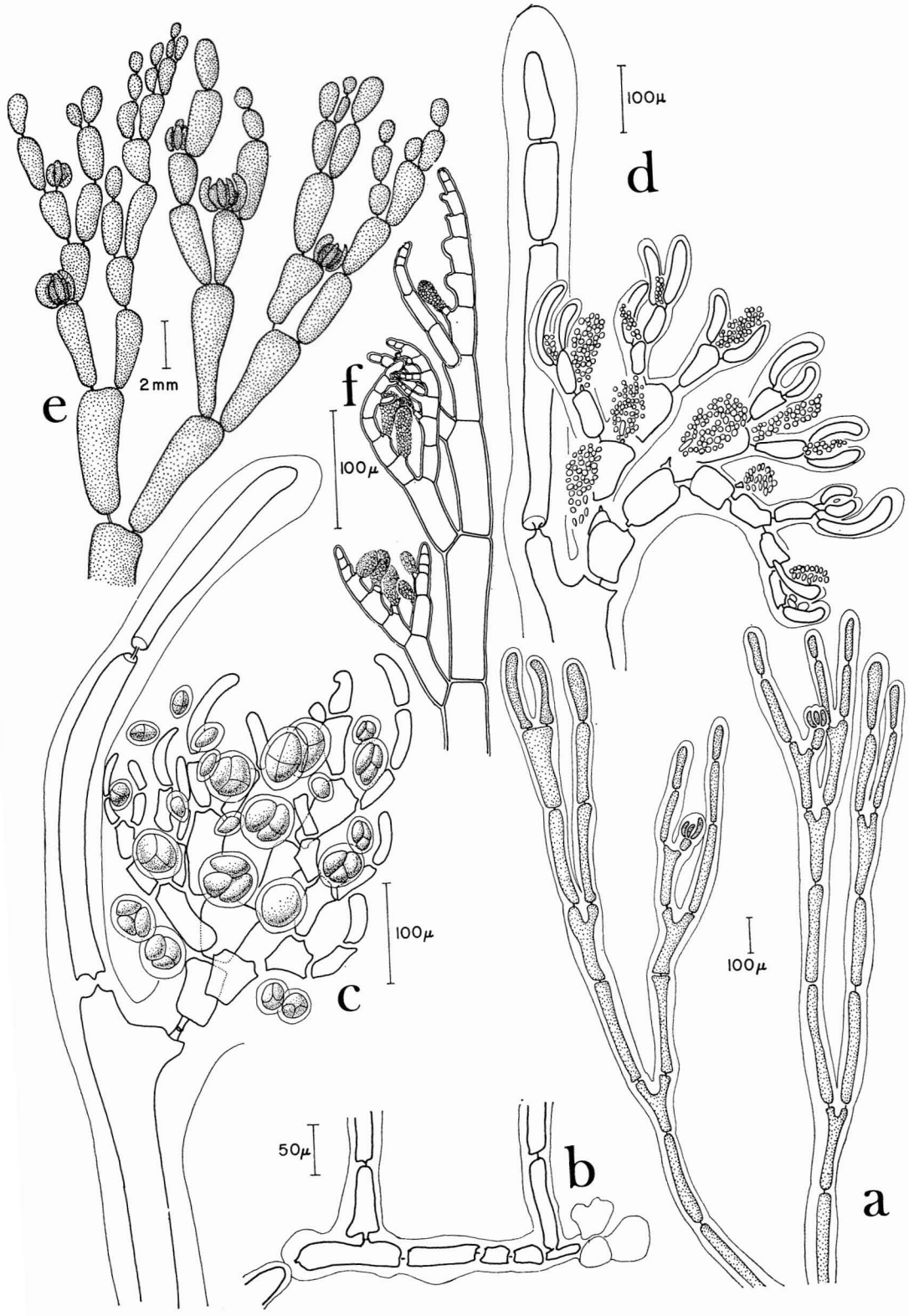
Distribution

The distribution of this species at present is in central California, but, because a wide variety of habitats is occupied, it may perhaps be found over a wider geographic range. The specimens on the type sheet, for example, were found in holes in granitic rock leeward of a high rock receiving the force of heavy surf and, therefore, was nearly constantly awash; other specimens have been found in protected shallow sandy pools beneath *Phyllospadix* hummocks at Pebble Beach.

Discussion

The material collected from Pacific Grove by Mrs. Weeks and reported upon by Setchell (1901) as *Bornetia secundiflora* has been recognized for some years as being distinct by James Jensen and myself, but it was not until recently that sexual material became available for study. This material shows that the structure of the cystocarps is very similar to that of *B. tenuis* Baldock and Womersley (1968) from Australia but that the arrangement of spermatangial and

FIG. 1. *Bornetia californica, Tiffaniella snyderae,* and *Griffithsia pacifica. a, Bornetia californica* from holotype sheet, upper half of cystocarpic specimen showing the short determinate branches bearing cystocarps; *b, B. californica* from holotype sheet, basal, creeping portion with two erect axes; *c, B. californica* from holotype sheet (semidiagrammatic), lateral showing determinate fertile branchlet with tetrasporangia; *d, B. californica* from holotype sheet (semidiagrammatic), spermatangial clusters with inflated terminal sterile cells (involucre); *e, Tiffaniella snyderae,* clusters of spermatangial heads; *f, Griffithsia pacifica,* habit of cystocarpic plant showing manner of attachment and involucre around the cystocarp.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tetrasporangial branches is different. The dendroid branch systems of the tetrasporangial and spermatangial laterals, which provide possibilities for larger numbers of tetrasporangia and spermatangia to be produced due to larger surface areas available, marks *B. californica;* whereas both tetrasporangia and spermatangia of *B. tenuis* appear to be confined to the adaxial surface, and the once-furcate branch systems are smaller. Although dependent to a degree on the age of the branch, the involucral cells topping the fertile branchlets of *B. tenuis* are proportionately larger than are those of *B. californica,* resulting in a lacy appearance of the tetrasporangial heads (Baldock and Womersley, 1968, Plate 3, Fig. 2, and isotype material, ADU). Furthermore, the larger sizes of cells in *B. californica* result in coarser thalli.

The four known species of *Bornetia* are *B. secundiflora* (the type species from the Mediterranean), *B. binderiana* and *B. tenuis* from Australia, and *B. californica.*

The three filamentous genera of large multinucleate cells in California, *Griffithsia* (*G. pacifica,* Fig. 1*e*), *Bornetia,* and *Spermothamnion* (*Tiffaniella* in this paper) are not always distinct from one another when examined as dried specimens that are sterile. Intertidal specimens of the three have cells averaging, respectively, 1–2 mm diameter, 250–500 μ, 80–100 μ in midsections (halfway from apex to base). Subtidal specimens of *Griffithsia* and *Tiffaniella,* however, tend to be more slender, and those of *Griffithsia* may be as narrow as 300 μ, those of *Tiffaniella,* 50 μ.

Tiffaniella snyderae (Farlow) new comb.

Figs. 1*f,* 2*a–b.*

Basionym

Spermothamnion snyderae Farlow (1899, p. 74); Smith, 1944, p. 322, Pl. 82, Figs. 3–5; Dawson, 1962, p. 45, Pl. 16, Figs. 3–5.

California Material Used in This Study

Vegetative and polysporic—Abbott 5709 (GMS), Mussel Point, Pacific Grove; J. Norris 664 (GMS), Point Aulon, Pacific Grove; Abbott 6848 (GMS), Carmel Submarine Canyon at 20 m, leg. Mark Littler; sexual thalli—Abbott 6849 (GMS, UC), Duxbury Reef, Marin County; J. Norris 937 (GMS) Cojo Point, Santa Barbara County; Nicholson 301, 302, 306, 307, 310 (GMS) between 6 and 10 m depth on a variety of algae, Santa Rosa Island; Abbott 6852 (GMS), Santa Monica, leg. G. J. Hollenberg; Abbott 6851 (GMS), Redondo Beach, leg. G. J. Hollenberg; Abbott 6850 (GMS) near Bird Rock east of Balboa, leg. G. J. Hollenberg.

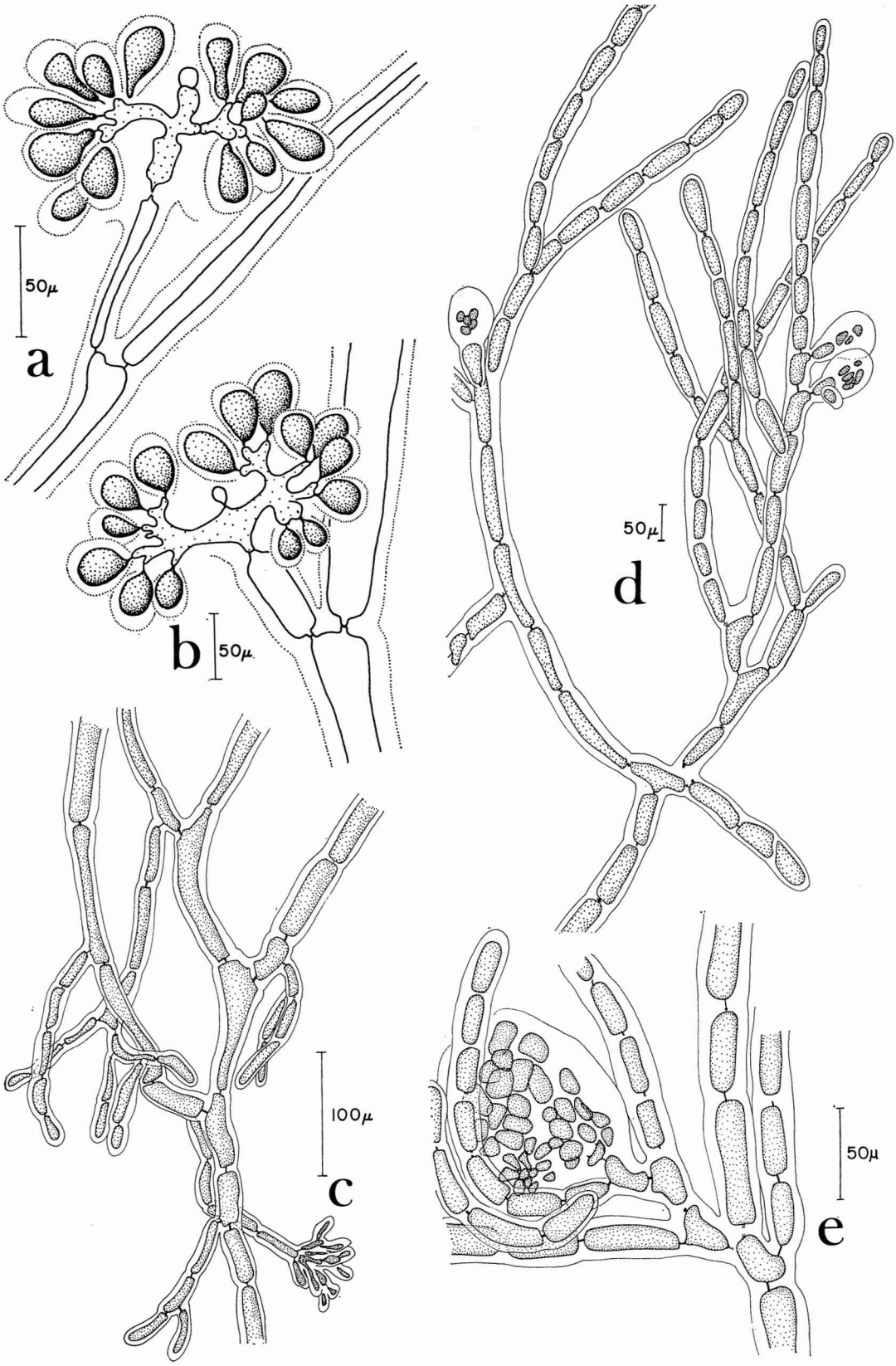
Distribution

Tiffaniella snyderae has been found from Washington to Baja California, and from the lower intertidal to more than 20 m depth, and is always saxicolous. On the contrary, most species of *Tiffaniella* (Doty and Menez, 1960) are epiphytic or partly endophytic, and thus the habit of the creeping basal portions, including the modified rhizoids, would seem to be expressive of the preferred substratum of the various species.

Discussion

Several characteristics have become associated with a segregate of *Spermothamnion* and a testing of these characteristics in specimens from over a wide geographic range has shown that they should be applied to *Tiffaniella* Doty and Menez (1960). These characteristics are: (1) no involucre around the cystocarp; (2) a T-

FIG. 2. *Tiffaniella* spp., *Callithamnion rupicolum,* and *Ptilothamnion codicolum. a, Tiffaniella saccorhiza,* mature gonimoblast showing partial fusion of fertile cells 1 and 2, and their fusion with two auxiliary cells (Abbott 4271 from Ewa Beach, Oahu, Hawaii, on *Codium reediae*); *b, Tiffaniella snyderae,* mature gonimoblast showing complete fusion of fertile cells 1 and 2 with two auxiliary cells and forming the horizontal arm of a T (Nicholson 306 from Santa Rosa Island, California); *c, Callithamnion rupicolum,* basal portion showing uniseriate and branched descending rhizoids, one of which has a digitate end. In some thalli, these rhizoids cohere laterally (Abbott 5401 from Asilomar Point, near Pacific Grove, California); *d, Ptilothamnion codicolum,* habit of a cystocarpic thallus and showing part of decumbent portion of thallus; *e, Ptilothamnion codicolum,* mature cystocarp showing fertile lateral arising from the basal cell of a vegetative lateral. The fertile lateral, after fertilization, has produced a branched sterile filament which serves as an involucre encircling the cystocarp, here seen with three developing groups of carposporangia (Abbott 5700, Guadalupe Island, Mexico).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shaped fusion cell made up of the basal and second cell of the fertile female axis and two auxiliary cells; (3) each terminal carposporangium is surrounded by an individual, gelatinous envelope; and (4) a creeping portion, usually with modified rhizoids, simple in some species such as *Tiffaniella codicola,* saccate as in *T. saccorhiza,* and with modified discs as in *T. snyderae. Spermothamnion,* on the other hand, is recognized as having an involucre of short, unbranched filaments which, in some species, are modified vegetative branches (Kylin, 1916; Newton, 1931), no T-shaped fusion cell, and no elaborate creeping portion.

Although frequently found in California, *Tiffaniella snyderae* is usually sterile. Of reproductive plants, the most frequently seen are polysporangial (Smith, 1944, Pl. 82, Fig. 4); the distinctive spermatangial plants (Fig. 1*f*) are not uncommon, but the cystocarpic plants (Fig. 2*b*) are rare, and more usually encountered south of Santa Barbara than in the north. A study of the development of the gonimoblast indicates that this should be a species of *Tiffaniella.* The most striking attribute of that genus—a lack of involucre—is especially clear in this species. This taxon (Fig. 2*b*) also shows a T-shaped fusion cell, terminal carposporangia, and modified rhizoids as does the type species, *T. saccorhiza* (Setch. and Gardn.) Doty and Menez (Fig. 2*a*). However, the three cells of the fertile axis remain discrete after production of carposporangia in *T. saccorhiza* (Fig. 2*a*) but cells 1 and 2 become fused in *T. snyderae* (Fig. 2*b*).

Callithamnion rupicolum Anderson
Fig. 2*c*

Anderson, 1894, p. 360, Figs. *A–B;* Smith, 1944, p. 319, Pl. 81, Fig. 3.

Synonyms

Callithamnion rigidum Dawson, 1962, p. 33, Pl. 10, Figs, 4–5; *Callithamnion uncinatum* Dawson, 1962, p. 35, Pl. 11, Fig. 4.

Description

Thalli in dense, soft, felted tufts, usually on *Corallina,* and saxicolous as well, 1–2 cm high, attached by many uniseriate branched rhizoids (Fig. 2*c*) with or without modified tips; axes branched distichously once and occasionally twice pinnately, most alternately placed second order branches simple and sometimes downwardly recurved, but occasionally pinnately branched at right angles to the axis with attenuate, rounded, or uncinate apices. Tetrasporangia adaxial, seriate, or only a few and not seriate along second order branches. Spermatangia in small, continuous, flat clusters on the adaxial side of laterals; cystocarps rarely found, terminal to branchlets, irregularly shaped.

Distribution

Species common throughout California, saxicolous on the open coast, and also at tide levels occupied by *Corallina vancouveriensis* (to plus 3.5 ft) and by *Corallina chilensis* (as low as minus-1.5-ft tide level).

Discussion

A study of large numbers of specimens of *Callithamnion rupicolum* from the region of the type locality (Monterey Bay) has shown far more variation within populations than either Smith (1944) or Dawson (1962) had observed. Dawson's recognition of *C. rigidum* and *C. uncinatum* puts too narrow a concept on the species limits of *C. rupicolum,* and, furthermore, his concept ignores the observation of the present author that the branching patterns attributed as species characters of these two taxa are present in the populations of *C. rupicolum.* For example, laterals with uncinate apexes, supposedly specific to *C. uncinatum,* are common in *C. rupicolum;* likewise, the branchlets which do not recurve in *C. rigidum* are found in *C. rupicolum* as well. Dawson (1962, p. 33) infers that *C. rupicolum* is corticated. This is not the case, although frequently descending rhizoids (Fig. 2*c*) which issue from axial cells at the basal portions of the thalli fuse laterally and give a corticated appearance, much as in some species of *Cladophora* (Chlorophyta). These are not cortications in any definition of that condition in the Ceramiales.

Ptilothamnion codicolum (Dawson) new comb.

Fig. 2*d–e*

Basionym

Pleonosporium codicolum Dawson, 1962, p. 39, Pl. 14, Figs. 4–5.

Description

Thalli partly endophytic, partly epiphytic in *Codium,* or wholly epiphytic and entangled with other algae, the epiphytic portions 3–(5) mm high, branched fasciculately or alternately, secund, or opposite, or not branched; cells of epiphytic portions (20)–26–32 μ wide, wider in midsections and 2.5 times longer, tapering only slightly toward the branch apices, the cells then becoming shorter. Cells of endophytic portions nearly the same width, but longer, 25–30 μ wide by 30–100 (250) μ long. Endophytic portions occasionally ending in a few unmodified rhizoids, occasionally horizontally branching and becoming erect in adjacent portions of host.

Mature polysporangia 90–(100) by 104 μ, usually low on the thallus, singly or in pairs, borne on one-celled stalks, secund or opposite, of 16–(18) spores; spermatangia in short, broad, oval heads, terminating one-celled secund or opposite laterals; procarps low on thallus, near axils of basal branches, on one-celled laterals which produce one-two bifurcate sterile branches functioning as an involucre following fertilization. Mature cystocarp 90–175 μ wide, irregular in outline, of several gonimolobes maturing in turn, and contained in a common gelatinous envelope.

Distribution

Guadalupe Island, Pacific Mexico—Dawson 8318, type specimen (AHF) in *Codium fragile;* Abbott 5700 (GMS), from the same place and the same host, leg. Eric Barham, Jan. 23, 1965. Santa Rosa Island, California—at 20 ft depth, entangled with other algae (*Murrayellopsis* and *Trailliella*), Abbott 5881 (GMS). Santa Catalina Island, California—at 30 ft depth, entangled with other algae, Nicholson 395 (GMS).

Discussion

Dawson (1962, p. 39) described only polysporangial material for this species, on which, however, no positive identification can be made since several similar genera have polysporangia. Polysporangia are known in a variety of species of *Pleonosporium, Spermothamnion* and *Tiffaniella* but as yet have not been reported in *Ptilothamnion. Ptilothamnion* is characterized (Kylin, 1928) by a three-celled fertile axis, a single auxiliary cell in the procarp, an involucre, and only the terminal cells or nearly all cells of the gonionoblast are converted into carposporangia which, in either condition, mature differentially in three–four gonimolobes, all surrounded by a common gelatinous envelope. These features are shown by *P. codicolum.* In contrast, *Spermothamnion* and *Tiffaniella* each have two auxiliary cells, and only the terminal cells of the gonimoblast become carposporangia, each in an individual gelatinous spore sac. Moreover, *Tiffaniella* does not have an involucre, and *Spermothamnion* produces one from modified vegetative branches. *Pleonosporium* is characterized by a two-celled fertile axis.

The Santa Rosa Island and Santa Catalina Island material is sterile; branching is unilateral or irregular, or not branched; lower portions are decumbent, simple, reversing the direction of branching when once again becoming erect. The measurements of these filaments are similar in proportion to the partly endophytic thalli from Guadalupe Island.

This is the first report of *Ptilothamnion* in the northeastern Pacific.

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