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A REVIEW OF CERAMIUM ALONG THE PACIFIC COAST OF NORTH AMERICA WITH SPECIAL REFERENCE TO ITS MEXICAN REPRESENTATIVES [1]

E. YALE DAWSON

As a result of explorations for marine algae along the Pacific Mexican coast during the last 25 years, the number of species of *Ceramium* recorded in our Pacific North American marine flora has been increased nearly five-fold. Notwithstanding, no key to the species, nor survey of the genus as it is represented in our flora has been prepared, while the task of identifying our plants has become increasingly more difficult and uncertain.

Within the past four years the writer's field work in Mexico has brought to hand some three hundred separate collections of *Ceramium*, study of which has shown that all but two of the known Pacific Coast species occur in Mexico. Several apparently undescribed plants have been detected, and these, together with some troublesome uncertainties among our older species, have called for a practical treatment of the genus at this time. Of each of these new Mexican collections, material kept in liquid preservative has made possible the preparation in a uniform manner of a series of permanent study-slides in which the specimens exhibit minimum distortion.

Dr. George J. Hollenberg of the University of Redlands, Redlands, California, has kindly made available for this study his fine collection of *Ceramium* from southern California. These specimens, particularly his numerous slide preparations, have been most useful in verifying a number of determinations and in indicating northernmost localities in the distribution of many species.

Examples of all of the collections cited, except those of Hollenberg, are on file in the Herbarium of the Allan Hancock Foundation. All collection numbers are the writer's unless otherwise indicated. The dates of the author's collections are as follows: 16–1094, January–February 1946; 1095–1655, April 1946; 1646–1989, May 1946; 2756–3145, October 1946; 3146–3581, November 1946; 3582–3764, December 1946; 3765–3940, January–February 1947; 5143–5312, September 1948; 6462–7278, March 1949.

The drawings were made by the author.

Acknowledgments are due to Dr. G. F. Papenfuss and to Mr. P. C. Silva of the University of California for the loan of specimens, and to Dr. Carl L. Hubbs of Scripps Institution of Oceanography, La Jolla, California for the contribution of specimens, particularly from Guadalupe Island. To Dr. George Hollenberg I am especially indebted for the use of his large collection of specimens and for other aids in this study.

[1] Contribution from the Allan Hancock Foundation.

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A KEY TO THE SPECIES OF CERAMIUM OF THE PACIFIC COAST OF NORTH AMERICA [1]

1. Thallus completely corticated throughout 2
1. Thallus with nodal cortication for the most part continuous, but at least in some part with ecorticate internodal spaces, or the cortex thin and loose over internodes 8
1. Thallus with cortication only at the nodes, or with uninterrupted cortication only in older, lower parts or on reproductive branches 9
   2. Thallus bearing deciduous or persistent spines on apices or on short, lateral branches 3
   2. Spines absent 4
3. With sharp, unicellular spines at apices or terminating short, lateral branchlets ..... **1. Ceramium horridum**
3. With two or more multicellular spines terminating mature apices of main or lateral branches ..... **7. Ceramium pacificum** (in part)
   4. Cortical cells, at least for the greater part, in distinct longitudinal rows; apices divergent ..... **2. Ceramium Eatonianum**
   4. Cortical cells not in distinct, longitudinal rows; apices divergent or forcipate 5
5. Plants with penetrating, bulb-tipped, pigmented rhizoids ..... **3. Ceramium codicola**
5. Plants without bulbous rhizoids 6
   6. Plants creeping, extremely robust, the cortex 200 μ thick or more ..... **5. Ceramium obesum**
   6. Plants erect, not particularly robust; cortex much thinner 7
7. Apices divergent; with many short, proliferous branches, densely congested above ..... **6. Ceramium viscainoense**
7. Apices more or less incurved; with many proliferous branchlets, but these not congested in upper parts .. **7. Ceramium pacificum** (in part)
   8. Cortical bands only slightly separated above, covering the expanding internodes below by basipetal growth, but the secondary cortication thin, loose and often incomplete; with many proliferous branchlets ..... **8. Ceramium washingtoniense**
   8. Nodal cortication discontinuous, particularly so in lower parts, usually continuous above or irregularly discontinuous; usually without conspicuous proliferous branchlets ..... **4. Ceramium sinicola** (in part)
   8A. Cortication continuous above, but not in lower and middle portions .. .. **4. Ceramium sinicola** var. **typicum**
   8A. Cortication generally continuous above, but conspicuously interrupted at the dichotomies ..... **4. Ceramium sinicola** var. **interruptum**

[1] It should be emphasized that identifications according to this key will be most successful when the material being examined is fresh or in liquid-preserved state, since drying distorts the appearance and arrangement of the cortical cells upon which a number of distinctions are based.

8A. Cortication continuous except in extreme basal parts ..... **4. Ceramium sinicola** var. **Johnstonii**

9. Plants bearing conspicuous multicellular spines 10

9. Plants without conspicuous spines 11

10. Spines mainly abaxial, more or less deciduous ..... **9. Ceramium paniculatum**

10. Spines whorled at the nodes, persistent ..... **10. Ceramium hamatispinum**

11. Cortical band showing conspicuous basipetal and (or) acropetal secondary growth 12

11. Cortical band without conspicuous basipetal or acropetal secondary growth 13

12. Tetrasporangia immersed within the cortical band ..... **11. Ceramium Evermannii**

12. Tetrasporangia projecting from the cortical band ..... **12. Ceramium californicum**

13. Cortical cells arranged in distinct horizontal and vertical rows in lower two thirds of the nodes ..... **14. Ceramium recticorticum**

13. Cortical cells not arranged in vertical rows 14

14. Outer cortical cells of nodal band separated into two groups by a horizontal clear space usually at about the lower third of the node; tetrasporangia involucrate 15

14. Outer cortical cells of nodal band not clearly divided into two groups; tetrasporangia immersed, involucrate or naked 17

15. Nodes of most filaments each bearing, at first abaxially, a short, thick, apically rounded, unicellular hair, or these later sometimes whorled ..... **13. Ceramium fimbriatum**

15. Nodes without such a specialized hair 16

16. Cells of lower portion of divided cortical band distinctly and persistently horizontally elongated .... **15. Ceramium Masonii**

16. Cells of lower portion of divided cortical band, except in young stages, angular, small and not distinctly horizontally elongated ..... **16. Ceramium Taylorii**

17. Tetrasporangia immersed in the cortex, not projecting 18

17. Tetrasporangia projecting, naked 23

17. Tetrasporangia projecting and involucrate, at least by bracteate filaments (sometimes secondary tetrasporangia obscurely involucrate in *C. personatum*) 20

18. With conspicuous opposite branching; procumbent ..... **17. Ceramium procumbens**

18. Without conspicuous opposite branching; erect or entangled 19

19. Filaments 140–200 μ diam. or more **4. Ceramium sinicola** (in part)

19. Filaments 80–100 μ diam. ..... **18. Ceramium equisetoides**

20. Filaments less than 50 μ diam. 21

20. Filaments 70–200 μ diam. 22

21. Tetrasporangia solitary at the nodes, the involucres unilateral ..... **19. Ceramium serpens**

21. Tetrasporangia whorled at the nodes, the involucres symmetrical ..... **20. Ceramium Camoui**

22. Cortical band about half as long as broad; tetrasporangia initially secund, mainly abaxial, later whorled, more or less involucrate by bracteate filaments; with descending rhizoidal appendages within some of the axial cells ..... **24. Ceramium personatum**

22. Cortical band about half as long as broad; tetrasporangia initially secund, mainly adaxial, later whorled, slightly involucrate; without appendages within the axial cells ..... **21. Ceramium Gardneri**

22. Cortical band one third to half as long as broad; tetrasporangia secund, abaxial, conspicuously involucrate throughout; without appendages within the axial cells ..... **22. Ceramium mazatlanense**

23. Plants smaller, the lower nodes rarely exceeding 130 μ in diameter 24

23. Plants larger, the lower nodes 150–450 μ in diameter (sometimes not over 130 μ in slender forms of *C. caudatum*) 26

24. Internodes ordinarily less than 3 times as long as cortical band; adult nodes of more than 2 tiers of cells 25

24. Internodes, except near tips, 4–10 times as long as cortical band; nodes of only 2 tiers of cells ... **23. Ceramium affine**

24A. Filaments less than 35 μ diam. ..... **23. Ceramium affine** var. **originale**

24A. Filaments more than 40 μ diam. ..... **23. Ceramium affine** var. **peninsularis**

25. Cortical band consisting of larger, rounded, downwardly directed cells in lower part of band, and smaller, angular cells in upper part; lower internodes 1½–2 times as long as broad; distantly branched ..... **25. Ceramium avalonae**

25. Cortical bands with irregularly arranged, small, angular cells on the surface throughout; lower internodes less than as long as broad; rather densely branched above ..... **26. Ceramium zacae** (in part)

26. Upper branches reduced in diameter, commonly 100 μ or less; tetrasporangia appearing large compared to bearing cortical band, ¼ the diameter of the band or larger 27

26. Upper branches not much reduced in diameter, commonly over 150 μ (to 300 μ); tetrasporangia mostly appearing small compared to bearing cortical band 28

27. Older internodes less than as long as broad ..... **26. Ceramium zacae** (in part)

27. Older internodes 1.5–2.5 times as long as broad ..... **27. Ceramium caudatum**

28. Apices prominently circinate-forcipate; tetrasporangia mainly projecting from adaxial surface of the node or sometimes scattered around the entire node ..... **28. Ceramium clarionensis**

28. Apices not circinate; tetrasporangia whorled, projecting from upper half, particularly the upper margin, of the cortical band ..... **29. Ceramium ornatum**

SYSTEMATIC LIST

1. CERAMIUM HORRIDUM Setchell & Gardner

Setchell & Gardner, 1924, p. 777, pl. 26, figs. 49, 50, pl. 79; Dawson, 1944, p. 318.

Previously well-known in the Gulf of California from Guaymas, Sonora and northward, this distinctive plant has recently been collected in the

southern Gulf of California at Isla Carmen (Dawson 6965), in San Lorenzo Channel (Dawson 6926) and at Mangles Anchorage north of Isla Carmen (AHF Sta. 526–36). Its spination makes it one of the most readily recognized of the completely corticated species of our coast.

2. CERAMIUM EATONIANUM (Farlow) De Toni

De Toni, 1903, p. 1493; Smith, 1944, p. 327, pl. 84, figs. 3–4; Dawson, 1945a, p. 62, 67; 1949a, p. 223; Taylor, 1945, p. 271; Doty, 1947, p. 187. *Centroceras Eatonianum* Farlow, 1875, p. 373. *Ceramium zebrinum* J. Agardh, 1894, p. 37. *Centroceras oregonense* J. Agardh, 1876, p. 107.

Although long well-known in California and in Oregon, this plant has previously been reported in Mexico only from Punta Descanso, Cabo Colnett and Isla Cedros. Recent collections show that it is common along virtually the entire west coast of Baja California. Specimens are now at hand from Punta Baja (Dawson 1142), Miller's Landing (1379), Punta Santa Rosalía (1426, 1513, 2918), Bahía Ositos (1591) and from Bahía Santa María, Isla Magdalena (7267).

3. CERAMIUM CODICOLA J. Agardh

Plate 1, fig. 6

J. Agardh, 1894, p. 23; Setchell, 1905, p. 60; Smith, 1944, p. 326, pl. 84, fig. 1; Doty 1947, p. 187; Dawson, 1944, p. 318 (in part). *Ceramium codiophila* Setchell & Gardner, 1937, p. 89, pl. 8, figs. 23, 24; Dawson, 1945, p. 25.

Although this species has been known in the California flora for over half a century, it has apparently become increasingly misunderstood as the knowledge of our flora has been extended southward. In 1905, Setchell correctly pointed out one of the major distinguishing features of *Ceramium codicola*: unbranched, chromatophore-containing rhizoids with large, globular ends. Smith, 1944, reiterated this character in describing the plant from Monterey, but it has not heretofore been noticed that the plant distributed in the Phycotheca Boreali-Americana as no. 248 and verified by Kylin, 1941, as identical with the Agardhian type, is not identical with the plant most commonly found epiphytic on *Codium fragile* at La Jolla, and elsewhere in southern California. We have, in fact, two species of *Ceramium* of similar external appearance epiphytic on *Codium*, the one, *C. codicola*, of northern occurrence, north to Alaska, and the other, *C. sinicola*, of southern occurrence south to San José del Cabo and in the Gulf of California (see discussion below). In southern California the ranges of the two species overlap, *C. codicola* being occasional in drift at La Jolla and common on *Codium* in the Channel Islands. *C. sinicola* is common on intertidal *Codium* at La Jolla and may occur on a number of other hosts.

The specimens from Isla Guadalupe, Baja California described by Setchell and Gardner as *Ceramium codiophila* seem clearly to correspond with the original concept of *C. codicola*. Similarly far southern locals for this species are represented by Dawson 2838 from Punta Santa Rosalía, Bahía Viscaino and by Howell 20b, Bahía San Bartolome, Baja California.

4. **CERAMIUM SINICOLA** Setchell & Gardner

Plate 1, figs. 4–5

Setchell & Gardner, 1924, p. 773, pl. 25, figs. 40, 41, pl. 75; Dawson, 1944, p. 315; Hollenberg, 1948, p. 158 (in major part). *Ceramium bicorne* Setchell & Gardner, 1924, p. 773, pl. 28, fig. 64, pl. 74. *Ceramium Johnstonii* Setchell & Gardner, 1924, p. 774, pl. 76, 77. *Ceramium interruptum* Setchell & Gardner, 1924, p. 775, pl. 26, fig. 47. *Ceramium codicola* J. Agardh, as interpreted by Dawson, 1944, p. 318 (in part); 1945, p. 67; 1949, p. 26.

Hollenberg's recent report of this species in southern California has called for a review of the species as a whole, and particularly for a clarification of the type locality. The type specimen, found entangled with a *Laurencia* species, was cited by Setchell and Gardner from the Gulf of California following their assumption that "Ensenada Bay" indicated on the original label was in that region. Reëxamination of the original *Laurencia* specimen, Ivan Johnston 67, kindly loaned by the Herbarium of the University of California, shows that it is probably *L. subopposita*, not a species of the Gulf of California, and is associated with another plant unknown there, *Pterosiphonia Baileyi*. A comparison of the date, April 7, 1921, with the general account (Slevin, 1923) of the Expedition of the California Academy of Sciences to the Gulf of California in 1921, reveals that on that date Johnston was aboard the steamer Mazatlán which had departed from Los Angeles, southward bound, on April 5. This would have placed Johnston at Bahía de Todos Santos (often known as Ensenada Bay) Baja California on the date indicated on the label, and explains the identity of the *Laurencia* and *Pterosiphonia* which are not in keeping with the flora of the Gulf. *Ceramium sinicola* becomes, thus, a species positively known from Pacific Baja California by reason of the type. This enables us more readily to accept a wide distribution for this species including southern California, Pacific Baja California and the Gulf of California, an interpretation strongly supported by the large Mexican *Ceramium* collections now at hand.

Although both *Ceramium sinicola* and *C. codicola* occur on *Codium* along southern California and northern Baja California where their ranges overlap, the characters of their rhizoids make them readily distinguishable. The former produces slender, branched, non-bulbous rhizoids (fig. 5) which may be of various lengths and depths of penetration depending upon the texture of the host to which they attach. In *C. codicola*, which seems to occur only on *Codium*, the unbranched rhizoids are pigmented and bulbous at the tips (fig. 6).

One to several multicellular spines commonly occur on mature apices of *C. sinicola* (fig. 4). Such spines appear to be absent in *C. codicola*.

Ceramium sinicola is an extremely variable plant, in habitat, size and in cortication, and in some of its varied forms may be confused with other species. It is best identified by means of a series of several specimens, both juvenile and mature, among which the characters particularly of the cortication may be interpreted. In the great majority of cases the uppermost,

mature parts of the plants show complete cortication, or cortication only here and there interrupted, most commonly just above the dichotomies. The more slender, basal branches, however, ordinarily show prominent internodal spaces between the truncate cortical bands. In some of the more slender forms, and those growing in less exposed situations, there may be widely discontinuous cortication with internodes in the lowermost, prostrate portions up to 3 times the length of the cortical bands. Depending upon the continuous or discontinuous character of the cortication, three varieties may be recognized (see key): *C. sinicola* var. **typicum** nom. nov., *C. sinicola* var. *Johnstonii* (S. & G.) Dawson, and *C. sinicola* var. *interruptum* (S. & G.) Dawson.

Since *Ceramium sinicola* is already well known as an abundant and widely distributed species epiphytic on various algae throughout the Gulf of California, further collections need not be cited for that area. Its occurrence along the Pacific Coast of California and Baja California may be outlined, however, by the following collections: CALIFORNIA — Hollenberg 624.6, Whites Point, San Pedro; Hollenberg 797, 812, Santa Catalina Island; Hollenberg 581.6, 1598, Corona del Mar; Dawson 316, 2084, 5422, La Jolla. BAJA CALIFORNIA — Dawson 246, Punta Descanso; 1161, Punta Baja; 6707, Isla Magdalena (Pacific side); 6902, Cabeza Ballena; 2953, Miller's Landing.

5. CERAMIUM OBESUM sp. nov.

Plate 1, figs. 7–9

Thallis prostratis, repentibus, rhizoidum plurium (ubi contactum factum) ope affixis, cylindricis, 90–1100 μ diametro, totis bene corticatis, ramulis secundariis numerosis spinescentibus donatis; cortice bistratoso ad 300 μ crasso.

Plants prostrate, creeping, growing over themselves and other small algae and debris, attaching by masses of small rhizoids produced from all contacting surfaces, very coarse, cylindrical, 900–1100 μ diam., with axes 20–22 mm. long, completely corticated throughout, abruptly reduced at the apex to the short, coarse, strongly forcipate tips; primary branching dichotomous, infrequent; secondary branching irregular, frequent, consisting mostly of very short branchlets with strongly circinately curved tips; cortex very thick, completely covering the axes, consisting of an inner layer of thick-walled rotund cells 25–100 μ diam. adjoining the central axial cells which are about 400 μ diam., and an outer layer of densely packed small anticlinally elongated cells 15–25 μ long by 5–9 μ wide; reproduction not seen.

TYPE: Dawson 964, on intertidal rocky shore at Bahía Agua Dulce, Isla Tiburón, Sonora, Mexico. February 21, 1946. HAHF 5279.

This extremely robust species is suggestive in anatomy and gross morphology of *Ceramium crassum* Okam. of Japan, but its prostrate, creeping habit and rhizoidal attachment among mat-forming small algae distinguishes it from that erect, epiphytic species.

6. CERAMIUM VISCAINOENSE sp. nov.

Plate 1, figs. 1–3

Thallis 15–25 mm. altis, rosulatis, saxicolis, pro more dichotome ramosis; ramis adultioribus 400–500 μ diametro, nodis constrictis; cortice toto continuo; ramis secundariis proliferis brevibus, multifariis, supra congestis; apicibus divergentibus, acutis; tetrasporangiis immersis.

Thalli 15–25 mm. high, tufted, saxicolous, attached by massed and coalesced short rhizoids which in mature plants form a spongy disc, consisting of several to many dichotomously branched axes arising from the base; older branches 400–500 μ diam., catenately constricted at the nodes, gradually reduced in diameter above and the constrictions less prominent; secondary proliferous branches multifarious, short, increasingly abundant and more congested above; ultimate branches divergent, non-forcipate, acute; cortex continuous throughout, primarily of irregularly disposed small angular cells and a few larger cells at the junction of the rotund axial cells, generally thin or incomplete over the bulging midparts of the central axial cells, the longitudinally arranged small, mostly elongated cells of young segments becoming in part increasingly longer or even filamentous as secondary, acropetal and basipetal cortical growth progresses; tetrasporangia 30–35 μ diam., completely immersed in the cortex; cystocarps surrounded by 3–5 involucral branchlets.

TYPE: Dawson 1430, intertidal rocky shore at Punta Santa Rosalía, Baja California, Mexico, April 13, 1946. HAHF 5225.

Ceramium viscainoense shows by its microscopic characters a similarity to *C. pacificum*. A comparison of specimens of both species collected at Punta Santa Rosalía on the same day, however, indicates several apparently significant differences. Most conspicuous in *C. viscainoense* are the divergent apices and the dense massing of short, secondary branches in the upper parts of the plant. These short branches are in turn branched, the ultimate segments being spine-like (fig. 2). The prominent constrictions at the nodes and the thin, loose cortications of the internodes (fig. 3) also appear to be characteristic.

7. CERAMIUM PACIFICUM (Collins) Kylin

Plate 4, fig. 30

Kylin, 1925, p. 61; 1941, p. 29; Smith, 1944, p. 326, pl. 83, fig. 3; Dawson, 1945a, p. 67; Doty, 1947, p. 187. *Ceramium rubrum* var. *pacificum* Collins, in Phyc. Bor. Amer. no. 893, 1747.

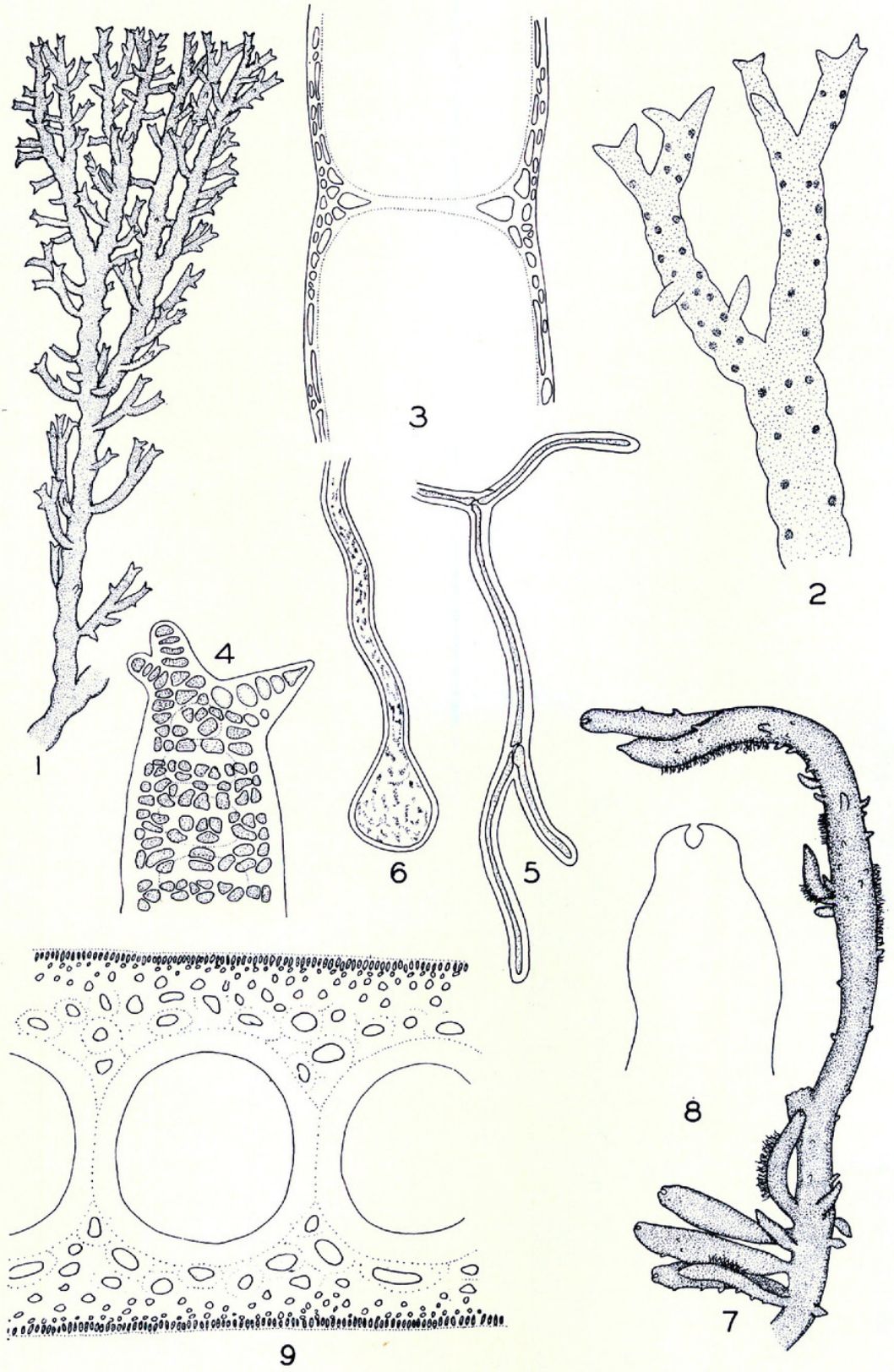
PLATE 1

Figs. 1–3. *Ceramium viscainoense*. **1.** Habit of a portion of the type specimen, × 7.5. **2.** Terminal part of a tetrasporangial branch of the same, × 30. **3.** Longitudinal section of an older node, × 80.

Figs. 4–5. *Ceramium sinicola*. **4.** Apex of a mature branch to show spine, × 300. **5.** Part of a typical branched rhizoid, × 120.

Fig. 6. *Ceramium codicola*. A typical, unbranched, bulb-tipped rhizoid, × 120.

Figs. 7–9. *Ceramium obesum*. **7.** Habit of part of the type specimen, × 5. **8.** Outline of a mature apex to show forcipate tips, × 27. **9.** Longitudinal section through a main branch from the type specimen, × 55.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Widely distributed along the California coast and northward to Vancouver Island, this plant has been reported in Mexico only from extreme northwestern Baja California. Recent collections include several luxuriant examples (Dawson 1509, 1610, 1557) from the area just south of Punta María at the northern edge of Bahía Viscaino.

The specimens of completely corticated *Ceramium* from southern Alaska cited by several authors under *C. rubrum* (see Setchell & Gardner, 1903) have not been reviewed, but they may be expected to represent far northern examples of *C. pacificum*.

8. CERAMIUM WASHINGTONIENSE Kylin

Kylin, 1925, p. 62, fig. 41; Doty, 1947, p. 187.

This northern *Ceramium* appears to be the only one of our coast not to be expected to occur in Mexico. Kylin has pointed out several distinctions from its apparent near-relative *C. pacificum*. It is also notable that the continuous cortication above, with only thin separating lines between the nodes, becomes slightly discontinuous below as a result of the elongation of the internodes at a rate slightly greater than that of the growth (mainly basipetal) of the secondary corticating cell rows.

9. CERAMIUM PANICULATUM Okamura

Okamura, 1921, p. 114, pl. 179, figs. 8–16; Dawson, 1944, p. 319.

First reported in the eastern Pacific from Guaymas, Sonora, this interesting plant has recently appeared in several other Mexican collections: Dawson 1980, 3522, Guaymas, Sonora, 3237, Punta Palmilla, Baja Calif., 6810, Cabeza Ballena, Baja Calif., and 3637, Mazatlán, Sinaloa. It would seem to be restricted to the more tropical waters of the Pacific Mexican coast. Tetrasporangia found on Dawson 3237 are essentially like those of Japanese specimens.

It should be noted that in some cases, as in the Guaymas collections 3522 and 1980, that the spines on some branches may be only scantily developed, or occasionally not at all.

10. CERAMIUM HAMATISPINUM sp. nov.

Plate 3, figs. 20–22.

Thallis in algarum pulvinis intertextis, 90–130 μ diametro, distanter dichotome ramosis, ad nodos tantum corticatis; apicibus circinnatis; nodis verticillo spinarum 5–6 persistentium, crassarum, pro more uncinatarum, multicellularium armatis.

Thalli forming entangled masses amid small, mat-dwelling algae, the filaments 90–130 μ diam., or 50–70 μ diam. in young parts, irregularly and distantly, dichotomously, divergently branched, corticated only at the nodes; apices circinate; nodal cortex 40–60 μ long, of irregularly arranged small, angular cells and producing a whorl of 5–6 usually 3–celled, nondeciduous, stout spines 30–50 μ long with sharp, usually hooked tips, the hook directed basally; internodes elongating early, becoming 100–250 μ long in older filament parts; nodes occasionally with slender, accessory rhizoids; secondary cortical expansion essentially absent; reproduction not seen.

TYPE: Dawson 3706, intertidal, Mira Mar, Nayarit, Mexico, December 20, 1946. HAHF 48800.

This is one of the most distinctive of Pacific *Ceramium* species by manner of the conspicuous whorls of stout, usually hooked spines arising from the middle of each node and persisting throughout the life of the filament.

11. CERAMIUM EVERMANNII Setchell & Gardner

Setchell & Gardner, 1930, p. 169, pl. 8, figs. 28–29.

Although some sterile, southern California specimens such as Hollenberg 3343 from Corona del Mar correspond with this species in their vegetative features, *Ceramium Evermannii* remains positively known only from the type locality, Isla Guadalupe, Baja California. The specimens cited under this name by Dawson, 1945, have proved upon reëxamination to be *Ceramium californicum*, since emergent, rather than immersed, tetrasporangia have been detected.

12. CERAMIUM CALIFORNICUM J. Agardh

Plate 3, fig. 18.

J. Agardh, 1894, p. 45; Kylin, 1925, p. 61; 1941, p. 29; Collins, Holden & Setchell, in Phyc. Bor. Amer. no. 447. *Ceramium Evermannii* Setchell & Gardner, as interpreted by Dawson, 1945a, p. 62.

This species is amply distinct from our other incompletely corticate species by its tetrasporangial and cortical characters. The cortex is of small, irregularly disposed angular cells external to the larger, submerged nodal cells. The outer cortex grows by both basipetal and acropetal expansion such that in older parts it more or less completely covers the internodes. The projecting tetrasporangia distinguish this plant from the apparently closely related *C. Evermannii.*

Specimens are now at hand from several localities of northwest Mexico: Dawson 5164, 5183, 6494, Cabo Colnett; 1167, 1213, Punta Baja; 1510, Punta Santa Rosalía; 6711, Bahía Magdalena. In the latter specimens the internodes are short above and the cortex in lower parts completely covers the internodes. Most of the specimens examined show a more or less distinct constriction of the cortical band at the nodal junction.

13. CERAMIUM FIMBRIATUM Setchell & Gardner

Setchell & Gardner, 1924, p. 777, pl. 26, figs. 43–44; 1937, p. 88, pl. 7, fig. 18; Dawson, 1944, p. 317.

This readily recognized species has heretofore been recorded only from the Gulf of California and from extreme southern Baja California. Recent collections demonstrate its wide occurrence along the Pacific Coast of Mexico: Hollenberg 2571, Punta Banda, Baja Calif., Dec. 1938; Dawson 1407, Punta Santa Rosalía, Baja Calif.; Williams 4/24/46, Scammon Lagoon, Baja Calif.; Dawson 6826, Cabeza Ballena, Baja Calif.; Dawson 3596, Mazatlán, Sinaloa; Dawson 3842a, Acapulco, Guerrero. It is closely related to the group of species including *C. Masonii*, *C. recticorticum* and *C. Taylorii* in which the tetrasporangia are whorled and involucrate, and in which the cortical band is divided at about the lower third into two

distinct parts. In *C. fimbriatum* the cells of this lower cortical part are often horizontally elongated somewhat as in *C. Masonii.*

14. CERAMIUM RECTICORTICUM sp. nov.

Plate 3, figs. 23–24.

Thallis epiphyticis, e filamentis basalibus ope rhizoidum affixis; partibus erectis ad 3 mm. altis, 50–60 μ diametro, ad nodos tantum corticatis, alternatim ramosis; zonis corticalibus e cellulis rectangularibus factis horizontaliter elongatis, seriebus horizontalibus verticalibus bene formatis, opere ad nodi marginem superum tantum interrupto; tetrasporangiis verticillatis, involucratis.

Thalli epiphytic, 1.5–3 mm. high, often densely tufted, attached to the host by prostrate, basal parts of filaments bearing long rhizoids; branching apparently alternate; filaments 50–60 μ in diam. above, with non-forcipate, slightly incurved apices, corticate only at the nodes; cortical bands about 2/3 as long as broad, slightly tumid, consisting, except at the upper margin, of more or less rectangular cells horizontally elongated and arranged in about four definite horizontal and vertical rows, these regular rows maintained and usually unmodified by growth or enlargement below; internodes scarcely evident in uppermost 500 μ of branch tips, lengthening to 10–30 μ somewhat lower, and then elongating markedly to 300–400 μ in the entangled, basal filaments from which verticils of rhizoids arise at the nodes; tetrasporangia 20–25 μ diam., maturing within 300 μ of apex of terminal branches, borne in whorls of 3–5 (mostly 4) within the cortical band which is modified by their expansion to form an involucre; cystocarps and antheridia unknown.

TYPE: Dawson 1769, on *Coeloseira pacifica*, Bahía Bocochibampo, near Guaymas, Sonora, May 16, 1946. HAHF 48795.

Additional material: Dawson 501, 509, 455a, 1706, 1749, 1772, 3566, epiphytic on various hosts, Bahía Bocochibampo, Sonora; 3667, Mazatlán, Sinaloa.

This species differs from closely related *Ceramium Taylorii* by the strikingly regular arrangement of the cortical cells. At Bahía Bocochibampo,

PLATE 2

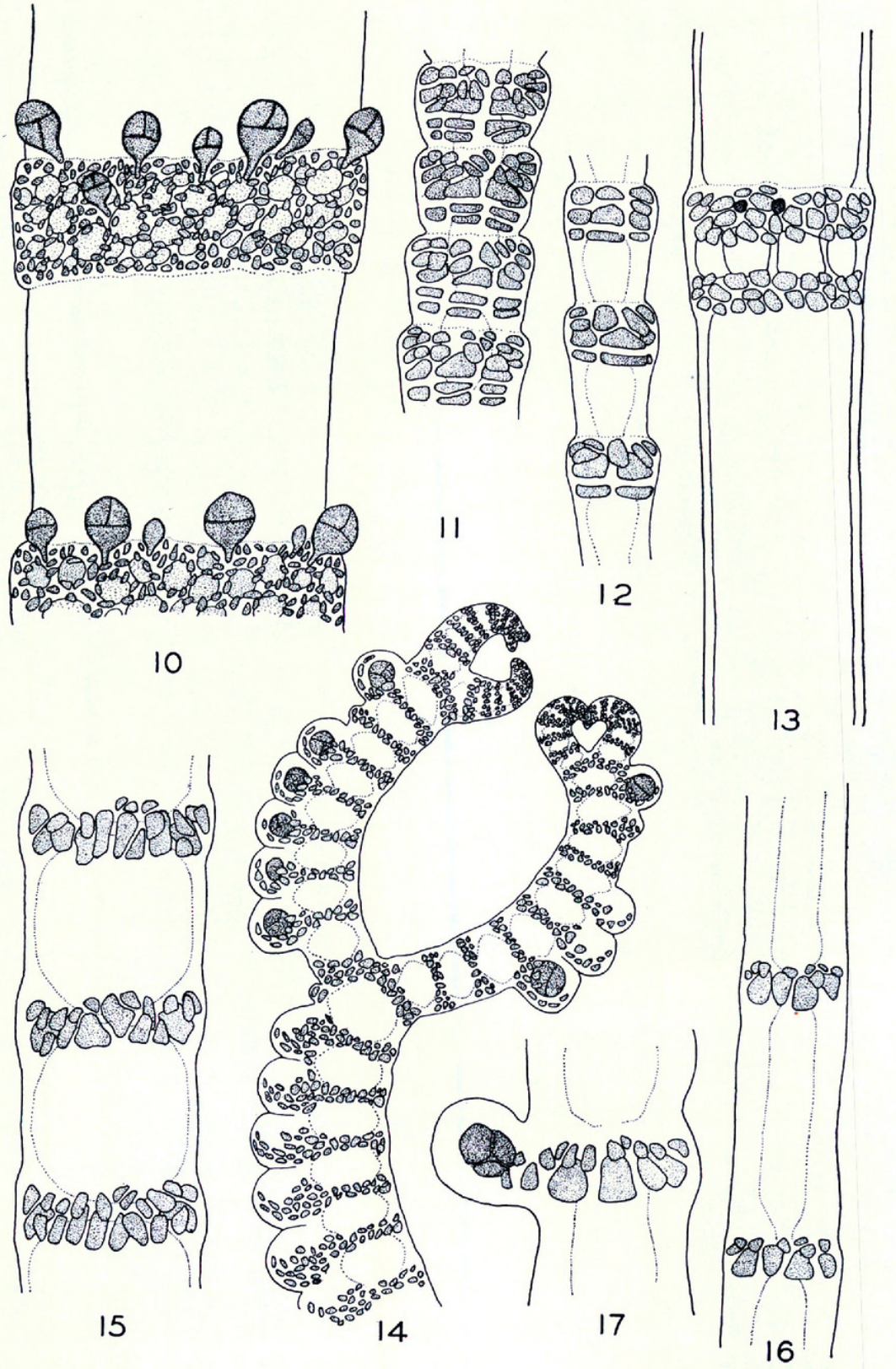
Fig. 10. *Ceramium ornatum.* A portion of a tetrasporangial filament from the type collection, × 125.

Figs. 11–12. *Ceramium Masonii.* **11.** Portion of the upper part of a plant of Dawson 3417 from La Paz, × 250. **12.** Portion of a filament of Dawson 6770 from Cabeza Ballena, × 250.

Fig. 13. *Ceramium Taylorii.* Portion 3 mm. from the tip of a filament of an uncommon form with broader and more medianly situated space between the two parts of the divided outer cortical band (Dawson 3675, Mazatlan) × 250.

Figs. 14–15. *Ceramium mazatlanense.* **14.** Upper part of a tetrasporangial plant to show short nodal bands and abaxial tetrasporangia, × 125. **15.** Part of a filament 1.5 mm. from the apex of a mature tetrasporangial plant of the type collection, × 250.

Figs. 16–17. *Ceramium affine* var. *peninsularis.* **16.** A sterile part of a filament from the type collection, × 225. **17.** A tetrasporangial node from the type specimen, × 330.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where both species have been found growing together, they are easily distinguished.

15. CERAMIUM MASONII sp. nov.

Plate 2, figs. 11–12

Ceramium gracillimum Griffiths & Harvey, as interpreted by Dawson, 1944, p. 319. *Ceramium transversale* Collins & Hervey, as interpreted by Setchell & Gardner, 1930, p. 170, pl. 7, figs. 23, 24; Collins, Holden & Setchell, in Phyc. Bor. Amer. no. 2150.

Thallis epiphyticis ope rhizoidum affixis e filamentis inferis subprostratis vel intertextis orientibus, 4–5 (10) mm. altis, 40–50 μ parte supera diametro, parte infera 60–80 μ diametro tantum, ad nodos corticatis, alternatim ramosis; zonis corticalibus in tertio infero linea perspicua partitis, zonae ipsius tertio infero seriebus 1–2 cellularum elongatarum horizontaliter facto; tetrasporangiis verticillatis, involucratis.

Thalli epiphytic, attached by rhizoids from the nodes of semi-prostrate or entangled lower filaments, to 4–5 (or 10) mm. high, 40–50 μ diam. above, 60–80 μ diam. below, corticated only at the nodes, without secondary cortical expansion; branching apparently alternate; apices non-forcipate, slightly incurved; internodes long below, to 5 times the nodal diameter; cortical bands divided in their lower third by a clear line, consisting in the upper two thirds of larger, angular cells cutting off a few smaller, superficial cells, the lower third of 1–2 tiers of horizontally elongated cells; tetrasporangia whorled, borne within the cortical band which is modified by their growth to form an involucre; antheridia in whorled tufts at the nodes.

TYPE: Dawson 6756, epiphytic on *Galaxaura*, Cabeza Ballena, Baja California, Mexico, March 11, 1949. HAHF 48796.

Additional material: MEXICO — Dawson 6770, Cabeza Ballena; 3442, 3417, Bahía de La Paz; 470, Bahía Bocochibampo, Sonora; 3518, Ensenada de San Francisco, Sonora; 6730, Punta Frailes, Baja Calif.; 6631, Isla Margarita, Baja Calif.; Williams 5/14/46, Isla Cedros, Baja Calif.; Hubbs 46–144, Isla Guadalupe, Baja Calif., Dec. 1946 (identical with the specimens originally collected by Mason on Isla Guadalupe and assigned to *C. transversale* by Setchell & Gardner). CALIFORNIA — Hollenberg 2227, Corona del Mar, Dec. 1937; Phyc. Bor. Amer. 2150, Laguna Beach, Feb. 1913.

Study of the several species of Mexican *Ceramium* in which the cortical band is divided in its lower third has led to a reëxamination of the *Ceramium gracillimum* of Europe and the possibly synonymous *C. transversale* of the western Atlantic and Caribbean in an effort to determine more accurately the relationships of the Pacific Coast plant. At the outset it is assumed that the name *C. byssoideum* Harvey is to be considered synonymous with *C. gracillimum* Griffiths & Harvey in accordance with the studies of Feldmann-Mazoyer (1940). A comparison, then, of the Pacific plants and those of Europe recognized under the latter name has shown some significant differences. Chief among these are a greater regularity of the elongated cells of the lower part of the cortical band in the Pacific plant, the involucrate, whorled, tetrasporangial arrangement, and the absence of the conspicuous gland-cells of *C. gracillimum*. These dif-

ferences appear to indicate that the Pacific American plants are not conspecific with the European. As for *C. transversale* Collins & Hervey, an examination of some of the type material from Bermuda shows no apparent vegetative difference, though the manner of production of tetrasporangia appears to be unlike that in the Pacific specimens. In *C. transversale* the tetrasporangia are sub-secund and only 1–2 at a node, while in the Pacific plants the tetrasporangia are regularly whorled and in groups of 3 or more.

Inasmuch as there appear to be many uncertainties in an attempt to identify our Pacific Coast specimens either with the European *C. gracillimum* or with the doubtfully distinct western Atlantic *C. transversale*, and in view of the apparent tetrasporangial differences in *C. Masonii*, it has seemed best to consider our Pacific plant as an independent species. The taxonomic history of many other of our plants earlier identified with Atlantic species lends support to this view.

16. CERAMIUM TAYLORII sp. nov.

Plate 2, fig. 13; Plate 4, figs. 31–33

Ceramium fastigiatum Harvey, as interpreted by Taylor, 1945, p. 271 (in part). *Ceramium gracillimum* Griffiths & Harvey, as interpreted by Hollenberg, 1948, p. 158.

Thallis ope rhizoidum affixis a filamentis basalibus prostratis orientium; partibus erectis 5–16 mm. altis, diametro supra 60–80 μ, subtus ad 180 μ, ad nodos tantum corticatis, alternatim ramosis; zonis corticalibus subtumidis, in tertio infero linea perspicua partitis; zonae ipsius tertio infero in cellulis parvis angularibus partito; tetrasporangiis verticillatis, involucratis.

Thalli epiphytic or saxicolous, arising from prostrate filaments adhering by rhizoids from the ventral nodal surfaces, the erect parts to 5 (or to 16) mm. high, 60–80 μ diam. above, to 180 μ diam. below, apparently alternately branched; tips non-forcipate, divergent or somewhat incurved in youth; cortical bands somewhat tumid, about 2/3 as long as broad, separated by internodal spaces of 40 μ or less above, but sometimes to 150 μ below (or rarely to 700–800 μ in unusual plants of lax habit), divided in the lower third into two parts by a clear line, the cells in the lower third often at first horizontally elongated, but ultimately divided up into small, angular cells, the upper part of the band consisting of several larger, deep-seated cells cutting off smaller cells toward the top and outside of the band; tetrasporangia whorled, 2–6 at a node, about 30 μ diam., borne within the tumid upper 2/3 of the divided cortical band which becomes modified by their expansion to form an involucre; old branches bearing empty involucres appearing catenate; antheridia borne in a more or less continuous superficial layer on terminal branches above the region of internodal elongation, tending to be confined to adaxial surfaces; cystocarps borne terminally, surrounded and completely overarched by 5–6 long, clasping, involucral branches.

TYPE: Dawson 3393, Cabeza Ballena, Baja California, Mexico, November 9, 1946. HAHF 48797.

Additional material: PACIFIC BAJA CALIFORNIA — Dawson 211a, Punta Descanso; 7268, Bahía Santa María, Isla Magdalena; 1644, El Cardón,

near Punta María; 1576, 1587, Bahía Los Ositos; 2814, 1425, Punta Santa Rosalía; 6708, Bahía Magdalena. GULF OF CALIFORNIA — 613, 617, 1898, 1962, 1969, 1982, 3520, Ensenada de San Francisco; 759, 786, 724, 744, 800, Isla Patos; 1002, 1018, Isla Partida; 1039, Isla Raza; 7176, Puerto Escondido; 7051, Isla Carmen; 3401, 3368, 3342, 3320, Cabeza Ballena. SINALOA — 3658, 3599, 3675, 3623, 3618, Mazatlán. NAYARIT — 3704, Mira Mar. GUERRERO — 3878, 3899, Acapulco.

Several specimens collected by Hollenberg in southern California, particularly at Laguna Beach, have been seen and verified as this species.

A comparison of Taylor's Mexican specimens with recent collections from Pacific Mexico and with typical *Ceramium fastigiatum* from the Atlantic revealed that two different species are involved. Superficially, in size, habit and in the tumid appearance of the cortical bands, *C. Taylorii* resembles *C. fastigiatum*, but in structure of the cortex they are quite distinct. *C. Taylorii* is particularly easily recognized by the fact that the cortex is divided by a distinct horizontal line, usually in its lower third, into two parts in which cell divisions in each are such as not to obscure or disrupt this line. In *C. fastigiatum* such a division of the cortex does not occur and the cells of the band are irregularly disposed with no special horizontal or vertical arrangement. This division of the cortex is similar to that in *C. Masonii*, but in that plant the cells of the lower part of the cortical band are distinctly horizontally elongated and remain so, while in *C. Taylorii* they become divided up in an angular manner. In *C. Masonii* the number of cell rows in the lower cortical third is usually at first one, later two. In *C. Taylorii* this lower part of the band is broader, usually of two tiers at first, later three or sometimes four. The division into angular cells may sometimes result in horizontally elongated cells, but these are of irregular shape and disposition.

17. CERAMIUM PROCUMBENS Setchell & Gardner

Setchell & Gardner, 1924, p. 772, pl. 27, figs. 51–54; Dawson, 1944, p. 318; Hollenberg, 1948, p. 158.

This small, epiphytic plant with extensive prostrate parts and conspicuous opposite branching, first reported in the Gulf of California, has been shown by Hollenberg to be a common epiphyte along southern California. He has also collected it on Santa Catalina Island, California (Hollenberg 759, April 1935). His California specimens have been verified and compared with material from various hosts taken both along Pacific Baja California (Dawson 2763, 2800, Punta Santa Rosalía) and in the Gulf of California (1323, Bahía de Los Angeles, Baja Calif.; 1816, Ensenada de San Francisco, Sonora).

18. CERAMIUM EQUISETOIDES Dawson

Dawson, 1944, p. 320, pl. 51, fig. 1. *Ceramium sinicola* var. *interruptum* (Setchell & Gardner) Dawson, as interpreted by Hollenberg, 1948, p. 158 (in minor part).

The type has been reëxamined and compared with several new collections from the Gulf of California. It now appears that this species may

be related, because of its immersed tetrasporangia, both to *Ceramium procumbens* and to *C. sinicola*, from which it is distinguished, respectively, by its lack of opposite branches, and by its characteristically elongated internodes and proportionally short cortical bands. In some instances the tetrasporangial branches are 2–3 times forked and occasionally with the swollen fertile parts interrupted just above the dichotomies by 1–2 vegetative segments with ecorticate internodes, somewhat as in *Ceramium sinicola* var. *interruptum*.

Recent collections from five stations between Puerto Libertad, Sonora and La Paz, Baja California confirm the wide range within the Gulf of California. Hollenberg's material from Balboa Harbor, California, including his no. 1082, Oct. 1935, agrees with this species. Its occurrence in the protected harbor appears to be in accord with the ecological requirements of the species as indicated by its habitat in the Gulf of California.

19. CERAMIUM SERPENS Setchell & Gardner

Setchell & Gardner, 1924, p. 775, pl. 27, fig. 58; Dawson, 1944, p. 318.

This species is similar in size and in the involucrate tetrasporangia to *Ceramium Camoui*, but the tetrasporangia are usually solitary at the nodes rather than in whorls. The involucre, thus, is unilateral. Plants may be much taller than the type, though of the same filament diameter. Dawson 3132 from La Paz, Baja California is topotypic, but is more than 10 mm. high, with elongated internodes below. A collection from Punta Palmilla, Baja California, Dawson 3264, contains specimens identical with the type illustration.

Perhaps related here is a plant from Cabo Pulmo, Baja California, Dawson 3097, epiphytic on *Dictyota crenulata*. It has solitary, emergent, non-involucrate tetrasporangia and heavier cortical bands with more tiers of cells than in *Ceramium affine*.

20. CERAMIUM CAMOUII Dawson

Dawson, 1944, p. 319, pl. 51, figs. 2–3.

This minute, inconspicuous plant with its highly developed tetrasporangial involucres grows entangled amid other microscopic algae on rock surfaces. Since it seems not to occur in pure stands of its own kind, it is easily overlooked and its presence has been detected thus far only in two of the recent Mexican collections: Dawson 1751, entangled with *Centroceras*, Bahía Bocochibampo, Sonora; 3467, entangled with *Polysiphonia*, La Paz, Baja California. A tetrasporic collection by Hollenberg, 2545, from the bay side of Punta Banda, Baja California, is identical with Dawson 1751 and places this species for the first time in the flora of the outer Pacific Coast. The cortical bands of *C. Camoui* are conspicuously tumid, extremely so when bearing tetrasporangia, and the internodes characteristically long.

21. CERAMIUM GARDNERI Kylin

Plate 3, fig. 19.

Kylin, 1941, p. 29; Smith, 1944, p. 325, pl. 84, fig. 2. *Ceramium californicum* J. Agardh, as interpreted by Gardner, in Phycotheca Boreali-Americana no. 2248.

Although this species has not been reported in California south of Monterey, two specimens in agreement with cotype material in the Hancock Foundation copy of Phyc. Bor. Amer. are at hand: Cooper 470, Dec. 1946 from Ventura, and Hollenberg 1325, April 1936, from Santa Cruz Island. It has not yet been identified with certainty in the Mexican collections.

Ceramium Gardneri is similar to *C. personatum* and may be distinguished by its tetrasporangia which are initially secund and adaxial. In *C. personatum* the tetrasporangia are at first abaxial.

The plants from Puget Sound and Vancouver Island cited by Collins (1913) as *Ceramium tenuissimum* (Phyc. Bor. Amer. 1298) and as *C. strictum*, are apparently related to *C. Gardneri* and are in need of further examination.

22. CERAMIUM MAZATLANENSE sp. nov.

Plate 2, figs. 14–15.

Thallis epiphyticis, 3–4 mm. altis, ope rhizoidum e filamento prostrato nascentium affixis, 90–110 μ diametro, ad nodos tantum corticatis; zonis corticalibus parvis, 25–30 μ, cellulis angularibus; tetrasporangiis emergentibus, secundis, 1–3 aggregatis in facie abaxiali ramorum, involucratis.

Thalli epiphytic, 3–4 mm. high, attached by rhizoids from the ventral surface of a prostrate, basal part of a filament; erect filaments 90–100 μ diam., rather irregularly dichotomously branched, corticated only at the nodes, without secondary cortical expansion; apices forcipate; cortical band very short, 25–30 μ long, consisting of angular cells 7–25 μ in greatest diameter, the largest below and beneath, bearing numerous fine hairs; internodes elongated below, sometimes to 150 μ; tetrasporangia projecting, secund, borne singly or in groups of 2–3 at the nodes on the abaxial sides

PLATE 3

Fig. 18. *Ceramium californicum*. Part of a filament 1 cm. below the apex, from Dawson 5164, Cabo Colnett, × 100.

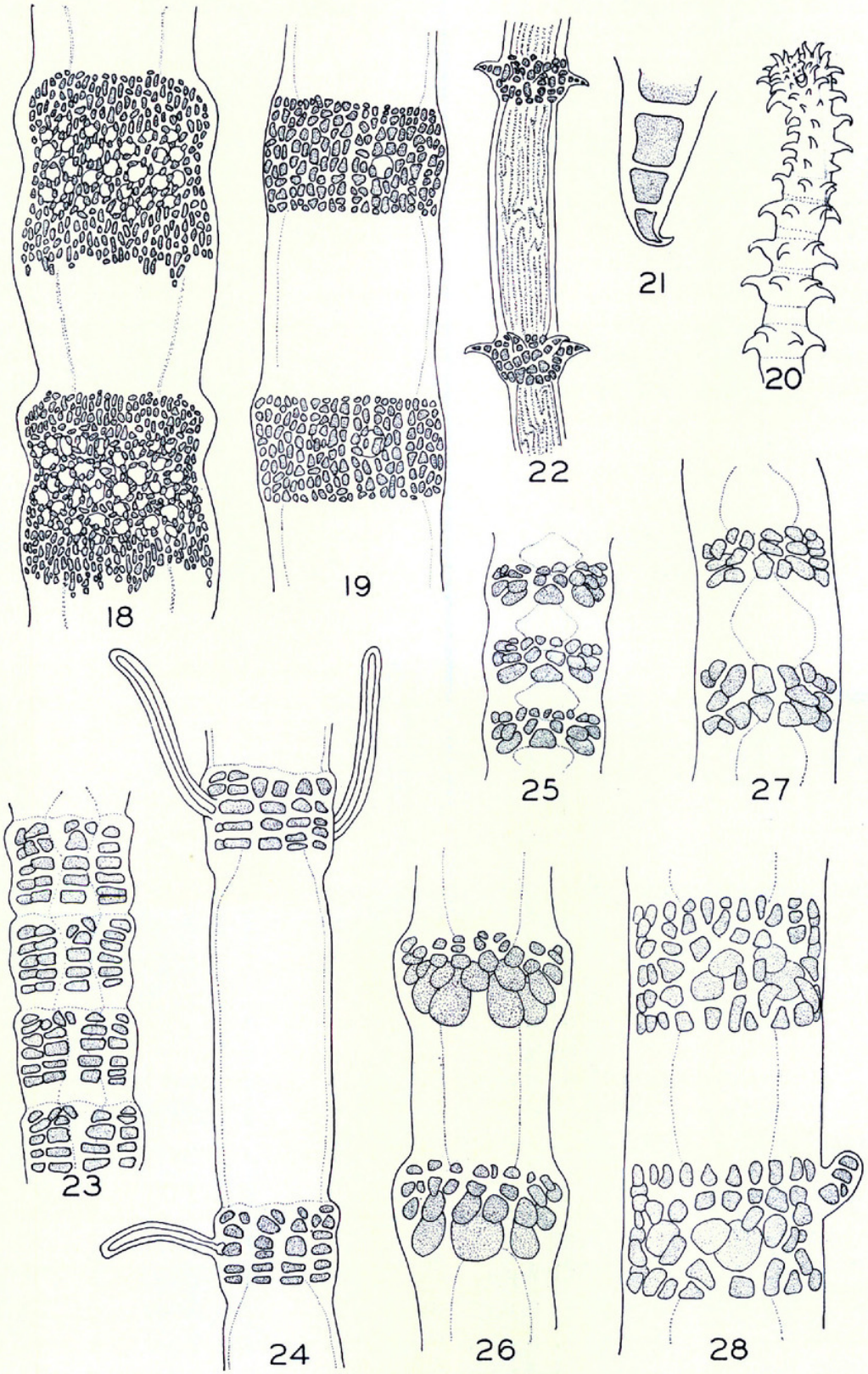
Fig. 19. *Ceramium Gardneri*. Part of a filament 1 cm. below the apex, from a cotype specimen in Phyc. Bor. Amer. no. 2248, × 100.

Figs. 20–22. *Ceramium hamatispinum*. **20.** Terminal part of a young filament from the type collection to show abundant spines and circinate tips, × 85. **21.** Detail of multicellular, hooked spine, × 550. **22.** Part of an old filament to show persistent, whorled spines, × 100.

Figs. 23–24. *Ceramium recticorticum*. **23.** A series of cortical bands from a subterminal portion of the type specimen, × 250. **24.** An older portion of a filament of the type specimen showing persistence of vertical rows of cells, the long internodes and rhizoids, × 250.

Figs. 25–26. *Ceramium avalonae*. **25.** A series of nodes near the apex of a topotype specimen, × 225. **26.** An older portion of a filament of the same plant to show lower nodes, × 350.

Figs. 27–28. *Ceramium zacae*. **27.** Young nodes of a plant from the type collection, × 225. **28.** Lower nodes of a plant from the type collection, × 350.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of the branches, about 35 μ diam., half enveloped by a cortical involucre; antheridia in low, pulvinate masses at the nodes, partially or completely encircling them; cystocarps not seen.

TYPE: Dawson 3606, epiphytic on *Codium*, Mazatlán, Sinaloa, Mexico, December 8, 1946. HAHF 48798.

Additional material: Dawson 3815, 3819, at granite headland south of Salina Cruz, Oaxaca, Mexico, Jan. 1947; Dawson 40–657, rocky point just north of Kino, Sonora, July 16, 1940.

This species has a nodal structure suggestive of *Ceramium Gardneri* though the cortical bands are much shorter. The solitary, abaxial, involucrate tetrasporangia are further distinctive as well as the presence of creeping filaments "rooting down" to the host. The tetrasporangial specimens from Salina Cruz show regularly abaxial, strongly involucrate tetrasporangia, but do not have the circinately curved tips of the type. Their apices are more attenuate than those of the type and but slightly forcipate.

23. CERAMIUM AFFINE Setchell & Gardner

Plate 2, figs. 16–17.

Setchell & Gardner, 1930, p. 172; Dawson, 1944, p. 317, pl. 51, fig. 4.

The type material of *Ceramium affine* from Isla Guadalupe, Baja California apparently represents a slender variant of this species. Recent collections contain examples identical in form and reproduction with the type, but of larger size. The only specimens known in which the filament diameter is as small as in the type (24–28 μ) are those from Puerto Refugio in the Gulf of California (see Dawson, 1944). The large form of this species, found in several collections from Mexico and in one from southern California, exhibits vegetative characters of nodal cortication and internodal elongation virtually identical with the type, though the plants are of fully twice the size in all dimensions. Despite this range of size among vegetative parts of the two variants, the tetrasporangia are essentially the same in each: about 40 μ in diameter including the thick, hyaline envelope.

The name *Ceramium affine* var. **peninsularis** var. nov. is proposed for the large variant.

Cum speciei forma typica optime quadrante, at partis vegetativis duplo majore; tetrasporangiis pro ratione minoribus, formae typicae accedentibus.

Like the type of the species but twice the size in all vegetative dimensions, 60–70 μ diam.; tetrasporangia as in the type, approximately 40 μ diam.

TYPE: Williams, April 27, 1946, dredged in 4–6 m., Isla Concha, Scammon Lagoon, Baja California, Mexico. HAHF 48799.

Additional material: Williams, May 1946, Scammon Lagoon, Baja California; Dawson 6892, Punta Frailes, Baja Calif.; Hollenberg 1590, Corona del Mar, California, Nov. 1936.

The plant identified by Taylor, 1939, as *Ceramium fastigiatum* forma, from Punta Gorda, Baja California, is probably the same as the present plant.

It is proposed to designate the small variant represented by the type of the species as *Ceramium affine* var. **originale** nom. nov.

The plant from Ecuador referred questionably to *Ceramium affine* by Taylor, 1945, has been reëxamined. Although the tetrasporangial arrangement is similar, it appears to be an entirely distinct species.

24. CERAMIUM PERSONATUM Setchell & Gardner

Setchell & Gardner, 1930, p. 171, pl. 6, figs. 21–22.

Heretofore known only from Isla Guadalupe, this species has been detected in recent collections from the northern Bahía Viscaino. It seems closely related to *Ceramium Gardneri*, but may be distinguished by its tetrasporangia which are initially secund and abaxial, later becoming whorled. There may be considerable resemblance to *Ceramium zacae* in some instances, especially in tetrasporangial parts, but *C. zacae* differs by its short, lower internodes and non-tumid cortical bands, as well as by its non-bracteate tetrasporangia. The descending rhizoidal appendages within the internodal cells reported in the original description have been seen in each of the specimens and appear to provide a good specific character. Three collections from Pacific Baja California are referable here: Dawson 1511, Punta Santa Rosalía; 1575, 1594, Bahía Ositos. All have abaxial tetrasporangia more or less clearly involucrate by bracteate filaments. The Bahía Ositos collections include specimens up to 25 mm. high with quite tumid nodes and many secondary branchlets.

The specimens from Costa Rica referred questionably to this species by Taylor, 1945, are sterile and cannot be identified with certainty.

25. CERAMIUM AVALONAE Dawson

Plate 3, figs. 25–26.

Dawson, 1949, p. 17, pl. 5, fig. 31, pl. 14, fig. 56.

Ceramium avalonae shows considerable superficial, microscopic resemblance to *C. zacae* and has a similar tetrasporangial arrangement. The branching habit and the structure of the nodal cortication, however, are amply distinct. The disposition of the large cells in the lower part of the node, cutting off smaller cells above and toward the outside is a character which persists in older parts of the filaments. The outer cortical cells of *C. zacae* are irregularly arranged. In it the larger cells lie interior to the smaller ones and are ordinarily situated in the middle of the nodes rather than in the lower part. *C. zacae* is more abundantly branched above than *C. avalonae*, and the older nodes are not tumid as in the latter. The lower internodes of *C. zacae* are relatively shorter than in *C. avalonae*, being less than as long as wide, rather than 1.5 times as long as wide or more. New materials show that the tetrasporangia of *C. avalonae* are not necessarily solitary at the nodes as originally described, though the abaxial arrangement is maintained even when two or more tetrasporangia are produced at a node.

Several collections by the writer and by G. J. Hollenberg from the type locality, Santa Catalina Island, California have yielded *Ceramium avalonae*.

A tetrasporic specimen from Isla Guadalupe, Hubbs 12/7/46, extends its range into Mexican waters.

26. CERAMIUM ZACAE Setchell & Gardner

Plate 3, figs. 27–28.

Setchell & Gardner, 1937, p. 89, pl. 8, figs. 22a–22c; Dawson, 1945a, p. 62.

Recent collections by Hubbs, 8/20/46, from Isla Cedros near the type locality of *Ceramium zacae* at Bahía San Bartolomé, have yielded typical mature examples of this species. These plants show clearly the short internodes which distinguish *C. zacae* both from *C. avalonae* and *C. caudatum*. From *C. caudatum* it also differs by its non-tumid nodes which are not provided with whorled rhizoids or secondary uncinate branches as in that species.

The original description states that the tetrasporangia are arranged in two regular rows, one on each flank of the upper dichotomies, but re-examination of material from the type collection shows that the tetrasporangia are often whorled in groups of three or more at a node.

Some collections from southern California which serve to extend the known distribution of this species northward are: Dawson 343, La Jolla; Hollenberg 584.5, Corona del Mar; Dawson 5674, Santa Catalina Island.

27. CERAMIUM CAUDATUM Setchell & Gardner

Setchell & Gardner, 1924, p. 776, pl. 27, figs. 55–57; Dawson, 1944, p. 317.

Ceramium caudatum is a rather variable species which sometimes is difficult to determine by means of the key. It is in some ways similar to *C. zacae*, to *C. avalonae* and to *C. personatum*, particularly in its tetrasporangial parts. From *C. zacae* it is easily distinguished by its longer, lower internodes and tumid cortical bands. From *C. avalonae* it differs in larger size, in the irregular disposition of the cells of the cortical band, and in the whorled rather than typically abaxial tetrasporangia. From *C. personatum* it is distinct in its lack of descending appendages within the internodal cells and in the non-involucrate or non-bracteate tetrasporangia.

Ceramium caudatum is often provided with characteristic whorled rhizoids at the nodes and commonly produces uncinate accessory branchlets.

This species has recently been detected in several collections from the Gulf of California, the most typical being Dawson 3480, Bahía Empalme, Sonora, and 857, Isla Jorge, Sonora. Hollenberg has found typical material in southern California: Hollenberg 644, upper Balboa Harbor, and Hollenberg 820, Santa Catalina Island. A collection by Hubbs, 12/7/46, from Isla Guadalupe also appears to be referable here.

28. CERAMIUM CLARIONENSIS Setchell & Gardner

Plate 4, fig. 29.

Setchell & Gardner, 1930, p. 170, pl. 7, figs. 25–27.

The present study has shown that this plant is a common and easily recognized species both in the Gulf of California and along the Pacific Coast of southern California and Baja California. The moderately large

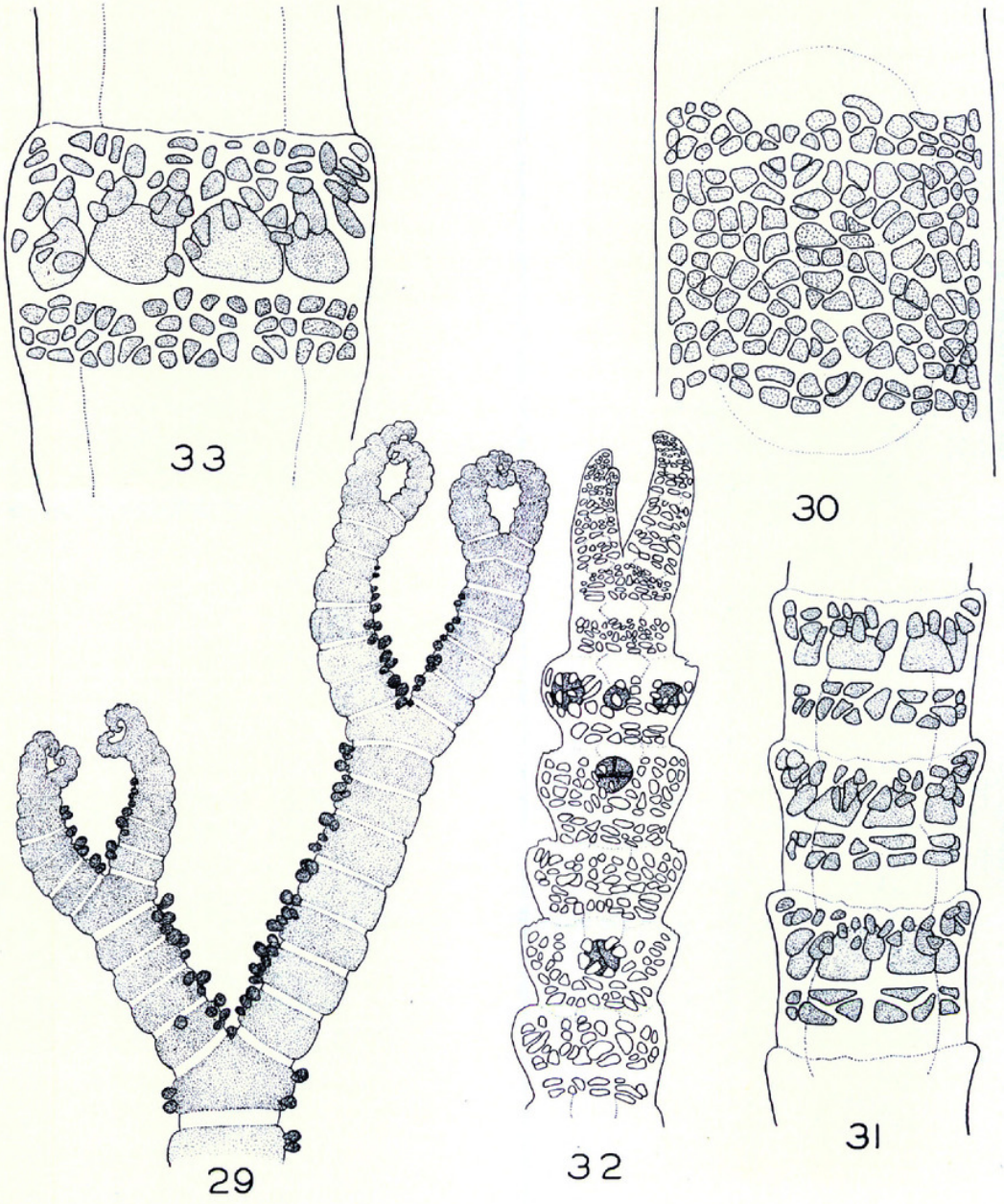

PLATE 4

Fig. 29. *Ceramium clarionensis.* Profile of a terminal portion of a tetrasporangial plant from Guaymas, Sonora, showing adaxial fertile areas, × 55.

Fig. 30. *Ceramium pacificum.* A young node from Dawson 1610, Bahía Viscaino, × 235.

Figs. 31–33. *Ceramium Taylorii.* **31.** A series of young nodes from mithin 1 mm. of the apex of a filament, showing distinct division of the cortical band, × 250. **32.** Terminal part of a tetrasporangial branch showing involucrate condition, × 150. **33.** An older, lower node showing small, angular cells of lower portion of cortical band, × 250.

size, the strongly circinate apices and the truncate cortical bands becoming tumid below, are distinctive vegetative characters. The production of numerous, emergent tetrasporangia, sometimes all the way around the node, or commonly only on the adaxial side, without cortical modification, is a distinctive reproductive character. The tetrasporic characters of the type material have been reëxamined and found not to be represented clearly in the original description or illustration. The tetrasporangia are not as fully developed in numbers on the type as in some of the new material, but those present show a much more clearly emergent, projecting character than is indicated by the Setchell and Gardner illustration. Furthermore, the occurrence of bracteate filaments associated with the tetrasporangia are neither of regular nor of conspicuous occurrence in the type material reëxamined. Such filaments within the tetrasporangial wall are not ordinarily present in the other collections now at hand.

Although short hairs may be present or absent, almost every specimen exhibits to some degree the presence, external to the cortical cells, of small, often globular masses of material staining deeply with aniline blue. These globules are often extremely conspicuous and in some cases are obviously exudation products for they occur external to the cell membrane and in contact with the cortical cell by means of a slender extension of the cell contents through the wall to the exterior. Sometimes the globules are of such regular occurrence and of such uniform size as to give a highly ornamented aspect to the filament (in this regard see Setchell & Gardner, 1930, pl. 7, fig. 25). At other times they may be smeared, giving an unsightly appearance to the slide-preparation. Similar forms suggesting "gland cells" are commonly observed in *Ceramium Taylorii*.

Recorded heretofore only from Isla Clarion, the species is now at hand from many localities along the Pacific Coast. Its distribution may be outlined according to the following collections:

CALIFORNIA — Hollenberg 516, Corona del Mar; Hollenberg 549, Balboa Harbor; Dawson 2088, La Jolla. PACIFIC BAJA CALIFORNIA — Williams 4/30/46, Scammon Lagoon; Williams 5/14/46, Isla Cedros; Dawson 1393, Miller's Landing. GULF OF CALIFORNIA AND SOUTHWARD — Dawson 679, Puerto Libertad, Sonora; 850, Isla Jorge, Sonora; 745, Isla Patos, Sonora; 1018a, Isla Partida, Baja California; 612a, Ensenada de San Francisco, Sonora; 7028, Isla Espiritu Santo, Baja California; 6800, Cabeza Ballena, Baja California; 3696, Mira Mar, Nayarit.

In some instances field records show that these plants produce a brilliant green iridescence in nature. This was particularly true of several from northern localities in the Gulf of California.

A number of recent collections are tetrasporangial, but only those from summer stations. None collected earlier than March shows reproduction. The Mira Mar plant, collected in December, is antheridial, but cystocarpic plants have not yet been noted.

The degree of development of the small, angular cells which usually form a continuous, outermost layer of the cortical band is variable in

this species. In a few cases, notably in Dawson 2813 from Punta Santa Rosalía, Baja California, they may be so scantily developed as to cause the underlying layer of larger cells to appear superficial, thus giving a different appearance to the cortical band.

Those parts of plants in which the tetrasporangia may occur all the way around the node give an appearance strikingly like that in *Ceramium ornatum*. The quite invariably circinate branch-tips of *C. clarionensis*, however, provide a ready distinction from the non-circinate *C. ornatum*.

29. CERAMIUM ORNATUM Setchell & Gardner

Plate 2, fig. 10.

Setchell & Gardner, 1930, p. 172.

This species has not again been detected and may be presumed to be a Guadalupe Island endemic. An examination of part of the type material reveals that the diameter of the main axes is 300–450 μ, rather than 130 μ as given in the original description. Since no illustration has heretofore appeared for this species, a drawing is given from a plant of the type collection.

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LOS ANGELES, CALIFORNIA

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