Brackish-Water Algae from the Hawaiian Islands[1]

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MARINE ALGAE FROM the Hawaiian Islands (in older literature, the Sandwich Islands) have been collected or studied by a few phycologists. Brackish-water species, however, although essentially marine in relationship, have not been systematically studied for this area.

The present study of the brackish-water species was begun late in 1943, in connection with a survey co-operatively conducted by the University of Hawaii and the Territorial Board of Agriculture and Forestry, on fishponds bordering the ocean. At first, two ponds on the island of Oahu were selected for study. In the following year, however, more data and investigation of other ponds seemed desirable. Three additional ponds on Oahu and eight on the island of Molokai were selected and included in the survey. The study of algae, as well as that of animal life, was thus extended to include all these fishponds.

It soon became apparent that the variety of algal forms present in the chosen ponds constituted so large a problem that it would be best to enlist the aid of certain specialists. Myxophyceae were sent to Francis Drouet of the Chicago Natural History Museum and diatoms were sent to Paul S. Conger of the U. S. National Museum, where earlier collections of Hawaiian diatoms are deposited. In the present report are included the bulk of the Chlorophyceae, and all Phaeophyceae and Rhodophyceae.

In the course of this study, a preliminary account of some of these algae by J. T. Conover, made under the direction of G. F. Papenfuss at the University of California, was received. Since the majority of the species in the notes of Conover had already been determined, there was little in his account that requires special mention here.

The present writer reports 9 genera of green algae, 1 of brown, and 11 of red. The algae studied are in the writer's herbarium; duplicate sets will be deposited in the herbarium of the Bishop Museum, and elsewhere if quantity permits.

Species listed seem to include those previously known only from the marine, or only from fresh-water, habitats, with the exception of one species of *Polysiphonia.* This genus, to the writer's knowledge, is known only from strictly saline or brackish-water habitats; it was found in a fresh-water pond, and was accompanied by such a well-known fresh-water genus as *Spirogyra.*

The writer is indebted to Charles Engard, who collected nearly all the specimens of algae. Members of the University fisheries staff, especially Yoshinori Tanada, were extremely helpful with habitat data. Thanks are extended to Kazue Watanabe, who executed most of the drawings.

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[2] The author completed most of the work on this paper while on the Department of Botany staff, University of Hawaii, and finished the manuscript at the University of California, Berkeley, with the aid of the excellent algal herbarium (cited as U. C. Herb.) and library at the latter institution.

HABITAT

The fishponds already mentioned are discussed by Hiatt (ined.) from the standpoint of construction and as a habitat for fish and invertebrates. These ponds are usually enclosures along the seacoast but may at times be exposed directly to the sea. They are enclosed by a stone or mud wall oceanward. Into some ponds fresh-water streams enter on the land side. The ponds were handed down among the natives for generations, and were used mainly for the purpose of raising fish for the kings and chieftains of the various islands until 50 years ago, when they became somewhat commercialized. Several of the ponds under study, however, are still held within the original families who were given the ponds by chieftains.

The continued utilization of these fishponds no doubt has been encouraged by the desire of various racial groups in the Hawaiian Islands for certain kinds of table fish which live in brackish water, at least during part of their life history. It was found by the zoologists in the 1946 biological survey that the two most desirable fish, mullet (*Mugil cephalos*) and milkfish or awa (*Chanos chanos*), fed largely on microbenthos, and the milkfish fed also on larger algae if they were available (Hiatt, *loc. cit.*). Identification of the dominant algae was made in order to help "farm" the fishponds intelligently, as it was found that the food chain ultimately rested with some of these forms.

These ponds furnish a type of habitat the study of which may give additional ecological information. They are not usually more than 6 feet in depth, and thus would allow the penetration of light sufficient for the growth of algae. However, the water is usually turbid and stirred by the wind. The bottom, consisting of mud, or more rarely mud and sand, is frequently moved by the ebb and flow of the tide through the gates from the adjoining ocean. In most ponds, therefore, the algae must of necessity be attached to the walls or on halophytic phanerogams [*Batis maritima, Halophila ovalis* (R. Br.) Hooker; see Fig. 1].

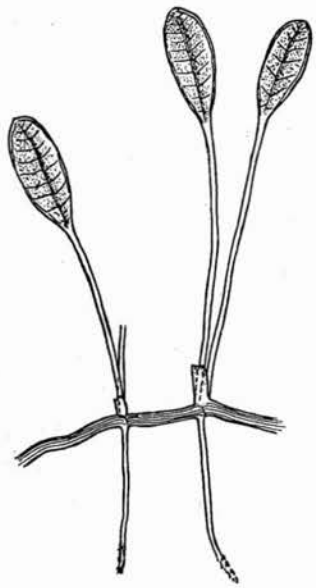

FIG. 1. *Halophila ovalis* (R. Br.) Hooker. Habit of a portion of a plant from Molii Pond. Natural size.

Most of the algae show an affinity for the more marine (sea wall) portions of the ponds. They are found abundantly in such localities, and but sparingly in other regions of the ponds. The fresh-water species are restricted to the mouths of streams where there is little contact with the ocean, or to fresh-water ponds which are apparently fed by artesian wells. Diatoms are abundant epiphytically, and in some ponds form a thick mat on the floor of the pond, mixed with other small algae and the larvae of certain animals.

No seasonal variation in the appearance and disappearance of various forms was noted.

OCCURRENCE OF ALGAE

The ubiquitous *Enteromorpha* appeared in all stations of the ponds, in water ranging in salinity from that of the open ocean to almost fresh. Two distinct species, showing much variability, were recognized. The two species of *Ulva* present, on the other hand, showed distinct preference for the more saline portions. *Cladophora,* that troublesome entity, was present in all situations; such distribution would lead one to believe that variations of marine and fresh-water forms are to be found mixed in the ponds. Other green algae did not occur in great quantity, as did the three just mentioned.

True fresh-water algae (*Spirogyra,* desmids) were recorded from the fresh-water ponds.

The only brown alga found was *Ectocarpus indicus,* which occurred as a common epiphyte on other algae as well as on other plants. The variation shown by this species led to a critical examination of all species which might be growing in this area. The results, which are included with the species description, require placing in synonymy two species, one of which was so placed quite independently of Boergesen (1941).

The red alga collected most frequently (from all but two ponds) was a species of *Polysiphonia,* described here as new to science. Another species of *Polysiphonia* found abundantly in fresh water could not be identified with the foregoing species, nor with any other, as it lacked reproductive organs. This seems to be a new record for the occurrence of this genus in fresh water (chlorinity values were 2.48 to 2.54 parts per thousand). This species was found in a fresh-water pond, strangely called Salt Lake, which is apparently fed by subterranean wells. An old connection with the sea has apparently been sealed off. Other red algae found in some quantity are *Erythrotrichia carnea, Centroceras clavulatum,* and species of *Ceramium.* The red algal species were nearly in contact with the ocean and thus may be thought to be marine, with the exception of the fresh-water *Polysiphonia.*

KEY TO THE ALGAE

A simple key is presented to aid the interested reader with some botanical training to identify as far as genera the algae found in the fishponds. Technical terms have therefore been reduced to a minimum.

PART I. CHLOROPHYCEAE. The grass-green algae.

1. Plants with uninucleate cells.....2
1. Plants multinucleate or with multinucleate cells 4
2. Parenchymatous 3
2. Filamentous, unbranched, free-floating, with spiral chloroplasts .....*Spirogyra,* p. 196
3. Tubular plants, one layer thick in section .....*Enteromorpha,* p. 196
3. Foliose plants, membranous, with simple to cleft margins, two layers thick in section.....*Ulva,* p. 197
4. Filaments unbranched 5
4. Filaments profusely branched.....7
5. Entangled 6
5. Attached, rhizoids only from the basal cell, cells often bulbous..... .....*Chaetomorpha,* p. 197
6. Floating, or if attached with short rhizoidal branches along the entire attaching length, with few to several nuclei..*Rhizoclonium,* p. 197
6. Matted, completely multinucleate, non-septate except at the location of reproductive organs..... ..... *Vaucheria,* p. 198
7. Plants in bushy soft tufts, the branches lateral, opposite, alternate, or fascicled, cut off from the main axis .....*Cladophora,* p. 198
7. Branches not cut off from the main axis 8

8. Branches radial, the plant erect, without trabeculae..*Bryopsis,* p. 198
8. Branches opposite mainly (in some marine species whorled), the plants with rhizomatous base and erect leaf-like portions, with trabeculae .....*Caulerpa,* p. 199

PART II. PHAEOPHYCEAE. The brown algae.
Plants epiphytic, branches secund, with sporangia pedicellate or sessile, lateral or terminal.....*Ectocarpus,* p. 199

PART III. RHODOPHYCEAE. The red algae.
1. Plants epiphytic, filamentous, mostly microscopic, with little differentiation of reproductive parts, asexual reproduction mainly by monospores..2
1. Plants erect, filamentous to compressed, wiry to firm and cartilaginous, asexual reproduction by tetraspores 3
2. Thalli erect or creeping, uniseriate; in well-developed specimens 3 to 4 cells thick at base, chromatophore stellate.....*Erythrotrichia,* p. 200
2. Thalli erect, arising from a pseudoparenchymatous base, or from a single cell, branches chiefly lateral, chromatophores parietal.....*Acrochaetium,* p. 203
3. Axis flattened 4
3. Axis terete 5
4. Branching pinnate, tetrasporangia cruciate, in sori in swollen lateral branches.....*Gelidium,* p. 203
4. Branching dichotomous or lateral, tetrasporangia cruciate, scattered in the thallus.....*Grateloupia,* p. 205
5. Plants wiry, sparingly branched, in matted tufts.....*Wurdemannia,* p. 204
5. Plants flaccid, bushy, with many branches 6
6. Tetrasporangia zonate, branches frequently terminating in a hook .....*Hypnea,* p. 206
6. Tetrasporangia cruciate, branches free 7
7. Plants large, the thallus cylindrical and parenchymatous..*Gracilaria,* p. 206
7. Plants mainly epiphytic, essentially filamentous 8
8. With corticications, the superficial cells shorter than the central cell..9
8. Without corticications, the superficial cells as long as the central cell 10
9. Plants corticated at the nodes, or but little beyond.....*Ceramium,* p. 208
9. Cortication throughout of small rectangular cells in a longitudinal series.....*Centroceras,* p. 207
10. Colorless hairs lateral, spiralling, male and female reproductive structures borne in connection with the hairs..*Polysiphonia,* p. 212
10. Hairs in threes, terminal, tetrasporangia borne on the determinate branches..*Taenioma,* p. 210

DESCRIPTIONS OF SPECIES

CHLOROPHYCEAE

Spirogyra Link, 1820: 5

Two species are distinguished in this genus on the basis of number of chloroplasts. One species is from Salt Lake, and the other from a fresh-water pond adjacent to Ualapue. Neither species can be identified because of the absence of fertile material.

Enteromorpha Link, 1820: 5

Enteromorpha flexuosa (Wulfen) J. Agardh, Till Alg. Syst. (3): 126, 1883.

Plants tufted, to 14 cm. in height, usually less, crenelated or simple, with little or generally no branching. Cells usually arranged longitudinally in a straight series (Setchell and Gardner 1920: 256). Specimens com-

pare favorably with those in U. C. Herb., and one in herbarium of Bishop Museum. Hawaiian specimens examined: *Tilden 558* (Bishop); *Reed 171, 198, 312, 452, 487, 515* (U.C.).

Found in Kuapa Pond at various stations, Kihalaeo Pond, Kupeke, Keawanui, Niaupala, Ilae, and Molii.

Reported from the Hawaiian group by Lemmermann (1905), Reed (1907), Rock (1913), and MacCaughey (1918).

Enteromorpha intestinalis (Linn.) Link, Epistola, p. 5, 1820.

Plants to 20 cm. in height, much branched, the branches whorled, alternate, or opposite. Cells angular in surface view. Some of the specimens from the ponds are in agreement with Setchell Hawaiian Algae *16,* determined by Collins (U.C.).

In all the major ponds.

Reported from the Hawaiian Islands by Reed, Setchell (1905), Rock, and MacCaughey.

Ulva Linnaeus, 1753:1163

Ulva Lactuca Linn., Sp. Plantarum 2: 1163, 1753.

Plants to 15 cm. in height, expanded, with scalloped margins, attached to rocks, twigs, wood, and other algae. Plants are usually light green in color. Base with many rhizoids.

In all the major ponds.

Reported from the Hawaiian Islands by Lemmermann, Reed, Rock, and MacCaughey. Abundant in marine habitats.

Ulva fasciata Delile, Flore d'Egypte, p. 153, 1813 (see Fig. 2).

Dark green plants to 20 cm. in height, cleft and digitate, attached to rocks, forming large patches. Plants not as membranous as *U. Lactuca.* Rhizoids are few.

Collected in Kihaloko, Keawanui, Ualapue, Niaupala, all on Molokai Island.

Reported by Setchell, Reed, Tilden (1901*a*), Reinbold (1907), Rock, and Neal (1930).

FIG. 2. *Ulva fasciata* Delile. Habit of a plant from Keawanui Pond. ¼ natural size.

Chaetomorpha Kützing, 1845: 203

Chaetomorpha aerea (Dillwyn) Kützing, Sp. Alg., 379, 1849.

Tufts of unbranched filaments to 4 mm. in height. Cells inflated, to 120 μ in width, the walls thickened and stratified.

Molii on *Batis maritima,* Kupeke on a bivalve, Keawanui on pond wall.

Chaetomorpha antennina has been reported by Reed, and I have examined her collections of this species. None are of the *Ch. aerea* type. Others reporting other species of *Chaetomorpha* from Hawaii are Chamberlain (1860), Reinbold, Lemmermann, and MacCaughey. Setchell, MacCaughey, and Rock also report *Ch. antennina.*

Rhizoclonium Kützing, 1843: 261

Rhizoclonium sp.

Only one undeveloped specimen, whose determination to species is not possible.

Ualapue Pond, entangled on *Polysiphonia.* Newly reported here for the islands.

Vaucheria De Candolle, 1801: 17

Plants matted, floating, or on the bottom of shallow parts of the ponds. Filaments entangled, coenocytic, with spherical oogonia or antheridia. These structures are stalked or (in ours) sessile.

Three types of plants are found in the ponds, one with no reproductive organs. Determination is thus incomplete for this specimen. The genus is newly reported from the Hawaiian Islands.

Vaucheria dichotoma (Linn.) C. Agardh, Synop. Alg. Scand., 47, 1817.

Large, free-floating masses, in the summer with oogonia and antheridia. Oogonia sessile, globular; antheridia with a terminal opening, sessile, shaped much like oogonia but slightly more elongate.

Kuapa Pond. In abundance.

Vaucheria Thuretii Woronin, *in* Bot. Zeit., 157, 1869.

Filaments 60–80 μ in diameter, in dense patches. Plants monoecious, with sessile spherical oogonia; antheridia curving to a lateral pore.

Keawanui Pond. Rare.

Vaucheria sp.

A sterile specimen, with measurements smaller than the two species just mentioned, was found in Molii Pond attached to a mollusk.

Cladophora Kützing, 1843: 262

Plants bushy, to 15 cm. in height, with prominent lateral branches cut off from the main axes. Each cell multinucleate with many chloroplasts.

A most variable genus, with representatives by far the most commonly found in brackish water. Identification cannot be made with certainty without a large amount of comparative material. Lacking this, determination must be left at the genus.

In all the ponds, but in abundance especially in the more saline ones.

Compared with the published illustrations of Brand (1905), these specimens show much variation, and relationships cannot be established without examining the specimens used by him.

Bryopsis Lamouroux, 1809*a*: 133

Bryopsis pennata Lamouroux var. *secunda* (Harvey) Collins and Hervey, Amer. Acad. Arts and Sci., Proc. 53: 62, 1917.

Only one plant, 2 cm. in height, was collected, in the more saline portions of Keawanui Pond. The main branches arise from a rhizoidal base, and branch in a pinnate manner, the pinnules opposite each other. A few branches show the secund type of orientation. The plant is dark green.

Distribution: Florida, Bermuda, Bahamas and islands of the West Indies to Aruba Island, Netherlands West Indies (for the species).

A rather exhaustive comparison has been made of this specimen with other *Bryopsis* specimens from this area, and also from other parts of the world, with emphasis on tropical forms. These comparisons have been made in the University of California Herbarium.

With certain specimens from Hawaii (*Reed 1173, 1150, 1068*) our specimen is in good agreement. Close comparison is also possible with plants from Samoa and Tahiti (*Setchell 1087,* Tutuila, and *Setchell and Parks 5185,* Tahiti, both as *B. Harveyana*), from Formosa (legit Y. Yamada), and to some extent specimens from Dwarka (*Boergesen 5534* as *B. plumosa*), the Gulf of California (Turner's Island, *Dawson 688* as *B. plumosa* var. *pennata*), and from New Guinea (*Kärubach 29,* det. Grunow, as *B. Harveyana*). Specimens on sheets 341389, 341498, and 341390 which have been determined as *B. Harveyana* by Setchell show little agreement with our specimens. These plants are from the Malay Peninsula. Likewise little similarity can be detected between the Hawaiian specimens and those of the Atlantic determined as *B. plumosa* (exemplified by *Setchell 150* from Woods Hole), or of the Caribbean forms of this species.

The North American specimens seem to be Boergesen's variety *typica* of *B. plumosa.* Boergesen's varieties *pennata, Harveyana,* and *Leprieurii* of *B. plumosa* (1911: 147; 1913: 115) show more

similarity to variety *typica* than do our specimens to any of these. Boergesen (1946: 341) has raised *B. Harveyana* to specific rank. Setchell's *B. Harveyana* of Samoa (1924) and Tahiti (1926) should not be included in synonymy with *B. plumosa* var. *Harveyana,* as those specimens are quite different from Boergesen's specimens.

It is obvious from the literature that there is great confusion as to species limits in this genus. Lacking critical specimens, I am following the interpretation of Taylor (1928) and of Collins and Hervey (1917). At best, this practice is not too satisfactory, as the Pacific plants by and large are somewhat different from the Atlantic and Caribbean forms. A large suite of specimens and comparison with type material are desirable.

Bryopsis plumosa has been reported from the Hawaiian Islands by Chamberlain, Tilden, and MacCaughey. I have examined the Tilden specimen (453) in American Algae Century V (1901*b*), and find it to be identical with ours. In all probability, the records are in agreement with the material mentioned here.

Caulerpa Lamouroux, 1809*b*: 136

Caulerpa Sertularioides (Gmelin) Howe *in* Torrey Bot. Club Bul. 32: 576, 1905.

Plants to 4 cm. in height, creeping parts clinging tightly to sand and rock particles, the upper portions flattened laterally, with opposite or nearly opposite "leaflets."

At one station, adjacent to the main regions of Kuapa Pond, near the connections to the sea.

The genus is common in marine habitats in the Hawaiian Islands; this species and one related closely to it are among the more prominent members of the genus in Hawaii. Reported from the Hawaiian group by Eubank (1946).

PHAEOPHYCEAE

Ectocarpus Lyngbye, 1819: 130

Plants tufted, filamentous, arising from a single basal cell, or from a group of cells, with or without rhizoids at the base, attached to twigs, wood, or other algae. Plants in this series to 6 cm. in height, but more usually 1–2 cm. Reproduction by plurilocular or unilocular sporangia.

In the sense of Hamel (1939: 66–67) the species which is described below would more properly fit in the segregated genus *Feldmannia,* which differs in a few characters—mainly in that it has discoid chromatophores, whereas the limits of *Ectocarpus* are such as include only those members of this complex which have ribbon-like chromatophores.

One of the characters used to separate *Feldmannia* further is the strong ramifications of filaments near the base, a character not shown by our plants. Sporangia are typically pedicellate in *Feldmannia,* a condition only infrequently occurring in our specimens.

Giffordia, in the sense of Hamel, is characterized by discoid chromatophores also, but sporangia are always sessile, and the plant has intercalary growth. These are not constant characters in our plants.

It would thus seem best to retain the species below in the genus *Ectocarpus, sensu latiore,* until European workers who have authentic material can establish further characters for the separations so badly needed in this complex.

In making a survey of literature pertinent to Hawaiian material, some confusion was encountered with *Ectocarpus Duchassaingianus* Grunow (1870), recorded for the Pacific from Samoa (Setchell, 1924). From the literature, this species seemed identical with *Ectocarpus indicus* Sonder, recorded earlier by Weber-van Bosse (1913: 129) from Malaya. The writer has examined material used by Setchell in his study, and has concluded that his plants are synonymous with *E. indicus* Sonder.

When these studies were completed, reprints of Boergesen's instructive Mauritius papers were received, and it was interesting to find that he had come to the same conclusions regarding *E. Duchassaingianus,* which he based on specimens from the Danish West Indies (Virgin Islands).

Examination of a large number of specimens collected in the fishponds and in marine habitats, as well as those deposited in the herbarium of the Bishop Museum, Honolulu, and the herbarium of the University of California, Berkeley, has led the writer to believe that there is much variation in specimens as well as in interpretation of *Ectocarpus indicus*. These notes, and those that directly follow, are a result of the examination of a large series. Such studies have led the writer to consider *Ectocarpus Mitchellae* in the sense of Saunders (1901, in Tilden 1901*b*) and *E. Sargassi* Saunders as identical with the material in the present investigation. These specimens are from Hawaii and are distributed by Tilden (American Algae Century V, nos. 439, 440a, and 440b). I have examined both Bishop Museum and University of California specimens of the exsiccatae and find them identical with *E. indicus*.

Ectocarpus indicus Sonder, *in* Zollinger, H. Verzeichn. . . . indischen Archipel. . . . 1842–48, p. 3 (not as usually cited: *in* A. Moritzi, Syst. Verzeichn, 1857) (see Fig. 3*a–d*).

Ectocarpus Duchassaingianus Grunow, Alg. Novara, 1870, p. 45.

Ectocarpus Sargassi Saunders, *in* Tilden American Algae Century V, nos. 440a and 440b, 1901*b*.

Plants tufted, branching primarily dichotomous with many lateral branches, the main branches about 10 μ wide. Sporangia attached, sessile or stalked, on the inner surface of the branches, oval to oval-clavate, distributed throughout the plant. Plants rising from a creeping base.

Abundant in Kuapa Pond, usually on *Batis maritima;* Wailupe, Molii Ponds, on Oahu Island. Also found in Keawanui, Kupeke, Ualapue, Niaupala Ponds, Molokai Island.

In the marine habitat, commonly occurring on species of *Sargassum*.

Specimens examined (in U. C. Herb.): as *Ectocarpus indicus, Potts 1173a,* determined by Setchell, from Samoa; *Lindauer 28,* det. Lindauer, from New Zealand; *Nasr 259* from Egypt (Red Sea); *Li 124* ex herb. Tseng, det. Setchell, from China; *K. G. Iyengar 83,* det. Gardner, from Bombay; as *E. Duchassaingianus: Tilden 32,* det. Tilden, from Tahiti; *Boergesen 1093, 1250,* det. Boergesen, from the Virgin Islands[3]; *Hamel 45,* det. Hamel, from the French Antilles; *Taylor 39308, 39602,* det. Taylor, from the Netherlands West Indies.

Tilden 440a, 440b, as *Ectocarpus Sargassi* Saunders, det. Saunders, in Tilden American Algae Century V; *439* as *E. Mitchellae,* det. Saunders. These specimens are from the Hawaiian Islands. (Exsiccatae from Bishop Museum and University of California Herbaria examined.)

Distribution: Throughout warmer seas.

Previously reported by Reed, MacCaughey, Lemmermann, and Neal.

RHODOPHYCEAE

Erythrotrichia Areschoug, 1847: 209

Erythrotrichia carnea (Dillwyn) J. Agardh, Till Alg. Syst. (6): 15, 1883.

Plants attached singly, or in small loose tufts, to 4 cm. in height, the uniseriate filaments attached to other algae by a single disk-shaped basal cell which may become lobed. The lower, older parts of the plant may be two or three cells in width. Chromatophore stellate, with a prominent pyrenoid. Reproductive structures not seen.

Found in all major fishponds, epiphytic on *Enteromorpha* spp., *Grateloupia, Polysiphonia,* and *Gelidium. Erythrotrichia carnea* is here reported from the Hawaiian

[3] These specimens as well as others collected by Boergesen in the Virgin Islands and identified as *E. Duchassaingianus* (1913: 159) were transferred by him to *E. indicus* (1941: 16).

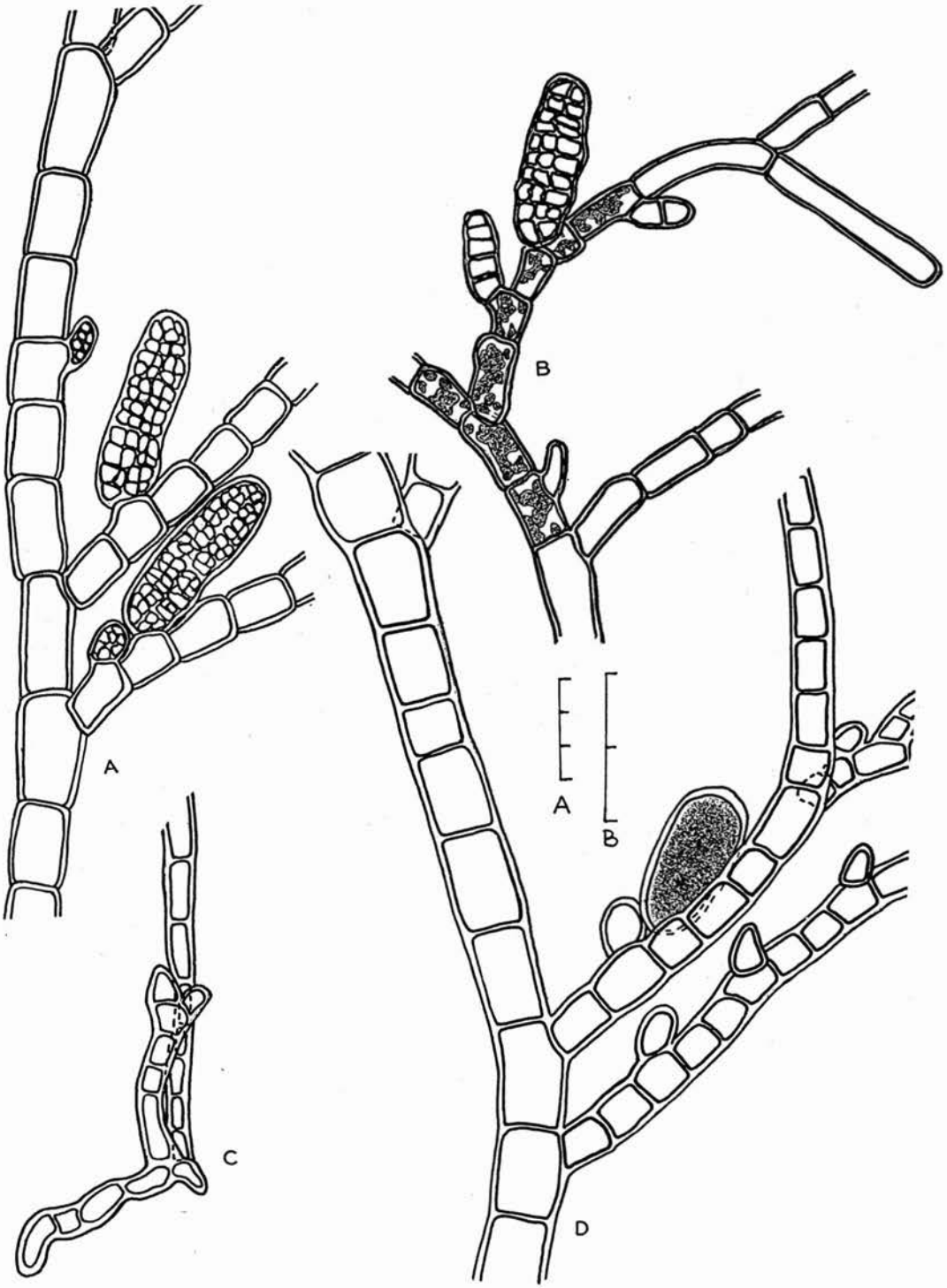

FIG. 3. *Ectocarpus indicus* Sonder. A. Portion of plant with plurilocular sporangia. Scale B (divisions 50 microns). B. Portion of plant showing chromatophores. Scale B (divisions 50 microns). C. Basal portion. Scale A (divisions 100 microns). D. Portion of plant with mature unilocular sporangium. Scale B (divisions 50 microns).

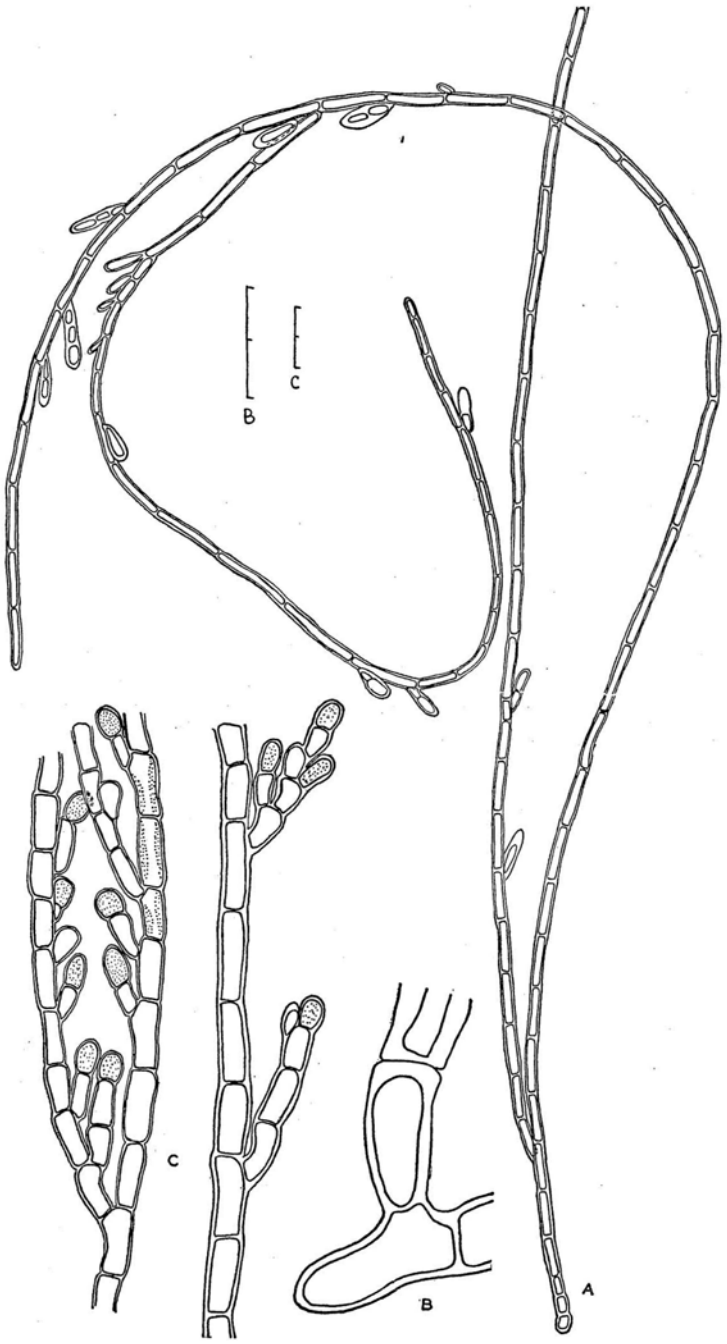

FIG. 4. *Acrochaetium robustum* Boergesen. A. Habit of plant with monosporangia. Note single basal cell. Scale B (divisions 50 microns). B. Portion of plant with part of multicellular base. Scale C (divisions 10 microns). *Acrochaetium seriatum* Boergesen: C. Portions of plants showing monosporangia. Scale C (divisions 10 microns).

Islands for the first time. It occurs commonly on many marine algae in this area.

Distribution: Occurring commonly in the tropics, epiphytic on littoral and sublittoral algae; extending into temperate waters as far north as England (type locality).

Acrochaetium Nägeli, 1861: 402

The treatment of this genus is based on the work of Papenfuss (1945), who has seen our specimens.

Acrochaetium robustum Boergesen, Mar. Alg. D. W. I., 2 (1): 40–43, 1915 (see Fig. 4*a–b*).

Plants tufted, to 1 cm. in height, epiphytic, with a simple or branched basal cell partly to wholly endophytic. Branching predominantly lateral, sometimes alternate, but at the base dichotomous. Cells with a parietal chromatophore and a single pyrenoid, and with pit connections readily seen. Cells to 4 μ in width, and twice as long. Monosporangia prominent, sessile or pedicellate, appearing laterally near the tips of the fronds, singly or in pairs. Terminal sporangia are often seen. Sexual organs not seen.

Found in Kuapa Pond, epiphytic on *Batis maritima,* and a piece of coniferous wood. Not the same species as other marine specimens from this area. The genus is newly reported from the Hawaiian Islands.

Distribution: Danish West Indies, Japan.

Acrochaetium seriatum Boergesen, Mar. Alg. D. W. I., 2 (1): 32–35, 1915 (see Fig. 4*c*).

Plants to 5 mm. in height, tufted, soft, epiphytic on *Ulva fasciata.* Branching chiefly lateral, occasionally alternate. Erect portions arising from a multicellular creeping base. Monosporangia borne singly or in clusters, sessile or pedicellate. In Keawanui Pond, Molokai Island, on *Ulva fasciata.*

Distribution: Danish West Indies, Macassar.

Both these species of *Acrochaetium* were collected in the more saline portions of Kuapa and Keawanui. In all probability they are not true brackish-water species. Species of *Acrochaetium* occur frequently on larger algae in the marine environment in this area.

Gelidium Lamouroux, 1813: 40

Gelidium pusillum (Stackhouse) Le Jolis *in* Soc. Sci. Nat. Cherbourg, Mem. 10: 139, 1863 (see Fig. 5).

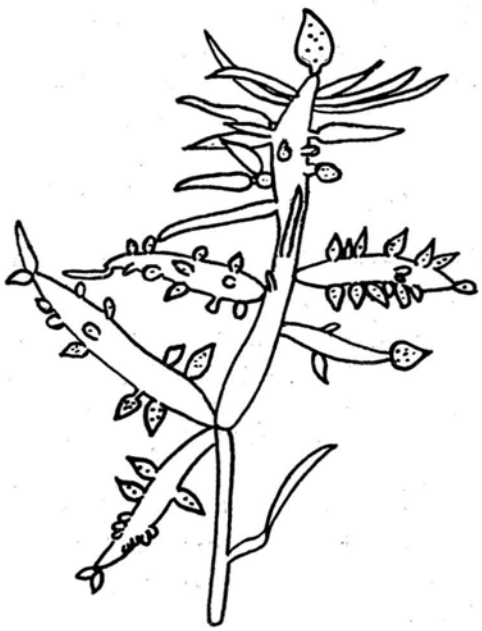

FIG. 5. *Gelidium pusillum* (Stackh.) Le Jolis. Habit of portion of a plant. × 4.

Plants small, associated loosely in clusters, with a creeping base bearing erect parts to 3 cm. in height. Branching irregularly pinnate or alternate, with both branches and axis markedly flattened. Rhizines occupy a large central area of the branches with small cortical cells in three rows on the outside.

Tetrasporangia in small bulbous lateral branchlets, sunken below the surface. Tetraspores in cruciate groups when mature, the

young tetrasporangia frequently showing only one division. Sexual plants not seen.

Found in Molii Pond, Oahu; Ilae, Keawanui, Kupeke, and Ualapue Ponds, Molokai, infrequently occurring, and with many epiphytic diatoms and *Erythrotrichia carnea.*

Distribution: In the tropics, northward to England (type locality).

This species is a variable one, and perhaps these plants represent a distinct entity, but for the present it seems best to identify them with the species. All species of *Gelidium* are named "limu loloa" or "limu ekahakaha" by the Hawaiians. The species here noted has been questioned by Reed. MacCaughey lists the species. It does not seem to be either of the *Gelidium* spp. listed by Neal.

Gelidium pusillum var. *conchicola* Piccone and Grunow *in* Piccone, Contribuzione all'algologia Eritrea, Nuovo Giornale Bot. Ital., 16: 316, 1884.

Plants smaller than the species, to 5 mm. forming tufts, but inconspicuous. Blades flattened especially at the tips. Rhizomes with small colorless rhizoids. The plant is sterile.

Fragment of plants from Molii Pond, associated with *Cladophora* sp. and *Polysiphonia.* Newly reported from the Hawaiian Islands.

Distribution: Bermuda, Florida, Colombia.

These plants agree favorably with description and figures of Taylor (1928).

Wurdemannia Harvey, 1853: 245

Genus incertae sedis. Taylor, 1928, 1941, 1943, 1945, lists the genus with the Gelidiales, but in 1940 lists it in the Cryptonemiales (Rhodophyllidaceae). Feldmann and Hamel, 1934, list it in the Gelidiales. Harvey (1853) and Boergesen (1919–20) list it as uncertain.

Wurdemannia miniata (Draparnaud) Feldmann et Hamel *in* Revue Générale de Botanique 46: 545, 1934 (see Fig. 6; Fig. 7*b*).

Wurdemannia setacea Harvey, Nereis Bor. Am. (2): 245, 1853.

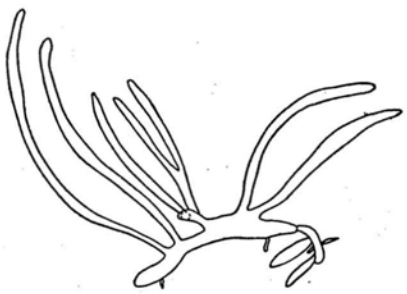

FIG. 6. *Wurdemannia miniata* (Drap.) Feldmann et Hamel. Habit of plant. × 1½.

Plants in thickly matted dark red tufts to 4 cm. in height, attached to the substratum by numerous disk-shaped holdfasts from which run several cylindrical rhizomes. Main axis erect, sparingly branched, terete, and of firm consistency. The young branches show large medullary cells which become smaller toward the outside. Superficial cells are somewhat square and contain many chromatophores. In surface view, these cells are small and irregularly shaped.

Tetrasporangia are found in sori near the tips of the branches with few modified sterile filaments. The sporangia are zonately divided. Sexual plants are not known.

Found in Molii, Oahu Island; Ilae and Keawanui, Molokai Island.

Distribution: Mediterranean (Montpellier, type locality). Harvey's plant was collected at Key West. It is also known in the Atlantic from the Brazilian coast northward to Bermuda.

Reported here for the first time from the Hawaiian Islands, and for the Pacific.

When sexual plants are known, this species will probably be segregated from the Gelidiales because of its zonate tetrasporangia.

Grateloupia C. Agardh, 1820: 221

Grateloupia filicina (Wulfen) C. Agardh, Syst. Alg., 241, 1824.

Grateloupia filicina forma *hawaiiana* Mazza, Nuova Not., 26: 75, 1915.

Plants purplish-red, cartilaginous, 14 cm. in height, erect, the fronds attached in groups by a single holdfast; branching with a percurrent main axis, the whole plant assuming a pyramidal shape. Branches to 3 mm. in diameter, linear, acuminate. Medulla composed of spherical cells of moderate size in transverse section, occasionally showing stored dextrin particles, surrounded on the outer surface by two layers of compact small cells. Plants collected are sterile.

Found in Keawanui, near pond gate in quiet water, with much epiphytic *Erythrotrichia carnea.*

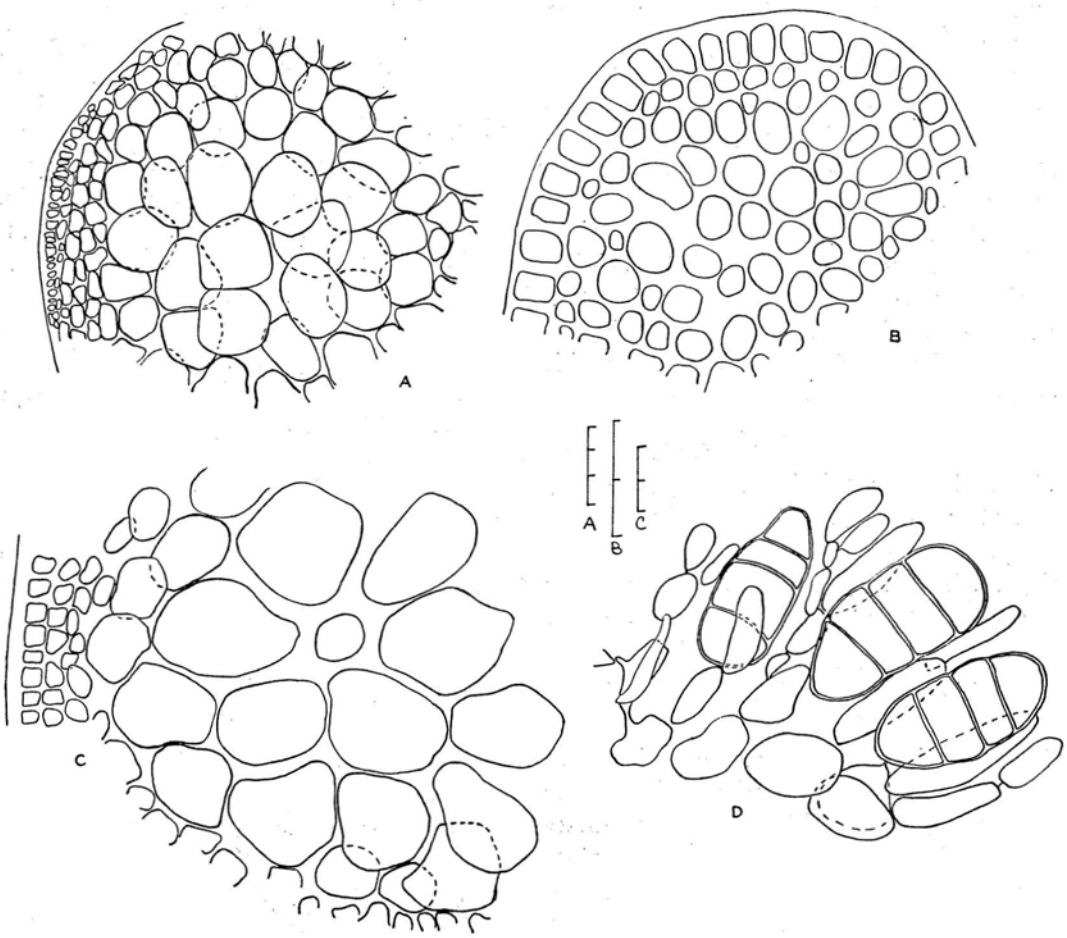

FIG. 7. A. *Gracilaria coronopifolia* J. Agardh. Cross section of thallus. Scale A (divisions 100 microns). B. *Wurdemannia miniata* (Drap.) Feldmann et Hamel. Cross section of thallus. Scale C (divisions 10 microns). C. *Hypnea nidulans* Setchell. Cross section of thallus. Scale B (divisions 50 microns). D. *Hypnea nidulans* Setchell. Cross section of portion of fertile branch showing tetrasporangia. Scale C (divisions 10 microns).

Distribution: Widely occurring in warm waters, into colder regions.

This is an alga of choice eating qualities, much desired by Hawaiians. It grows well in various localities on the islands of Hawaii and Maui especially, and is occasionally seen in certain localities on the island of Oahu, where it is said to have been planted for the late Queen Liliuokalani. The alga is known on Hawaii as "limu huluhuluwaena," and on Maui as "limu pakeleawaa." If it were not so well known, it would be difficult to place the plants collected, because they are sterile.

Grateloupia filicina has been reported from the Hawaiian area by Reed, Rock, MacCaughey, and Setchell. *G. dichotoma,* reported by Chamberlain, has not been substantiated.

Specimens examined (in Herbarium Bishop Museum): *Drew 641,* Waikiki; Rock, Apr., May, 1908, Waikiki; Bailey in 1876, Lanai Island. *Tilden 507,* Kapaa (Kauai Island), does not seem to be this genus.

Gracilaria Greville, 1830: 121

Gracilaria coronopifolia J. Agardh, Sp. Alg. 2 (2): 592–593, 1852 (see Fig. 7*a;* Fig. 9).

Gracilaria No. 1, No. 2, Neal, Hawaiian Marine Algae, 68, Fig. 18*b,* 1930.

Plants erect, to 15 cm. in height, pink at tips, white below, with one or more fronds attached to a single holdfast. Branching frequent, dichotomous, arcuate at tips, with a corymbose aspect. Branches cylindrical in transverse section with a large medullary region of colorless rounded cells slightly thickened, surrounded by a narrow cortical layer and a layer of smaller superficial cells. Female plants with prominent pink to red cystocarps in the upper branches. Cystocarps with thick outer covering and a small ostiole. Male and tetrasporangial plants not seen.

Found in Keawanui and Ilae ponds, Molokai.

Distribution: "ad Wahoo [Oahu] Insularum Sandwicensium." Apparently endemic to the Hawaiian Islands, and found quite commonly in the marine habitat. Reported by Reinbold.

The "limu manauea" of the Hawaiians (the "ogo" of the Japanese) is characteristic of sandy, sheltered areas about the islands. Two other species of *Gracilaria* are listed in the literature from Hawaii: *G. confervoides* by Chamberlain and MacCaughey, and *G. euchemoides* by Chamberlain. Neither of these species has been collected by the writer. *G. coronopifolia* has been mentioned by Chamberlain, Lemmermann, Reed, Rock, MacCaughey, and Setchell, and questioned by Neal. Neal's two species (No. 1 and 2) are this species. Other forms from the islands have been studied but it is difficult to place them with certainty.

Hypnea Lamouroux, 1813: 131

Hypnea nidifica J. Agardh, Sp. Alg. 2 (2): 451, 1852 (see Fig. 8).

FIG. 8. *Hypnea nidifica* J. Agardh. Habit of a portion of a plant. × 2.

Plants erect to 20 cm. in height, or more usually matted and attached epiphytically to other algae, with slender branches alternate or whorled and closely beset with very short branchlets, the ultimate tips simple and straight. Plants red to reddish-green when fresh. In section, the main axis shows a large medullary layer surrounded by cortical cells in radial rows of smaller cells, and a somewhat firm superficial layer of angular cells. Tetrasporangia circling the base of the short branchlets, the cortical cells forming distinct radial filaments in these areas. Sporangia zonately divided. Male and female plants not seen.

Found in Ilae Pond, growing with *Ceramium* spp., and *Polysiphonia.* In the Hawaiian area, common in sandy shallow waters.

Distribution: "ad insulis Sandwich." Reported by Reinbold from the Hawaiian Islands, and from Malaya by Weber-van Bosse (1928: 453).

Hypnea nidifica seems more closely related to *H. cornuta* in habit than to *H. cervicornis,* a comparison made by J. Agardh. The anatomy of the frond is closer to the next species than to the two species just mentioned. Tetrasporangia are like those of most other species.

The species has been listed by Chamberlain, Lemmermann, Reed, Setchell, Rock, MacCaughey, and Neal. *Hypnea armata* has been listed by Reed, Rock, and MacCaughey. *Hypnea cornuta, H. pannosa,* and *H. divaricata* mentioned by Chamberlain have not been verified.

Hypnea nidulans Setchell, Veg. Tutuila Island, Carnegie Inst. Wash. 20: 161–162, 1924 (see Fig. 7*c–d*).

Plants smaller than *H. nidifica,* much twisted and branched, growing in small tufts among other algae. It is chiefly differentiated from *H. nidifica* in having tetrasporangia in nemathecia near the tips of the fertile branchlets. In cross section, the cortical cells are smaller, with small uniform superficial cells. Only tetrasporangial plants were collected.

Found in Molii Pond. Newly reported from the Hawaiian Islands.

Distribution: Samoa (type locality), *Setchell 1084,* type, in U.C. Herb., *Setchell and Parks 5158* in Herb. Bishop Museum. Also reported by Boergesen (1943: 62) from Mauritius and by Weber-van Bosse (1928: 454) from Malaya.

FIG. 9. *Gracilaria coronopifolia* J. Agardh. Habit of a portion of a cystocarpic plant. Natural size.

Centroceras Kützing, 1841: 731

Centroceras clavulatum (C. Agardh) Montagne, Flore d'Algerie, 140, 1840–1850.

Plants filamentous, usually in matted tufts, stiff and brittle, or floating and entangled with other algae; dark purplish-red in color, or pinkish where exposed. Fishpond specimens are 6–8 cm. in height with irregular branching and short internodes at the tops of the branches, the tips sometimes forcipate. Spines at the nodes most prominent in the upper parts of the filaments, 4 to 6; in the older parts usually 2 or deciduous. Spines are of two or more cells. Cortical cells in section, 28 to 40 in the nodal portions. Tetrasporangia sub-external, formed in a horizontal row of 4 to 8 at the nodes, tetrahedrally divided.

Found abundantly in portions of several fishponds open to the sea: Molii on Oahu Island; Ilae, Keawanui, Kupeke on Molokai Island.

Widely distributed throughout tropical waters. It is one of the most frequently encountered of shallow-water algae in the Hawaiian area. *Tilden 401* (American Algae, Century V) in Herbarium University of California as *Ceramium diaphanum* is *Centroceras clavulatum*. This specimen is from the Hawaiian Islands.

The structure of plants of this species is very variable, but the species is readily separated from the next (*Ceramium*) in being more brittle and usually larger, and in possessing continuous corticating cells.

It is listed from the Hawaiian Islands by J. Agardh, Chamberlain, Setchell, Reed, and Rock, and, as *Ceramium clavulatum* C. Agardh, by Lemmermann and MacCaughey.

Ceramium (Roth) Lyngbye, 1819: 117

Ceramium is a large and complex genus. The limits of many of the species, especially the tropical ones, are as yet ill defined. Consequently, it seems best not to assign specific names to either of the following species, especially since not all necessary plants were found.

Ceramium sp. (1) (see Fig. 10*a–b*).

Plants 4–8 cm. in height, dark pink to red, lying in soft tangled mats among other algae. Base of plants sometimes with rhizoids, the upper ends usually free. Branching irregularly dichotomous, with prominent forcipate

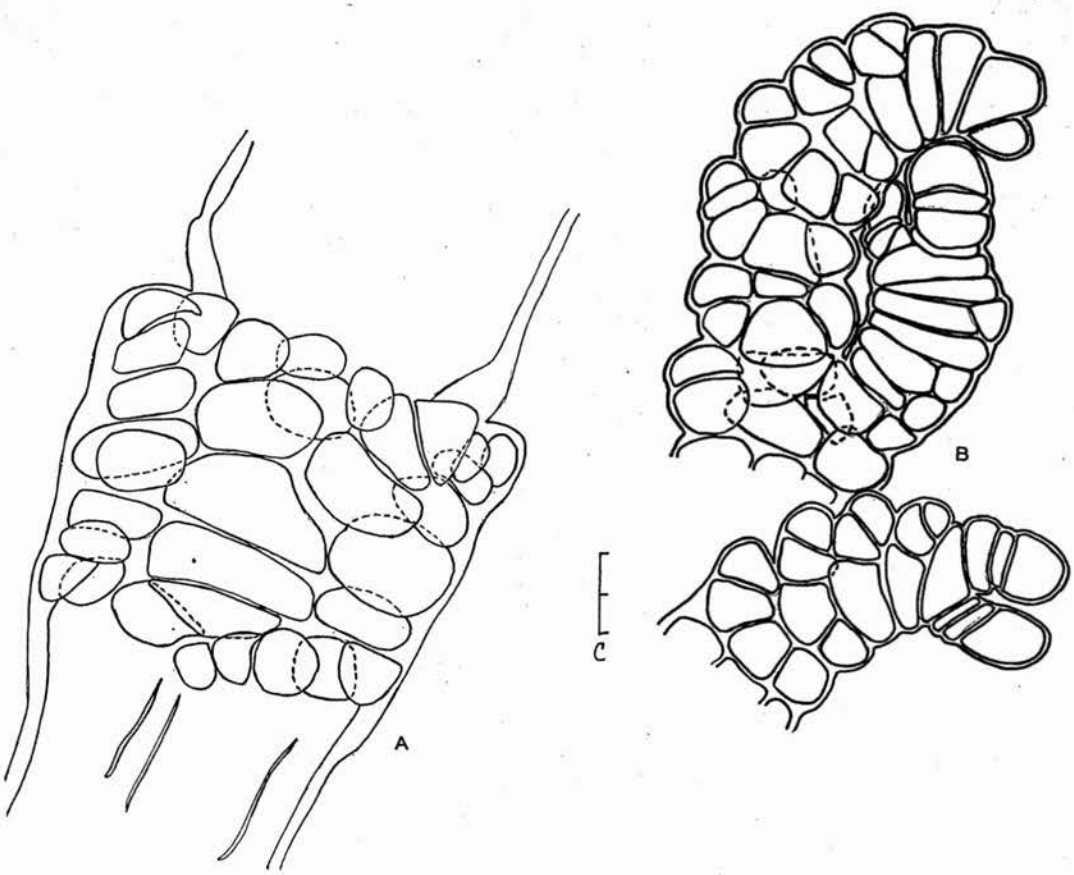

FIG. 10. *Ceramium* sp. (1). A. Nodal region showing cortication. Scale C (divisions 10 microns). B. Tips of two plants, in the above figure showing forcipate nature. Scale C (divisions 10 microns).

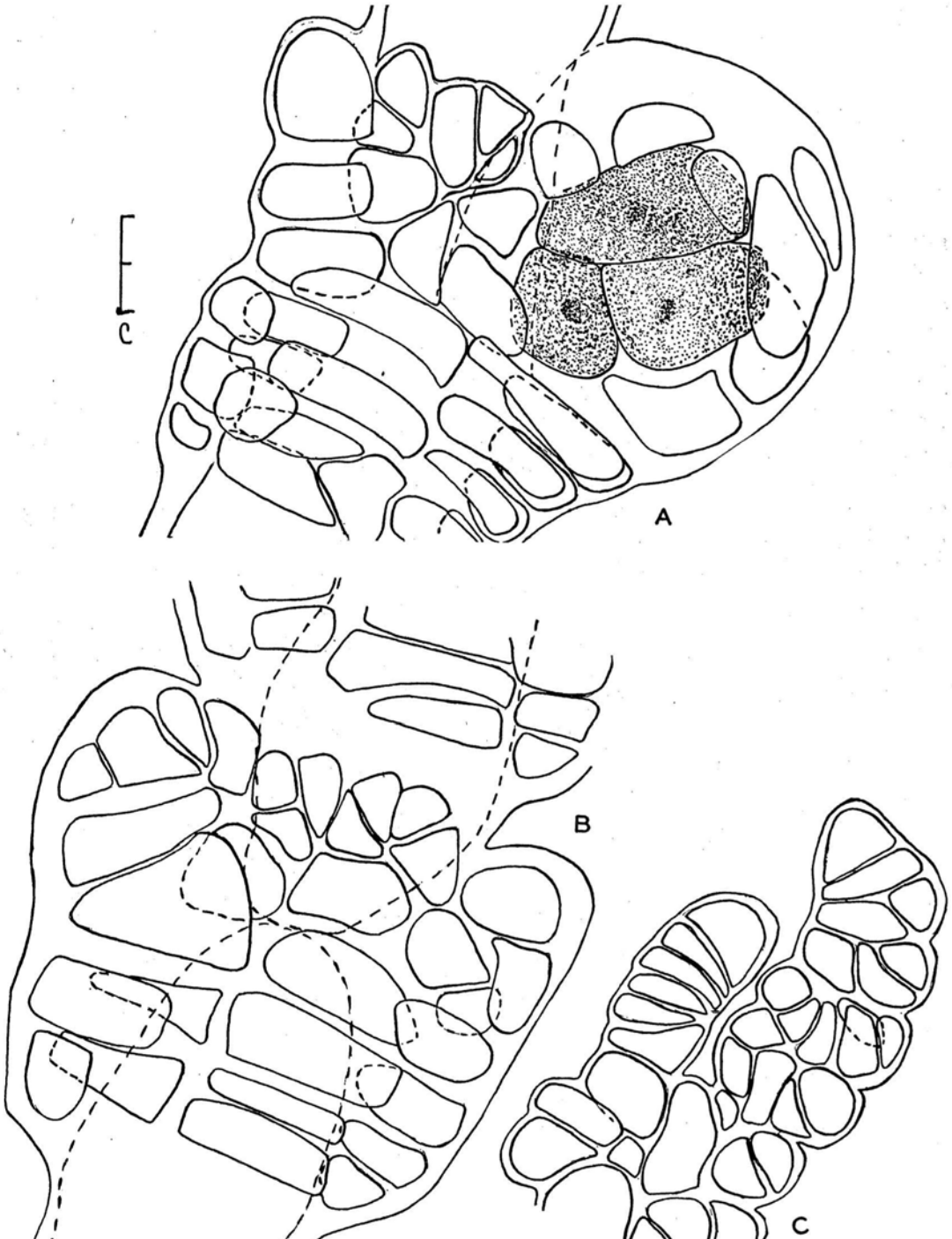

FIG. 11. *Ceramium* sp. (2). A. Nodal region showing cortication and tetrasporangium. Scale C (divisions 10 microns). B. Detail of node, showing underlying central cells. Scale C (divisions 10 microns). C. Tips of plant. Scale C (divisions 10 microns).

tips in some plants, and only a suggestion in others.

Specimens collected are sterile.

Found in Ilae Pond, Molokai Island.

Ceramium sp. (2) (see Fig. 11*a–b*).

Plants 2–3 cm. in height, dark pink, tufted, erect, branching with a percurrent main axis, the tips dichotomous and occasionally forcipate. Outer edges of the branches markedly dentate. Nodal bands close in the younger parts, in the older parts quite separated. Mature nodes marked by three rows of flattened cells below the septum, and smaller, angular cells above. Tetrasporangia 70 μ in diameter, sub-exposed, with an upgrowth of smaller cortical cells over them. Sporangia usually single at the node, rarely two. Spermatangial and carpogonial plants not seen.

Found in Ilae Pond, Molokai Island, and Molii Pond, Oahu Island, in the more saline portions adjacent to the sea.

Neither of these species of *Ceramium* seems to be one of those reported previously from the islands: *C. Kuetzingianum* by MacCaughey and *Ceramium* sp. by Neal. *Ceramium diaphanum* by Tilden is *Centroceras clavulatum.*

Taenioma J. Agardh, 1863: 1256

A detailed account of this genus, and particularly the following species, may be found in Papenfuss (1944) and Tseng (1944).

Taenioma perpusillum (J. Agardh) J. Agardh, Sp. Alg. 2 (3): 1257, 1863.

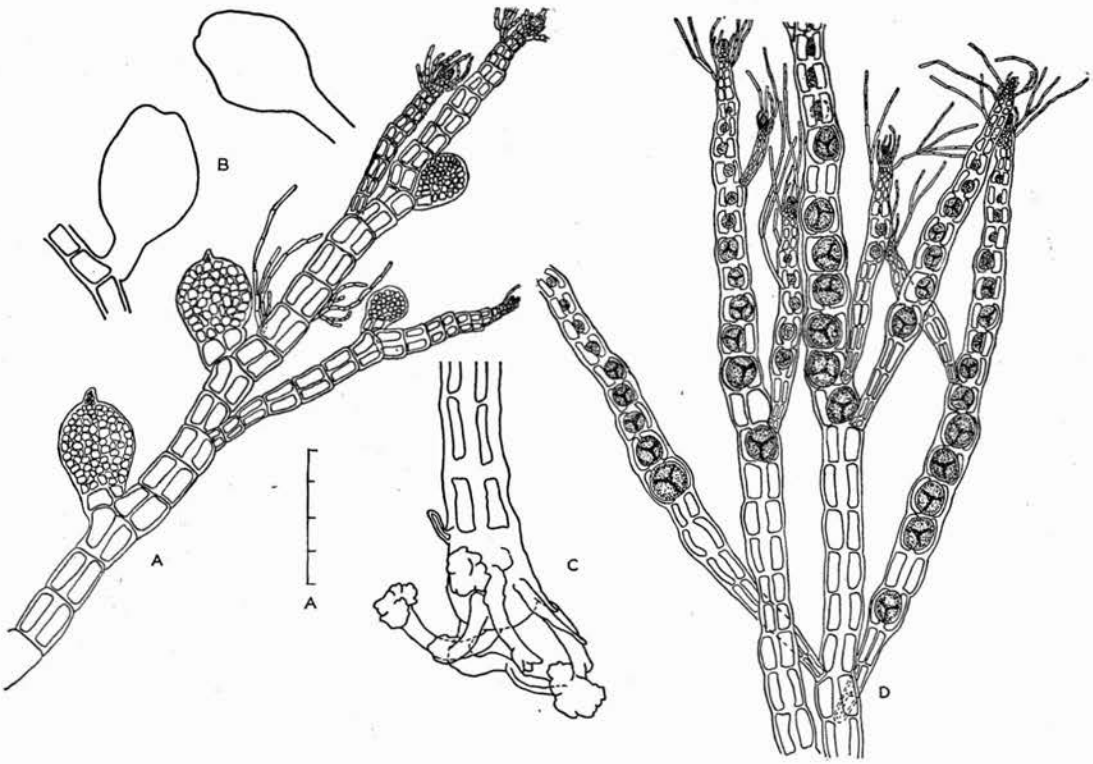

FIG. 12. *Polysiphonia aquamara* Abbott. Type specimens. Scale A (divisions 100 microns). A. Habit of cystocarpic plant showing young and mature cystocarps. B. Shape of cystocarps from another branch. C. Basal portion of tetrasporangial plant. D. Habit of plant showing tetrasporangia (cover cells have been omitted).

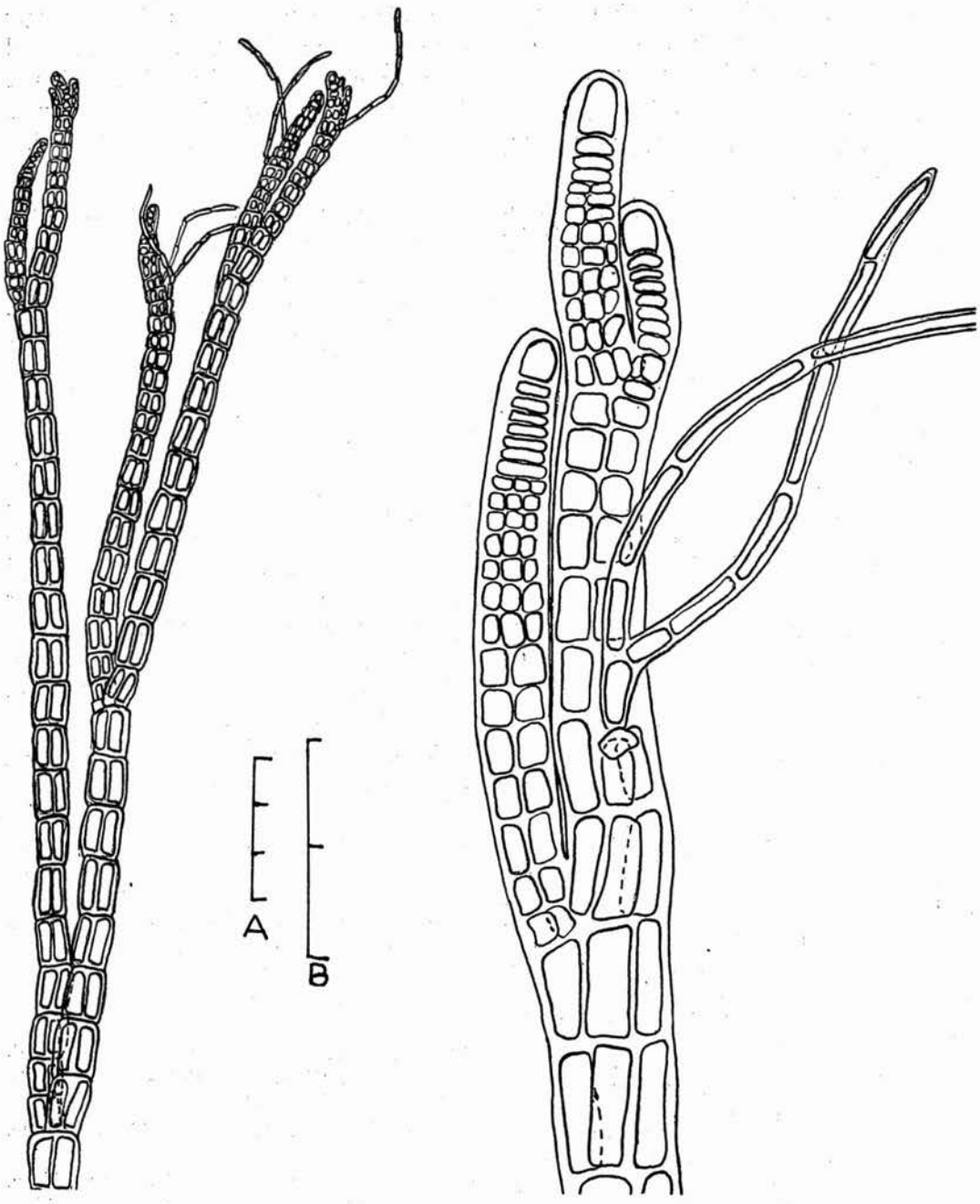

FIG. 13. *Polysiphonia* sp. Habit of sterile plants from fresh-water pond (Salt Lake). Illustration on left, Scale A (divisions 100 microns); on right, Scale B (divisions 50 microns).

Plants in small tufts, epiphytic on other algae, or on small sessile animals, filamentous and soft. The determinate branches of this species end in three hairs as opposed to two terminal hairs in *T. macrourum.*

Specimens collected were sterile.

Keawanui Pond, Molokai Island, with *Polysiphonia.*

This species is uncommon in this area. Reported from the Hawaiian Islands by Chamberlain and Papenfuss.

Polysiphonia Greville, 1824: 90

Section *Oligosiphonia*

Polysiphonia aquamara sp. nov. (see Fig. 12*a–d*).

Plantae penicillatim fasciculatae, ad 8 cm. longitudine sed plerumque minores, roseo-purpureae, molles, erectae, basi rhizoideis permultis praedito nec repente, ramis adscendentibus, alternis, origine spiralibus. Trichoblasti in articulos omnes insertae; cellulae pericentrales 4, haud corticatae; tetrasporangia e ramulis secondariis ultimis, plantae apicem versus locatis, orta, in serie recta vel tortuosa. Plantae cystocarpicae validiores, cystocarpis alternis, late urceolatis.

In *Batidem maritimam* vel plantas alteras phanerogamicas, raro in lapides vel conchas obsoletas, crescentes.

Plants tufted, without a prostrate creeping portion, to 8 cm. in height, usually smaller, reddish-purple, soft. Base composed of many rhizoids. Erect filaments arise from the base with branches ascending, alternate and spiraling in a counterclockwise directon, slightly divergent to ¼, with branching chiefly at the tips. Trichoblasts frequently appearing whorled, inserted in the young parts on every segment alternately, in the older parts leaving scar cells. The branches of the trichoblasts are 2 to 3 ranked, 50–200 μ in length, in the male plants covering ⅓ the length of the tips of the axis. Pericentral cells 4, non-corticated.

Tetrasporangia borne in ultimate branches near the tip of the plant, in a straight series or tortulose, or when in the main branches occasionally alternate. Spores dark brown to blackish, sporangia 4-partite, 20 μ (usually less) in diameter.

Antheridial clusters borne on the basal unbranched portion of a trichoblast, alternate, subcylindrical, with antheridia blunt to round. Cystocarpic plants stouter than others, the cystocarps alternate, broad urn-shaped, with pyriform carpospores.

TYPE: *Abbott 1535,* legit C. J. Engard, from Station 7, Kuapa Pond, Oahu Island, epiphytic on *Batis maritima.* This number includes tetrasporangial, cystocarpic, and spermatangial plants, of which I designate the tetrasporangial as the type specimen. These plants were collected April 7, 1944.

This new species of *Polysiphonia* is very abundant in the major fishponds, occurring on *Batis maritima,* rocks, and dead shells. It resembles *P. subtillisima,* which has also been found outside the strictly marine environment, but is distinguished from it in that it has no prostrate creeping portion.

Polysiphonia sp. (see Fig. 13).

A species of *Polysiphonia* found in fresh water (Salt Lake Pond, Oahu); grows abundantly on the pond walls, attached to phanerogams, or to rocks. It has four pericentral cells. Infrequent trichoblasts are found near the tips of the plants. Although repeated collections were made, no fertile material was found. The salinity in this pond was found to be nearly that of fresh water (2.5).

To the best of my knowledge, this is the first report of the genus in fresh water.

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