

An Account of the Species of Polysiphonia on the Pacific Coast of North America. I.
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ently higher in total auxin than those with starchy endosperm.

Exploratory experiments with immature kernels of diploid and tetraploid corn also failed to reveal

any evidence of a relationship between polyploidy and the amount of auxin stored in kernels.

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AN ACCOUNT OF THE SPECIES OF POLYSIPHONIA ON THE PACIFIC COAST OF NORTH AMERICA. I. OLIGOSIPHONIA ¹

George J. Hollenberg

THE NAME *Polysiphonia* was first proposed by Greville (1824). *Hutchinsia* had been previously proposed for this group of plants by C. A. Agardh (1817), but proved inadmissible because of prior application of this name by Robert Brown to a group of cruciferous plants. At least fourteen other names have been employed at one time or another to designate this group, as listed by De Toni (1903). When first proposed, *Polysiphonia* included practically all of the evidently segmented plants now placed in the Rhodomelaceae. As finally delimited by Falkenberg (1901), *Polysiphonia* includes those radially symmetrical members of the Rhodomelaceae in which (1) at least the ultimate branches are evidently polysiphonous; (2) most of the branches arise exogenously by a more or less diagonal division of subapical cells before these have cut off pericentral cells; (3) all branches are essentially similar and indeterminate; and (4) only one tetrasporangium is borne normally in each segment. Erect branches arise mostly as assurgent extensions of prostrate branches or exogenously, but they may also arise endogenously from the central cells after the formation of pericentral cells.

Endogenous branches in *Polysiphonia* and closely related genera may usually be distinguished from exogenous branches, not only by their manner of origin, but also by the nature of the basal segment of the branch at the point of insertion. In exogenous branches there is usually a reduced number of pericentral cells in the basal segment. This is rarely if ever characteristic of endogenous branches. Furthermore, basal segments of exogenous branches are usually considerably shorter than corresponding segments in the parent branch and also considerably

shorter than more distant segments of the same branch.

Falkenberg (1901, p. 55) describes two types of endogenous origin of branches in the Rhodomelaceae. Normal endogenous branches arise at certain definite positions and in regular sequence in relation to the shoot apex. Adventitious branches arise endogenously at almost any position and do not bear a regular sequence relationship to the origin of other branches. In *Polysiphonia* all branches are adventitious since they do not arise in constant positions in regular sequence with respect to the segments. Although for the most part the branches are not endogenous, in several specimens of *P. hemisphaerica* Aresch. from the Baltic, which were examined, all branches seemed to be endogenous.

It seems also desirable to distinguish two types of exogenous branch. These may be designated as normally exogenous branches, which arise directly from branch primordia cut off from the subapical cells, and cicatrigenous branches, which arise from scar-cells. The scar-cells are persistent basal cells of trichoblasts, commonly left when the trichoblasts or hairs are shed. Since in *Polysiphonia* all trichoblasts arise exogenously, all cicatrigenous branches are indirectly exogenous. In *Polysiphonia* most of the so-called accessory branches are cicatrigenous, but the term accessory seems to be used somewhat loosely in this connection.

Falkenberg distinguishes two morphological or developmental types of branch in the Rhodomelaceae. Determinate branches, which do not ordinarily give rise to further branches, he designates as "Kurztriebe," whereas indeterminate branches of potentially unlimited growth are designated as "Langtriebe." In *Polysiphonia* all branches are at least

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theoretically indeterminate, although in certain species, and especially in certain varieties of *P. pacifica* of this paper, the ultimate branchlets are commonly more or less determinate.

As has been shown by Falkenberg (1901) and other investigators, the number of pericentral cells is usually quite constant if there are only four, but the number becomes in general more variable as the number of pericentral cells is increased. Tetrasporic branches usually appear to have one or two more pericentral cells than have the vegetative branches of the same plant, due to the formation of two cover cells by division of the fruiting pericentral cell.

With respect to the sequence of origin of pericentral cells in *Polysiphonia*, reference may be made to the work of Falkenberg (1901) and Rosenberg (1933). No data in regard to this question are available in the case of the species treated in this paper.

Trichoblasts or hairs are present in most species of *Polysiphonia*. In a few species trichoblasts are entirely wanting. In other species they are exceedingly rare or seasonal in their occurrence, or occur only in connection with sexual reproductive structures. As pointed out by Falkenberg (1901), trichoblasts always arise exogenously. In most cases they are soon deciduous. The basal cell is usually very short and persists as an inconspicuous scar-cell at the node between the pericentral cells. In certain species some of the trichoblasts, especially those in whose axils branches arise, do not leave scar-cells. Under circumstances as yet poorly understood, trichoblast primordia may remain undeveloped and form persistent scar-cells directly. As has been already pointed out, the scar-cells may sometimes give rise to cicatrigenous branches, but most of them do not.

Trichoblasts usually arise in very definite positions, which have been shown by Falkenberg (1901) to be of very great taxonomic importance. There seem to be no known cases in which more than one trichoblast has arisen on a given segment. Most commonly a single segment intervenes between successive trichoblasts, but in some species two or more segments occur between successive trichoblasts. The trichoblasts are usually arranged in a spiral line running in a counter-clockwise direction toward the tip of the branch, when the branch is viewed from the apex. Accordingly, Rosenberg (1933) and other investigators, who have studied the origin of branches and trichoblasts in *Polysiphonia*, speak of the trichoblasts as usually spiralling to the left. Plants are rarely found in which the direction of the spiral is reversed. The divergence of the trichoblasts in the spiral is relatively constant and usually bears some relation to the number of pericentral cells.

In most of the species of *Polysiphonia* found on the Pacific coast of North America the position of the trichoblasts is a very constant feature, but in at least one local species they are very irregularly placed, as they are in a number of European species. Even in such cases, however, there is often a distinct

tendency for the trichoblasts to be arranged in definite positions.

Exogenous branches, arising subapically, almost invariably appear in positions comparable to those in which the trichoblasts arise and in the same spiral line, so that trichoblasts and branches are homologous structures with respect to origin. In some cases the entire primordium becomes the branch, but in other species the primordium divides and one fork, usually the outer one, develops into a trichoblast and the other one develops into the branch. Hence various investigators speak of branches as originating in connection with trichoblasts or not in connection with trichoblasts (replacing trichoblasts). Trichoblasts in whose axils branches arise are sometimes spoken of as "leaves."

In certain species of *Polysiphonia* the pericentral cells are more or less obscured by the development of an outer layer of cortical cells. The cortical filaments arise from small cells cut off in most cases from the corners of the pericentral cells.

As has been shown by Falkenberg (1901) and confirmed by later studies, the vegetative features, briefly discussed in the preceding paragraphs, are much more important taxonomically than are the reproductive features. The latter exhibit for the most part a monotonous uniformity. Accordingly an extended discussion of the reproductive structures of *Polysiphonia* is neither desirable nor necessary for the present purpose. Such differences as do occur will be mentioned in connection with the different species in so far as reproductive structures are known.

A great deal of synonymy has accumulated in the genus *Polysiphonia*, especially in the tetrasiphonous members of the genus. Much of this synonymy could probably have been avoided if more attention had been given to critical structural features, which have for the most part been pointed out by Falkenberg (1901). Especially important are the positions of trichoblasts and scar-cells; origin of branches, whether endogenous or exogenous, whether entirely replacing trichoblasts or arising in connection with them; and the nature of the antheridial branches and their relation to trichoblasts. Another feature of considerable taxonomic significance which needs more attention is the nature and origin of attachment organs. A monographic treatment of the genus is greatly needed, but can hardly be undertaken in the present state of international relations.

Twenty-one species of *Polysiphonia* are known to the writer from the Pacific coast of North America. One of these, *P. Brodiaei* Grev., is practically indistinguishable from the European plant of that name and may prove to be an introduced species. *P. pacifica* n. sp. is closely similar to *P. urceolata* (Lightf.) Grev. from Europe and the Atlantic coast of North America. *P. curta* Montague and *P. paniculata* Montagne and possibly *P. pacifica* are found also on the Pacific coast of South America. Although not at present evident, it seems probable that further study may show some definite affinities between the

species on the two sides of the Pacific basin. Within the range of the study, *P. paniculata* and varieties of a species which has been heretofore designated as *P. sancti-petri* Collins, as well as varieties of *P. pacifica*, are found along the entire Pacific coast of North America. *P. Macounii* n. sp. is known only from the region of Vancouver Island, and *P. pungens* n. sp. only from Vancouver Island to the southern Alaskan coast. *P. Brodiaei* and *P. Snyderae* Kylin occur from Washington to southern California, and *P. flaccidissima* n. sp. occurs from central to southern California. The remaining thirteen species are known only south of Point Conception on the coast of California. Two species are so far known only from the Gulf of California.

Along the California coast there seems to be no marked seasonal fluctuation in the occurrence of the various species of *Polysiphonia*, except in the case of *P. flaccidissima*, which seems to occur in abundance in characteristic locations only during the fall and winter months. There is likewise little or no evidence of seasonal variation along the coast of Oregon and Washington, but insufficient collections are available for conclusive statements. Collections from Alaska are of course very inadequate.

During the progress of the study all specimens from the region were examined which are to be found in the following herbaria (designated in the treatment of species by the accompanying symbols): University of California (C); Farlow Herbarium (F); Marshall Field Museum of Natural History (Fi); Hopkins Marine Station (Hop.); New York Botanical Garden (N.Y.); University of Washington (W); and the herbarium of the writer (H). In addition the writer has been privileged to examine specimens collected by Dr. Francis Drouet and Mr. Donald Richards along the coast of Sonora, Mexico, in 1939, by Mr. E. Yale Dawson in the Gulf of California in 1940, and by Dr. W. R. Taylor off the west coast of Mexico during the Hancock expedition of 1934. The writer is grateful for the opportunity of examining material from all of these sources, and is especially indebted to the late Dr. N. L. Gardner of the University of California whose numerous collections along the entire Pacific coast of North America have so greatly facilitated this study. Of the many specimens examined only a few representative specimens other than the types will, in the case of most species, be cited. Specimens in the above mentioned herbaria have been fully annotated for the most part and citation in this paper seems unnecessary.

The tetrasiphonous species will be treated in part I of this paper, and the species with five or more pericentral cells will be taken up in part II to appear at a later date.

Key to the species of Polysiphonia on the Pacific Coast of North America

1. Plants with 4 pericentral cells..... 2
1. Plants with more than 4 pericentral cells (Part II of this paper) 12
2. Trichoblasts and scar-cells wanting or very rare; tetrasporangia in straight series..... 3

2. Trichoblasts or scar-cells frequent to abundant.. 4
3. Ultimate branchlets sharply pointed and more or less determinate..... *P. pungens* n. sp.
3. Ultimate branchlets not sharply pointed, although frequently more or less determinate.
P. pacifica n. sp.
4. Trichoblasts and scar-cells infrequent and irregularly inserted..... *P. sonorensis* n. sp.
4. Trichoblasts and scar-cells frequent and in regular positions 5
5. Trichoblasts and branches alternating in spiral succession 2-3 segments apart and with $\frac{1}{4}$ divergence.
P. decussata n. sp.
5. A trichoblast, scar-cell, or a branch occurring on every segment 6
6. Plants with longitudinal cortical filaments on older parts..... *P. Macounii* n. sp.
6. Plants without cortical filaments..... 7
7. Plants minute tufted epiphytes mostly under 1 cm. high, with endophytic rhizoids composed of two cells..... *P. minutissima* n. sp.
7. Plants larger, rhizoids unicellular..... 8
8. Segments in main axes rarely longer than broad.. 9
8. Segments in main axes commonly longer than broad 10
9. Main axes very prominent and straight; plants tufted, mostly epiphytic..... *P. acuminata* Gard.
9. Main axes less prominent, plants forming low mats on rocks..... *P. simplex* n. sp.
10. Branching dichotomous throughout; plants with discoid attachment..... *P. Masonii* S. & G.
10. Branching not dichotomous throughout; attachment usually not discoid..... 11
11. One fork of branch primordia forming a trichoblast, branches arising accordingly in the axils of trichoblasts..... *P. flaccidissima* n. sp.
11. Branch primordia not forming trichoblasts but entirely replacing them..... *P. Snyderae* Kylin

POLYSIPHONIA pungens sp. nov. (fig. 1, 10).—Plantae 10–15 cm. altae, profuse ramosae, cum ramis fere laxis praecipue deorsum; axibus principibus 180–260 μ crassis, cum segmentis 8–15 diametros longis; subultimis ramis virgatis et in segmentis 2–4 ramula breviora et recta et determinata et acute pungentia undique ferentibus; ramulis apicem ramorum parce aut non excedentibus; cellulis pericentralibus 4, omnino ecorticatis; trichoblastis et cicatricellulis deficientibus; tetrasporangiis in seriebus rectis in ramulis ultimis; cystocarpis et ramis antheridialibus ignotis; colore rubro aut fusco-rubro.

Plants 10–15 cm. high, profusely branched, with branching mostly lax, especially below; main axes 180–260 μ in diameter, composed of segments 8–15 diameters long; subultimate branches virgate, bearing at intervals of 2–4 segments relatively short straight determinate and sharply pointed branchlets on all sides; branchlets not at all or scarcely exceeding the branch tips; pericentral cells 4, without cortication; trichoblasts and scar-cells wanting; tetrasporangia in straight series in the ultimate branchlets; cystocarps and antheridia unknown; plants red or brownish purple, known only from the vicinity of Vancouver Island, British Columbia and from Alaska.

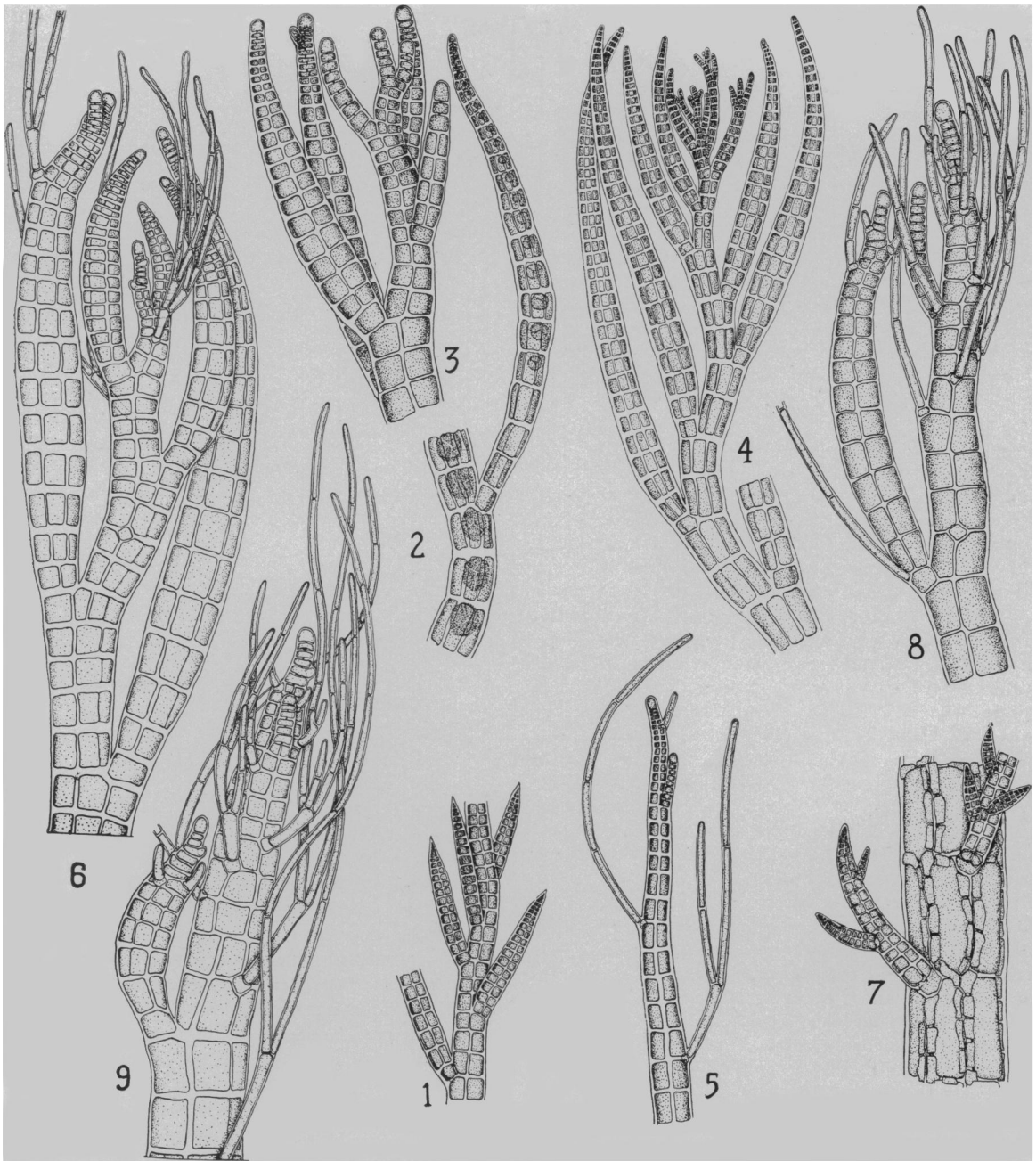


Fig. 1-9. All drawings were made with the aid of a camera lucida.—Fig. 1. Portion of a branch of *P. pungens* n. sp. $\times 85$.—Fig. 2. Tetrasporic branch of *P. pacifica* n. sp. $\times 80$.—Fig. 3. Tip of a branch of *P. pacifica* n. sp. $\times 360$.—Fig. 4. Branch tip of *P. pacifica* var. *disticha* n. var. $\times 85$.—Fig. 5. Branch tip of *P. sonorensis* n. sp. $\times 70$.—Fig. 6. Branch tip of *P. decussata* n. sp. $\times 360$.—Fig. 7. Portion of a larger branch of *P. Macounii* n. sp. $\times 17$.—Fig. 8. Branch tip of *P. flaccidissima* n. sp. $\times 325$.—Fig. 9. Branch tip of *P. Snyderae* Kylin. $\times 360$.

Type no. 314925 in the herbarium of the University of California, collected by R. B. Wylie on Valenar Rock, Gravina Island, lat. $55^{\circ} 26' N.$, Alaska, May, 1913. Several additional specimens from British Columbia were collected by John Macoun, of the Geological Survey of Canada about 1909, or perhaps a few years previous to this time: Macoun 34, without date or locality (F); Macoun 93, Vancouver Is.,

without date (C); Macoun 136, Qualicum, Vancouver Is., without date (N.Y.).

This species is very close to *P. pacifica* of this paper, especially to those varieties with determinate branchlets. It differs in the virgate ultimate branches and the sharply pointed branchlets which they bear. The color is usually more red and not dark brownish or black as is common on *P. pacifica* var. *determinata*.

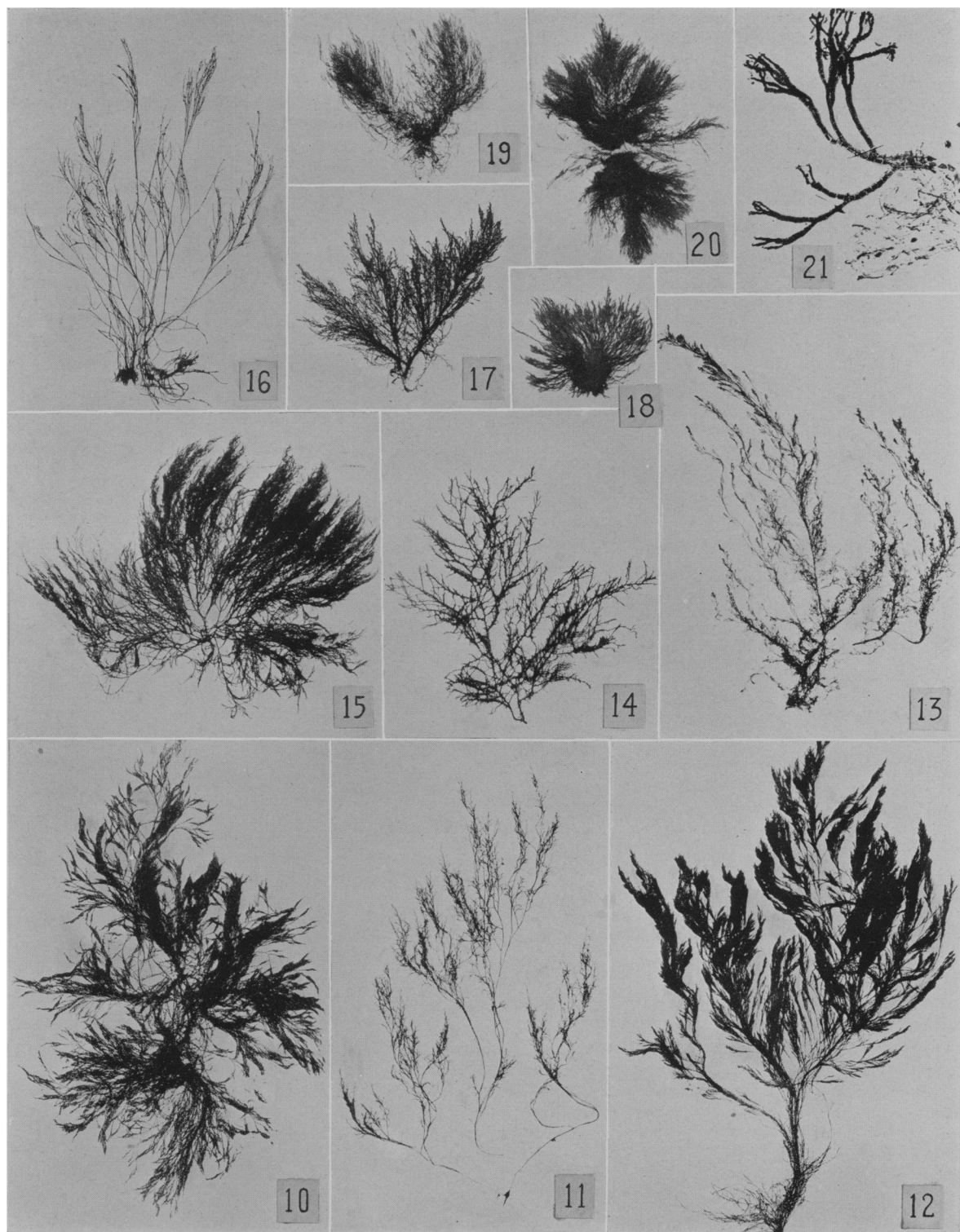


Fig. 10-21.—Fig. 10. Type specimen of *P. pungens* n. sp. $\times 0.4$.—Fig. 11. Type specimen of *P. pacifica* var. *gracilis* n. var. $\times 0.5$.—Fig. 12. Type specimen of *P. pacifica* n. sp. $\times 0.5$.—Fig. 13. A slender form of *P. pacifica*. $\times 0.5$.—Fig. 14. Type specimen of *P. Macounii* n. sp. $\times 0.5$.—Fig. 15. Type specimen of *P. Snyderae* var. *heteromorpha* n. var. $\times 0.5$.—Fig. 16. Type specimen of *P. pacifica* var. *distans* n. var. $\times 0.5$.—Fig. 17. Type specimen of *P. pacifica* var. *disticha* n. var. $\times 0.5$.—Fig. 18. Type specimen of *P. simplex* n. sp. $\times 0.5$.—Fig. 19. Type specimen of *P. flaccidissima* var. *Smithii* n. var. $\times 0.5$.—Fig. 20. Type specimen of *P. sonorensis* n. sp. $\times 0.5$.—Fig. 21. Photomicrograph

POLYSIPHONIA pacifica sp. nov. (fig. 2, 3, 12, 13). —Plantae medio-rubrae aut fusco-rubrae vel parce nigrae et molles aut firmae, cum filamentis repentibus inconspicuis, per rhizoidia unicellularia in intervallis irregularibus affixae, unum solum per segmentum, ex centro inferiorum cellularum pericentralium ut ex-crescentia orta, a quibus muris transversis non abscissa sunt; ramis erectis fere endogene ortis, (2) 10–20–(25) cm. altis, laxe ramosis praecipue infra, fere cum nudis regionibus longioribus; ramis alternantibus, interdum aliquanto distichis, cum axibus primis distinctis aut indistinctis et 60–200–(300) μ crassis; ramis multorum ordinum; ramulis fere apicem crescentem haud excedentibus; fere cum 3–5 segmentis inter ramos succedentes; cellulis pericentralibus 4, omnino ecorticate; segmentis ramorum primorum fere 6–10 diametros longis, multo brevioribus in ramulis ultimis, qui fere apice attenuati sunt; trichoblastis et cicatricellulis rarissimis; tetrasporangiis 60–70–(100) μ crassis, in seriebus longis et rectis in ramulis ultimis, tripartite divis; cystocarpis ovoido-globosis, leviter vel manifeste urceolatis, brevius pedicellatis, 200–500 μ crassis; cylindratis ramis antheridialibus cum breve apice sterile unius aut plurium cellularum, ab toto ramo fructifero ortis; plantae fere saxis adhaerentes.

Plants medium to dark red or nearly black, adhering well or poorly to paper, with inconspicuous creeping filaments attached by unicellular rhizoids arising at irregular intervals, never more than one per segment, as outgrowths from the center of the lower pericentral cells, from which they are not cut off by cross walls; erect branches arising mostly endogenously, 10–20–(25) cm. high, mostly laxly branched, especially below, with relatively long naked regions; branching alternate, sometimes somewhat distichous, with main axes distinct or indistinct, 100–200–(300) μ in diam.; branches of many orders, typically not exceeding the growing tip, with (2)–4–5—many segments between successive branches; pericentral cells 4 in vegetative branches, totally ecorticate, the segments in the main branches (4)–6–10–(20) diam. long, well separated by clear septa and much shorter in the ultimate branchlets, which are commonly considerably attenuate at the tip but not pungent; trichoblasts and scar-cells exceedingly rare; tetrasporangia 60–70–(100) μ diam., in long straight series in the ultimate branchlets, tripartitely divided; cystocarps slightly to conspicuously urceolate, briefly pedicellate, 200–500–(675) μ in diam.; antheridial branches cylindrical, with a short sterile tip of one to several cells, formed from the entire fruiting branch; plants growing on rocks, pilings, etc., in the lower littoral and sublittoral zone from Alaska to Lower California.

A specimen (fig. 12) in the herbarium of the New York Botanical Garden has been selected as the type. It was collected by Dr. C. L. Anderson at Santa Cruz but bears no date. It is tetrasporic. A more delicate representative of the species is shown in figure 13.

of a portion of a male plant from the type material of *P. minutissima* n. sp. $\times 15$, showing the basal tuft of rhizoids in the lower right hand corner.

This plant was collected by N. L. Gardner, 2750, from stones and logs, at Empire, Coos Bay, Oregon. *P. pacifica* is a very variable species, as is *P. urceolata* (Lightf.) Grev., to which it is closely related. The latter plant is common in Europe and along the Atlantic coast of North America. In both plants the antheridial branch arises from the entire trichoblast primordium. The sterile tip is generally much shorter, however, in the Pacific coast plant. In both plants the rhizoids arise as extensions from the middle of the lower pericentral cells and are not cut off by cross walls from the pericentral cells. The Pacific Coast plant is in general somewhat more robust and a much more variable plant. Furthermore, trichoblasts and scar-cells are much more rare in the case of the Pacific Coast plant. These structures are reputed to be rare in the case of *P. urceolata*, but the writer has been able to find either trichoblasts or scar-cells in nearly every specimen of *P. urceolata* which was examined from the Atlantic coast of North America and in many of those from Europe. In over a hundred specimens of *P. pacifica* which were examined, representing collections during all seasons of the year, only one instance of either trichoblasts or scar-cells was observed except for occasional trichoblasts on cystocarps and scar-cells left by deciduous antheridial branches.

Among the specimens of *Polysiphonia* from Peru, which M. A. Howe (1914) identified as *P. abscissa* Hook. and Harv., several seem identical with typical specimens of *P. pacifica*, but as Howe states, several entities are probably represented in the Peruvian material under this name, and the writer has been unable to obtain authentic material of *P. abscissa* from the Cape Horn region from which the type came.

Key to the varieties of *P. pacifica*

1. Plants small and delicate, mostly under 4 cm. high.
P. pacifica var. *delicatula* n. var.
1. Plants larger and more robust, commonly 10–25 cm. high 2
2. Ultimate branchlets relatively short, rigid and more or less determinate 3
2. Ultimate branchlets indeterminate 5
3. Ultimate branchlets more or less distichous, main axes usually covered with branchlets throughout *P. pacifica* var. *disticha* n. var.
3. Ultimate branchlets not noticeably distichous, main axes usually with long naked portions below 4
4. Branching usually dense, main axes macroscopically indistinct above and commonly exceeded by the uppermost branchlets.
P. pacifica var. *determinata* n. var.
4. Branching lax to very lax, main axes distinct to the tips, which are usually not exceeded by the upper branchlets *P. pacifica* var. *gracilis* n. var.
5. Branches mostly delicate and soft, abundantly branched; color red. *P. pacifica* n. sp.
5. Branches coarse to very coarse, up to 300 μ in diameter, distant; color usually very dark.
P. pacifica var. *distans* n. var.

P. pacifica var. **delicatula** var. nov.—Plantae rubrae, 0.5–2.0 cm. altae; axibus principibus 60–110 μ crassis, cum segmentis 1.5–2–(3) diametros longis; ramis omnibus indeterminatis, cum apicibus brevibus et fere obtusis; apicibus frequenter aliquanto forcipatis; trichoblastis raris; tetrasporangiis 50–60 μ crassis in seriebus rectis; cystocarpis aperte sine trichoblastis; ramis antheridialibus tenuibus, 140–200 \times 30–40 μ crassis, in pediculis brevissimis, cicatricellulas persistentes relinquentibus; plantae ad saxa et sublicas, fere in aqua profunda aut placida, affixae.

Plants red, 0.5–2.0 cm. high, rarely higher, main branches 60–110 μ diam., of segments 1.5–2–(3) diameters long; branches all indeterminate short and mostly blunt; branch apices often somewhat forcipate; trichoblasts wanting or exceedingly rare; tetrasporangia 50–60 μ in diam., in straight series; cystocarps seemingly without hairs; antheridial branches slender, 140–200 \times 30–40 μ , on very short pedicels, leaving persistent scar-cells when shed; plants occurring from central California to the Gulf of California, Mexico, on pilings and rocks in deep or sheltered water.

Type: Hollenberg 2888, collected from low tide level on pilings of the municipal wharf at Monterey, California, July 20, 1939, male and cystocarpic (H.). This plant has more rigid and more forcipate tips than have plants from the lagoons of southern California and from the Gulf of California. The scar-cells left by deciduous antheridial branches indicate that the antheridial branches are homologous with trichoblasts and not with branches of the thallus as Falkenberg (1901) concluded in the case of the similar antheridial branches of *P. urceolata*.

P. pacifica var. **disticha** var. nov. (fig. 4, 17).—Plantae 3–7 cm. altae, cum structura et ramis fructiferentibus ut in specie, sed plantis fere parvioribus, cum ultimis ramulis determinatis, primum incurvatis, demum rectis aut recurvatis, cum apicibus acutis, spiraliter alterne aut vulgo in alternis geminis, in intervallis 2–3 segmentorum, per totam longitudinem omnium ramorum ortis, vulgo partim distichis aut aperte distichis fere propter axem modice torsum.

Plants 3–7 cm. high, with chief structural features and reproduction as in the species, but plants mostly smaller with ultimate branchlets determinate, at first incurved, and finally straight or strongly incurved, with acute tips, spirally arranged in an alternate manner or commonly in alternating pairs every 2–3 segments throughout the length of all branches, commonly partly distichous or apparently distichous as a result largely of twisting of the axis; plants occurring mostly in the upper littoral zone in exposed places, central California to Vancouver Island, British Columbia, and probably extending northward.

Type: no. 276091 (fig. 17) in the herbarium of the University of California, collected by N. L. Gardner, 3888a, on the ocean side and three miles south of Cape Flattery, Washington, June, 1917. Other specimens examined include: N. L. Gardner 4405, from a stone wall above high tide level, "Fort Point," San

Francisco, California, Feb. 1919 (C., H.); and N. L. Gardner 3850, from the type locality, April, 1927 (C.). This variety has more or less determinate branchlets as in var. *determinata*, in which the branchlets are likewise somewhat distichous at times, but var. *disticha* is usually much smaller and its main axes are clothed with more or less determinate branchlets below as well as above.

P. pacifica var. **determinata** var. nov.—Plantae fere 10–15 cm. altae, deorsum laxae, cum axibus principibus 170–340 μ crassis, et segmentis deorsum 6–8 diametros longis, sursum brevioribus; ultimis ramulis crassioribus, aliquanto determinatis et plerumque cristas densas et aliquanto pencillatas formantibus, plerumque apicem crescentem aperte excedentibus, fere non distichis; trichoblastis solum in exemplis raris visis; tetrasporangiis et ramis antheridialibus ut in specie; cystocarpis magnis et aliquanto urceolatis; plantae fusco-rubrae.

Plants mostly 10–15 cm. high, lax below, with main axes 170–340 μ in diameter and segments 6–8 diameters long below, and shorter above; ultimate branchlets relatively coarse, more or less determinate and often forming more or less dense pencillate tufts, often extending well beyond the growing point of the branch, and mostly not distichous; trichoblasts wanting except for very rare instances; tetrasporangia and antheridial branches as in the species; cystocarps relatively large and more or less urceolate; plants dark brownish red to nearly black when dry, adhering only moderately well to paper from which they are readily loosened on moistening, occurring from central California to Alaska.

Type: N. L. Gardner 3327, on rocks, low littoral zone in cove beyond the first point south of Pebble Beach, Monterey County, California, May 1916 (C. 276272); Phyc. Bor. Amer. 1697, at least in part, John Macoun, Vancouver Is., British Columbia.

Many additional specimens of this common variety are to be found in the various herbaria mentioned. Similarities between this and the preceding variety have already been mentioned in connection with the discussion of that variety. In no. 3888 (C., H.) collected by N. L. Gardner from the upper littoral tide pools along the open coast 3 miles south of Cape Flattery, Washington, frequent forked hairs were present toward the branch tips, and occasional scar-cells were present. They were not in any constant positions, however, and the tetrasporangia were in straight series as in the species.

P. pacifica var. **gracilis** var. nov. (fig. 11).—Plantae obscure fusco-rubrae, 10–20 cm. altae, laxiores ramosae; ramis ordinum plurium, cum axibus principibus distinctioribus, vulgo deorsum nudis, sursum cum 1-multis subramulis; structura et tetrasporangiis ut in specie; cystocarpis et antheridiis ignotis.

Plants dull brownish red, 10–20 cm. high, very laxly branched in most cases; branches of several orders, with leading axes very distinct and commonly

naked below, above with slender lateral branchlets, which are more or less determinate and mostly simple or with 1-several short ramuli toward their tips; finer structural details and tetrasporangia as in the species, cystocarps and antheridia unknown; plants known only from the vicinity of San Juan and Orcas Islands along the coast of Washington.

Type: N. L. Gardner 2313, dredged in Deer Harbor, Orcas Island, Washington, July, 1910 (No. 273756 in the Univ. of Calif. herbarium). A single additional collection is from the same general locality, by J. S. Martin 33, extreme low littoral, exposed to swift currents, Twin Rock, 2 miles east of Friday Harbor, San Juan Island, Washington, Aug. 1940 (W.). This variety is distinguished by its slender laxly branched habit and determinate, mostly unbranched branchlets. There are many segments between successive branches in the lower parts, but mostly four between the ultimate or subultimate laterals. Segments in the main branches are many diameters long below and mostly 2 diameters long above. Lateral branchlets which in turn bear short ramuli usually have 20–30 segments between the base of the branchlet and the first ramulus.

P. pacifica var. *distans* var. nov. (fig. 16).—Plantae crassulae sed flexiles, fusco-rubrae, 10–18 cm. altae, cum axibus principibus ad 300 μ crassis et segmentis 2–4–(8) diametros longis; ramis distantibus praecipue deorsum, cristas pencillatas non formantibus; ramulis juvenibus saepe valide incurvatis; cystocarpis urceolatis, 550–675 μ crassis, cum labro ostioli crasso et fere quadralobato; tetrasporangiis in seriebus brevibus ad apicem ramulorum breviorum et ultimorum; plantis antheridialibus ignotis.

Plants coarse but limber, dark brownish-red, drying darker, 10–18 cm. high, with main axes up to 300 μ in diam., of segments 2–4–(8) diameters long; branching distant especially below; branches not forming pencillate tufts; young branchlets often strongly incurved; tetrasporangia in short series near the tips of short ultimate branchlets; cystocarps urceolate, 550–675 μ in diam., with thick mostly four-lobed ostiolar rim; antheridial plants unknown; plants adhering only moderately well to paper, occurring from British Columbia to central California.

Type: Hollenberg 2722, cystocarpic, afloat at the south end of Carmel Beach, Monterey County, California, June 22, 1939 (H.), (Isotype, Hop.). Three additional collections may be mentioned; Port Renfrew, British Columbia, Misses E. Butler and J. Polley 112, without date but probably about 1900, and distributed by W. A. Setchell as *P. senticulosa* Harv. (C.); Vancouver Island, B. C., without date, Robert Connell, tetrasporic (C.); Santa Cruz, C. L. Anderson without date, with some of the characteristics of *P. pacifica* var. *determinata* (N. Y.). The coarse laxly branched filaments, very large cystocarps, and tetrasporangia in short series seem the distinctive features of this variety.

POLYSIPHONIA sonorensis sp. nov. (fig. 5, 20).—Plantae 4–5 cm. altae ex ramis prostratis et repentibus; ramis prostratis 120–175 μ crassis, per rhizoidia unicellularia in intervallis irregularibus affixis; rhizoidiis uno solo per segmentum, ex centro inferiorum cellularum pericentralium excrescentibus, per muros transversos non abscissis; erectis ramis ex ramis prostratis fere endogene aut interdum exogene ortis, 70–100 μ crassis, cum segmentis fere 1.5–2 diametros longis, aliquanto dense ramosis, cum ramis lateralibus exogene fere in angulis acutis orientibus in intervallis irregularibus fere 10–20 segmentis separatis; ramis principibus indistinctis; ramulis ultimis tenuibus, 30–35 μ crassis, ad fundamentum modice attenuatis, ex segmentis fere unum diametrum longis aut brevioribus; cellulis pericentralibus 4, ecorticatis; trichoblastis tenuibus et numerosis ad 1 mm. longis, in intervallis irregularibus, cum 1–2 furcis, deciduis, frequenter cicatricellulas persistentes relinquentibus; ramis cum trichoblastis in origine non conjunctis; ramis fructiferentibus ignotis; plantis colore similibus lateri.

Plants forming dense tufts of a terra cotta color, 4–5 cm. high from prostrate creeping filaments; prostrate filaments 120–175 μ diam., attached by unicellular rhizoids which arise as outgrowths of the center of the pericentral cells, from which they are not cut off by cross walls; erect branches arising mostly endogenously or sometimes exogenously from the prostrate branches, 70–100 μ in diam., their segments mostly 1.5–2.0 diam. long; branching dense, the lateral branches arising exogenously at irregular intervals (4)–10–20 or more segments apart, mostly at an acute angle with the main axis, which is usually indistinct; ultimate branchlets slender, 30–35 μ in diam., slightly narrowed at the base, of segments mostly 1 diam. long or shorter; pericentral cells 4, not corticated; trichoblasts numerous, delicate, arising at irregular intervals, once or twice forked, to 1 mm. long, deciduous, often leaving inconspicuous scar-cells; branches not associated with trichoblasts in origin; reproduction unknown; plants adhering moderately well to paper on drying but readily removed, known only from the Gulf of California.

The type specimen is no. 3426a collected by Francis Drouet and Donald Richards afloat along the southeastern shore of the bay of Empalme, Sonora, Mexico, Dec. 23, 1939 (Fi.). The same investigators also collected this plant as no. 3144 (Fi.) from rocks between tide marks on the northwest shore of the harbor at Guaymas, Sonora, Mexico, on Dec. 4 of the same year.

In the nature and origin of the rhizoids, the pelucid nature of the transverse septa, and general structural details this plant closely resembles *P. pacifica*. It differs from the latter in the numerous irregularly occurring trichoblasts, which are exceedingly rare in *P. pacifica*; and also in having a greater number, and a more irregular number, of segments between successive branches. The frequent trichoblasts suggest a possible affinity with *P. urceolata* (Lightf.) Grev., but in the latter species the tricho-

blasts when present seem to be more regularly arranged in a spiral with one-fourth divergence according to Rosenvinge (1924) and other investigators. Furthermore, according to Falkenberg (1901) there is a more or less constant interval of 3–4 segments between successive branches in *P. urceolata*. Finally the terra cotta color of *P. sonorensis* is seemingly distinctive. From the imperfectly known *P. subtilissima* Montagne the present species differs in color, in the narrower angle of insertion of the branches, and in the manner of branching which does not seem at all dichotomous below in *P. sonorensis* as described for *P. subtilissima*. The Pacific coast plant also has more numerous trichoblasts than have specimens of *Polysiphonia* from the coast of Mississippi identified as *P. subtilissima* by W. R. Taylor.

POLYSIPHONIA decussata sp. nov. (fig. 6).—Plantae 1–2 cm. altae, assurgentes ex fundamento prostrato et repente, 150–180 μ crasso et cum segmentis fere circiter unum diametrum longis, per rhizoidia unicellularia 160 aut etiam 800 μ longa cum apicibus lobatis affixo; rhizoidiis in brevioribus intervallis ortis, fere unum per segmentum, ab fine proximale cellularum pericentralium a quibus muro transverso non abscissa sunt; ramis erectis 150–170 μ crassis, cum segmentis 0.5–1.0–(1.5) diametros longis; ramis plurimum ordinum, exogenibus aut rare cicatrigenibus, fere alternante distichis in 4–6 segmenta; ramulis ultimis forte incurvatis, saepe apices ramorum excedentibus et superarcuantibus; cellulis pericentralibus 4, circum parvum cellulam centralem, omnino ecorticatis; trichoblastis simplicibus aut semel aut bis furcatis, 200–360 longis, decussate alternantibus cum ramis ita dispositis ut rami cum trichoblastis aut cicatricellulis persistentibus laevam spiram quartum divergentum faciant; trichoblastis aut cicatricellulis distichis in ramulis ultimis, fere 2 segmenta separatis; cicatricellulis saepe ex trichoblastorum primordiis orientibus; tetrasporangiis 35–60 μ crassis, in seriebus aliquanto continuis in ramulis ultimis, irregularibus sed apparenter in spiris non positis; cystocarpis ovoidis, aliquanto urceolatis, breve pedicellatis 250–320 x 300–430 μ crassis, in loco rami; ramis antheridialibus 30–40 x 100–150 μ , ramum primum trichoblasti constituentibus; plantae colore fusco-russeo, saxis adhaerentes.

Plants 1–2 cm. high, assurgent from a prostrate creeping base 150–180 μ in diam. and composed of segments mostly about 1 diameter long, attached by unicellular rhizoids up to 160 or even 800 μ long with lobed tips; rhizoids arising at short intervals, seldom more than one per segment, from the proximal end of the pericentral cells from which they are not cut off by a cross wall; erect branches 150–170 μ in diam., their segments 0.5–1.0–(1.5) diam. long; branches of several orders, exogenous or rarely cicatrigenous, arising in an alternately distichous manner every 4–6 segments; ultimate branchlets strongly incurved, often exceeding and overarching the branch tip; pericentral cells 4 around a small central cell, totally ecorticate; trichoblasts simple or

once or twice forked, 200–360 μ long, decussately alternate, with the branches so arranged that they, together with the trichoblasts or persistent scar-cells, form a left hand spiral with $\frac{1}{4}$ divergence, 2–3 segments intervening between a branch and the next higher or lower trichoblast in the spiral; trichoblasts and scar-cells distichous on the ultimate branchlets, mostly 2 segments apart; scar-cells often represented by undeveloped trichoblast primordia; tetrasporangia 35–60 μ in diam., in more or less continuous series in the ultimate branchlets, shifting in position but seemingly not in a regular spiral arrangement; cystocarps ovoid, somewhat urceolate, briefly pedicellate, measuring 250–320 x 300–430 μ , replacing a branch; when young surmounted by a slender forked hair; antheridial branches 30–40 x 100–150 μ , arising as a primary branch of a trichoblast; plants deep reddish brown, forming tufts or somewhat matted on rocks or intermingled with other matted algae.

Type: Hollenberg 2649, cystocarpic, tufted, on boulders, medium low tide level, near the mouth of Topango Canyon, Los Angeles County, California, June 4, 1939 (H.). Only two other collections have been made: at Fairview Point, Laguna Beach, Orange County, California, Hollenberg 1114, tetrasporic, Nov. 1935 (H.); and at Park Point, LaJolla, San Diego County, California, in the middle littoral zone on rocks, Hollenberg 2634a, male, May, 1939 (H.).

This diminutive plant seems very distinct from other Pacific coast species, especially in the arrangement of the branches and trichoblasts. Branch tips frequently have the aspect of a *Pterosiphonia*, but it is excluded from that genus because of the trichoblasts and the nondecurent insertion of the branches and shortened basal segments of branches. The arrangement of trichoblasts and branches is very similar to that of a series of plants from the Atlantic coast of both North and South America, which have been commonly identified as *Polysiphonia subtilissima* Montagne. However, the Atlantic coast plants are much larger, up to 12 cm. high and more irregularly branched. Several plants from the coast of Mississippi, which are considered by W. R. Taylor to be more definitely identified with the type of *P. subtilissima*, were found by the writer to have little if any regularity in the insertion of the branches. They are much more laxly branched than the Pacific coast plants and young branchlets are not at all incurved.

POLYSIPHONIA Macounii sp. nov. (fig. 7, 14).—Plantae 10–12 cm. altae ex ramis repentibus et dense implexis, per rhizoidia unicellularia et numerosa affixae; axibus principibus 500–600 μ crassis, cum segmentis deorsum 1–2 diametros longis et sursum brevioribus diametro; ramis aliquot vel multorum ordinum, fere exogenibus; ultimis ramulis numerosis et fere aliquanto determinatis, brevibus et calcari similibus et obtusis; cellulis pericentralibus 4, cum corticatis filamentis sparsis, in longitudinem juncturis cellularum pericentralium axis primi extensis; trichoblastis furcatis et brevibus, una per segmentum

spiram laevam quantum divergentem facientibus, mox deciduis, cicatricellulas persistentes relinquentibus; ramis a cicatricellulis frequenter ortis; ramis trichoblastorum vicem; ramis fructiferentibus ignotis.

Plants 10–12 cm. high from densely matted creeping branches attached by numerous unicellular rhizoids; main axes 500–600 μ in diam., their segments 1–2 diam. long below, and shorter than broad above; branches of several to many orders, mostly exogenous, the ultimate branchlets abundant, short obtuse and spur-like, and mostly more or less determinate; pericentral cells 4, with a number of cortical filaments extending longitudinally along the junctures of the pericentral cells in the main axes; trichoblasts short and forked, one on each segment, arranged in a left hand spiral with $\frac{1}{4}$ divergence, soon deciduous, leaving scar-cells from which accessory cicatrigenous branches may arise in considerable numbers; branches replacing trichoblasts; reproductive structures unknown; plants known only from the vicinity of Vancouver Island, British Columbia.

A series of specimens in the herbarium of the New York Botanical Garden is considered the type collection. These specimens are to be found in a packet labeled "*P. senticulosa*" from the Collins herbarium. Fragmentary notes on portions of the original wrapper indicate that this collection is no. 105, collected by John Macoun at Qualicum, Vancouver Island, British Columbia. No date is given, but John Macoun, who was naturalist on the Geological and Natural History Survey of Canada, probably collected this material about 1909 or shortly previous to this time. The only other known specimens were likewise collected by Macoun from the same general region; John Macoun no. 106, without date or locality (C.); Amphitrite Point, Barkley Sound, west coast of Vancouver Is., Macoun 93 in part (C.); and Victoria B. C., J. Macoun, without date (N. Y.).

Kylin (1941) established the genus *Orcasia* with Harvey's *Polysiphonia senticulosa* as the type species, and Kylin's photograph (fig. 33) represents a plant strikingly similar to the specimens of *P. Macounii* from the same general region. No authentic material of *Orcasia senticulosa* (Harv.) Kylin is available for examination and Kylin does not give figures of structural details. However, Macoun's specimens show no clear distinction between determinate and indeterminate branches, and the more indeterminate branches rarely if ever arise endogenously, but are mostly exogenous as indicated by the reduced number of pericentral cells in the basal segment and the absence of evidence of disturbance of the pericentral cells adjacent to the point of origin. No young branches were found arising endogenously from the base of determinate branchlets as described for *Orcasia*, and it seems doubtful if Macoun's plants can be identified with *O. senticulosa*. Some of the smaller branchlets are cicatrigenous in origin, and some of the erect branches seem to arise endogenously from the prostrate branches as in a number of species of *Polysiphonia*. Finally the main

axes of *P. Macounii* are usually corticated along the lines of juncture of the pericentral cells, whereas neither the original description of *P. senticulosa* nor Kylin's description of *Orcasia senticulosa* indicate that the plant is corticated. Lacking data concerning the origin of branches in relation to trichoblasts and concerning reproductive structures, critical comparisons with certain somewhat similar species of *Polysiphonia* are at present impossible. In general structural features *P. Macounii* is suggestive of *P. novae-angliae* Taylor from the New England region. The latter plant, however, is much more finely branched, with branches of all orders essentially similar, and the main axes are somewhat more completely corticated. From *P. fibrillosa* Grev. the west coast plant differs in color, in the spur-like branchlets, and in the lack of a discoid attachment organ. It differs from *P. subulata* (Dulc.) J. Ag. from Europe not only in the branching habit and the extent of cortication, but in the fact that branchlets are neither pectinate nor corymbosely fastigate as described for that species.

POLYSIPHONIA minutissima sp. nov. (fig. 21).—Plantae epiphyticae pusilles et cristatae, fere minus 3 mm. altae aut ad 6 mm., a crista rhizoidiorum ortae, qui in hospitem profunde penetrant; rhizoidiis e 1–3 cellulis compositis, interdum furcatis, cum apicibus obtusis et saepe aliquanto tumentibus, ad 1 mm. longis; ramis erectis cristatis, a fundamento assurgentibus; ramis complurum ordinum, exogenibus, ramis succedentibus per nulla intervalla constantia separatis; ramis principibus indistinctis, ad 145 μ crassis, cum segmentis fere unius diametri longis aut brevioribus; cellulis pericentralibus 4, omnino ecorticatis; trichoblastis brevibus, una per segmentum, in spira laeva cum $\frac{1}{4}$ declinatione, mox deciduis, cicatricellulas persistentes relinquentibus; tetrasporangiis in seriebus brevibus et spiralibus, ad 80 μ crassis, in ramulis ultimis tumentibus; cystocarpiis paulo urceolatis, parce sessilibus, 225–290 μ crassis, trichoblastorum vicem; ramis antheridialibus circa 40 x 135 μ , ut unus ramus trichoblasti ortis, sine apicibus sterilibus; plantae obscure rubrae.

Plants epiphytic, diminutive, tufted, mostly under 3 mm. high or up to 6 mm. high, from a tuft of rhizoids deeply penetrating the host; rhizoids composed of 1–3 cells, often branched, with blunt and often swollen tips, up to 1 mm. long, cut off by a cross wall from the proximal end of the pericentral cells; erect branches assurgent from a prostrate rosette-like base, giving the plant the aspect of a diminutive tumbleweed; branches of several orders, exogenous replacing trichoblasts, with no constant interval between successive branches; main axes indistinct, up to 145 μ in diam., their segments mostly 1 diam. long or less; pericentral cells 4, totally ecorticate; trichoblasts short, one per segment, arising in a left hand spiral with $\frac{1}{4}$ divergence, soon deciduous, leaving persistent scar-cells; tetrasporangia in short spiral series, up to 80 μ in diam., causing the ultimate branchlets to bulge; cystocarps slightly

urceolate and nearly sessile, 225–290 μ in diam., replacing trichoblasts; antheridial branches about 40 x 135 μ , comprising one branch of a trichoblast, without sterile tips; plants dull red in color.

Type: Hollenberg 2554, collected from the middle or lower littoral zone on the bay side of Punta Banda, Lower California, Mexico, Dec. 17, 1938, growing on *Codium fragile* (Suhr.) Hariot. (H.). The writer has also collected a plant which is slightly larger but seems to belong to this species from the north side of Catalina Island, off the coast of southern California. The latter plant is up to 6 mm. high. The diminutive size and assurgent tufted habit of a tumble weed are the most distinctive features of *P. minutissima*, together with the single tuft of deeply penetrating and often multicellular rhizoids. The branching is somewhat unilateral in the case of the outer lower branches.

POLYSIPHONIA acuminata N. L. Gardner, New Rhodophyceae VI, Univ. Calif. Publ. Bot. 14:100, 1927. Plants erect, 2–6 cm. high, tufted, epiphytic or saxicolous, attached by a penetrating tuft of rhizoids arising from the base of erect branches, or having prostrate branches of limited extent which are attached by numerous rhizoids arising 1-many per segment; rhizoids unicellular and cut off by a cross wall from the pericentral cells; central percurrent axis prominent, 300–500 μ in diam., its segments mostly shorter than broad, with numerous densely branched laterals spirally arranged, resulting in slenderly conical or attenuate frond divisions; branches replacing trichoblasts, of several orders, with 2–6 (mostly 3) segments between successive branches; pericentral cells 4, relatively large, surrounding a small central cell, totally ecorticate; trichoblasts abundant 2–4 times forked, one per segment except when totally replaced by a branch, arising in a left hand spiral with $\frac{1}{4}$ divergence, soon deciduous, leaving scar-cells, the first trichoblast on a branch occurring 2–5 segments from the base of the branch, tetrasporangia 50–70 μ in diam., spirally arranged in swollen terminal branchlets; cystocarps numerous, nearly sessile, subspherical, 250–300 μ in diam.; antheridial branches measuring 100–150 x 30–50 μ , without sterile tip or with tip of 1–2 short sterile cells, arising as a primary fork of a trichoblast; plants medium to dark reddish brown, moderately adherent, growing in the upper littoral zone, chiefly in southern California.

The type material was collected by N. L. Gardner (no. 1968) at White's Point near San Pedro, Los Angeles County, California, June, 1908 (C.). It was distributed as Phyc. Bor.-Amer. no. 1599 under the name *Streblocladia camptoclada* (Mont.) Falk. Seventeen additional collections are available for study. Most of these were collected by the writer along the coast of southern California, including Catalina Island. One collection was made by N. L. Gardner in the Monterey region. The saxicolous specimens usually dry nearly black and have less distinct main axis, as compared with the epiphytic specimens. Usually the main axes are very straight and promi-

nent and the specimens are somewhat more delicate and a much lighter reddish or brownish color. The short segments in the main axes and the distinctness and straightness of these axes are in general the features which distinguish this species from *P. Snyderae* and *P. simplex* to which it is probably most closely related.

POLYSIPHONIA simplex sp. nov. (fig. 18).—Plantae saxicolae, saepe mattas densas aliquanto latas formantes, cum filamentis fundamentalibus repentibus et implicatis, 250–360 μ crassis, segmentis fere brevioribus uno diametro longis, per rhizoidia unicellularia a finibus proximalibus cellularum pericentralium abscissa et in discis lobatis terminata; filamentis prostratis ramos erectos 1–3–(7) cm. altos et 160–250 μ crassos cum axibus principibus distinctis et parce furcatis in modo exogene et assurgente productis; ramis exogenibus, in lateribus omnibus ortis; trichoblastis semel terque furcatis, in segmento una in collocazione spirale cum $\frac{1}{4}$ declinationibus ortis, mox deciduis, cicatricellulas persistentes relinquentibus; cum ramis trichoblastorum vicem, trichoblastis in origine non conjunctis; tetrasporangiis ad 70 μ crassis, in apicibus ramulorum aliquanto tumens spiralliter dispositis; cystocarpis ovoido-globosis, fere sessilibus, 300–350 μ crassis; ramis antheridialibus 100–170 x 35–40 μ crassis, furcis primis trichoblastorum ortis, sine apicibus sterilibus; plantae fuscae vel obscura-fuscae.

Plants saxicolous, forming dense mats often of considerable extent, with creeping tangled basal filaments 250–360 μ in diam., composed of segments mostly shorter than broad, attached by unicellular rhizoids with lobed tips, which are cut off from the proximal end of the pericentral cells by a curving wall; prostrate filaments giving rise in an exogenous assurgent manner to erect branches 1–3–(7) cm. high and 160–250 μ in diam., with main axes distinct but not prominent, and sparingly branched; branches exogenous, arising on all sides; trichoblasts 1–3 times forked, one per segment, arising in a left hand spiral with one fourth divergence, soon deciduous, leaving persistent scar-cells; branches replacing trichoblasts, not arising in connection with them; first trichoblast on a branch arising (1)–3–4 segments from the branch base; tetrasporangia up to 70 μ diam., spirally arranged in the somewhat bulging branch tips; cystocarps ovoido-globose, sessile, 300–350 μ in diam.; antheridial branches arising from one fork of a trichoblast, measuring 100–170 x 35–40 μ , without sterile tips; plants medium to dark brown, drying nearly black, growing in the middle to upper littoral zone along the coast of southern California and Lower California, and possibly present in the Gulf of California.

Type: Hollenberg 2115, from rocks, Laguna Beach, Orange County, California, May 14, 1937 (H.). Additional representative specimens studied include: La Jolla, San Diego County, California, from boulders at low water mark, Mrs. M. S. Snyder, Phyc. Bor.-Amer. 246, issued as *Lophosiphonia vilum* (J. Ag.) S. & G. (C., N. Y., Fi.); and from the

bay side of Punta Banda, Lower California, Mexico, Hollenberg 2563, Dec. 1938 (H.).

P. simplex is very common on sand-swept rocks in the middle littoral zone along the coast of southern California. It seems to be a perennial. In structural details it is close to *P. Snyderae* Kylin, as has been pointed out by Kylin (1941) in his discussion of Phyc. Bor.-Amer. 246. It differs from the latter species in habitat, in the densely matted habit with its much more extensive prostrate system of branches, and in having segments rarely longer than broad. In some cases the trichoblast primordia remain unicellular and directly constitute the scar-cells, as frequently occurs also in other species. In a number of detailed respects *P. simplex* is close to *P. ferulacea* (Suhr.) J. Ag., which has been recorded by Taylor (1928) from Florida and from the Danish West Indies by Boergesen (1919), but differs from the latter plant as described by these investigators in the low matted habit, in its slightly longer segments, and in the lack of sterile tips on the antheridial branches.

The writer has been privileged to examine a number of species of *Polysiphonia* collected by Mr. E. Yale Dawson in the Gulf of California. Nine of these the writer has placed provisionally with *P. simplex*. In Dawson's plants the segments are all very short, mostly less than half as long as broad. Hence they might better be placed with *P. ferulacea*, were it not for the low matted habit of *P. simplex*. Of special interest is the fact that in Dawson's number 284 from Puerto Refugio two tetrasporangia commonly occur in each segment. The other specimens are seemingly sterile.

POLYSIPHONIA Masonii Setchell and Gardner, Mar. Alg. Revill. Is., Proc. Calif. Acad. Sci. 19:160, 1930. Plants 2–3 cm. high, flaccid, attached by a bundle of short unicellular rhizoids with discoid tips; main axes 350–400 μ in diam. below, repeatedly and regularly dichotomously branched; pericentral cells 4, ecorticate, composed of segments hardly longer than broad in the main axis, shorter above; trichoblasts dichotomously or trichotomously branched, arising one per segment in spiral arrangement with $\frac{1}{4}$ divergence, deciduous, leaving persistent scar-cells; relation of trichoblasts to origin of branches not observed; tetrasporangia in spiral series in the ultimate branchlets, 85–95 μ in diam.; cystocarps subspherical, nearly sessile, 300–325 μ in diam.; antheridial branches arising from a primary branch of a trichoblast, broadly fusiform; plants reddish brown, epiphytic.

Type: H. L. Mason 86, on *Zostera*, Guadalupe Is., west coast of Mexico, April 1925, in the herbarium of the California Academy of Science. The above description is largely adapted from Setchell and Gardner's description after an examination of the type and only known material. In many detailed characteristics this plant is close to *P. Snyderae* Kylin, but the regularly dichotomous branching throughout and the somewhat discoid attachment organ, together with the lack of additional material, have made it

seem desirable to retain the name as a distinct entity at least for the present.

POLYSIPHONIA flaccidissima sp. nov. (fig. 8).—Plantae 10–20 mm. altae a filamentis repentibus; partibus prostratis 70–85 μ crassis, e segmentis fere 1.5 diametros longis, per rhizoidia unicellularia affixae; rhizoidiis variis longitudine, cum apicibus lobatis aut sine lobis, fere unum per segmentum, a finibus proximalibus cellulorum pericentralium abscissis; ramis erectis 70–80 μ crassis, cum segmentis 1–2 diametros longis et sursum brevioribus, exogenibus et assurgentibus a partibus repentibus, cum principibus axibus indistinctis; ramis aliquot vel multorum ordinum, omnibus exogenibus, cum trichoblastis in origine conjunctis ad utrumque terminum gradatim angustis, primum plerumque stristis et ad axem principem curvatis; cellulis pericentralibus 4, omnino ecorticatis; trichoblastis simplicibus aut fere cum furcis singularibus saepe ad apicem incurvatis aut spiralibus, fere cum apicibus obtusis, una per segmentum in spira laeva cum $\frac{1}{4}$ declinatione, mox deciduis, cicatricellulas persistentes relinquentes; tetrasporangiis 50–70 μ crassis, in seriebus continuis aut interruptis, plerumque spiraler in ramulis ultimis et subultimis ortis; cystocarpiis et ramis antheridialibus ignotis; plantae rubrae fere ad saxa et algas corallinas affixae.

Plants 10–20 mm. high from creeping basal filaments; prostrate portions 70–85 μ in diam., the segments mostly 1.5 diam. long, attached by unicellular rhizoids of variable length; rhizoids with or without lobed tips, usually one per segment, commonly two segments apart and cut off from the proximal end of the pericentral cells; erect branches 70–80 μ in diam., their segments 1–2 diam. long and shorter above, exogenous and assurgent from the creeping filaments, with indistinct main axes; branches of several to many orders, all exogenous and arising in connection with trichoblasts, narrowed gradually at both ends, at first usually strict and curving toward the main axis; pericentral cells 4, totally ecorticate; trichoblasts simple or mostly with a single fork; tapering only slightly to the blunt tips, which are often incurved or coiled, arising singly per segment in a left hand spiral with $\frac{1}{4}$ divergence, soon deciduous, leaving persistent scar-cells, or the scar-cells sometimes arising directly from undeveloped trichoblast primordia; tetrasporangia 50–70 μ in diam., in continuous or interrupted and usually spiralling series in the ultimate and subultimate branches, which are more or less swollen, each sporangium appearing above and spirally to the left of the scar-cell immediately below; cystocarps and antheridial branches unknown; color red; plants occurring on rocks and corallines, mostly in exposed places near high tide level along the coast of southern California.

Type: Hollenberg 2269, growing on corallines in shallow depressions on a large wave-swept rocky point at Laguna Beach, Orange County, California, Jan. 1, 1938. It is partly tetrasporic. The species in its typical diminutive form is represented by a number of additional collections by the writer at the same

locality and at other places, including a collection from Catalina Island and a collection as far south as Punta Banda, Lower California, Mexico. The latter collection was made on the bay side of the point in more sheltered water. All collections were made during the months of November to April inclusive and observations throughout the various seasons of the year at the type locality indicate that the plant is an annual at least as far as its appearance in the upper littoral zone is concerned, although var. *Smithii* was collected in the Monterey region in August.

P. flaccidissima is in general similar to *P. havanensis* Montagne as figured by Boergesen (1919, fig. 260, 261). The West Indian plant, however, is described as considerably larger, with leading branches more distinct, and with rhizoids continuous with the pericentral cells bearing them. Furthermore, the relative positions of the young branches and associated trichoblasts are seemingly different in the two species, and the Pacific coast plant rarely if ever bears adventitious branches as described by Boergesen for *P. havanensis*.

P. flaccidissima var. **Smithii** var. nov. (fig. 19).—Plantae 3–5 cm. altae, fere laxius ramosae quam in specie, cum axibus principibus ad 140 μ crassis et cum segmentis (2)–4–6 diametros longis; ramis fructiferis ignotis; plantae sublicis et saxi et conchis fere in aqua placida affixae.

Plants 3–5 cm. high, mostly more laxly branched than in the species, with main axes up to 140 μ in diam., segments (2)–4–6 diameters long; fruiting unknown; plants attached to piling, stones and shells in sheltered or deep water along the coast of central and southern California.

This variety is distinguished by its more luxurious habit, with larger branches and longer segments, and by the habitat. Number 1146 in the herbarium of the writer is considered the type collection. This collection was made from shells and stones near the highway bridge, Newport Bay, Orange County, California, Dec. 8, 1935. Three additional collections have been made: LaJolla, San Diego County, California, from wharf piling at low tide level, Hollenberg 1965, Dec. 1936 (H.); Pacific Grove, Monterey County, California, dredged from rocks at 35–40 ft., G. M. Smith, Aug. 1941, (Hop.); and San Francisco, from floats of Yacht Club, Feb. 1932, N. L. Gardner 6984 (C.).

POLYSIPHONIA Snyderae Kylin, Californische Rhodophyceen, Lunds. Univ. Årsskr. N.F. Avd. 2, 37:35, Taf. 12, fig. 34, 1941; (fig. 9); *Polysiphonia senticulosa* Snyder in Phyc. Bor.-Amer. 638, False Bay, San Diego, California, Jan. 1899, non *Polysiphonia senticulosa* Harvey.

Plants 5–12 cm. high, from a discoid base or mostly assurgent from a prostrate creeping base of limited extent, attached by unicellular rhizoids of variable length and mostly with lobed tips, arising 1–2–(5) per segment from the proximal ends of the pericentral cells from which they are cut off by a cross wall; erect branches 300–400 μ in diam. below, the

segments (0.5)–1–2–(3) diameters long, richly dichotomously branched and mostly naked below, the chief branches repeatedly alternately branched in a more or less dichotomous corymbose manner; pericentral cells 4, without cortications; trichoblasts numerous, arising one per segment in a left hand spiral with $\frac{1}{4}$ divergence, 2–3 times forked, soon deciduous, leaving persistent scar-cells; branches arising at irregular intervals, commonly 6–10 segments apart, in the trichoblast spiral, a branch completely replacing a trichoblast; tetrasporangia 60–70 μ in diam., in segments mostly one diameter long or slightly longer, in series in the ultimate and subultimate branchlets, slightly spiraling; cystocarps abundant, ovoid to nearly spherical on short pedicels of one segment, 300–350 μ in diam., replacing branchlets or trichoblasts in the spiral; antheridial branches comprising a primary fork of a trichoblast; plants dull or pale reddish brown to dull red, epiphytic on other algae or attached to wood, shells, etc., at low tide level, mostly in sheltered bays, Washington to southern California, and in the Gulf of California and south at least as far as the Revillagigedo Islands off the west coast of Mexico.

P. Snyderae is common in sheltered water of bays along the coast of southern California. In many respects it is similar to *P. simplex* and to *P. acuminata* but the segments in the main branches are distinctly shorter in both of these plants than in *P. Snyderae*. The matted habit of *P. simplex* is also distinctive, and as Kylin (1941) has pointed out, *P. Snyderae* is more dichotomous in its branching and has much less distinct main axes than *P. acuminata*. *P. Snyderae* is also similar in many respects to *P. tongatensis* Harvey, which De Toni (1903) places under *P. mollis* Hook. and Harv. The latter plant was described by Harvey (1847) from Tasmania. No specimens of *P. mollis* were available for examination, but judging by Harvey's description it seems possible that our plant may be identical with that species. In any case the writer is of the opinion that *P. tongatensis* (?) reported by Setchell and Gardner (1930) from the Revillagigedo Islands, and certain specimens in the herbarium of the New York Botanical Garden, which are labeled *P. tongatensis* and were collected in Hawaii, the Society Islands, and the Friendly Islands, are very close to if not identical with *P. Snyderae*. Also Robert E. Coker 124 and 126 (N. Y.) from Peru, referred by Howe (1914) to *P. abscissa* Hook. & Harv. are likewise probably referable to *P. Snyderae*. Furthermore, no 200528 in the herbarium of the University of California, which was collected in Japan and identified by K. Yendo as *P. urceolata* has most of the detailed structural features of *P. Snyderae*. *P. Snyderae* differs from *P. novae-angliae* Taylor in the absence of cortical filaments.

P. Snyderae var. **heteromorpha** var. nov. (fig. 15).—Plantae cum structura et ramis fructiferentibus ut in specie, sed cum ramulis numerosis accessoris et cicatrigenibus in partibus inferioribus axorum primariorum orientibus et aliquanto distinctioribus

quam in specie; ramulis fere brevibus, saepe aliquanto determinatis; plantae tenuiores quam species.

Plants with vegetative and reproductive structures mostly as in the species, but with numerous cicatrigenous branchlets arising in the lower parts of the main axes, which are somewhat more distinct than in the species; ultimate branchlets mostly short and often somewhat determinate; plants known only from the coast of Washington and the vicinity of Vancouver Island, British Columbia.

Type (fig. 15), N. L. Gardner 3837a, from pools in the middle littoral zone about three miles south of Cape Flattery, Washington, on the ocean side, May, 1917 (C. 276664). Several additional specimens in the herbarium of the New York Botanical Garden collected by John Macoun in the vicinity of Vancouver Island, may belong here, although they are coarser. The variety differs from the species chiefly in the numerous cicatrigenous branchlets and in the short, more or less determinate, ultimate branchlets.

P. Snyderae var. **intricata** var. nov.—Plantae cum structura et ramis fructiferentibus ut in specie, sed cum partibus inferioribus implicatis et intertextis.

Plants with the general features of the species but with more intricately branched and tangled filaments toward the base rather than with a single point of attachment as is common in the species.

Type: no. 3307 (Fi.) of Francis Drouet and Donald Richards, afloat four miles east of Guaymas, Sonora, Mexico, Dec. 1940. Several additional specimens are from the same general region. This variety differs from the species in the intricate and tangled

basal branches, the plant forming loose masses in which the individual plants are indistinguishable.

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AUXIN AND CALINES IN SEEDLINGS FROM X-RAYED SEEDS¹

G. F. Smith and H. Kersten

IT HAS been previously established by Went (1938a, 1938b) that certain specific factors other than auxin are involved in the growth of plants. These have been placed in a group of plant hormones termed "calines," having the essential character of being transported through living tissues only. Included are: rhizocaline, obtained from the cotyledons in the case of etiolated pea seedlings, which with auxin is responsible for root formation; caulocaline, formed in the roots, which is necessary in conjunction with auxin for stem elongation; and phyllocaline, a requisite for leaf growth which is auxin independent and, in the case of pea seedlings germinated in the dark, is derived solely from the cotyledons. The schemes of activity of these factors as correlated with auxin

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in both light- and dark-germinated pea seedlings are diagrammed in figures 1 and 2.

Originally the presence and the differential character of the calines were indicated by tests in which the supply of one or another of the calines was experimentally removed by the excision of various plant parts. For example, a removal of the cotyledons from etiolated pea seedlings exhibited modifications in the elongation of stems in which growth in length ultimately ceased (Went, 1938a).

Additional evidence for the existence of calines as well as for their habit of transport through living tissues only, was assembled by performing experiments in which various amounts of calines were added by grafting experiments with peas using bases of varieties having different contents of some caline (Went, 1938b). In all instances it was found essential that in a graft union incorporating vascular tissue continuity be accomplished between stock and scion before any influence of the base type is exhibited (Hayward and Went, 1939).

The investigation described in this paper supplies further data for the presence of calines, and especially stresses their differential character as they are