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PHYCOLOGICAL NOTES—I

GEORGE J. HOLLENBERG

HAPALOSPONGIDION was established by Saunders (1899) on material collected at Pacific Grove, California. It is a brown alga which forms cushion-like small gelatinous thalli on rocks in the upper littoral zone. As described by Saunders, it is composed of a basal distromatic layer bearing erect closely packed and mostly unbranched filaments, which are free except at the tips, and which adhere on account of copious quantities of mucilaginous material. Saunders described both unilocular and plurilocular sporangia. The former he described as terminal and usually single, although he also described and figured series of enlarged cells in the erect filaments, which he took for immature or abortive unilocular sporangia. Largely on the strength of the latter observation, it seems, Setchell and Gardner (1924, 1925) doubted Saunders' description of single terminal unilocular sporangia and concluded that *Hapalospongidion gelatinosum* Saunders should be united with *Microspongium* under the name *M. saundersii* S. & G. In this disposition of Saunders' plant these investigators seem to have disregarded the fact that in the type species, *Microspongium gelatinosum,* described by Reinke (1888), both types of reproductive structures are laterally inserted on the erect filaments.

Saunders' plant (fig. 14) has been found by the writer at a number of places along the coast of southern California and near Carmel in central California. It has also been found by the writer as far south as Punta Banda, Lower California, Mexico. Examination of no. 583 of the Hancock Expedition of 1934, collected at Petillan Bay, Mexico, by Dr. W. R. Taylor, shows that it is the same as Saunders' plant.

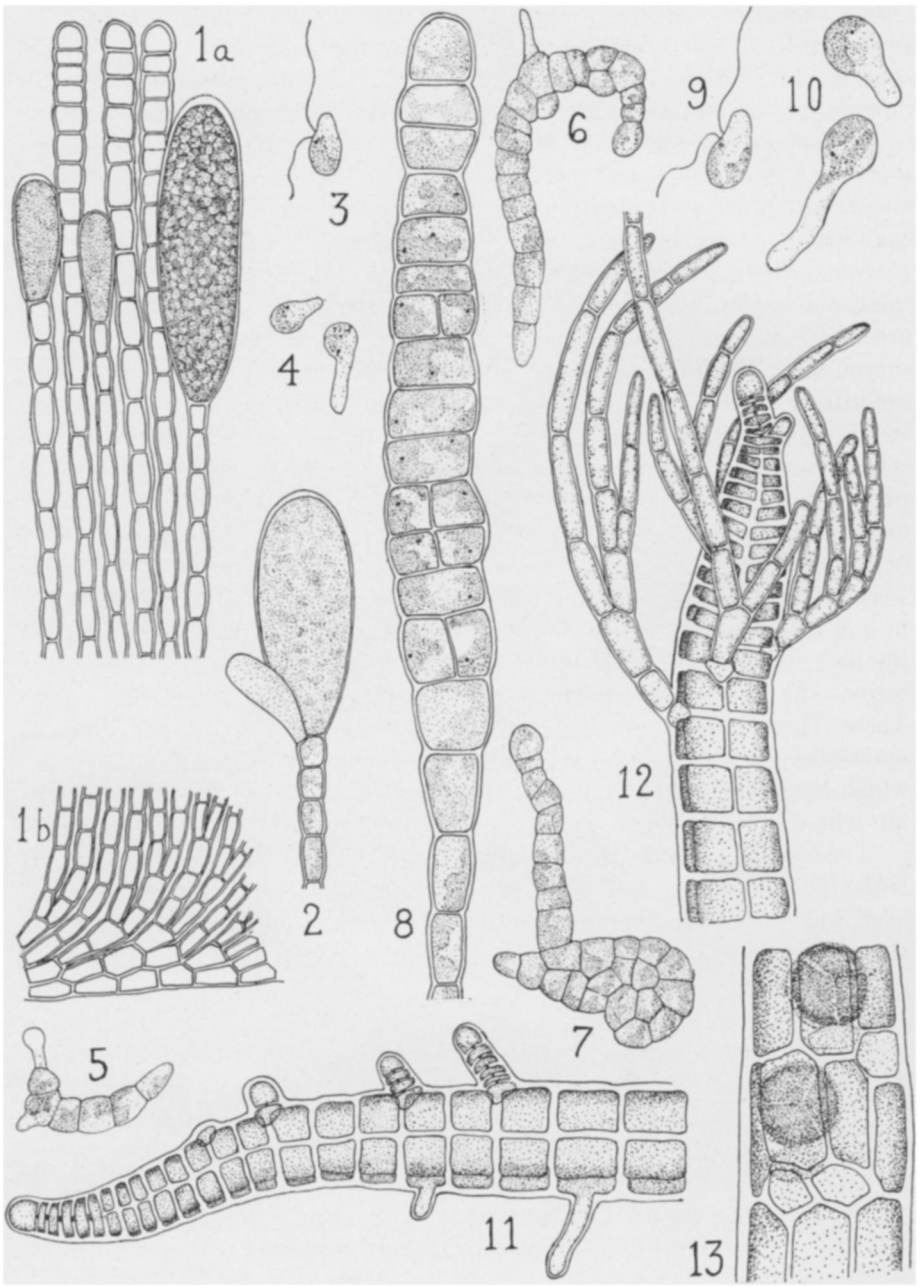
Near Corona del Mar in Orange County, California, the plant is usually abundant throughout the winter over an area several feet in diameter on a certain large rocky point. It has been observed at this locality for several successive seasons, and although it usually partially disappears during the winter months, it can be found at all seasons of the year. Both types of reproductive structures have been found a number of times. They correspond closely to Saunders' description and figures. Mature unilocular sporangia (fig. 1a) are relatively large, measuring 25–35 × 80–140 μ. They are oblong in shape and strictly terminal. They occur singly at the tips of the erect filaments. The tips of the sporangia are well below the tips of adjacent sterile filaments. No seriate intercalary unilocular sporangia were observed, and it seems probable that structures of such a nature reported by Saunders were abortive plurilocular sporangia. A few lateral outgrowths (fig. 2) were observed at the base of unilocular sporangia. These may be interpreted as

abortive accessory unilocular sporangia or possibly the true tip of the fruiting filament. In the latter case the unilocular sporangium could be thought of as actually lateral in position. A single very large nucleus is present in very young unilocular sporangia, suggesting that meiosis occurs in these reproductive structures as might well be expected, but no cytological studies were undertaken to determine the nature of the first nuclear divisions.

Normal plurilocular sporangia (fig. 8) occur on plants distinct from those which bear the unilocular sporangia, although both types of plants are often indistinguishably associated as a result of coalescence. The plurilocular sporangia are intercalary near the tips of the erect filaments, as described by Saunders. Their development is initiated by transverse divisions of cells immediately below the apical cell of a filament. One and usually two longitudinal divisions follow, resulting in the production of two tiers of four cells from each cell of the erect filament. These observations seem to necessitate retention of Saunders' genus *Hapalospongidion,* with *H. gelatinosum* as the type species.

Saunders does not describe motile reproductive cells of *Hapalospongidion* and did not study the development of germlings. The writer finds that zoids from both types of reproductive structures are of the usual form (figs. 3, 9), containing a single chromatophore and distinct stigma as well as two unequal flagella laterally inserted. Neither type of zoid gave evidence of fusing in the cultures. They were allowed to settle on cover-glasses and germling stages were studied in a manner similar to that employed for *Hapterophycus* (Hollenberg 1941). Examination of the cultures 12 hours after liberation of the zoids showed the formation of germ tubes (fig. 4). A single stigma was present at this time in germlings from both types of reproductive structures. It seems probable, therefore, that both types of zoids ordinarily germinate without fusing under culture conditions. The development of germlings from plurilocular sporangia was followed in the cultures for a period of one month. The entire contents of the germling initial usually migrates into the germ tube and is cut off from the old wall of the germling initial by a cross wall (fig. 5). Subsequent growth and cell divisions result in the formation of a short filament, usually provided with a single rhizoid. Longitudinal and irregular divisions, commonly accompanied by development of a sharp bend in the filament at the point of active cell division, soon initiate the development of a discoid thallus (figs. 6, 7). Although the development of the germlings was not followed beyond the development of this initial discoid thallus, it seems evident that the life cycle involves a facultative alternation of similar but distinct generations, parthenogenetic development of gametes seemingly repeating the haploid generation.

The writer has for some time been impressed with the similarity of the descriptions of certain other members of the Ralfsiaceae to *Hapalospon-*



gidion. *Mesospora* was described as a new genus by Madame Weber-van Bosse (1910), with *M. schmidtii* from the Malay archipelago as the type species. This plant was also found by the same investigator at several stations during the Siboga Expedition (Weber-van Bosse 1913). Later *Mesospora van-bossae* was described by Boergesen (1924) from Easter Island in the south Pacific. Still more recently Feldmann (1937) described *Mesospora mediterranea* from the Mediterranean. The writer has not been privileged to examine specimens of any of these species, but all are strikingly similar to *Hapalospongidion gelatinosum* in a number of important respects. In all of these plants the erect filaments are free except at the tips, where they are described as being united by a surface layer of the very gelatinous material surrounding the filaments. In all of these plants the plurilocular sporangia are intercalary, and separated from the tips of the filaments by one or more sterile cells, each cell in the fertile region dividing into the ultimate fruiting cells in a manner similar to that described by Saunders for the California plant. In all three plants the erect filaments arise from a basal stratum mostly two cells thick. In *M. mediterranea* Feldmann describes cell rows developing to some extent downward from this distromatic layer, and the writer has observed the same condition in *Hapalospongidion gelatinosum* in one instance. Unilocular sporangia are described as arising laterally at the base of erect filaments in the case of *M. schmidtii*, and Feldmann describes and figures lateral unilocular sporangia in the Mediterranean plant. These reproductive structures are not known in *M. van-bossae*. In *M. schmidtii* a series of large intercalary cells are described similar to those which Saunders interpreted as immature or abortive unilocular sporangia, but which as noted above are more probably abortive plurilocular sporangia.

The only important distinction between *Mesospora* and *Hapalospongidion* is the terminal position of the unilocular sporangia in the latter plant. However, as noted above, occasional unilocular sporangia bear lateral proliferations at the base, suggesting that in *Hapalospongidion* these reproductive

Explanation of figures 1–13

FIGS. 1–10. *Hapalospongidion gelatinosum* Saunders. FIG. 1a. Unilocular sporangia and paraphyses. ×500. FIG. 1b. Erect filaments of the thallus arising from the distromatic basal layer. ×500. FIG. 2. Immature unilocular sporangium showing rudimentary tip of filament (?). ×500. FIG. 3. Zoid from unilocular sporangium. ×1000. FIG. 4. Germinating zoids from unilocular sporangium. ×500. FIGS. 5–6. Germlings developing from zoids from plurilocular sporangia, one month old. ×500. FIG. 7. Germling from zoid from plurilocular sporangium, two months old. ×500. FIG. 8. Plurilocular sporangium at upper end of erect filament of thallus. ×1000. FIG. 9. Zoid from plurilocular sporangium. ×1000. FIG. 10. Germinating zoids from plurilocular sporangia. ×1000. FIGS. 11–13. *Lophosiphonia villum* (J. Ag.) S. & G. FIG. 11. Tip of prostrate branch showing rhizoids and adventitiously endogenous erect branches arising from the central cells. The latter are not shown. ×250. FIG. 12. Tip of erect branch showing arrangement of trichoblasts. ×250. FIG. 13. Portion of erect branch with tetrasporangia and double scar-cells. ×500.

structures may in some cases be thought of as essentially lateral. For the present it seems best, however, to retain *Mesospora* as a distinct genus.

A study of the type material of *Ralfsia pangoensis*, described by Setchell (1924) from Pagopago Harbor, Samoa, shows that this plant is a species of *Hapalospongidion*, with all the characteristic features of the genus, except that plurilocular sporangia are unknown. **Hapalospongidion pangoensis** (Setchell) Hollenberg, comb. nov., differs from *H. gelatinosum* chiefly in the shorter erect filaments, which are mostly under 200 μ long. The cells of the erect filaments are considerably shorter and more nearly cylindrical than in *H. gelatinosum*.

Pterochondria Hollenberg, gen. nov. Thallus polysiphonous, complanate, ecorticate, erect from a rhizoidal base embedded in the cryptostomata of *Cystoseira;* branching alternate, distichous, the branches slightly

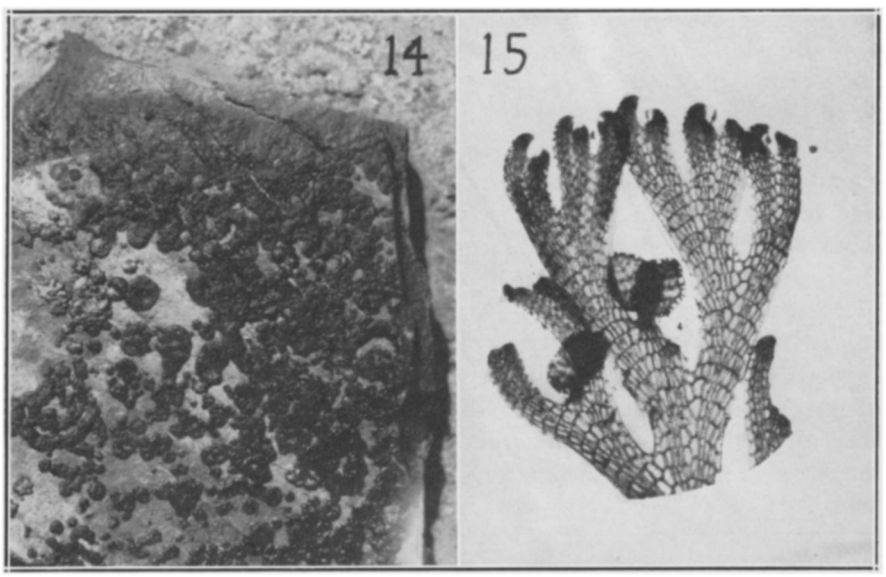


FIG. 14. Photograph of numerous plants of *Hapalospongidion gelatinosum* Saunders growing on a rock fragment. × 1. FIG. 15. Photomicrograph of a portion of *Pterochondria pygmaea* (Setch.) Hollenberg. × 30.

decurrent and of several to many orders, with mostly 3–5 segments between successive branches and with ultimate branchlets determinate; trichoblasts wanting; tetrasporangia one per segment, in straight series embedded in the adaxial side of the ultimate branchlets, tripartitely divided; antheridia covering the flat faces of flattened ovoid discs except for a sterile row of marginal cells; cystocarps globular ovoid, nearly sessile on the branches.

Thallus polysiphonus complanatus, ecorticatus, erectus ex fundamento radicato in cryptostomatibus *Cystoseirae* immerso; cum ramis alternantibus, distichis, aliquantum decurrentibus, ordinibus paucis aut multis, plerumque cum 3–5 segmentis inter ramos succedentes et cum ramulis ultimis determi-

natis; sine trichoblastis; tetrasporangiis singulis in segmentis in serie recta in latere adaxiale ramulorum ultimorum immersis, tripartite divisis; antheridiis superficies planas discorum complanatorum et ovatorum praeter ordinem sterilem cellulorum marginalium tegentibus; cystocarpiis ovoido-globosis fere sessilibus in ramis.

There are two known species of *Pterochondria:* **P. woodii** (Harv.) Hollenberg, comb. nov., is the type species; *Pterosiphonia woodii* (Harv.) Falkenberg, Rhodomelaceen, 274. 1901; Setchell and Gardner, Algae Northwest. Am., 329. 1903; *Polysiphonia woodii* Harvey, Ner. Bor. Amer. 52. 1853. This species is commonly 15–20 cm. high and occurs commonly on *Cystoseira* from the vicinity of Monterey, California, to British Columbia. It seems to occur frequently on *Pleurophycus* stipes also.

Pterochondria pygmaea (Setchell) Hollenberg, comb. nov.; *Pterosiphonia pygmaea* (Setchell) Kylin, Calif. Rhodophyceen, 38. 1941; *Pterosiphonia woodii* f. *pygmaea* Setchell, Phycotheca Bor.-Am. no. *1744*. 1911. This is a diminutive species mostly under 2 cm. high, known only from southern California, where it occurs chiefly on *Cystoseira osmundacea* (Menz.) Ag., but is also reported as occurring on *Pelagophycus porra* (Leman) Setchell.

Two features distinguish this genus from all known species of *Pterosiphonia:* the discoid antheridial branches (fig. 15), and the lack of a cylindrical creeping base. A very similar male reproductive structure occurs in *Chondria* and also in *Acanthophora* (cf. Boergesen 1918). Falkenberg (1901) states that the antheridial branches of *Pterosiphonia dendroidea* (Mont.) Falk. are cylindrical structures similar to those of *Polysiphonia.* The writer has observed male reproductive structures in several species of *Pterosiphonia* along the California coast. In all these species the antheridial branches seem to be cylindrical. It seems probable that this is true of all true species of *Pterosiphonia.* Falkenberg (1901) figures discoid antheridial branches for *Polysiphonia virgata* but it seems improbable that this will prove to be an accurate observation concerning a species of *Polysiphonia.*

Concerning the attachment organs of *Pterochondria,* F. S. Collins, in an unpublished manuscript on the Rhodomelaceae of North America, states that the spores germinate in the cryptostomata of *Cystoseira osmundaceae,* and that the young filaments are at first monosiphonous, but become polysiphonous soon after emerging from the cryptostomata.

The bluntly uncinate tips of determinate branchlets, especially evident in the case of young ramuli, seem characteristic of *Pterochondria.* This condition is seemingly due to a much retarded development of pericentral cells on the inner side of the branchlets. This also seems to account for the beak-like appearance of apices of branches, and possibly also for the staggered arrangement of the pericentral cells of a branchlet with respect to those of

the axis in the region where the branchlet is decurrent on the axis. Harvey (1853) mentions the latter condition indirectly in his original description of *Polysiphonia woodii,* when he speaks of the pericentral cells as being arranged in two axes.

TAENIOMA CLEVELANDII Farlow. *Taenioma perpusillum,* the type species, was originally described by J. G. Agardh (1851–1863) from material collected on the Pacific Coast of Mexico by Liebmann. The plant has since been collected from a number of places including points along the Atlantic coast of North America and in Europe. There was a difference of opinion whether the plant should be placed in the Delesseriaceae or the Rhodomelaceae until Thompson (1910) described the morphology and sexual reproductive structures and showed that the plant is a member of the Rhodomelaceae. *Taenioma clevelandii* was described by Farlow (1877) from material collected by Cleveland at San Diego, California. As pointed out by Farlow, the California plant is much larger, up to 10 cm. high, and lacks the fasciculate branching of *T. perpusillum.* However, De Toni (1924) makes *T. clevelandii* a synonym of *T. perpusillum,* without giving reasons for so doing. In the herbarium of the University of California are several specimens of *Taenioma* collected along the coast of California from San Diego to Central California. During the summer of 1941 the writer collected this relatively rare plant afloat near Pacific Grove, California. Examination of this material, which was tetrasporic, and the other specimens in the herbarium of the University of California, one or more of which bore tetrasporangia, but none of which bore sexual reproductive structures, has led the writer to conclude that *T. clevelandii* is amply distinct from *T. perpusillum.* It differs not only in size and lack of fasciculate branching, but in several more distinctive respects. In the first place many segments usually intervene between successive branches in *T. clevelandii,* whereas relatively few segments occur between successive branches in *T. perpusillum.* Furthermore, the branches do not end in hairs in any of the specimens of *T. clevelandii* examined by the writer. Farlow failed to mention two additional points of difference. *T. clevelandii* has a rhizome as *T. perpusillum* has, but the flanking cells, which in the genus *Taenioma* are marginal in position on the flattened branches, and which are only half as long as the pericentral cells, occur on all branches, including the basal rhizome, in *T. clevelandii,* rather than on the ultimate branches only as in *T. perpusillum.* Finally, rhizoids are all unicellular in the specimens of *T. perpusillum* available for examination, whereas those of *T. clevelandii* are usually composed of two cells. In *T. clevelandii* branches arise from the center of the flat faces of the axes, presumably from the central cell.

GELIDIUM CALOGLOSSOIDES Howe. This species was originally described by Howe (1914) from Peru, and seems not to have been reported in the

literature since. During the past several years the writer has repeatedly encountered a diminutive creeping species of *Gelidium* along the coast of southern California and several times also in the Monterey region in the central part of the state. Examination of type material shows that these plants must be placed with Howe's species, from which they differ only in the lack of dwarf ventral branchlets near the hapterous attachment organs, which Howe described as frequently present in the Peruvian plant, and which the writer observed in the type material. Examination of additional material from Peru will be necessary to determine whether or not this is a constant difference. Tetrasporangia occur in diagonal rows in the lateral and finally somewhat erect branchlets as in the Peruvian plant. The internal structure is also very similar.

LOPHOSIPHONIA VILLUM (J. Ag.) S. & G., figs. 11–13. *Lophosiphonia villum* (J. Ag.) Setchell and Gardner, Algae Northwest. Am. *329*. 1903; Kylin, Lunds Univ. Årsskr. N. F. Avd. 2. **37**: 40, 1941. *Polysiphonia villum* J. Agardh, Sp. Alg. II. 941, 1863. Plants erect, 5–10–(18) mm. high, from prostrate creeping branches 40–60–(80) μ diam., of segments 1–1.5 diam. long, without trichoblasts, attached by frequent unicellular rhizoids with expanded lobed tips; rhizoids arising as outgrowths from the middle of the pericentral cells from which they are not cut off by a cross wall; erect branches simple or sparingly branched 40–80–(100) μ diam., of segments 1–2 diam. long, arising at irregular intervals mostly every 2–4 segments in a strictly endogenous manner, at first arching toward the tips of the prostrate branches; lateral branches arising from erect branches exogenously or endogenously, independent of the trichoblasts which they may replace; pericentral cells 4, totally without cortication; chromatophores forming transverse bands in the pericentral cells; trichoblasts mostly infrequent and often wanting, but sometimes relatively abundant, irregular in occurrence but tending to occur one per segment in a left hand spiral with one fourth divergence when abundant, once or twice or sometimes thrice forked, rather stiff, often recurved or even coiled, 15–20 μ diam., 250–480 μ long, soon deciduous, leaving persistent scar-cells which sometimes divide to form double scar-cells (fig. 13); tetrasporangia 50–60 μ diam. one per short swollen segment in more or less continuous straight series; antheridial branches cylindrical, incurved, arising from the entire branch primordium, 70–170 × 20–35 μ, on short one-celled pedicels, without sterile tips; cystocarps ovoid, sessile, more or less erect, 150–190 μ diam.; plants dark reddish brown, attached in small tufts or forming a continuous stratum on rocks and other algae, often intermingled with other mat forming algae, frequent mostly in the middle and upper littoral zone, central California to tropical America.

This plant has been collected by the writer about 20 different times, mostly along the coast of southern California. In general the plants agree well with the original description by J. Agardh (1863). Professor W. A. Setchell has kindly allowed the writer to examine some unpublished notes

which he made while examining types in European herbaria. Among these is a note to the effect that no trichoblasts are present in the type material of *Polysiphonia villum* in the Agardhian herbarium. However, the writer finds that the presence of trichoblasts is a variable condition in this plant, as is also the degree of branching of erect branches. The plant is readily recognized locally by its diminutive size, and by the relatively little branched or unbranched erect branches arising endogenously from prominent and permanently prostrate branches. These characters seem to warrant placing the plant in *Lophosiphonia* as Setchell and Gardner (1903) and Kylin (1941) have done. However, in this plant, as in certain other species of *Lophosiphonia* and *Polysiphonia,* the vagueness of the characters distinguishing these two genera is most vexingly evident.

According to Falkenberg (1901) the most characteristic features of *Lophosiphonia* are: (1) relatively limited and mostly simple or sparingly branched erect branches from distinctly and permanently prostrate branches; and (2) adventitiously endogenous origin of all branches. Examination of several specimens of *Polysiphonia hemisphaerica* Aresch. from the Baltic Sea indicates that in this plant all branches arise endogenously and adventitiously, but the erect branches are several inches high and repeatedly branched. Further study may necessitate removal of this plant from the genus *Polysiphonia,* but it certainly cannot be placed in the genus *Lophosiphonia.* In *Lophosiphonia villum* all erect branches and most of the lateral branches to which they give rise are produced in an adventitiously endogenous manner. However, careful examination shows that lateral branches frequently arise exogenously by division of subapical cells. A further complicating feature is the fact that in *Lophosiphonia villum* the rhizoids arise from the prostrate branches as outgrowths of the pericentral cells from which they are not cut off by a cross wall. In this respect as well as the origin of antheridial branches from the entire trichoblast primordia, *L. villum* is closely similar to a species of *Polysiphonia* common along the Pacific Coast of North America, which has been commonly identified as *P. urceolata* (Lightf.) Grev., but is seemingly a distinct species. Furthermore, it should be noted in this connection that in a number of local species of *Polysiphonia* erect branches frequently arise endogenously from distinctly prostrate branches.

The foregoing considerations make it seem necessary to conclude that, if the genus *Lophosiphonia* is to be retained at all, its characteristic features need to be more clearly delimited if possible. Accordingly it is proposed that the concept of the genus expressed by Falkenberg (1901) be modified slightly so as to include only those Rhodomelaceous plants with a single tetrasporangium per segment, which have relatively prominent and strictly prostrate branches giving rise to erect branches in a strictly adventitious and

endogenous manner, and in which the erect branches are relatively short and simple or bear relatively few lateral branches in an adventitious and *mostly* in an endogenous manner. This characterization differs from Falkenberg's concept only in that it provides that some of the lateral branches may arise exogenously from the erect branches. It is admittedly relative, perhaps even more so than Falkenberg's concept of the genus, but this modification seems necessary if the genus is to be retained at all. There will probably continue to be some confusion concerning the limitations of the genus, but if one should adhere strictly to Falkenberg's concept of the genus, *Lophosiphonia villum* would need to be returned to the genus *Polysiphonia,* in spite of its habit, since not all branches arise endogenously. This would perhaps be more confusing than helpful. Hence it has seemed best to conclude with Setchell and Gardner that it belongs in *Lophosiphonia.*

SUMMARY

1. *Hapalospongidion* should be recognized as a valid genus in the Ralfsiaceae.

2. *Pterochondria* is described as a new genus differing from *Pterosiphonia* in the flattened discoid antheridial branches similar to those of *Chondria* and in the lack of a creeping base.

3. *Taenioma clevelandii* Farlow is a valid species distinguished from *T. perpusillum* J. Ag. chiefly by the occurrence of the characteristic short flanking cells on all branches, including the prostrate rhizome, and by the rhizoids which are composed mostly of two cells rather than of one as in the type species.

4. *Gelidium caloglossoides* Howe occurs frequently along the coast of southern California.

5. *Lophosiphonia villum* (J. Ag.) S. & G. is somewhat intermediate between *Lophosiphonia* and *Polysiphonia.* Its inclusion in the first named genus seems to require a slight modification of Falkenberg's concept of the genus.

UNIVERSITY OF REDLANDS
REDLANDS, CALIFORNIA

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