The Genus *Galaxaura* (Rhodophyta) in Micronesia[1]

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Abstract.—An annotated list is given of the genus *Galaxaura* (Chaetangiaceae, Rhodophyta) from Micronesia. Thirteen species of the genus have been identified. The following species are reported for the first time from Micronesia: *G. subfruticulosa, G. subverticillata, G. robusta, G. pacifica, G. rugosa, G. hystrix,* and *G. ventricosa.* Keys to the Micronesian species of *Galaxaura* are provided.

Introduction

Galaxaura is a common genus on tropical and subtropical areas of the world. Past records (Tsuda and Wray, 1977; Tsuda and Tobias, 1977) indicate that only nine species have, thus far, been reported from Micronesia. They are *G. acuminata* Kjellman (Dawson, 1956), *G. elongata* J. Agardh (Cloud, 1959), *G. fasciculata* Kjellman (Dawson, 1956; Kanda, 1942, 1944; Tanaka, 1936; Trono, 1969; Tsuda, 1972), *G. fastigiata* Decaisne (Abbott, 1961; Dawson, 1957; Tanaka, 1936; Tsuda, 1972), *G. filamentosa* Chou (Abbott, 1961; Bryan, 1975; Chapman, 1955; Dawson, 1956, 1957; Gilmartin, 1961; Trono, 1969; Tsuda and Kami, 1973), *G. glabriuscula* Kjellman (Emery, 1962), *G. marginata* Lamouroux (Bryan, 1975), *G. oblongata* (Ellis and Solander) Lamouroux (Bryan, 1975; Cloud, 1959; Trono, 1969; Tsuda, 1972), and *G. veprecula* Kjellman (Tsuda and Tobias, 1977).

This paper provides an annotated list of the genus *Galaxaura* of the family Chaetangiaceae (Nemaliales, Rhodophyta) from Micronesia. The study was based on approximately 80 mounted specimens which were collected from various islands in Micronesia and are deposited in the Herbarium of the Marine Laboratory, University of Guam.

KEY TO THE SPECIES OF *GALAXAURA* OF MICRONESIA

1. Plants with branches terete throughout ..... 2.
1′. Plants with branches complanate at least above ..... 11.
2. Epidermal layer absent; free assimilatory filaments generally persisting, the surface therefore pilose ..... 3.
2′. Epidermal layer well developed; free assimilatory filaments absent, or, if present, very few ..... 6.

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3. All free assimilatory filaments long and of the same type; supporting cell of free assimilatory filaments at the periphery not well differentiated .. *G. filamentosa*
3′. Free assimilatory filaments of two types, long and short ..... 4.
4. Apical cells of the short assimilatory filaments larger than the basal ones; texture very rigid ..... *G. fasciculata*
4′. Apical cells of the short assimilatory filaments smaller than the basal ones; calcium accumulation weak, and, thus, not so rigid ..... 5.
5. Long assimilatory filaments evenly distributed over the thallus surfaces ..... *G. subfruticulosa*
5′. Long assimilatory filaments verticillately arranged near the branch tips ..... *G. subverticillata*
6. Cortex composed of subfilamentous tissue, remaining attached to the medullary filaments after decalcification ..... *G. oblongata*
6′. Cortex composed of parenchymatous tissue ..... 7.
7. Branches smooth, distinctly articulate, segments swollen; inner cortex outwardly supporting slender stalk cells, each of which with 1–2 distal cells closely adjacent to each other and forming the epidermis ..... *G. robusta*
7′. Branches usually annulately rugose, segments not conspicuously swollen ... 8.
8. Free assimilatory filaments absent ..... *G. pacifica*
8′. Free assimilatory filaments present ..... 9.
9. Branches smooth ..... *G. glabriuscula*
9′. Branches conspicuously annulate rugose ..... 10.
10. Thallus small, segments more or less short, 3–6 mm long, calcium accumulation weak ..... *G. rugosa*
10′. Thallus more or less large, segments 5–14 mm long, calcium accumulation more or less thick ..... *G. elongata*
11. Inner cortex outwardly supporting slender stalk cells each with 1–2 distal cells ..... *G. marginata*
11′. Inner cortex bearing on the outer side one layer of small depressed cells forming a continuous epidermis ..... 12.
12. Thallus chalky, spinulose cells on all sides of the axes ..... *G. hystrix*
12′. Thallus smooth, shiny, spinulose cells only on the thickened thallus margins ..... *G. ventricosa*

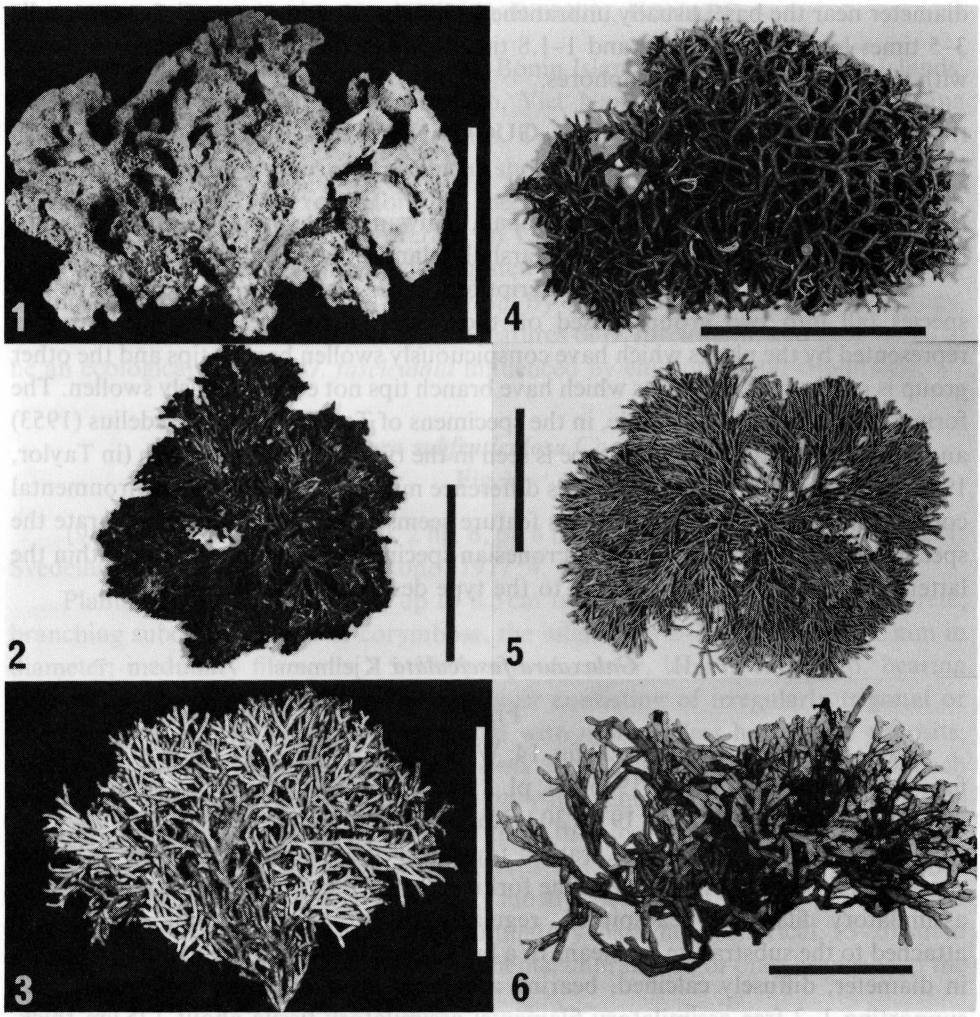
Systematic Account

I. *Galaxaura filamentosa* Chou in Taylor

Fig. 1.

1945 : 139; Chou, 1945 : 39, pl. 6 fig. 1, pl. 9 figs. 1–6; Dawson, 1952 : 51, pl. 19 fig. 2; Svedelius, 1953 : 33, figs. 29–32; Dawson, 1954 : 419, fig. 30a; Trono, 1969: 46; Womersley and Bailey, 1970 : 303; Itono, 1977 : 3, fig. 1.

Plants to 3.3 cm tall, irregularly dichotomously branched, attached by small



Figs. 1–6. Habit of plants. Fig. 1. *Galaxaura filamentosa* (scale: 2 cm). Fig. 2. *Galaxaura fasciculata* (scale: 5 cm). Fig. 3. *Galaxaura subfruticulosa* (scale: 5 cm). Fig. 4. *Galaxaura subverticillata* (scale: 5 cm). Fig. 5. *Galaxaura oblongata* (scale: 5 cm). Fig. 6. *Galaxaura robusta* (scale: 5 cm).

discoid holdfast; internodes 2–5 mm long, encrusted with very weak lime deposit at the medullary layers; densely covered with thick free assimilatory filaments, villous; axes caespitose, 0.5–0.8 mm in diameter except for free assimilatory filaments; medulla consisting of intertwined filaments measuring 19–29 μm in diameter and at the periphery giving rise to more or less thickly arranged free assimilatory filaments, supporting cells of the assimilatory filaments not conspicuously differentiated; free assimilatory filaments of one kind only, about 0.8–1.5 mm long and 19–25 μm in

diameter near the base, usually unbranched, slightly tapering toward the apex, cells 3–5 times long near the base and 1–1.8 times long in the upper parts and provided with well developed chromatophores.

HABITAT: ANATAHAN (RT 4816), GUGUAN (WJT 48), AGRIHAN (WJT 195), MAUG (RT 4841, RT 4857).

DISTRIBUTION: Southern parts of Japan, Taiwan, Viet Nam, Solomon Islands, Mariana Islands, Caroline Islands, Marshall Islands, Hawaiian Islands.

In reference to previous circumscriptions of *G. filamentosa,* specimens of this species fall into two groups based on their external features, i.e., one group is represented by the plants which have conspicuously swollen branch tips and the other group is represented by plants which have branch tips not conspicuously swollen. The former type is seen, for example, in the specimens of Tanaka (1936), Svedelius (1953) and Itono (1977), and the latter type is seen in the type specimens of Chou (in Taylor, 1945) and Dawson (1952, 1954). This difference may be caused by the environmental conditions where they grow, but this feature seems to be insufficient to separate the specimens into two species. The Micronesian specimens of this species fall within the latter type, and, thus, are identical to the type description of the species.

II. ***Galaxaura fasciculata*** Kjellman

Fig.2.

1900 : 53, pl. 5 figs. 1–9, pl. 20 fig. 14; W. V. Bosse, 1921 : 211; Tanaka, 1936 : 147, figs. 5–6, pl. 34 fig. 3; Chou, 1945 : 44, pl. 2 fig. 2, pl. 8 fig. 1; Dawson, 1954 : 519, fig. 29b; Womersley and Bailey, 1970 : 303; Itono, 1977 : 4, figs. 2–3.

Plants bushy, 5–9 cm tall, rather tough in consistency; tomentose branches spreading, 4–11 mm long between the forkings, 0.8–1 mm in diameter excluding free assimilatory filaments, caespitose, regularly dichotomous forming dense tuft; attached to the substratum by means of a broad disc; medullary filaments 12.5–15 μm in diameter, diffusely calcified, bearing a cortical layer of rather small cells, each supporting 1–2 free assimilatory filaments; assimilatory tissue about 125 μm thick, encrusted strongly with lime deposit; free assimilatory filaments of short and long types intermixed and evenly distributed over the whole surface of the frond and hence the frond appearing villous; short free assimilatory filaments consisting of two or three cells and increasing rapidly in size upwards, terminal cells almost globose or elliptical measuring 40–50 μm in diameter; long free assimilatory filaments reaching a length of about 1–1.5 mm, rarely branched, cylindrical measuring 17.5–20 μm in diameter, slightly constricted at the dissepiments.

HABITAT: Tumon Bay (RT2102, RT2538, RHR72), Cocos Lagoon (RR11), Merizo (RT2602), Nimitz Beach (RT1822), GUAM; Garapan Lagoon (RT3183), San Roque village (RT3244), Managaha Is. (RT3156), SAIPAN; Aurapushekaru Is. (RT4067), Ngerenghol (PL76), PALAU; Dublon Is. (RT3417), Fefan Is. (RT3535), TRUK;

Ponape (M. S. Doty 21661), Net (RT2370, RT2373), PONAPE.

DISTRIBUTION: Southern parts of Japan, Bonin Island, Taiwan, Philippine Islands, Celebes Islands, Java, Malay Archipelago, Viet Nam, Solomon Islands, Mariana Islands, Caroline Islands, Marshall Islands, Tonga.

Most of the 22 herbarium specimens show typical features of *G. fasciculata* in their external features, except for the specimens from San Vitores area, Guam (collected by Sister Mary Joyce Merten on 15 March 1969). The latter shows very short internodal segments and more congested features of the thallus, and, thus, may be considered a larger form of *G. filamentosa*. By examining the internal morphology, it becomes evident that this shows typical features of *G. fasciculata*, and thus seems to be an ecological form of *G. fasciculata* influenced by environmental conditions.

III. ***Galaxaura subfruticulosa*** Chou in Taylor
Fig.3.

1945 : 140; Chou, 1945 : 41, pl. 2 fig. 6, pl. 8 fig. 2; Dawson, 1952 : 52, pl. 20 fig. 1; Svedelius, 1953 : 51, figs. 43–47; Itono, 1977 : 4, fig. 4.

Plants loosely fruticulescent, up to 6.5 cm tall, the branches spreading, terete; branching subdichotomous or corymbose, the internodes 2–7 mm long, 1–1.5 mm in diameter; medullary filaments 7.5–15.0 μm in diameter, loosely entangled, bearing assimilatory layer outwardly; peripheral layer consisting of irregularly trigonal or quadrate cells, ca. 87.5 μm thick, encrusted with more or less heavy lime deposits; supporting cells of free assimilatory filaments at the periphery well developed, each supporting cell provided with 1–2 assimilatory filaments; free assimilatory filaments of short and long types intermixed, both with subcylindrical basal cells; short assimilatory filaments consisting of three cells but rarely of two cells, moniliform, terminal cells not exceedingly inflated, mostly decreasing slightly in diameter upwards, terminal cells spherical; long assimilatory filaments cylindrical, 15–20 μm in diameter, slightly constricted at the dissepiments, unbranched or once branched at the basal parts.

HABITAT: Sabeneta (RT3748), SAIPAN; Cave Beach Area (RT3696), TINIAN.

DISTRIBUTION: Southern parts of Japan, Mariana Islands, Hawaiian Islands, Pacific Mexico.

G. subfruticulosa is most closely related to *G. subverticillata*. The major difference between these two species is the presence of verticillate long assimilatory filaments in *G. subverticillata*. This feature is also seen in younger parts of *G. subfruticulosa*.

Chou (1945 : 46) cited the extended assimilatory filaments in *G. subfruticulosa* as well as other species of the section Subverticillatae may sometimes appear to be subverticillate at the upper parts of the branches, but she stressed that these are usually not distinct and are wider than the short assimilatory bands. Furthermore, she states that *G. subverticillata* differ from *G. subfruticulosa* in having assimilatory

filaments consisting of three cells, with terminal and subterminal cells distinctly smaller than the terminal basal cells.

These criteria, however, are not adequate to separate these two species, and it is not inconceivable that *G. subfruticulosa* and *G. subverticillata* will be found to be conspecific. I tentatively separate these two species, and suggest that it is necessary to examine them in culture and study their ecological features before finalizing our decision.

IV. ***Galaxaura subverticillata*** Kjellman

Fig.4.

1900 : 48, pl. 3 figs. 12–14, pl. 20 fig. 17; Börgesen, 1916 : 92, fig. 97; Tanaka, 1936 : 146, figs. 3–4, pl. 7 fig. 2; Svedelius, 1953 : 38, figs. 33–42; Taylor, 1960 : 339, pl. 44 fig. 6, pl. 45 fig. 9.

Plants about 5 cm tall, the holdfast not seen, loosely fruticulescent, the branches spreading, terete; branching regularly dichotomous, the internodes 3–11 mm long, 0.8–1 mm in diameter; medullary filaments 10–20 μm in diameter, closely entangled, bearing assimilatory layer outwardly; peripheral layers consisting of irregularly trigonal or quadrate cells, 32–50 μm thick, encrusted with lime deposits; supporting cells of the free assimilatory filaments at the periphery well developed, each supporting cell provided with 1–2 assimilatory filaments; free assimilatory filaments of short and long types, both with subcylindrical basal cells, short assimilatory filaments consisting of mostly 3 cells, gradually tapering towards the apex; long assimilatory filaments cylindrical, 14.5–19 μm in diameter, slightly constricted at the dissepiments, unbranched; long and short assimilatory filaments arranged in more or less distinct alternating zones in the upper parts of branches, and intermixed in the lower parts of the branches; calcification not heavy, causing canaliculate features at the branch tips when dried.

HABITAT: Seaward terrace and seaward cliff, between Putan Lananibot and Putan Adgidum (RT3582), TINIAN.

DISTRIBUTION: Bermuda, Florida, West Indies, East Indies, Japan, Philippine Islands, Mariana Islands, Hawaiian Islands.

My identification of the present Micronesian specimens as *G. subverticillata* is based on insufficient criteria. The major characteristics used to identify the present species as *G. subverticillata* are the verticillate arrangement of the long free assimilatory filaments and the regular dichotomous branching pattern. The verticillate arrangement of longer assimilatory filaments in the young branches is also seen in *G. subfruticulosa* as mentioned before, and, thus, does not seem to be an adequate criterion for separating the two species. The differences between *G. subverticillata* and *G. subfruticulosa* has been discussed by Chou (1945) and Svedelius (1953) and they retain these two species as distinct. In reference to their observations,

I tentatively separate these two species. The present Micronesian specimens of *G. subverticillata* closely resemble the figures of Kjellman (1900) and Tanaka (1936).

V. *Galaxaura oblongata* (Ellis & Solander) Lamouroux

Fig.5.

1816 : 262; Howe, 1920 : 559; Börgesen, 1927 : 71, figs. 39–41; 1942 : 49; Taylor, 1945 : 142; Chou, 1947 : 7, pl. 2 figs. 1–16, pl. 3 figs. 1–2; Taylor, 1960 : 341; Itono, 1977 : 13, figs. 18, 36.

Plants bushy, 4.5–9.5 cm tall, attached by small discoid holdfasts, caulescent parts absent or very short; branching abundantly dichotomous; segments terete, somewhat broader at the summit than below or almost cylindrical, 1–1.5 mm in diameter, 3–9 mm long, smooth or slightly annulate-rugose; medulla not calcified, consisting of loose filaments measuring 3.8–10 μm in diameter; cortex more or less thickly calcified, consisting of 3 layers and about 62 μm thick, the inner cells loosely arranged and connected successively by narrow protoplasmic strands, the inner one or two cells largest, the basal cells subglobose or slightly compressed, about 27.5–30 μm in diameter bearing small intermediate oval cells and the small flattened epidermal cells; epidermal cells closely arranged, polygonal in surface view, 15–20 μm in diameter, about 7.5–10 μm thick and semilunate in section, some epidermal cells raised above the general level of the surrounding epidermal cells, circular in surface view.

HABITAT: Asanite Bay (no. 4883, no. 5081, no. 5112), Agana (RT2466, RT2471), Nimitz Beach (RT1832), Tumon Bay (RHR105), Ritidian Pt. (RT2304), Ipan Beach (RT2011), GUAM; Tank Beach (RT3349), Bird Is. (RT3316), SAIPAN; Seaward terrace between Putan Lananibot and Putan Adgidum (RT3584), TINIAN; AGUIJAN (RT3608); Osakura Is. (RHR359e), TRUK; Sokehs (RT2363), Epwelkapw (MSD15637, MSD21741, MSD 21758, MSD21834), PONAPE.

DISTRIBUTION: West Indies, Florida, Brazil, Canary Islands, Mediterranean, Red Sea, India, Mauritius, Java, Australia, Sumatra, Hainan Island, Philippine Islands, Taiwan, Southern parts of Japan, Caroline Islands, Mariana Islands, Hawaiian Islands, Pacific Mexico, Ecuador.

The taxonomic considerations of members of the section Oblongatae (=Eugalaxaura Kjellman) has been made by many phycologists (Grunow, 1873–1874; Börgesen, 1927, 1942; Papenfuss and Chiang, 1969). Papenfuss and Chiang (1969 : 310) regarded 10 of 11 species of section Eugalaxaura to be conspecific to *G. oblongata*. When I observed the southern Japanese members of Eugalaxaura (1977), I separated the southern Japanese members of the section into four species based on very minute but inadequate characteristics. They are *G. fastigiata, G. pilifera, G. oblongata* and *G. cylindrica*; all are very similar in their external features. In identifying the Micronesian members of Eugalaxaura, it seems also possible to separate the specimens into two or three species based on very minute characteristics.

I, however, prefer to regard these specimens as *G. oblongata* based on the study of Papenfuss and Chiang (1969), since the morphological variations among the members of the Eugalaxaura are very minute.

VI. *Galaxaura robusta* Kjellman

Fig.6.

1900 : 85, pl. 18 figs. 19–32, pl. 20 fig. 42; Heydrich, 1907 : 103; W. V. Bosse, 1921 : 219; Tanaka, 1936 : 170, Figs. 38–39, pl. 44; Chou, 1947 : 46, pl. 3 figs. 1–10, pl. 9 fig. 2; Itono, 1977 : 8, Figs. 10, 29.

Plants forming tufts, up to 10 cm tall, the holdfast not seen; branches terete, glabrous, subdichotomously branched, angles narrow, subarticulate or slightly constricted at the nodes, the terete segments 5–19 mm long, 1–3.5 mm in diameter, smooth, slightly calcified in the cortex; medulla traversed by few loosely interwoven filaments measuring 12.5–15 μm in diameter; cortex composed of 1–2 layers of enlarged cells each outwardly supporting a slender stalk 12–17 μm long and 10–12 μm in diameter, usually once forked at the summit and bearing two epidermal cells; epidermal cells 37–45 μm in diameter, closely laterally-jointed and polyhedral in surface view, semilunate in section, 20–25 μm thick, containing well developed chromatophores, rarely provided with free filaments measuring 14–19 μm in diameter near the basal parts of the thallus.

HABITAT: Fefan Is. (RT3527), TRUK.

DISTRIBUTION: Indian Ocean, Malagasy, Malay Achipelago, Southern parts of Japan, Caroline Islands, Tonga.

Many phycologists consider *G. obtusata* (Solander) Lamouroux as the sexual plants of *G. robusta,* but Chou (1947) suggests that *G. umbellata* (Esp.) Lamouroux is the sexual plant of *G. robusta. G. obtusata* and *G. umbellata* are very similar and do not warrant separation into these two species.Unfortunately, neither *G. obtusata* nor *G. umbellata* was found among the Micronesian specimens examined.Only a single specimen is present in the Herbarium, and, thus, it seems to be a rare species in the Micronesian Islands.

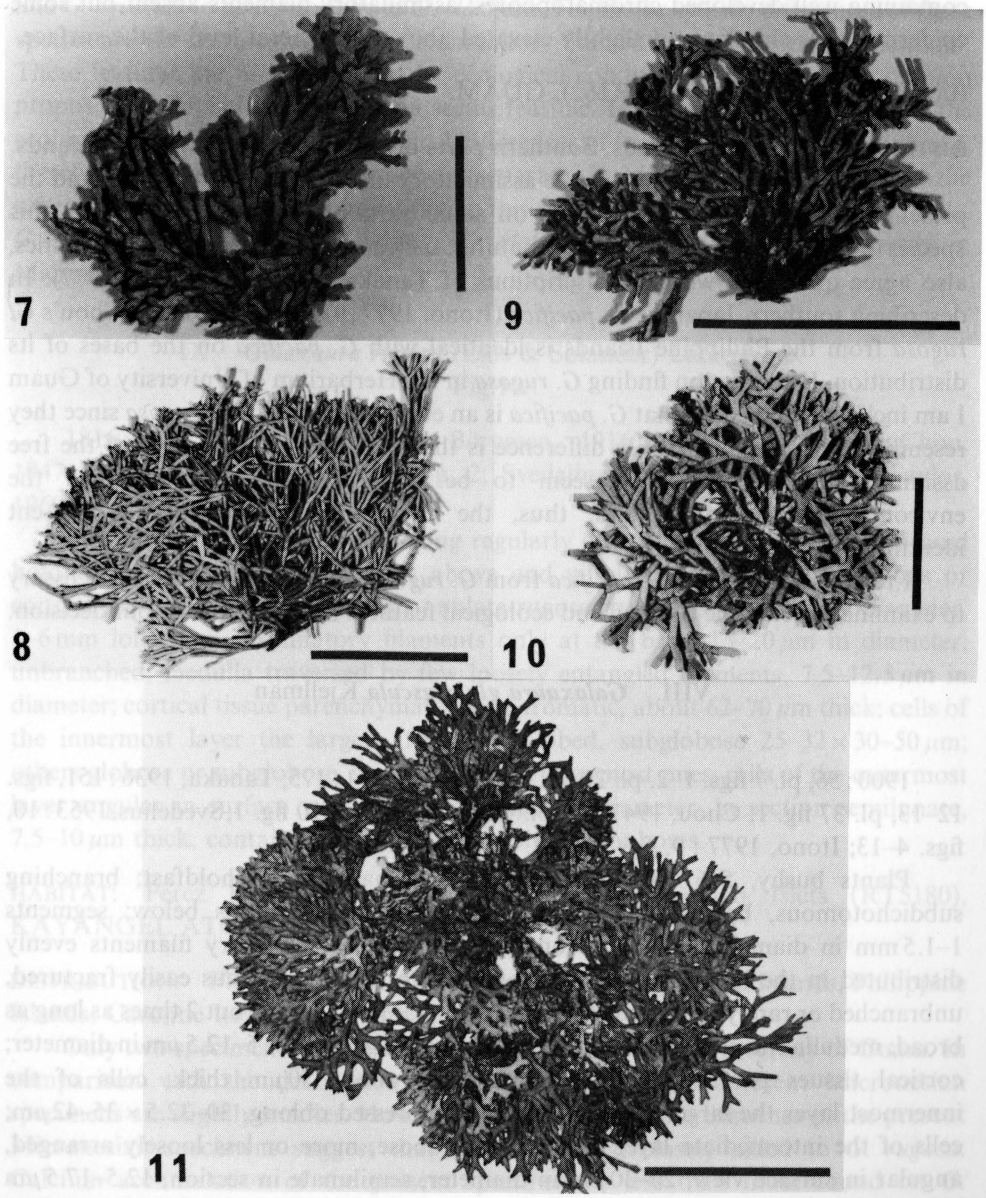
VII. *Galaxaura pacifica* Tanaka

Fig.7.

1935 : 55, pl. 17 fig. 2, text figs. 5–6; 1936 : 151, fig. 11; Itono, 1977 : 8, figs. 11, 30.

Plants about 4.5 cm tall, attached by more or less larger discoidal holdfast, lower stem-like portions very short consisting of numerous rhizoidal cells; branches dichotomous at short intervals, terete, the segments 3–5 mm long and 0.7–1 mm in diameter, clearly transversely rugose in some parts, more or less thickly calcified, upper portions glabrous; medullary filaments loosely entangled, 7.5–12.5 μm in diameter, giving rise to terminal cortical layer of more or less tightly arranged large

cells; cortex of radially branched sequence of cells, consisting of three layers of cells, the innermost oblong-ovate, 40–50 μm broad and 27–35 μm thick, the intermediate



Figs. 7–11. Habit of plants. Fig. 7. *Galaxaura pacifica* (scale: 2 cm). Fig. 8. *Galaxaura elongata* (scale: 5 cm). Fig. 9. *Galaxaura glabriuscula* (scale: 5 cm). Fig. 10. *Galaxaura rugosa* (scale: 2 cm). Fig. 11. *Galaxaura marginata* (scale: 5 cm).

cells smaller and nearly ovate measuring 22–30 μm in diameter, the outermost flattened, firmly joined laterally into an epidermis, polyhedral in surface view and 15–27 μm in diameter, semilunate in section measuring about 10–20 μm thick, containing well developed chromatophores; assimilatory filaments absent but some epidermal cells circular and slightly elevated above the general level of the surface.

HABITAT: Toguan Bay (RHR162), GUAM.

DISTRIBUTION: Bonin Islands, Southern parts of Japan, Taiwan, Mariana Islands.

The complete absence of the free assimilatory filaments on the branches and the presence of conspicuous annulations on some parts of the branches indicate this species to be *G. pacifica*. Other minute features, such as the dimensional characteristics, also agree quite well with the discriptions of Tanaka (1935) and Itono (1977). In describing southern Japanese *G. pacifica* (Itono, 1977 : 9), I suggested that Chou's *G. rugosa* from the Philippine Islands is identical with *G. pacifica* on the bases of its distribution. However, on finding *G. rugosa* in the Herbarium of University of Guam I am inclined to consider that *G. pacifica* is an ecological form of *G. rugosa* since they resemble each other. The only difference is the presence or the absence of the free assimilatory filaments which seem to be quite variable depending on the environmental conditions, and, thus, the characteristic used for the present identification is arbitrary.

I tentatively separate *G. pacifica* from *G. rugosa,* and suggest that it is necessary to examine in detail the cultural and ecological features before finalizing our decision.

VIII. ***Galaxaura glabriuscula*** Kjellman
Fig.9.

1900 : 56, pl. 7 figs. 1–2, pl. 20 fig. 26; Butters, 1911 : 175; Tanaka, 1936 : 151, figs. 12–13, pl. 37 fig. 1; Chou, 1947 : 11, pl. 4 figs. 14–24, pl. 10 fig. 1; Svedelius, 1953 : 10, figs. 4–13; Itono, 1977 : 9, figs. 12, 31.

Plants bushy, 5–6.5 cm tall, attached by small discoid holdfast; branching subdichotomous, branches terete, glabrous above and villous below; segments 1–1.5 mm in diameter, 3–11 mm long, smooth; free assimilatory filaments evenly distributed in the lower half of the fronds, slightly stiff and thus easily fractured, unbranched or rarely branched, 12.5–15 μm in diameter, cells about 2 times as long as broad; medulla traversed by few loosely entangled filaments of 5–12.5 μm in diameter; cortical tissues parenchymatous, tristromatic, about 50 μm thick; cells of the innermost layer the largest, subglobose or compressed oblong, 30–32.5 × 35–42 μm; cells of the intermediate layer smaller, subglobose, more or less loosely arranged, angular in surface view, 20–30 μm in diameter, semilunate in section, 12.5–17.5 μm thick; hair-bearing epidermal cells slightly raised above the level of the surrounding epidermal cells, circular in surface view.

HABITAT: Sabeneta (RT3760), SAIPAN; Seaward terrace and seaward cliff between Putan Lananibot and Putan Adgidun (RT3582, RT3583), TINIAN.

DISTRIBUTION: Southern parts of Japan, Bonin Islands, Java, Mariana Islands, Tahiti, Hawaiian Islands.

Papenfuss and Chiang (1969 : 313) considered that *G. glabriuscula, G. cuculligera,* and *G. squalida* to be conspecific to *G. elongata.* The major specific differences of these species are the features of the free assimilatory filaments and the sizes of the thalli. These features are highly affected by ecological conditions, and, thus, the opinion proposed by Papenfuss and Chiang seems feasible. However, our knowledge of the ecological effects on the morphological differences of these species is uncertain, and I, therefore, tentatively keep these species separate. In Micronesia four species of the section Microthoe have been identified in this paper, i.e., *G. pacifica, G. glabriuscula, G. rugosa* and *G. elongata.* Of these, *G. glabriuscula* is the commonest species in Micronesia.

IX. ***Galaxaura rugosa*** (Ellis & Solander) Lamouroux

Fig.10.

1816 : 263; Kjellman, 1900 : 55; Börgesen, 1916 : 100, figs. 105–106; Chou, 1947 : 13, pl. 4 figs. 12–13, pl. 10 fig. 2; Svedelius, 1953 : 18, figs. 14–17; Taylor, 1960 : 340.

Plants up to 3.5 cm tall, branching regularly dichotomous, attached by discoid holdfast; branches terete, glabrous above and villous at the base, continuous or constricted at the nodes, distinctly annulate-rugose; segments 1–1.3 mm in diameter, 3–6 mm long; free assimilatory filaments only at the base, 15–20 μm in diameter, unbranched; medulla traversed by few loosely entangled filaments, 7.5–12.5 μm in diameter; cortical tissue parenchymatous, tristromatic, about 62–70 μm thick; cells of the innermost layer the largest, frequently lobed, subglobose 25–32 × 30–50 μm; others globose or subglobose, smaller than the innermost ones; cells of the outermost layer angular in surface view, up to 20–25 μm in diameter, in section semilunate, 7.5–10 μm thick, containing well-developed chromatophores.

HABITAT: Perez beach (no number), GUAM; Ngariungo Islets (RT5180), KAYANGEL ATOLL.

DISTRIBUTION: Florida, Bahamas, Jamaica, West Indies, Virgin Islands, Philippine Islands, Caroline Islands, Mariana Islands, Hawaiian Islands.

Only two specimens are present in the Herbarium of the University of Guam. In comparison with the descriptions formerly published, the present Micronesian specimens are slightly smaller. However, conspicuous rugose branches of the present Micronesian specimens suggest that these are most closely allied to *G. rugosa.* Calcium accumulation of the present specimens is less than those found on *G. pacifica, G. glabriuscula* and *G. elongata,* and is, thus, easily separated.

X. ***Galaxaura elongata*** J. Agardh
Fig.8.

1876 : 529; Kjellman, 1900 : 56, pl. 7 figs. 6–12; Yendo, 1916 : 254; W. V. Bosse, 1921 : 212; Tanaka, 1936 : 153, figs. 16–17, pl. 38; Itono, 1977 : 10, figs. 14, 33.

Plants bushy, to about 9 cm tall, attachment not seen, branching regularly dichotomous or rarely subdichotomous, branches terete, villous, and more or less thickly calcified below, glabrous above; the segments 5–14 mm long, 0.9–1.2 mm in diameter, annulate-rugose; free assimilatory filaments only seen in lower parts of the thallus, straight and unbranched, ca. 15 μm in diameter, composed of short cylindrical cells, 2.5–3 times as long as broad, slightly constricted at the dissepiments, ca. 7.5 μm in diameter; medullary tissues consisting of loosely entangled filaments measuring 5–10 μm in diameter; cortical tissues parenchymatous, tristromatic, about 62.5–75 μm thick, strongly encrusted with lime deposits, cells of the innermost layer the largest, oblong-ovate, 37.5–75 μm broad and 22.5–45 μm thick, cells of intermediate layer globose or ovate, slightly smaller than those of the innermost layer, cells of the epidermis closely arranged, angular in surface view measuring 17.5–30 μm in diameter, semilunate or hemispherical in section, 12.5–20 μm thick, containing well developed chromatophores.

HABITAT: AGUIJAN (RT3607).

DISTRIBUTION: Australia, Malay Archipelago, Taiwan, Southern parts of Japan, Mariana Islands, Tonga.

The present description is based on a single specimen from Aguijan Island, Mariana Islands, and this suggests that *G. elongata* is rare in the Micronesian area.

XI. ***Galaxaura marginata*** (Ellis & Solander) Lamouroux
Fig.11.

Kjellman, 1900 : 77, pl. 20 fig. 6; Börgesen, 1916 : 106, figs. 115–117; Taylor, 1960 : 343, pl. 44 fig. 2, pl. 45 figs. 7–8.

Plants 6.5–10 cm tall; the branches smooth, dull, frequently with faint striations near the tips, flattened, regularly dichotomous; 1–2 mm broad, the segments 4–8 mm long and continuous, canaliculate when dried, about 325 μm thick, 425 μm thick at the thickened margins, lower parts of the fronds subterete without clear distinction from the stipe; proliferations frequent, frequently encircled at the base by a tuft of extended assimilatory filaments; stipes up to 2 mm in diameter, cylindrical, villous, consisting of rhizoidal filaments, attached by small discoid holdfast; medullary layer consisting of irregular filaments, 7.5–15 μm in diameter; the inner cortex composed of a pseudoparenchymatous layer of large, nearly colorless cells, about 50–75 μm thick, the inner cells slightly large, subglobose or compressed, 70–80 μm broad and 50–55 μm thick, the outer cells small, subglobose or pyriform, bearing on the outer side 1–2 cylindrical or cuneate-cylindrical stalk cells, these simple or once forked and

bearing 1–2 distal cells; distal cells of highly variable forms, some subglobose, spherical, and depressed, semilunate in section, and frequently provided with spines.

HABITAT: Tumon Bay (RT2089, RT2139, RSS18, RHR42), Bijita Point (RHR73), Agana Outfall (RT1753), GUAM; Garapan Lagoon (RT3223), Tanapag Lagoon (RT3732), SAIPAN; Cave Beach Area (RT3695) TINIAN.

DISTRIBUTION: Caribbean Sea, Brazil, Mariana Islands. Probably, this species is distributed in tropical and subtropical areas of the Indo-Pacific Oceans.

Several specimens from the Micronesian area had been collected and deposited in the Herbarium of the University of Guam. On examining the external morphological features of these specimens, I can't find any conspicuous difference on the specific level. However, the form of the outer, pilose layer cells differ. They are provided with ovoid, clavate, or semilunate photosynthetic cells and some of these are provided with apiculate projections. This suggests that the present Micronesian specimens are within the *G. clavigera-arborea-contigua-tenera-acuminata*-complex. Furthermore, some specimens are provided with photosynthetic cells which are highly variable even in the same plant, i.e., some parts are ovoid, clavate, depressed and other parts are provided with acuminate projections. This indicates that all of the specimens included here are identical.

Papenfuss and Chiang (1969) regarded *G. stupocaula* and *G. clavigera* as synonymous to *G. tenera* and, furthermore, they alluded briefly that these species are also conspecific with *G. marginata*. In my opinion, *G. contigua* Kjellman and *G. acuminata* Kjellman should also be included under *G. marginata*. Tanaka (1936) and Itono (1977) reported the rare occurrence of mucronate photosynthetic cells in *G. clavigera*, and thus they are highly variable. Although *G. marginata* is known originally from the Atlantic Ocean, the present Micronesian specimens should be referred to *G. marginata*. It is suggested that *G. marginata* should be a common inhabitant of both the Atlantic and Pacific Oceans.

XII. ***Galaxaura hystrix*** Kjellman

Figs.12, 14–16.

1900 : 79, pl. 16 figs. 1–9, pl. 20 fig. 34; Butters, 1911 : 182; Tanaka, 1936 : 166, figs. 32–33, pl. 43 fig. 2; Svedelius, 1953 : 29, figs. 24–26.

Plants arborescent, about 5 cm tall, attached by more or less large discoid holdfast, with comparatively long stipe measuring 17–23 mm long; stalks verticillately villous; branches terete below and compressed above, regularly dichotomous at narrow angles, internodes 4–8 mm long, 1.1–1.8 mm wide, membranous, 110–220 μm thick, canaliculate, 260–480 μm thick, at the thickened margins; medulla consisting of loose filaments measuring 5–12.5 μm in diameter; cortical layers about 65–83 μm thick, parenchymatous, cells of the innermost layer largest, compressed, frequently lobed; epidermal cells polygonal in surface view, 27.5–45 μm in diameter, closely laterally approximated, in section semilunate, 12.5–17.5 μm thick, mostly provided

with spinulose cells on almost every epidermal cells, clavate or elongate-spatulate, 27.5–30 μm tall, 10–12.5 μm in diameter, apices pointed or mucronate.

HABITAT: GUGUAN (RT5059).

DISTRIBUTION: Japan, Mariana Islands, Hawaiian Islands.

A single specimen, which I regarded as *G. hystrix,* is present in the collections of the University of Guam. This specimen is characterized by having spinulose cells on almost every epidermal cells, and by having dichotomous branches diverging at

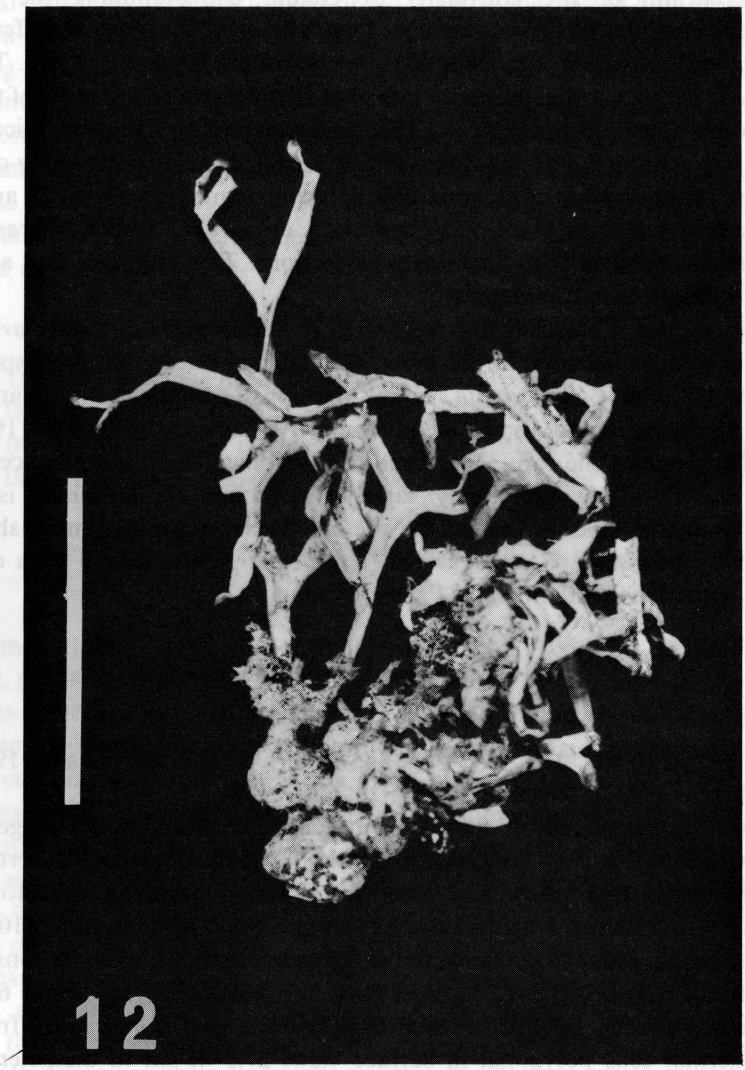


Fig. 12. *Galaxaura hystrix* (scale: 2 cm).

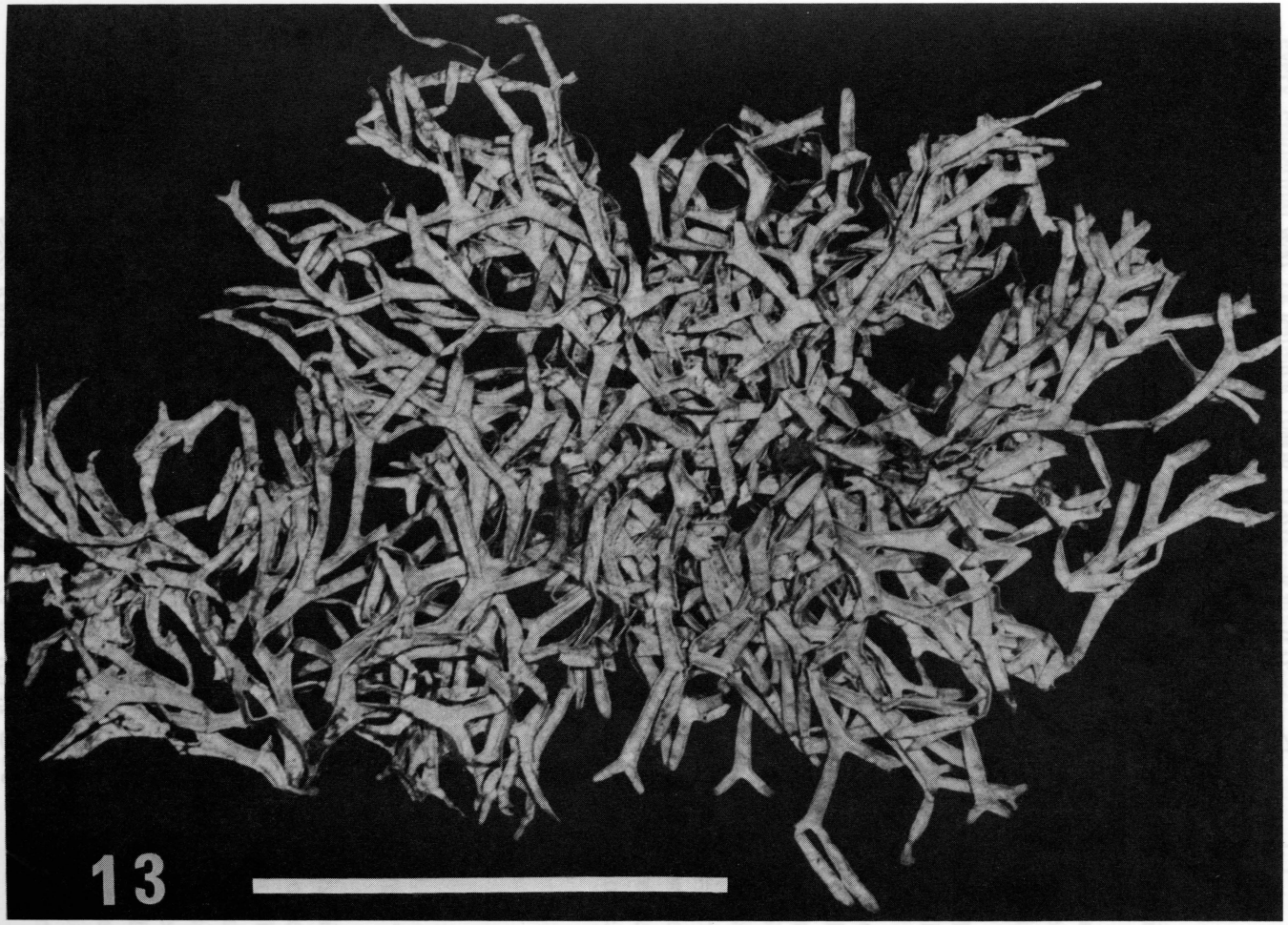
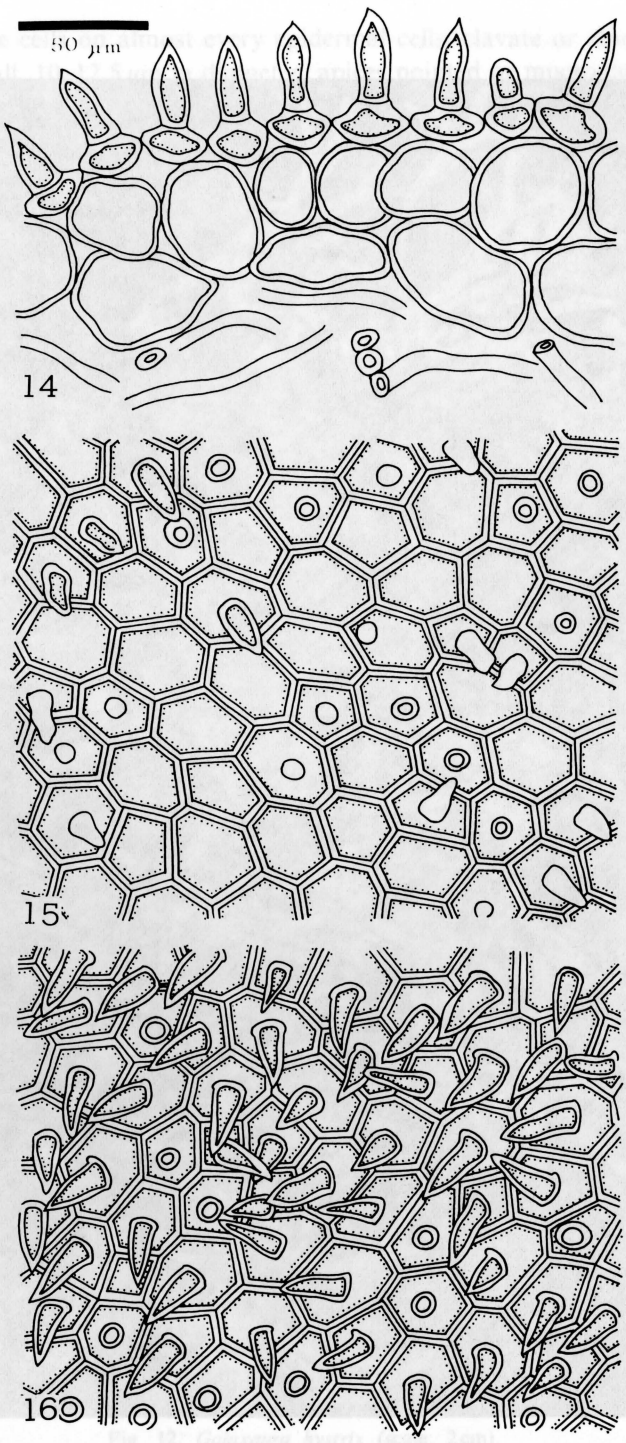


Fig. 13. Habit of plants. *Galaxaura ventricosa* (scale: 5 cm).



Figs. 14–16. *Galaxaura hystrix*. Fig. 14. Section of branch showing cortices and spinulose cells. Figs. 15–16. Surface views of epidermis.

narrow angles. Originally, *G. hystrix* is characterized in having spinulose cells on every epidermal cell (Kjellman, 1900). However, this feature is regarded to be insufficient criterion (Svedelius, 1953) since the occurrences of spinulose cells in certain member of Section Vepreculae are highly variable depending on the parts of fronds.

In the present specimen at hand, almost all epidermal cells are provided with spinulose cells (Figs.14, 16), but some parts lack spinulose cells. Upon examination of the portion where spinulose cells are absent, it becomes evident that spinulose cells are deciduous since some epidermal cells are provided with fractured spinulose cells (Fig.15), of which the cellular contents are worn out, or are only provided with circular rings on the outer side (Figs.15–16).

In reference to the figures of Kjellman (1900, pl. 16 figs. 5–6) and Tanaka (1936, fig. 33), *G. hystrix* is characterized in having the base of the papilla narrower than the general papilla breadth. In the present specimen at hand, however, the shapes of spinulose cells are highly variable and both types of spinulose cells are typical to *G. ventricosa, G. veprecula,* or *G. hystrix*. On the other hand, the external features of the frond and the branching manner of *G. hystrix* in the previously published papers, such as Kjellman (1900, pl. 20 fig. 340), Tanaka (1936, fig. 32) and Svedelius (1953, fig.24), seem to be of greater significance. Namely, according to the previously published papers, *G. hystrix* is characterized by having long, pronounced stipes and the branches diverging at narrow angles. These features are fundamentally observed in the specimen at hand, and I named it *G. hystrix*. However, it is most closely related to *G. veprecula* (Tsuda and Tobias, 1977), and closer observation on the ecological influences should be made.

XIII. ***Galaxaura ventricosa*** Kjellman
Fig.13.

1900 : 81, pl. 16 figs. 11–16, pl. 20 fig. 24; Taylor, 1945 : 143; Chou, 1947 : 18, pl. 6 figs. 9–12, pl. 12 fig. 2; Womersley and Bailey, 1970 : 304; Itono, 1977 : 23, figs. 26, 27, 45, pl. I-2.

Plants bushy, up to about 10 cm high, attached by a rather small discoid holdfast; stalks terete and villous, 10–15 mm long and 1.5–3 mm broad; branches smooth, glabrous, flattened, about 1.5–2.5 mm broad, regularly dichotomously branched with wide angles, segments 5–15 mm long, canaliculate when dried, about 100 μm thick, at the thickened margins 200–250 μm thick (except spinulose cells); medulla consisting of loose filaments measuring 5–7.5 μm in diameter; inner cortex composed of a parenchymatous layer usually two cell layers thick of large, nearly colorless oval cells, cells of the innermost layer largest, frequently lobed; epidermal cells polygonal in surface view, 25–32.5 μm in diameter, closely adhering laterally, in section semilunate, 12.5–17.5 μm thick; spinulose cells columnar and 35–37.5 μm long, mostly produced on the thickened margins.

HABITAT: Gab Gab Beach (RHR166), GUAM; Sabeneta (RT3751), Grotto (RT3775), SAIPAN; Mosalog Point (RT3365), Seaward terrace between Putan Lananibot and Putan Adgidum (RT3585), TINIAN.

DISTRIBUTION: Tropical western Africa, Solomon Islands, Southern parts of Japan, Mariana Islands, Pacific Mexico.

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