Studies on the Southern Japanese Species of *Galaxaura* (Rhodophyta)

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Abstract.—This paper deals with twenty species of *Galaxaura* collected from the southern parts of Japan. Of these, seven species are reported for the first time from the southern parts of Japan, i. e., *G. delabida* Kjellman, *G. pacifica* Tanaka, *G. glabriuscula* Kjellman, *G. pilifera* Kjellman, *G. cylindrica* (Solander) Lamouroux, *G. contigua* Kjellman and *G. ventricosa* Kjellman. *G. yamadae* Itono is described here as a new species.
Most of these species, except for *G. yamadae*, found in the southern Japan are found in Micronesia and the tropical Pacific.

Introduction

Howe (1917, 1918) demonstrated the occurrence of dimorphism both in sexual and asexual plants of *Galaxaura*. The asexual and the sexual phases differ not only in the reproductive organs that they bear, but also in certain anatomical features that are restricted to one phase or the other. After the demonstration of Howe, several authors suggested the different generations of the species (Börgesen, 1920; Dawson, 1952; Taylor, 1960; Chapman, V. J., 1963). The reports by some of these phycologists frequently differ. Thus, cultural experiments, as well as ecological examinations, are necessary before elaborating on the precise relationships of the sexual and asexual generations within each species.

After Tanaka (1935, 1936) initially treated the Japanese members of *Galaxaura*, the number of species recorded from the southern Japanese waters has increased. Some apparently unreported plants have been detected, and those together with some troublesome uncertainties among our previously known species, have called for a detailed treatment of the genus at this time. Although our knowledge on the dimorphism of *Galaxaura* is still fragmentary, this study brings together our interpretation of the *Galaxaura* species from the sourthern parts of Japan, and should prove useful to others studying this genus in the western Pacific.

KEY TO THE SPECIES OF *Galaxaura* OF THE SOUTHERN PARTS OF JAPAN

1. Plants with branches terete throughout ..... 2.
1. Plants with branches flattened ..... 15.
    2. Free assimilatory filaments generally persisting, the surface therefore pilose; epidermal layer absent ..... 3.

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2. Free assimilatory filaments absent, or, if present, very few; epidermal layer well developed ..... 6.

3. All free assimilatory filaments long and of the same type; supporting cell of free assimilatory filaments at the periphery not well differentiated ..... I. ***Galaxaura 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..... II. ***Galaxaura fasciculata***

4. Apical cells of the short assimilatory filaments smaller than the basal ones ..... 5.

5. Short assimilatory filaments usually composed of 3 cells ..... III. ***Galaxaura subfruticulosa***

5. Short assimilatory filaments usually composed of 2 cells ..... IV. ***Galaxaura delabida***

6. Cortex composed of parenchymatous tissue ..... 7.

6. Cortex composed of subfilamentous tissue, remaining attached to the medullary filaments after decalcification ..... 12.

7. Branches smooth, distinctly articulate, segments swollen ..... 8.

7. Branches usually annulately rugose, usually villous or hirsute below ..... 9.

8. Inner cortex bearing one layer of small depressed cells forming a continuous epidermis on the outer side ..... V. ***Galaxaura obtusata***

8. Inner cortex outwardly supporting slender stalk cells each of which with 1–2 distal cells closely laterally approximated forming the epidermis..... VI. ***Galaxaura robusta***

9. Free assimilatory filament absent..... VII. ***Galaxaura pacifica***

9. Free assimilatory filaments present ..... 10.

10. Extended assimilatory filaments often fasciculate; branches villous at least below..... VIII. ***Galaxaura glabriuscula***

10. Extended assimilatory filaments evenly distributed over the whole surface of thallus, except upper portion ..... 11.

11. Branching subdichotomous, internodes 2–7 mm long ..... IX. ***Galaxaura cuculligera***

11. Branching regularly dichotomous, internodes 7–25 mm long, conspicuously annulatory rugose..... X. ***Galaxaura elongata***

12. Abortive cell absent..... XI. ***Galaxaura fastigiata***

12. Abortive cells present ..... 13.

13. Cortex thin, less than 50 μm thick..... XII. ***Galaxaura pilifera***

13. Cortex thick, more than 60 μm thick ..... 14.

14. Segments somewhat broader at the summit than below, commonly exceeding 1 mm in diameter..... XIII. ***Galaxaura oblongata***

14. Segments cylindrical, seldom exceeding 1 mm in diameter ..... XIV. ***Galaxaura cylindrica***

15. Inner cortex outwardly supporting slender stalk cells each with 1–2 distal cells ..... 16.
15. Inner cortex bearing on the outer side one layer of small depressed cells forming a continuous epidermis ..... 18.
16. Stipes and branches below clearly indistinguishable, lower portion of the branches subterete..... XV. ***Galaxaura clavigera***
16. Stipes and branches clearly distinguishable ..... 17.
17. Outer cells on the stalk cells almost spherical or slightly oblong ..... XVI. ***Galaxaura arborea***
17. Outer cells on the stalk cells semilunate and depressed in cross section ..... XVII. ***Galaxaura contigua***
18. Epidermis smooth, without spinulose cell ..... XVIII. ***Galaxaura yamadae***
18. Epidermis bearing spinulose cells ..... 19.
19. Thallus chalky, frequently provided with spinulose cells ..... XIX. ***Galaxuara veprecula***
19. Thallus smooth, shiny, spinulose cells on the thickened thallus margins ..... XX. ***Galaxaura ventricosa***

Systematic List

I. *Galaxaura filamentosa* Chou ex Taylor

Fig. 1

Pacif. Mar. Alg. (1945), p. 139; Chou, Pacif. spec. *Galaxaura* I (1945), p. 39, pl. 6 fig. 1, pl. 9 figs. 1–6; Dawson, Mar. Red Alg. Pacif. Mexico (1952), p. 51, pl. 19 fig. 2; Svedelius, *Galaxaura* from Hawaii (1953), p. 33, figs. 29–32; Trono, Mar. Alg. Caroline Is. II (1969), p. 46; Womersley & Bailey, Mar. Alg. Solomon Is. (1970), p. 303.

Plants to 2 cm tall, irregularly dichotomously branched, internodes 2–4 mm long, encrusted with very weak limy deposit, densely covered with thick free assimilatory filaments, villous; axes caespitose, 1–1.3 mm in diameter except for free assimilatory filaments; medulla consisting of loosely intertwined filaments measuring 15–21 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 1 mm long and 15–20 μm in diameter near the base, usually unbranched, slightly tapering toward the apex, of cells about 3 times as long as broad and provided with well developed chromatophores.

HABITAT: Yoron Is. (Aug. 19, 1955), Hateruma Is. (Aug. 6–13, 1972), Yonaguni Is. (Oct. 30, 1959).

SYNONYM: *Galaxaura rudis* sensu Okamura, 1931: 190; Tanaka, 1936: 144.

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

Tanaka (1936: 144) regarded the present species as conspecific with *G. rudis* Kjellman (1900: 43). However, the size of the free assimilatory filaments and the entire absence of enlarged basal cell of the free assimilatory filaments of the present southern Japanese specimens make me regard them as identical with *Galaxaura filamentosa* Chou.

The type description of *G. filamentosa* appears in two separate papers (Chou ex Taylor, 1945; Chou, 1945). They are published in the same year and I am unable to decide which is the earlier paper. Dawson (1952) selected the paper of Chou (1945) as the earlier paper, but Womersley and Bailey (1970) selected Taylor's paper (Pacif. Mar. Alg., 1945) as valid. The author provisionally follows the opinion of Womersley and Bailey (1970).

Chou (1945: 40) suggested that *G. filamentosa* agrees well with *G. rudis* sensu Tanaka (1936) and Tseng (1941) in having undifferentiated supporting cell. The comparison of the present southern Japanese specimens with the type description of *G. filamentosa* reveals that the southern Japanese specimens are *G. filamentosa.*

II. ***Galaxaura fasciculata*** Kjellman

Figs. 2, 3

Floridé-slägtet *Galaxaura* (1900), p. 53, tab. 5 figs. 1–9, tab. 20 figs. 14; W. V. Bosse, Liste Alg. Siboga II (1921), p. 211; De Toni, Syll. Alg. VI (1924), p. 115; Tanaka, Gen. *Galaxaura* (1936), p. 147, figs. 5–6; Dawson, Mar. plants Nha Trang (1954), p. 519, fig. 29b; Womersley & Bailey, Mar. Alg. Solomon Is. (1970), p. 303.

Plants bushy, to 6.5 cm tall, rather tough in consistency; tomentose branches spreading, 0.5–1 cm long between the forkings, ca. 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 6–9 μm in diameter, diffusely calcified, bearing a cortical layer of rather small cells, each supporting 1–2 free assimilatory filaments; assimilatory tissues dense, about 90 μm thick, encrusted strongly with lime deposit; free assimilatory filaments of short and long types intermixed and evenly distributed over the whorl 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 30–45 μm in diameter; long free assimilatory filaments reaching a length of about 1 mm, rarely branched, cylindrical measuring 18–24 μm in diameter, very slightly constricted at the dissepiments.

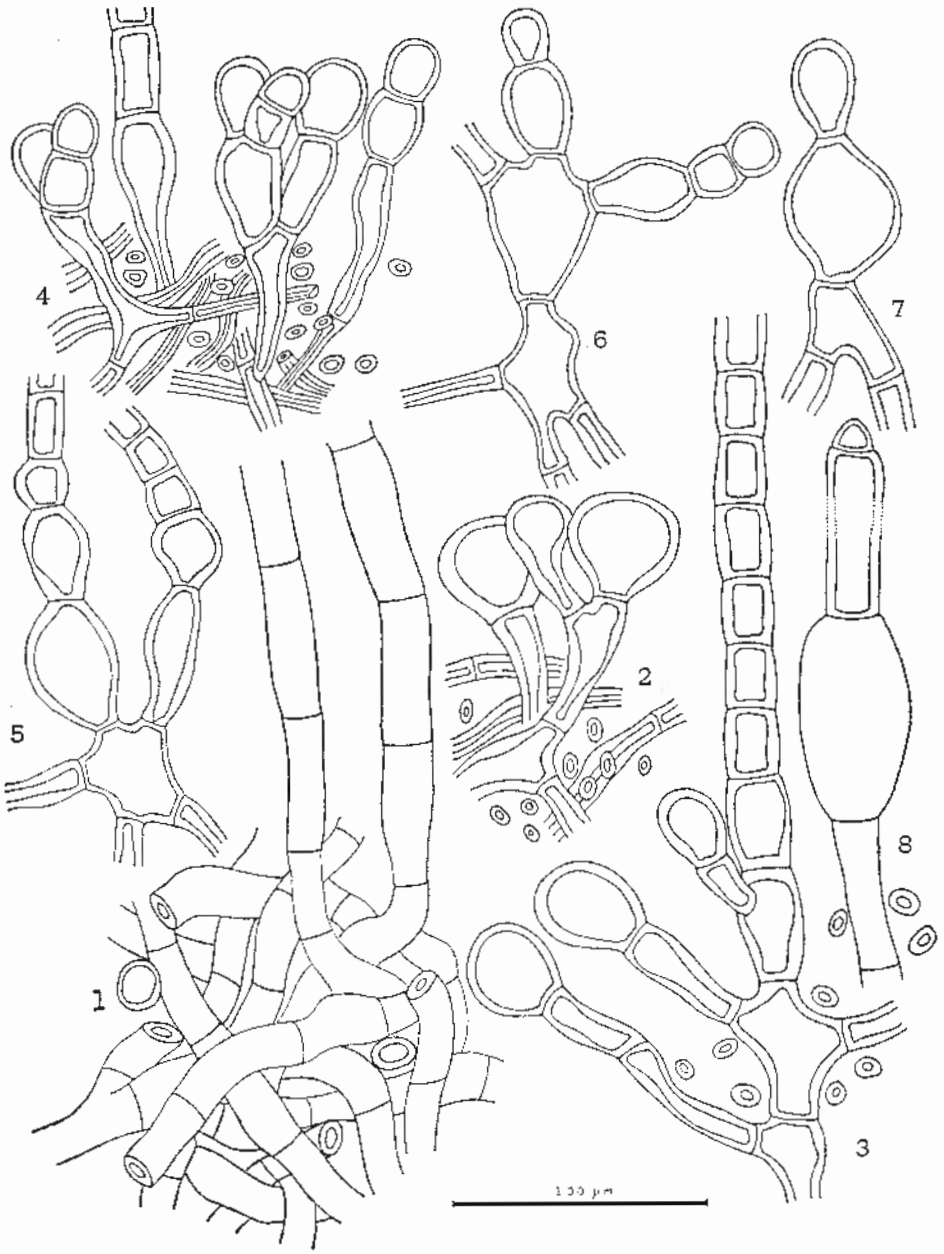
HABITAT: Ukeshima Is. (May, 1954), Amami Is. (June 29, 1970), Tokunoshima Is. (Oct. 14, 1966), Hatoma Is. (Aug. 5, 1970), Hateruma Is. (Aug. 6–13, 1972).

DISTRIBUTION: Celebes Islands, Malay Archipelago, Solomon Islands, Palau, Marshall Islands, Viet Nam, Taiwan, Bonin Islands, Southern parts of Japan.

III. ***Galaxaura subfruticulosa*** Chou ex Taylor

Fig. 4

Pacif. Mar. Alg. (1945), p. 140; Chou, Pacif. spec. *Galaxaura* I (1945), p. 41,



Figs. 1–7, Sections of branches showing free assimilatory filaments; Fig. 8, Section of stipe showing inflated supporting cell of free filament.
Fig. 1, *G. filamentosa*; Figs. 2–3, *G. fasciculata*; Fig. 4, *G. subfruticulosa*; Figs. 5–7, *G. delabida*; Fig. 8, *G. contigua*.

pl. 2 fig. 6, pl. 8 fig. 2; Dawson, Mar. Red Alg. Pacif. Mexico (1952), p. 52, pl. 20 fig. 1; Svedelius, *Galaxaura* from Hawaii (1953), p. 51, figs. 43–47.

Plants loosely fruticulescent, about 4 cm tall, the branches spreading, terete, attached to the substratum by a large disc; branching subdichotomous or corymbose, the internodes 1–10 mm long, 0.8–1 mm in diameter; medullary filaments 6–15 μm in diameter, loosely entangled, bearing assimilatory layer outwardly; peripheral layers consisting of irregularly trigonal or quadrate cells, 90–105 μm thick, encrusted with lime deposit; 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, about 24 μm in diameter, terminal cells spherical measuring 18–21 μm in diameter; long assimilatory filaments cylindrical, 15–18 μm in diameter, slightly constricted at the dissepiments, mostly unbranched.

HABITAT: Takarajima Is. (Feb., 1952), Ukeshima Is. (May 18, 1954), Kakeroma Is. (May 28, 1954), Yoro Is. (May, 1954), Okierabu Is. (May 24, 1954), Yoron Is. (May 22, 1954; Aug. 21, 1955), Hatoma Is. (Aug. 5, 1970).

SYNONYM: *Galaxaura fruticulosa* sensu Kjellman, 1900: 51; Tanaka, 1936: 148.

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

According to Chou (ex Taylor, 1945: 141), the type of *G. fruticulosa* is known from the Bahamas, but the name was adopted by Kjellman (1900) for a Japanese plant. Furthermore, Chou (1945: 43) cited that there was confusion in naming *G. fruticulosa*, and the correct citation for the name is *Galaxaura fruticulosa* (Solander) Lamouroux.

Chou (ex Taylor, 1945) established *G. subfruticulosa* and the southern Japanese specimens agree quite well with the type description and illustrations of *G. subfruticulosa*. I attribute the southern Japanese species as conspecific with *G. subfruticulosa*.

The Japanese species of *G. fruticulosa* adopted by Kjellman and Tanaka also reveal several features identical with *G. subfruticulosa*, and should be referred to as a separate species from *G. fruticulosa* (Solander) Lamouroux. The comparison of authentic specimens of *G. fruticulosa* from Bahama and Japan is necessary for complete discussion.

IV. ***Galaxaura delabida*** Kjellman

Figs. 5–7

Floridé-slägtet *Galaxaura* (1900), p. 49, tab. 3 figs. 15–23, tab. 20 fig. 12; Börgesen, Mar. Alg. D. W. Indies II (1916), p. 100; Tanaka, Gen. *Galaxaura* (1936), p. 150, figs. 9–10; Taylor, Trop. Mar. Alg. (1960), p. 338.

Plants densely tufted, about 4.5 cm tall; branches irregularly dichotomous, spreading, the segments below about 2–6 mm long, terete and about 1 mm in diameter excluding the free assimilatory filaments, strongly encrusted with lime; medullary filaments running loosely, 6–24 μm thick, bearing a cortical layer of rather poly-

hedral cells, each supporting 1–2 assimilatory filaments; free assimilatory filaments of two types; short free assimilatory filaments consisting of two or rarely three cells, the basal cells largest and elliptical or pyriform measuring 48–50 μm long and 36–42 μm broad, the terminal cells obovoid or semiglobose measuring 21–27 μm in diameter; long free assimilatory filaments cylindrical, 15–21 μm in diameter, lower 1–2 cells turgid, slightly constricted at the dissepiment, usually unbranched.
HABITAT: Amami Is. (May 18, 1954), Yoron Is. (May 22, 1954).
DISTRIBUTION: Virgin Islands, Bonin Islands, Southern parts of Japan.

G. delabida is difficult to distinguish from *G. subfruticulosa* in external appearances; however, the structures of the free assimilatory filaments of these two species differ slightly.

V. ***Galaxaura obtusata*** (Solander) Lamouroux
Figs. 9, 28

Hist. Polyo. Fex. (1816), p. 262; Kützing, Spec. Alg. (1849), p. 529; J. Agardh, Epicr. (1876), p. 525; Heydrich, Algenf. Ostasien (1894), p. 292; Howe, Bahama flora (ex Britton & Milispaugh) (1920), p. 559; W. V. Bosse, Liste Alg. Siboga II (1921), p. 220; Börgesen, Mar. Alg. Canary Is. III (1927), p. 78; Yamada, Note Jap. Alg. IV (1932), p. 274, pl. 7; Tanaka, Gen. *Galaxaura* (1936), p. 171, figs. 40–41; Taylor, Trop. Mar. Alg. (1960), p. 342, pl. 44 figs. 4–5, pl. 45 fig. 5.

Plants bushy, up to 10 cm tall, attached by small discoid holdfast; branches regularly dichotomously branched 5–12 times, angles narrow, terete, glabrous, segments 7–23 mm long, 1.5–4 mm in diameter, subarticulate or strongly constricted at the nodes; medulla traversed by few loosely interwoven filaments 9–15 μm in diameter; cortex lightly calcified, composed of a parenchymatous layer two cells thick of large, nearly colorless cells, bearing on the outer side one layer of small depressed cells forming a continuous epidermis; inner cells of the cortex depressed, 12–18 μm thick and 45–75 μm broad, intermediate cells oblong measuring about 30 μm thick and 39–45 μm broad; epidermal cells closely arranged, polygonal in surface view measuring 24–36 μm in diameter, semilunate in section, 6–12 μm thick, containing well developed chromatophores.
HABITAT: Tokunoshima Is. (Oct. 16, 1966), Mage Is. (Nov., 1968), Amami Is. (June 29, 1970), Hatoma Is. (July 26, 1970).
SYNONYM: *Corallina obtusata* Solander 1786: 113.
DISTRIBUTION: West Indies, Florida, Canary Islands, Australia, Polynesia, Malay Archipelago, Taiwan, Southern parts of Japan.

Howe (1917, 1918) suggested that *G. obtusata* and *G. robusta* belong to the same species, which displays two morphologically different generations of the life cycle. In the southern parts of Japan, there have been recorded only these two species among the members of Dichotomaria Decaisne, and it is most probable that Howe's suggestion is sound. However, the distributional ranges of these two species are not always coincidental, and until after the results of cultural experiments are obtained the author provisionally prefers to retain *G. obtusata* as distinct from *G. robusta*.

VI. *Galaxaura robusta* Kjellman
Figs. 10, 29

Floridé-slägtet *Galaxaura* (1900), p. 85, tab. 18 figs. 19–32, tab. 20 fig. 42; Heydrich, Alg. Loochoo-Inseln (1907), p. 103; W. V. Bosse, Liste Alg. Siboga II (1921), p. 219; Tanaka, Gen. *Galaxaura* (1936), p. 170 figs. 38–39.

Plants forming tufts, up to 11 cm tall, the holdfasts cushion shaped; branches terete, glabrous, 5–12 times regularly dichotomously branched, angles narrow, subarticulate or slightly constricted at the nodes, the terete segments 5–16 mm long, 1.5–4 mm in diameter, smooth, lightly calcified in the cortex; medulla traversed by few loosely interwoven filaments measuring 12–21 μm in diameter; cortex composed of one layer of greatly enlarged cells each outwardly supporting a slender stalk cells, inner cells compressed-oblong measuring 60–90 × 93–150 μm; stalk cells about 24 μm long and 15 μm in diameter, usually once forked at the summit and bearing two distal cells closely laterally jointed and polyhedral in surface view; epidermal cells 24–48 μm in diameter, semilunate in section, 30 μm thick, containing well developed chromatophores.

HABITAT: Amami Is. (May 20, 1954), Takarajima Is. (March, 1965), Tokunoshima Is. (Oct. 16, 1966), Mage Is. (Nov., 1968).

DISTRIBUTION: Indian Ocean, Madagascar, Malay Archipelago, Southern parts of Japan.

VII. *Galaxaura pacifica* Tanaka
Figs. 11, 30

New Spec. *Galaxaura* (1935), p. 55, pl. 17 fig. 2, text figs. 5–6; Gen. *Galaxaura* (1936), p. 151 fig. 11.

Plants to about 5 cm tall, attached by more or less larger discoidal holdfast to the substratum, lower stem-like portion about 5 mm long and almost cylindrical consisting of numerous rhizoidal cells; branches conspicuously and narrowly dichotomously branched, terete, the segments 5–11 mm long and 1.5–2 mm in diameter, clearly transversely rugose, more or less thickly calcified, upper portion glabrous; medullary filaments loosely entangled, 6–12 μm in diameter, giving rise to 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, 30–40 μm broad and 21–27 μm thick, the intermediate cells smaller and nearly spherical measuring 18–24 μm in diameter, the outermost flattened, firmly joined laterally into an epidermis, polyhedral in surface view and 18–21 μm in diameter, lens-shaped in section measuring about 9 μm thick, containing well developed chromatophores; assimilatory filaments deciduous and entirely absent in older parts.

HABITAT: Ukeshima Is. (May 18, 1954), Kakeroma Is. (May 28, 1954), Miyako Is. (Nov. 3, 1959).

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

The complete absence of free assimilatory filament in the present species is one of the most distinctive characteristic; however, in surface view some of the epidermal

cells appear occasionally circular and slightly elevated above the general level of the surface. These cells are reported in many species of *Galaxaura*, and are mostly thought to be an abortive cell of the free assimilatory filaments. This suggests that the free assimilatory filaments are early deciduous and are only seen in young plants of the species.

The present specimens are identical with the type description of *G. pacifica*. The southern Japanese specimens are also similar to *G. rugosa* (sensu Chou, 1947: 13) from the Philippine Islands. In comparison with the type description of *G. pacifica*, Chou's *G. rugosa* should be merged with *G. pacifica*. *G. rugosa* (Solander) Lamouroux is limited to the Atlantic waters and this species is characterized by having free assimilatory filaments in some older parts of the plants; instead *G. pacifica* is known from Pacific region and is characterized by having free assimilatory filaments, early deciduous. The author prefers to place the present southern Japanese species as *G. pacifica*, rather than *G. rugosa*.

VIII. *Galaxaura glabriuscula* Kjellman

Figs. 12, 31

Floridé-slägtet *Galaxaura* (1900), p. 56, tab. 7 figs. 1–2, tab. 20 fig. 26; Butters, *Liagora* and *Galaxaura* (1911), p. 175; Tanaka, Gen. *Galaxaura* (1936), p. 151, figs. 12–13, pl. 37 fig. 1; Chou, Pacif. spec. *Galaxaura* II (1947), p. 11, pl. IV figs. 14–24, pl. X fig. 1; Svedelius, *Galaxaura* from Hawaii (1953), p. 10, figs. 4–13.

Plants bushy, to about 7.5 cm tall, attached by a small discoid holdfast; branching regularly dichotomous; branches terete, glabrous above and villous below; segments 1–1.2 mm in diameter, 3–17 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, 15–18 μm in diameter, cells 1.8–2.3 times as long as broad; medulla traversed by few loosely entangled filaments, 9–15 μm in diameter; cortical tissues parenchymatous, tristromatic, about 54–60 μm thick; cells of the innermost layer the largest, subglobose or compressed oblong, 28–33 $\times$ 36–42 μm in diameter; cells of the intermediate layer smaller, subglobose, more or less loosely arranged; cells of the outermost layer forming epidermis, closely arranged, angular in surface view, 15–30 μm in diameter, semilunate in section, 9 μm thick; hair-bearing epidermal cells slightly raised above the level of the surrounding epidermal cells, circular in surface view.

HABITAT: Takarajima Is. (Feb., 1952).

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

In comparison with Tanaka's description (1936: 151) based on specimens from the Bonin Islands, the present southern Japanese specimens bear the many conspicuous larger free assimilatory filaments on the thallus surface, and it is more closely similar to Chou's Javanese *G. glabriuscula*. In habit, *G. glabriuscula* is closely related to *G. squalida* but I regard the present southern Japanese species as *G. glabriuscula* on the basis of characteristics as used by Chou (1947: 12).

IX. *Galaxaura cucullígera* Kjellman
Figs. 13, 32

Floridé-slägtet *Galaxaura* (1900), p. 58, tab. 6 figs. 22–30, tab. 20 fig. 30; Butters, *Liagora* and *Galaxaura* (1911), p. 178; W. V. Bosse, Liste Alg. Siboga II (1921), p. 212; Tanaka, Gen. *Galaxaura* (1936), p. 152, figs. 14–15.

Plants bushy, to 7 cm tall, umbellate, densely and irregularly dichotomously branched; branches 1.5 mm in diameter, internodes 2–7 mm long, terete, clearly transversely rugose, but otherwise smooth except that multicellular free assimilatory filaments usually appearing in the older parts of the plants; medullary filaments running loosely, 6–12 μm in diameter, giving rise at the periphery to a layer of tightly associated polyhedral peripheral cells; peripheral tissues consisting of three layers of cells, subparenchymatic, encrusted with lime, the innermost cells polyhedral or depressed-spherical, measuring 27–30 μm thick and 39–50 μm broad, the outermost flattened, lens-like in section, firmly joined laterally into an epidermis, polyhedral in surface view, up to 24 μm in diameter; free assimilatory filaments cylindrical, straight, 15–18 μm in diameter, subattenuate, persistent, not arranged in any conspicuous order, rarely branched.

HABITAT: Yoron Is. (May 22, 1954), Miyako Is. (March 3, 1959), Yonaguni Is. (Oct. 29, 1959), Hatoma Is. (July 3, 1959).

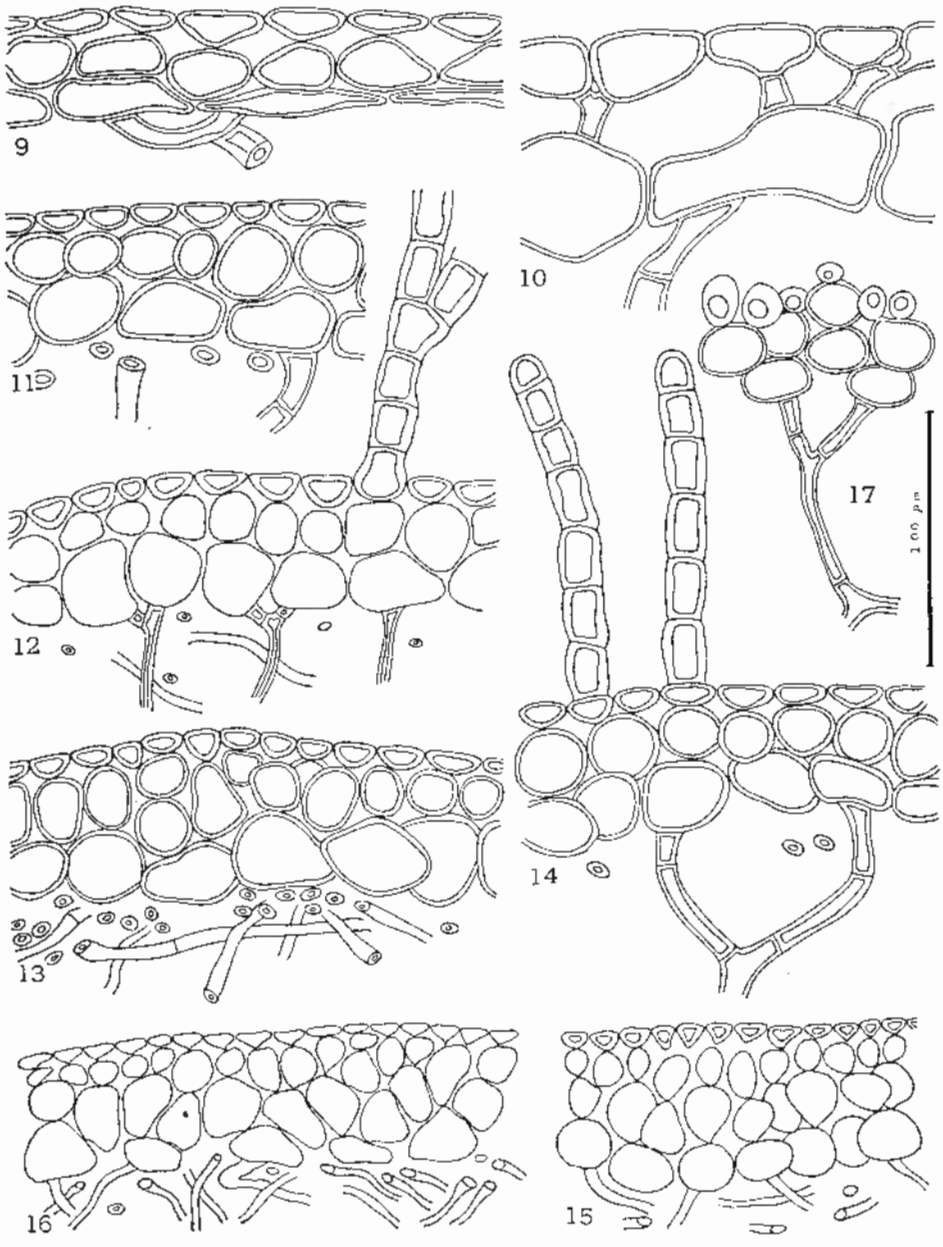
DISTRIBUTION: Hawaiian Islands, Malay Archipelago, Southern parts of Japan.

The southern Japanese species shows close similarity to *G. cucullígera* and *G. squalida*. *G. cucullígera*, the Pacific Ocean representative, is generally characterized by having cucullate proliferations, and *G. squalida*, the Atlantic Ocean representative, is, on the other hand, characterized by the absence of cucullate portion. However, Chou (1947: 10) recorded the occurrence of *G. squalida*, in which the cucullate proliferations also occur in some plants, and regarded the cucullate condition in some specimens of *G. squalida* as ecologically or physiologically caused by external factors. Thus, the distinction between *G. cucullígera* and *G. squalida* becomes more inconspicuous than ever regarded. Furthermore, comparisons of vegetative structures of *G. cucullígera* with the descriptions of *G. squalida* (Kjellman, 1900; Chou, 1947; Taylor, 1960; Börgesen, 1916) reveal that it is almost impossible to separate these two species. The author provisionally place the present southern Japanese species as *G. cucullígera*. It will be necessary to compare the authentic specimens of *G. cucullígera* and *G. squalida* before synonymizing one of the species.

X. *Galaxaura elongata* J. Agardh
Figs. 14, 33

Epicr. (1876), p. 529; Kjellman, Floridé-slägtet *Galaxaura* (1900), p. 56, tab. 7 figs. 6–12; W. V. Bosse, Liste Alg. Siboga II (1921), p. 212; Yendo, Note Alg. New to Japan V (1916), p. 254; De Toni, Syll. Alg. VI (1924), p. 113; Tanaka, Gen. *Galaxaura* (1936), p. 153, figs. 16–17.

Plants bushy, to about 13 cm tall, attached by broad discoid holdfasts, branch-



Figs. 9–17. Sections of branches showing cortices.
Fig. 9, *G. obtusata*; Fig. 10, *G. robusta*; Fig. 11, *G. pacifica*; Fig. 12, *G. glabriuscula*; Fig. 13, *G. cuculligera*; Fig. 14, *G. elongata*; Fig. 15, *G. fastigiata*; Fig. 16, *G. pilifera*; Fig. 17, *G. cylindrica*.

ing regularly dichotomous but rarely umbellate; branches terete, villous below, eventually more or less glabrous above; the segments about 1.5 mm broad, 7–25 mm long, annulate-rugose; free assimilatory filaments only seen in lower parts of the thallus, straight, unbranched, 15–18 μm in diameter, composed of short cylindrical cells 2–2.5 times as long as broad, slightly constricted at the dissepiments; medullary tissues consisting of loosely entangled filaments measuring 6–18 μm in diameter; cortical tissues parenchymatous, tristromatic, about 50–60 μm thick, strongly encrusted with lime deposits, cells of the innermost layer largest, oblong-ovate, 30–60 μm broad and 24–36 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, semilunate or hemispherical in section, 9–12 μm thick and 21–24 μm broad at the outer wall, containing well developed chromatophores.

HABITAT: Miyako Is. (Nov. 3, 1959).

DISTRIBUTION: Tonga, Australia, Malay Archipelago, Taiwan, Southern part of Japan.

XI. *Galaxaura fastigiata* Decaisne
Figs. 15, 34

Sur les Corallines (1842), p. 16; J. Agardh, Spec. Alg. (1876), p. 527; De Toni, Syll. Alg. IV (1897), p. 116; Kjellman, Floridé-slägtet *Galaxaura* (1900), p. 64, tab. 9 figs. 1–3, tab. 20 fig. 4; W. V. Bosse, Liste Alg. Siboga II (1921), p. 213; Okamura, Mar. Alg. Kotosho (1931), p. 109; Tanaka, Gen. *Galaxaura* (1936), p. 157, fig. 2; Dawson, Mar. Red Alg. Pacif. Mexico (1952), p. 50, pl. 20 fig. 2; Mar. Plant. Nha Trang (1954), p. 419, fig. 30b; Svedelius, *Galaxaura* from Hawaii (1953), p. 5, figs. 1–3; Womersley & Bailey, Mar. Alg. Solomon Is. (1970), p. 303.

Plants bushy, 3.5–7.5 cm tall, abundantly dichotomously branched, proliferations single or stellate; branches smooth or inconspicuously annulately rugose, terete, the segments somewhat broader at the summit than below, 0.8–1.5 mm in diameter, 3–9 mm long; the attachment holdfasts small, cushion-shaped; medulla not calcified, consisting of loosely running filaments, medullary filaments 6–21 μm in diameter; cortex thickly calcified, 4 cell layers and 57–66 μm thick, the inner cells loosely arranged, large and subglobose, 12–15 μm tall and 24–30 μm broad, the intermediate cells smaller, subglobose or pyriform and bearing small flattened epidermal cells; epidermal cells polygonal in surface view, 9–18 μm in diameter, semilunate in section and 4.5–6 μm thick.

HABITAT: Yoron Is. (May 22, 1954), Mage Is. (April 22, 1971), Hanaze (May 12, 1971).

DISTRIBUTION: Philippine Islands, New Caledonia, Solomon Islands, Micronesia, Polynesia, Hawaiian Islands, Malay Archipelago, Viet Nam, Taiwan, Bonin Islands, Southern parts of Japan.

XII. *Galaxaura pilifera* Kjellman
Figs. 16, 35

Floridé-slägtet *Galaxaura* (1900), p. 65, tab. 9 figs. 4–12, tab. 20 fig. 8; Börgesen, Mar. Alg. Mauritius III(1) (1942), p. 51, fig. 23; Mar. Alg. Mauritius Additions (1949), p. 44.

Plants bushy, 5–11 cm tall, regularly dichotomously branched, shortly stipitate; branches 0.8–1.6 mm in diameter, moderately calcified, segments cylindrical or somewhat broader at the summit than below, 5–13 mm long, weakly annulately rugose; medulla not calcified, medullary filaments running loosely, 3–6 μm in diameter; cortex somewhat calcified, 4 cell layers and about 50 μm thick, the inner cells loosely arranged, irregularly oval, 21–30 μm in diameter, bearing 1–2 smaller intermediate cells, and the small flattened surface cells; epidermal cells polygonal in surface view, 12–18 μm in diameter, closely arranged, in section semilunate, 6–9 μm thick, some epidermal cells slightly raised above the level of the surrounding epidermal cells, circular in surface view.

HABITAT: Amami Is. (May 18, 1954), Yoron Is. (May 22, 1954).

DISTRIBUTION: Mauritius Islands, Southern parts of Japan.

Kjellman (1900) described hairs in the lower parts of the fronds, but Börgesen (1942, 1949) and Svedelius (1945) were unable to find hairs on their specimens. In the southern Japanese specimens I was unable to find any hair cell. Instead, the materials are frequently provided with circular cells slightly elevated from the general level of the surface. This suggests the possible occurrence of hair cells in the early stages of the development. Present specimens are in close accordance to the descriptions and illustrations of *G. pilifera* (Kjellman, 1900; Börgesen, 1942) and undoutedly the Japanese specimens belong to *G. pilifera*.

XIII. *Galaxaura oblongata* (Solander) Lamouroux
Figs. 18, 36

Hist. polyp. Coralligen. (1816), p. 262; Howe, Bahama Flora (1920), p. 559; Börgesen, Mar. Alg. Canary III(1) (1927), p. 71, figs. 39–41; Mar. Alg. Mauritius III(1) (1942), p. 49; Taylor, Pacif. Mar. Alg. (1945), p. 142; Chou, Pacif. spec. *Galaxaura* II (1947), p. 7, pl. II figs. 1–16, pl. III figs. 1–14, pl. IX figs. 1–2.

Plants bushy, 5.5 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, 1–1.3 mm in diameter, 4–8 mm long, smooth or annulately rugose; medulla not calcified, consisting of loosely running filaments measuring 3–9 μm in diameter; cortex more or less thickly calcified, consisting of 4–5 layers and about 60 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 μm in diameter bearing 1–2 smaller intermediate oval cells and the small flattened epidermal cells; epidermal cells closely arranged, polygonal in surface view, 6–18 μm in diameter, about 12 μm thick and semilunate in section, some epidermal cells slightly raised above the level

of the surrounding epidermal cells, circular in surface view.
HABITAT: Kakeroma Is. (May 28, 1954), Yoro Is. (May, 1959), Yoron Is. (May 22, 1954), Yonaguni Is. (Nov. 1, 1959).
SYNONYM: *Corallina oblongata* Solander 1786: 114. *Galaxaura adriatica* Zanardini ex Börgesen 1927: 71. *Galaxaura fragilis* (Lamouroux) Kützing ex Börgesen 1927: 71.
DISTRIBUTION: West Indies, Canary Islands, Mediterranean, Red Sea, India, Mauritius, Java, Sumatra, Philippine Islands, Pacific Mexico, Ecuador, Hawaiian Islands, Florida, Brazil, Australia, Hainan Is., Southern parts of Japan.

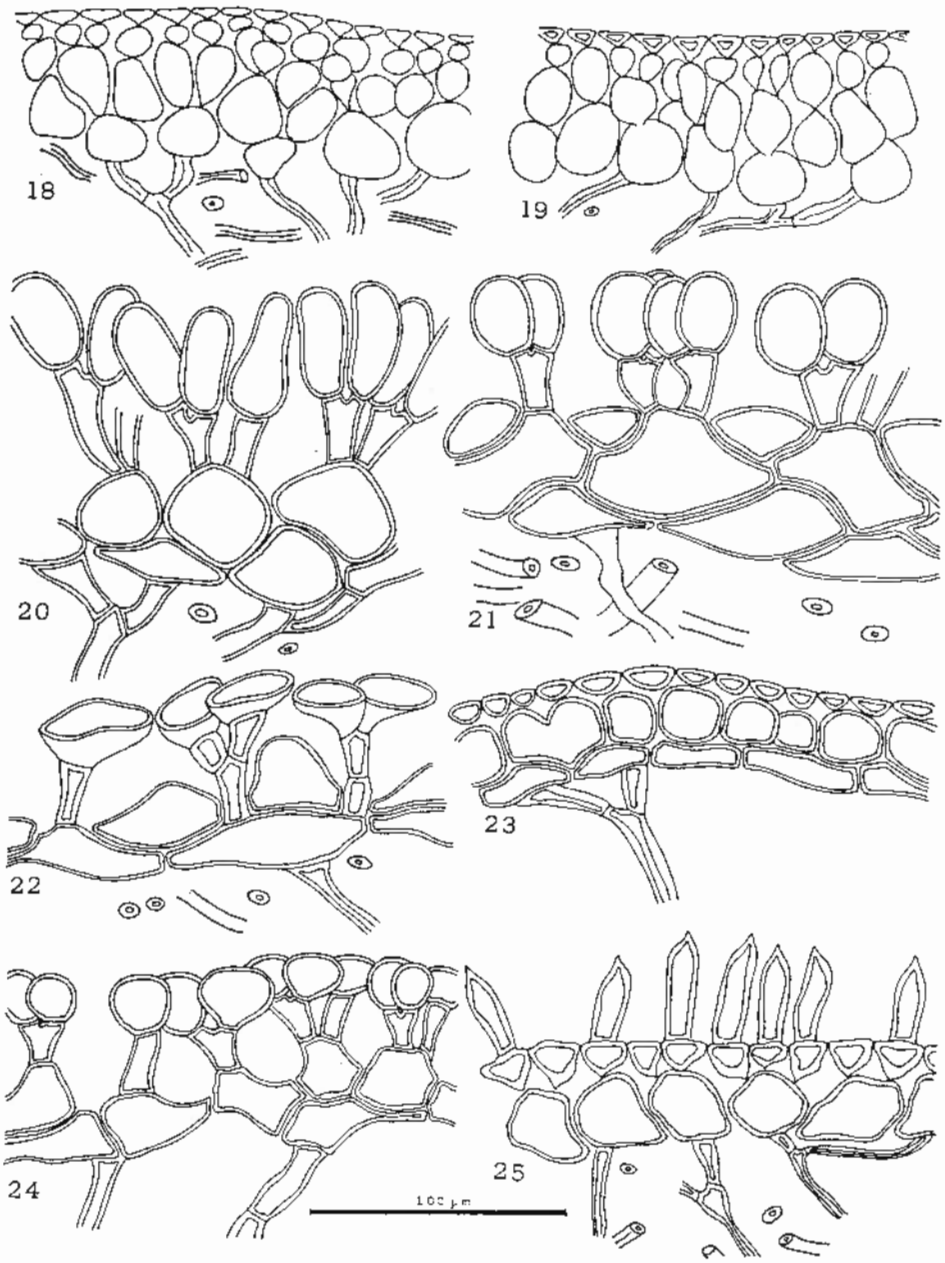
XIV. *Galaxaura cylindrica* (Solander) Lamouroux
Figs. 17, 19, 37

Zoophyte. flexibles (1812), p. 114; Kjellman, Floridé-slägtet *Galaxaura* (1900), p. 64, tab. 8 figs. 34–42, tab. 20 fig. 53; Börgesen, Mar. Alg. D. W. Ind. (1916), p. 106; Mar. Alg. Canary Is. (1927), p. 77; Mar. Alg. Mauritius III(1) (1942), p. 50; Chou, Pacif. spec. *Galaxaura* II (1947), p. 5, pl. I figs. 1–12, pl. III fig. 1.

Plants densely bushy, up to 13 cm tall, attached to the substratum by small discoid holdfasts; basal parts short-caulescent, upper branches erect, abundantly regularly dichotomously branched at narrow angles; branches firm and smooth without any conspicuous annular striation, well calcified in the cortical regions and becoming brittle on drying, 0.4–1 (rarely up to 1.2) mm in diameter, gradually tapering towards the apex, the segments 3–10 mm long; medulla not calcified, consisting of loosely running filaments, medullary filaments 6–18 μm in diameter; cortex thickly calcified, of 3–4 cell layers and about 60–84 μm thick, the inner cells loosely arranged, large, irregular, oval, 24–27 μm in diameter, bearing 1–2 smaller intermediate broadly oval cells and small flattened epidermal cells; epidermal cells polygonal in surface view, about 15–18 μm in diameter, semilunate in section and 9 μm thick, some epidermal cells slightly raised above the level of the surrounding epidermal cells, circular in surface view.
HABITAT: Takarajima Is. (May, 1952), Yoron Is. (Aug. 21, 1955), Miyako Is. (Nov. 3, 1959), Hateruma Is. (Aug. 6–13, 1972).
SYNONYM: *Corallina cylindrica* Solander 1786: 114.
DISTRIBUTION: West Indies, Atlantic coast of South America, Canary Islands, Red Sea, Mauritius, Philippine Islands, Southern parts of Japan.

G. fastigiata, *G. pilifera*, *G. oblongata* and *G. cylindrica* are the typical members of section Oblongatae (=Eugalaxaura sensu Kjellman). These four species closely resemble each other in their external features, and most of the Japanese phycologists have regarded the latter three species as *G. fastigiata*.

Svedelius (1945) considered that *G. pilifera* was synonymous to *G. fastigiata*, although Börgesen (1949) kept them separate. Svedelius (1945) also maintained *G. fastigiata* as distinct from *G. oblongata*, but Chou (1947) regarded *G. fastigiata* as a physiological form of *G. oblongata*. However, closer comparisons of the southern Japanese specimens show that they should be divided into four species, i. e.,



Figs. 18-25. Sections of branches showing cortices.
Fig. 18, *G. oblongata*; Fig. 19, *G. cylindrica*; Fig. 20, *G. clavigera*; Fig. 21, *G. arborea*; Fig. 22, *G. contigua*; Fig. 23, *G. yamadae* (sexual phase); Fig. 24, *G. yamadae* (asexual phase); Fig. 25, *G. veprecula*.

G. fastigiata, *G. pilifera*, *G. oblongata* and *G. cylindrica*. The characteristics used for the present identification are not so conspicuous and are arbitrary. These characteristics are probably induced by some ecological or physical factors. I tentatively separate these four species, and suggests that it is necessary to examine in detail the cultural and ecological features before finalizing our decision.

XV. ***Galaxaura clavigera*** Kjellman
Figs. 20, 38

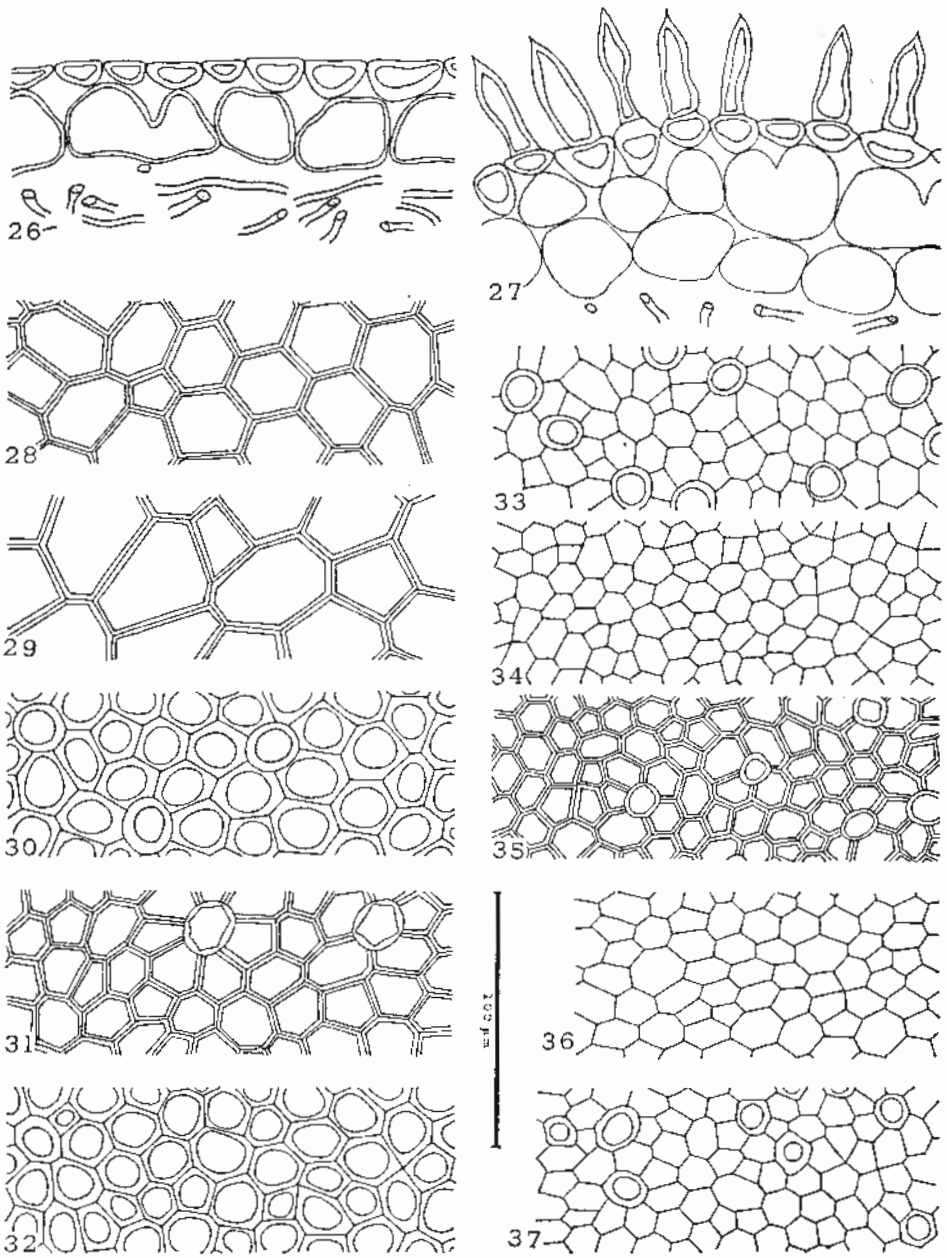
Floridé-slägtet *Galaxaura* (1900), p. 76, tab. 13 figs. 1–13, tab. 20 fig. 25; W. V. Bosse, Liste Alg. Siboga (1921), p. 216; Okamura, Mar. Alg. Kotosho (1931), p. 109; Tanaka, Gen. *Galaxaura* (1936), p. 163, figs. 28–29.

Plants rather large, up to 10 cm tall, the branches smooth, dull, frequently transversely banded, flattened, regularly dichotomous, 1–2 mm broad, the segments 3–9 mm long, about 440–470 μm thick, branch tips frequently encircled by tufts of extended assimilatory filaments; lower parts of the fronds terete or subterete without clear distinction from stipe; stipes cylindrical, 1.5–3 mm broad, villous consisting of rhizoidal filaments, attached by a rather large, discoid holdfast; medullary filaments 9–12 μm in diameter, running irregularly; the inner cortex composed of a pseudoparenchymatous layer 2–3 cells thick of large, nearly colorless cells; in the tetrasporic plants, the inner cortex bearing on the outer side rather slender stalk cells usually once divided at the summit and bearing two large, thick-walled, obovoid or sometimes apiculate assimilatory cells, assimilatory cells 18–21 μm in diameter and 36–42 μm long; in sexual plants the cortex bears on the outer side one layer of small depressed cells forming a continuous epidermis, cells of the epidermis angular in surface view, 21–27 μm in diameter, in section semilunate, 15 μm thick.

HABITAT: Kikaijima Is. (May 19, 1954), Kakeroma Is. (May 28, 1954), Amami Is. (June, 1956; June, 1961), Okierabu Is. (Aug. 9–12, 1957), Yoron Is. (May 22, 1954; Aug. 19, 1955), Yonaguni Is. (April 15, 1935; Oct. 30–31, 1959).

DISTRIBUTION: East Africa, Malay Archipelago, Taiwan, Bonin Islands, Southern parts of Japan.

G. clavigera shows structure of the asexual phase of the generation. The author was fortunate enough to find plants from Yoron Islands (collected on May 22, 1954) that are externally indistinguishable from that of *G. clavigera* but showing the sexual phase. The cortex of this plant has a layer of small depressed cells forming a continuous epidermis. The epidermal cells are not ornamented with any kind of accessory cell such as spinulose cell or extended assimilatory filaments, and this suggests that the asexual phase of *G. clavigera* should be found among members of section Angustifrondes (sensu Chou, 1947). Since it is impossible to separate the plants from *G. clavigera* on the basis of external features, these plants probably belong to the sexual phase of *G. clavigera*. The plants that I regarded as the sexual phase of *G. clavigera* do not agree with any currently recorded species of the genus. In some of the tetrasporic plants, the assimilatory cells on the stalk cells of the cortex



Figs. 26–27. Sections of branches showing cortices; Figs. 28–37, Surface views of epidermis.

Figs. 26–27, *G. ventricosa*; Fig. 28, *G. obtusata*; Fig. 29, *G. robusta*; Fig. 30, *G. pacifica*; Fig. 31, *G. glabriuscula*; Fig. 32, *G. cuculligera*; Fig. 33, *G. elongata*; Fig. 34, *G. fastigiata*; Fig. 35 *G. pilifera*; Fig. 36, *G. oblongata*; Fig. 37, *G. cylindrica*.

are apiculate as in *G. apiculata* Kjellman, but these apiculate assimilatory cells are frequently intermixed with typical obovoid assimilatory cells even in the same plant. The apiculate, mucronate assimilatory cells in these plants are probably affected by physiological or ecological factors.

XVI. *Galaxaura arborea* Kjellman
Figs. 21, 39

Floridé-slägtet *Galaxaura* (1900), p. 72, tab. 11 figs. 1–11, tab. 20 fig. 39; Yendo, Note Alg. New to Japan VIII (1918), p. 65; Tanaka, Gen. *Galaxaura* (1936), p. 161, figs. 24–25; Chou, Pacif. spec. *Galaxaura* II (1947), p. 50, pl. V figs. 1–5, pl. X figs. 1–2; Dawson, Mar. Red Alg. Pacif. Mexico (1952), p. 49, pl. 17 fig. 2.

Plants bushy, 5–8 cm tall, attached by a rather small cushion-shaped holdfast; stalks and branches terete and villous below, flattened above; stalks cylindrical, 1.5–2 mm broad and 7 mm long, consisting of numerous rhizoidal cells; branches flattened above, continuous or proliferous from subarticulate constrictions, where encircled by tufts of extended assimilatory filaments, segments 4–9 mm long, 1.5–2 mm wide, about 280 μm thick, fleshy-membranaceous, the margins slightly thickened, with faint transverse striations; the medullary filaments 9–18 μm in diameter; cortex subparenchymatous, about 60 μm thick, of 2–3 layers, the inner cells slightly larger, subglobose or compressed, 75–81 μm broad, 30–45 μm thick, the outer cells smaller, subglobose or pyriform, bearing 1–2 cylindrical or cuneate-cylindrical stalk cells, these simple or once forked; terminal cells subglobose to pyriform, 33 μm long and 27–30 μm broad.

HABITAT: Takarajima Is. (May, 1952; April 30, 1958; March, 1965), Amami Is. (Feb. 19, 1960), Miyako Is. (Nov. 2–3, 1959), Hateruma Is. (Aug. 6–13, 1972), Yonaguni Is. (Oct. 30, 1959).

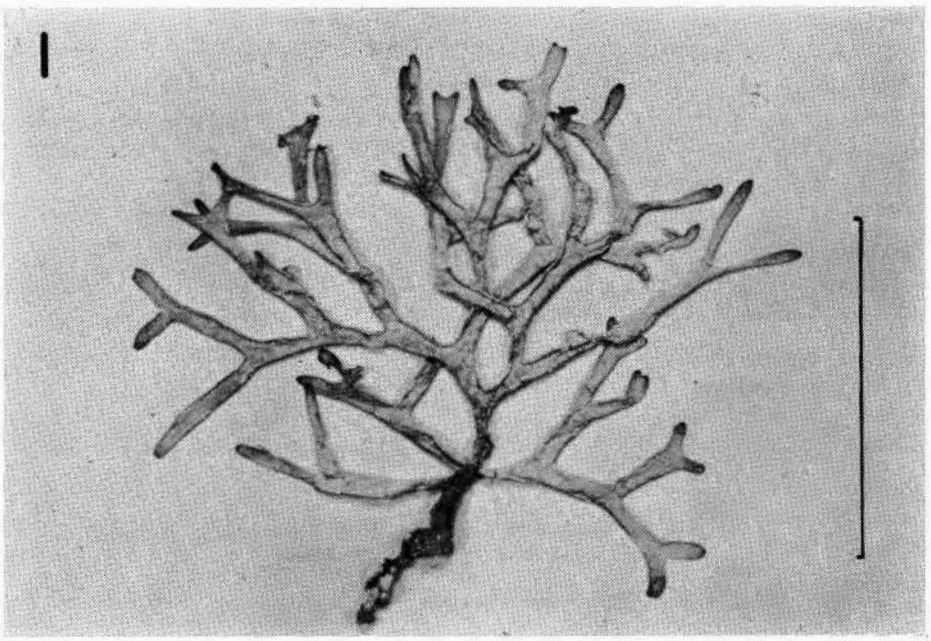
DISTRIBUTION: Australia, Hawaiian Islands, Philippine Islands, Southern parts of Japan.

Dawson (1952) suggested that *G. arborea* and *G. veprecula* may be the two phases of one natural species. However, each of these two species does not always have common distributional ranges and until this distributional problem will be clarified I cannot consider Dawson's view.

XVII. *Galaxaura contigua* Kjellman
Figs. 8, 22, 40, 41, Pl. I, 1

Floridé-slägtet *Galaxaura* (1900), p. 78, tab. 17 figs. 1–14, tab. 20 fig. 23.

Plants up to 5 cm tall or more, attached by a small discoid holdfast, shortly stipitate; stipes villous, 1.2–2 mm in diameter, 8 mm long; supporting cells of the filaments at the periphery well developed, cylindrical-oblong measuring 45 μm in diameter and 72–78 μm long, filaments 18–30 μm in diameter near the base, slightly tapering toward the apices; branches distinctly flattened, widely flabelliform, regularly or subregularly dichotomous; internodes continuous, 1.3–2 mm broad, 5–8 mm long, smooth and slightly shiny, with faint transverse striations near the apex, mar-



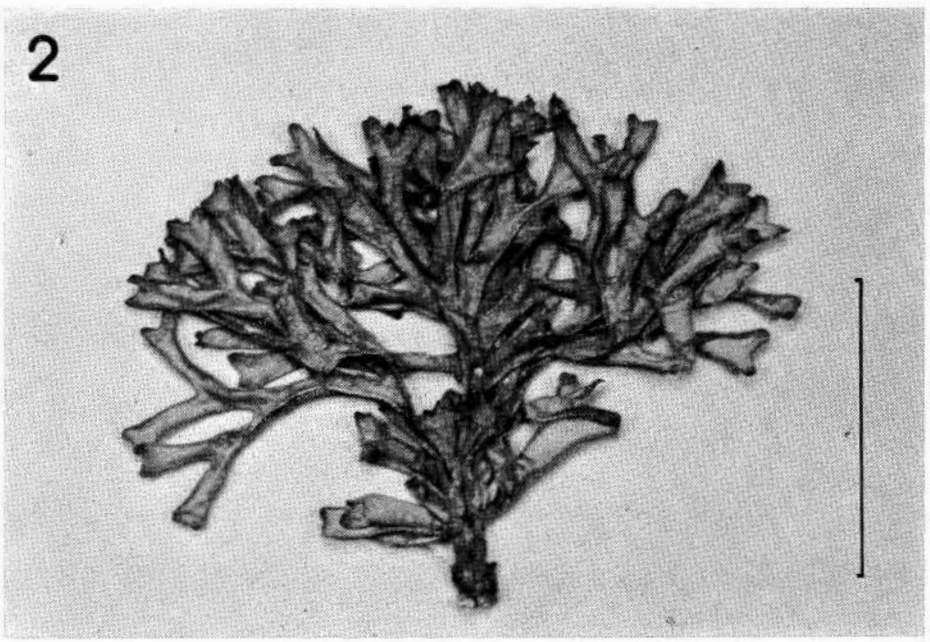


Plate I-1. Habit of *Galaxaura contigua*; Plate I-2, Habit of *Galaxaura ventricosa*. (Scales 3 cm).

gins not conspicuously thickened; medullary filaments 9–15 μm in diameter; inner cortex composed of a parenchymatous layer usually 2 cell layers thick of large, nearly colorless, compressed cells, with a pilose layer on the outer side, each outwardly supporting a slender stalk cell bearing 1–2 distal cells closely laterally approximated and polyhedral in surface view, 15–30 μm in diameter, forming epidermis; epidermal cells hemispherical in section.

HABITAT: Amami Is. (Feb. 19, 1960; June 29, 1970), Mage Is. (April 21, 1971).

DISTRIBUTION: Hawaiian Islands, Southern parts of Japan.

These specimens are characterized by having epidermal cells which are hemispherical in transverse section on the stalk cells. Such species is quite identical with *G. contigua* Kjellman originally known from the Hawaiian Islands, and the species is described here for the first time from the southern parts of Japan.

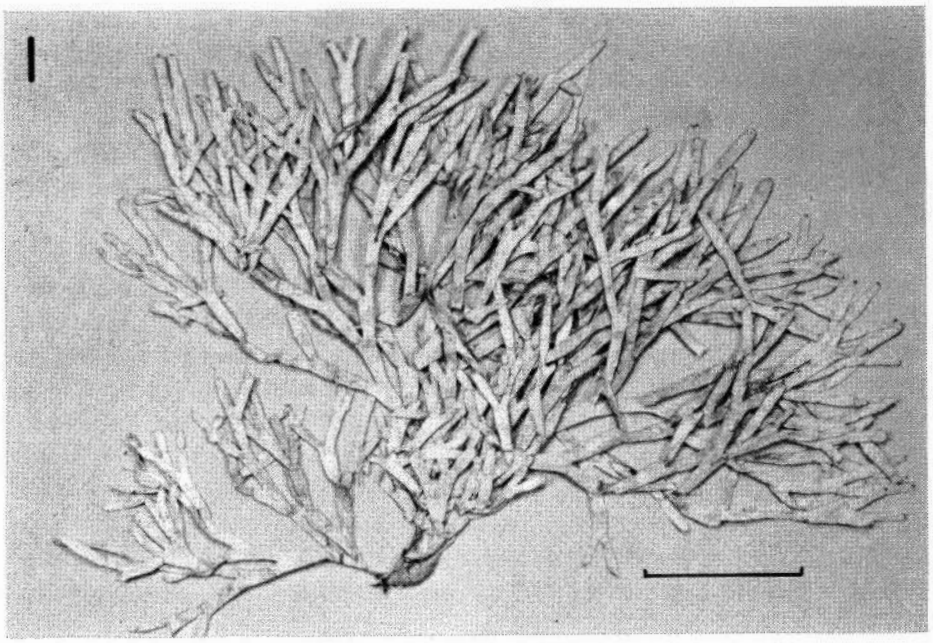
Externally, the Japanese specimens are very similar to *G. arborea* but the shape of the epidermal cells of the present species is apparently different from *G. arborea*.

XVIII. ***Galaxaura yamadae*** Itono sp. nov.

Figs. 23, 24, 42, 43; Pl. II, 1–2

Plantae arborescentes, ad 10 cm altae, regulariter dichotoma divisae, disco ad substratum adfixae; caudice partibusque ramorum basalibus subteretibus, 1.5 mm latis, 15–17 mm longis, villosus, ramis sursum compressis glabris; segmentis linealibus, continuis, 2.5–4 mm latis, 8–17 mm longis, ad 385 μm crassa, marginibus neve incrassatis neve involutis; plane calcificatis, siccitate fragilibus, inconspique transverse striatis; filamentis medullariis 6–18 μm diam., cortice intimis parenchymatoso, 2-stromatico, cellulis rotundis hemisphaericalibusque; in thallo sexualis cellulis epidermalibus angularibus in aspectu superficiali, circiter 18–27 μm diam. in sectioe transversali frondis lunatis, 9–12 μm altis; in thallo asexualis cellulis corticalibus cellulas 1 vel 2 subcylindricas vel clavatas stipitiformes ferentibus; cellulis stipitiformibus simplices vel furcatis, aut cellulam singulam terminalem ferentibus aut si furcatis cellulas duas terminales subglobosas vel ovoideas, 15–24 μm diam., 18 μm altas.

Plants densely bushy, up to 10 cm tall, the holdfasts cushion-shaped, basal parts terete and stalk-like; stipes villous, terete, 1.5 mm in diameter and 15–17 mm long; the branches smooth, dull, without any transverse striation, flattened, 2.5–4 mm broad, the segments 8–17 mm long, about 385 μm thick, regularly dichotomously branched, more or less thickly calcified in the cortex; medullary filaments running loosely, 6–18 μm thick; the inner cortex composed of a pseudoparenchymatous layer usually 2 cells thick of large, nearly colorless cells, with, in sexual plants, the cortex bearing on the outer side one layer of small depressed cells forming a continuous epidermis, epidermal cells polygonal, measuring 18–27 μm in diameter in surface view, semilunate in section and 9–12 μm thick, spinulose cell on the surface of epidermal cells absent; in tetrasporic plants, with a pilose layer on the outer side, each laterally consisting of a rather slender stalk cell once divided at the summit and bearing 1–2 large thick-walled, oval to obovoid assimilative cells 15–24 μm broad



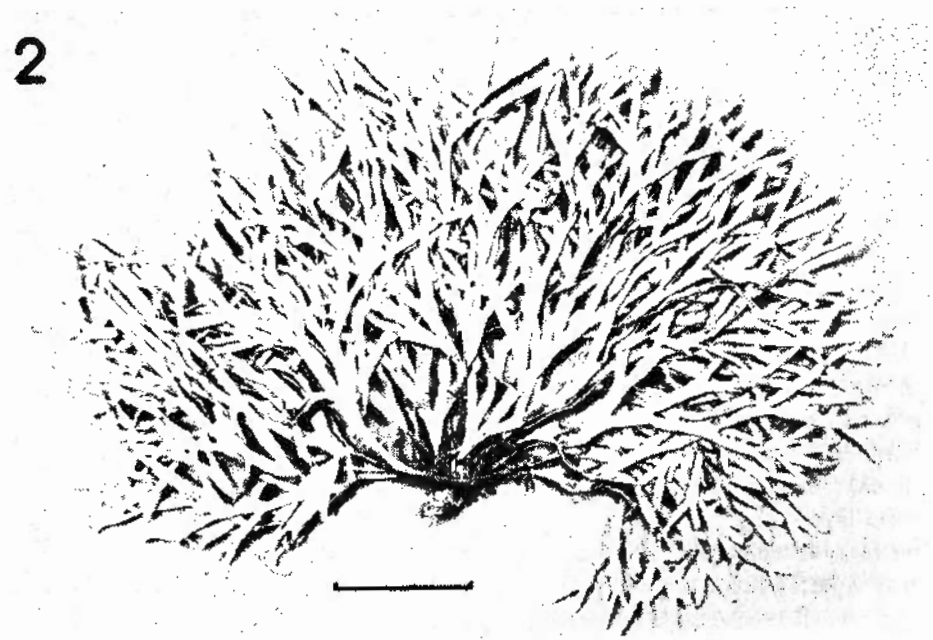


Plate II. Habit of *Galaxaura yamadae*. 1, Plant of the sexual phase. 2, Plant of the asexual phase. (Scales 3 cm).

and 18 μm long; some cortical cells occasionally circular and slightly elevated above the general level of the surface.

HOLOTYPE: HI19762 (sexual plant), deposited in the Herbarium of Faculty of Science, Kagoshima University.

TYPE LOCALITY: Western end of the Straits of Koniya, Amami Island (collected on June 29, 1970 by H. Itono; dredged from a depth of about 18 m).

DISTRIBUTION: Known only from the type locality.

Two specimens have been collected from the type locality, and these two specimens are similar in their external features. However, one of them shows the structures of the sexual phase and the other one shows structures of the asexual phase. Since the external features of these two specimens are quite identical, I regard these two as being different phases in the life cycle of the same natural species. Both asexual and sexual plants do not agree with any previously described species of the genus. The sexual plant of a new species is a typical member of the section Angustifrondes (Chou, 1945;=Laevifrons Kjellman) in the entire absence of spinulose cells on epidermal cells in sexual plant. The sexual plant of *G. yamadae* is similar to the description of *G. magna* in almost every respects, except for its much shorter internodes and much thicker fronds. The sexual plant of *G. yamadae* agrees in some degree with *G. vietnamensis* Dawson (1954: 417). However, *G. yamadae* is easily separated from *G. vietnamensis* in the entire absence of spinulose cells on epidermal cells in sexual plants; in *G. vietnamensis* spinulose cells are produced at the margins.

The species is so named in honor of the late Dr. Yukio Yamada, who contributed significantly to our knowledges of the southern Japanese marine algae.

XIX. ***Galaxaura veprecula*** Kjellman

Figs. 25, 44

Floridé-slägtet *Galaxaura* (1900), p. 80, tab. 16 figs. 17–33, tab. 20 fig. 20; Yendo, Note Alg. New to Japan VIII (1918), p. 66; Tanaka, Gen. *Galaxaura* (1936), p. 169, figs. 36–37; Taylor, Pacif. Mar. Alg. (1945), p. 143; Chou, Pacif. spec. *Galaxaura* II (1947), p. 16, pl. VI figs. 1–8, pl. XII fig. 1; Dawson, Mar. Red Alg. Pacif. Mexico (1952), p. 53, pl. 18 fig. 2.

Plants bushy, 5 cm tall, attached by more or less large discoid holdfasts, shortly stipitate; stalks and branches below terete, villous; branches divided regularly, dichotomously at wide angle, internodes 4–7 mm long, 1–2 mm wide, fleshy-membranous, the margins slightly thickened; medullary filaments 12–15 μm in diameter; cortical layers about 36 μm thick, consisting of inner layer of large oval cells and outer layer of epidermis; cells of inner layer 21–24 μm thick and 30–42 μm broad; cells of epidermis angular in surface view, 15–24 μm in diameter, closely laterally approximated, semilunate in section, 9–15 μm thick, containing well developed chromatophores; spinulose cells occurring in patches, irregularly scattered over the surface of the frond, clavate or elongate-spatulate, 30 μm tall, 9–12 μm in diameter, apices pointed or mucronate.

HABITAT: Tokunoshima Is. (Oct. 14, 1966).

DISTRIBUTION: Madagascar, Philippine Islands, Ecuador, Taiwan, Pacific Mexico, Southern part of Japan.

Early phycologists, who treated the members of *Galaxaura*, mostly described or illustrated the cortical layers of *G. veprecula* as consisting of two layers of oval or compressed-oval cells and a layer of epidermis on the outer surface. In the southern Japanese specimens, the cortical layers consist of one layer of large cells and one layer of epidermis (Fig. 25). However, the presence of spinulose cells on the epidermal cells and the plant habit suggest that the present southern Japanese specimens undoubtedly belong to *G. veprecula*, and the two or three cortical layers are probably affected by physiological or ecological factors.

XX. *Galaxaura ventricosa* Kjellman

Figs. 26, 27, 45; Pl. I, 2

Floridé-slägtet *Galaxaura* (1900), p. 81, tab. 16 figs. 11–16, tab. 20 fig. 24; Taylor, Pacif. Mar. Alg. (1945), p. 143; Chou, Pacif. spec. *Galaxaura* II (1947), p. 18, pl. VI figs. 9–12, pl. XII fig. 2; Womersley & Bailey, Mar. Alg. Solomon (1970), p. 304.

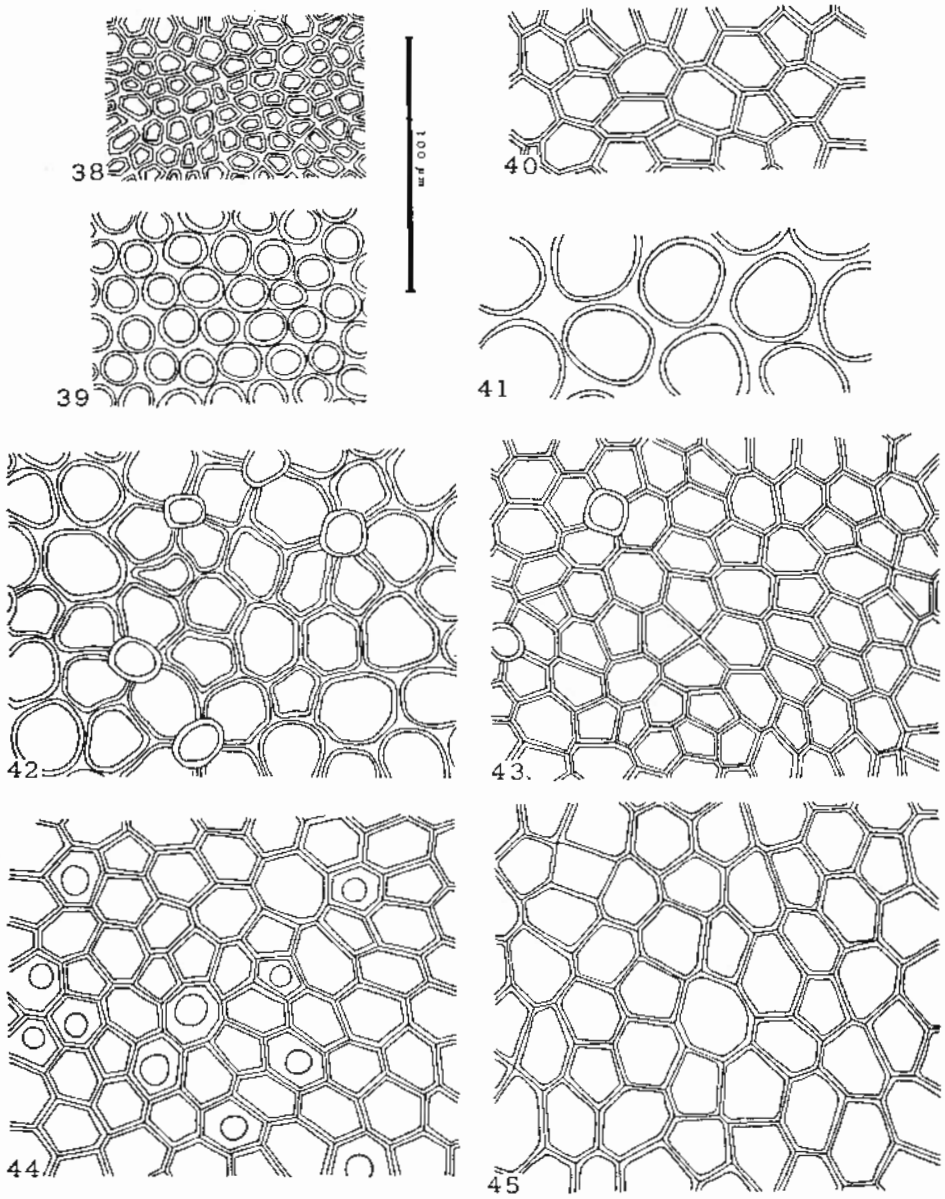
Plants bushy, up to 5.5 cm tall, attached by a rather small discoid holdfast; stalks terete and villous, 6–7 mm long and 1–1.5 mm broad; branches smooth, glabrous, flattened about 2–3 mm broad, regularly dichotomously branched with wide angle, segments 7–9 mm long, canaliculate in the herbarium specimens, 135–165 μm thick, at the thickened margin 385–400 μm thick (except spinulose cells), cells of the innermost layer largest, compressed, frequently lobed; epidermal cells containing chromatophore, polygonal in surface view, 24–30 μm in diameter, closely laterally approximated, in section semilunate, 15 μm thick; spinulose cells columnar, fusiform or elongate-spathulate, 12–15 μm in diameter and 39–45 μm long, with the apices rounded or acute, sometimes short acuminate or slightly mucronate, mostly produced on the outer faces of epidermal cells on the thickened margins.

HABITAT: Mage Is. (April 21, 1971).

SYNONYM: *Galaxaura yaeyamensis* Tanaka 1960: 98.

DISTRIBUTION: Tropical Western Africa, Tropical Eastern Atlantic, Pacific Mexico, Solomon Islands, Southern parts of Japan.

The southern Japanese specimens show a close similarity to *G. latifolia* and *G. veprecula* in their external features, but is easily separated from these two species on the positions of the spinulose cells on the epidermal cells. The presence of spinulose cells only at the thickened margins of the blades is one of most distinctive characteristics of *G. ventricosa*, and the comparison of both external and anatomical structures of the southern Japanese specimens show that the species is quite identical with that of *G. ventricosa*. Chou (1947: 19) suggests that the spinulose cells are variable in size, shape and frequency, and the presence or absence of the spinulose cells may not have any taxonomic significance at all, and Kjellman's use of the occurrence or absence of these cells to separate several species may be quite unwarranted. Chou (1947) separated *G. ventricosa* from *G. veprecula* on the basis of fronds width.



Figs. 38–45. Surface views of epidermis.
Fig. 38, *G. clavigera*; Fig. 39, *G. arborea*; Figs. 40–41, *G. contigua* (Fig. 41 shows epidermal cells after decalcification); Fig. 42 *G. yamadae* (asexual phase); Fig. 43, *G. yamadae* (sexual phase); Fig. 44, *G. veprecula*; Fig. 45, *G. ventricosa*.

The southern Japanese specimens differ from *G. veprecula* in having broader fronds as Chou's specimens, and the present species is placed tentatively here. It is necessary to examine carefully the nature of spinulose cells before finalizing our determination of the species.

Tanaka (1960: 98) described *G. yaeyamensis* on the basis of specimens from the Ryukyu Islands and Tanegashima Islands. *G. yaeyamensis* is also characterized in having spinulose cells only at the thickened margins of the fronds, but differs from *G. ventricosa* in the shape of stipes and branches. However, present observations have led me to regard *G. yaeyamensis* as probably a physiological form of *G. ventricosa*. *G. yaeyamensis* is referred here as synonymous to *G. ventricosa*.

ACKNOWLEDGEMENTS

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