CONTRIBUTIONS TO THE MORPHOLOGY OF THE GENUS *LAURENCIA* OF JAPAN. I

Yuzuru Saito
Faculty of Fisheries, Hokkaido University

The genus *Laurencia*, in the present territory of Japan, has been reported, so far as the writer is aware, to comprize nineteen species, one variety, and one form (Yamada, 1931, 1932, 1936 in Okamura; Yamada & Segawa, 1953), of which thirteen species and one form were newly established by Prof. Y. Yamada on the basis of Japanese materials. Of these thirteen species, eleven were described from the tetrasporiferous plants, one from the female plant, and the remaining one species from both tetrasporiferous and female plants. On the other hand, in the six exotic species which were reported by Yamada to occur in Japan, the tetrasporangia and cystocarps are known in two species, the tetrasporangia alone in another two species, and no reproductive organs in the remaining two species from Japanese materials. Thus the current knowledge of the Japanese species of *Laurencia*, especially concerning their reproductive organs, is rather incomplete. So the writer has been engaged for these several years in the morphological study of them with materials he collected by himself. Some of the results so far obtained were provisionally reported in two short papers (Saito, 1960, 1961). Now the writer wishes to publish more detailed descriptions and illustrations of the species studied in a series of articles under the present title.

1. *Laurencia venusta* Yamada

Yamada, 1931, p. 203, pl. 6, fig. a, textfig. H; in Okamura, 1936, p. 854; Okamura, 1931, p. 116; Takamatsu, 1939, p. 76, pl. 13, fig. 2; Saito, 1956, p. 106; Cribb, 1958, p. 168, pl. 5, fig. 11.

Japanese name. Himesozo (Yamada).

Specimens collected. Growing on rocks in the lower littoral zone. Moheji, near Hakodate, Hokkaido, 27 August (♀⊕), 5 September (⊕), 13 September (♂♀⊕), 30 Sepeember (⊕), 1963, Y. Saito.

Distirbution. *Japan.* Japan Sea coast of Honshu: Otose and Iwasaki, Tsugaru Province, Tobishima Isl., Ugo Province (Takamatsu, 1939); Kodomari, near Nou, Echigo Province (Saito, 1956); Kyushu: Koshikijima Isl., Satsuma Provice, Goto Isl., Hizen Province (Yamada, 1931). *Formosa* (Okamura, 1931) and *Australia* (Cribb, 1958).

The present species was established by Yamada (1931) on the basis of the tetrasporiferous specimens from Kyushu, Japan. The male plant was first reported by Cribb (1958) from Australia. The present paper reports for the first time the occurrence of this species in Hokkaido, and also the discovery of the female plant in the species and the male plant in Japan.

The fronds are erect, up to nearly 10 cm. high, with several erect axes densely tufted below with entangled, more or less coalescent, basal branches (Pl. I, Figs. 2–4). The erect axes are cylindrical, 690–920 μ diam., 2.2–9.6 cm. high (4.16 cm. high on the average among 63 individual plants), paniculately branched. The branching is alternate, opposite or verticillate; the branches are 540–620 μ diam., the ultimate sterile branchlet 310–460 μ diam. The fronds are purplish red, sometimes slightly greenish in colour, cartilaginous but not so rigid in texture, and adhere to paper when dried. The cortical cells are not elongated longitudinally in the surface view (Pl. IV, Fig. 1); they are neither elongated radially nor arraged as a palisade in the transverse section of a brachlet, 25–39(–52) μ long radially, 33–50(–58) μ wide (Pl. IV, Fig. 2). The cortical cells in the terminal portion of the ultimate branchlet are more or less flattened laterally, so that they are arranged somewhat as a palisade in a longitudinal section, but not projected above the frond surface (Pl. IV, Fig. 3). The lenticular thickenings of the cell walls in the medulla are abundant not only in the older tissue but also in the younger of the ultimate branchlets (Pl. II, Figs. 4-6, Pl. III, Figs. 3-5, Pl. IV, Figs. 2 & 3, Pl. V, Fig. 1, Pl. VII, Fig. 5). The apical cell of the ultimate branchlet is situated at the bottom of its apical depression, and it cuts off by oblique walls wedge-shaped segments which form the axial cell-row. All of the cells in the branchlet including those of the trichoblasts and of the young reproductive organs are linked to the axial cells or indirectly through the pericentral cells (Pl. IV, Fig. 3, Pl. V, Fig. 2, Pl. VII, Fig. 1, Pl. VIII, Fig. 1). The trichoblast arises from a young pericentral cell near the apical cell, and it is gradually displaced towards the periphery of the apical depression with the advance of growth, branching dichotomo-alternately or sometimes trichotomously or oppositely (Pl. VI, Fig. 4).

The male plant in the writer's collections is represented by a single fragmentary specimen, about 4 cm. in length, the upper half of which is shown in Pl. I, Fig. 1. One of the branches bearing many antheridial branchlets or receptacles from the lower half of the specimen is shown in Pl. II, Fig. 2. The terminal portion of those branchlets is characteristically broadened, attaining 340–910 μ in diameter, and bears one to three, or more, antheridial depressions, 75–160 μ deep and 2.7–2.9 times as broad as the depth, which are furnished with many fertile and sterile trichoblasts (Pl. V, Fig. 1). The fertile trichoblast, or antheridium, consists of a brached central axis and four pericentral cells, or spermatangial mother-cells, on each axial cell (Pl. VI, Figs. 1–3). Sometimes the axial cell cuts off one more set of spermatangial mother-cells (Pl. VI, Fig. 1). Each mother-cell gives rise to 2–3(–4) ovoid spermatangia, 7.8–9.7 μ long by 4.7–5.6 μ diam., which contain a large nucleus at their apices. The terminal cells of the fertile trichoblasts are vesicular in appearance, ovoid in shape and often very large, up to 36 μ long by 31 μ diam. (Pl. II, Fig. 7, Pl. V, Figs. 1 & 3, Pl. VI, Figs. 1 & 2).

In the female plant, the ultimate branchlets are slender while sterile, but their terminal portions become thickened and fist-shaped with the development of the procarps and the cystocarps (Pl. II, Fig. 1, Pl. III, Fig. 2). The initial cell of the procarps arises from a pericentral cell and acts as the fertile central cell of the procarp. This fertile cell is linked to the axial cell of the branchlet by the pericentral cell which gradually becomes elongated and filamentous below with the growth of the branchle tissue (Pl. VII, Fig. 1). The fertile central cell cuts off the supporting cell inwardly, i.e. towards the apical cell of the branchlet, and also a sterile cell on the opposite side (Pl. VII, Figs. 1 & 2). On the supporting cell is formed inwardly the four-celled carpogonial branch (Pl. III, 1, Pl. VII, Fig. 2), while on the sterile cell a number of small cells are arranged so as to form a part of the young pericarp. The pericentral cell beneath the fertile central cell of the procarp also cuts off sterile cells to contribute to the development of the pericarp (Pl. III, Fig. 1, Pl. VII, Figs. 2 & 3). After fertilization a large auxiliary cell is cut off from the supporting cell on the upper side and it fuses with the carpogonium which has already lost the protoplasmic continuity with the trichogyne (Pl. VII, Fig. 3). Further development of the procarp could not be traced until it reached a stage in which the gonimoblast cells began to be formed on the fusion-cell (Pl. VII, Fig. 4). The fusion-cell gradually increases in size by coalescing with the surrounding cells including central cell, the pericentral cell, the sterile cells and the older gonimoblast-cells. The developed pericarp consists of the above mentioned sterile cells and some cortical cells of the branchlet. The ripe cystocarp is ovoid in shape, up to 690 μ diam., and is provided with a carpostome. The cystocarpic cavity is filled with a stratified mucilaginous substance which stains well with haematoxylin. The innermost cells of the pericarp are rich in content and markedly filamentous, indicating that they probably supply nutriment to the gonimoblast through the fusion-cell. The terminal cell of each gonimoblast-branch enlarges to form a carpospore (Pl. III, Figs. 3 & 4, Pl. VII, Fig. 5).

The tetrasporophyte is provided at maturity with the stichidia converted from the ultimate branchlets. The stichidia are cylindrical, 450–520 μ diam., and are beset in the portion with many dark purplish spots or tetrasporangia which are scattered over the surface. After the shedding of the spores, these spots become colourless and the stichidia look undulate on the surface (Pl. II, Fig. 3, Pl. III, Fig. 5). The tetrasporangium originates from a pericentral cell near the growing apex in the apical depression of a branchlet. The fertile pericentral cell cuts off a sporangium and cover-cells, and it becomes elongated and filamentous below with the growth of the brachlet tissues (Pl. III, Figs. 6 & 7, Pl. VIII, Fig. 1). The fertile pericentral cell is also linked by means of secondary pit-connections with some of the cortical cells derived from the division of a neighbouring pericentral cell lying beneath it. The elongated pericentral cell is later divided into several segments, so that the sporangium tends to be interpreted erroneously as having been produced from the cortical cells as described by Kylin (1923). The first nuclear division of the sporangium can be observed while the sporangium is at the periphery of the apical depression (Pl. VIII, Fig. 2), whereas the second division can be observed when the sporangium is not in the depression but on the lateral surface of the stichidium (Pl. III, Fig. 5, Pl. VIII, Fig. 3). The division of the sporangium is tetrahedral.

The above description is based on the specimens from Moheji, Hokkaido. It agrees well in general with the descriptions of the preset species given by the authors cited above except that the Australian plant was reported to be smaller in both external and internal dimensions than the Japanese plant and to have annular, instead of lenticular thickenings of the cell walls.

The wrirer is greatly indebted to Professor J. Tokida for valuable advice and kindness in reading the manuscript, and to Professor Y. Yamada for kind guidance in identifying the species.

Summary

Laurencia venusta Yamada which has previously been known from Honshu and Kyushu in Japan and from Formosa and Australia is reported herein to occur in Hakodate Bay, Hokkaido. Descriptions and illustrations of the sexual, male and female, and the tetrasporangial plants are given in this paper. The following characteristics are worthy of special mention.

1. The cavity of the antheridial receptacles in the *Laurencia venusta* is shallower than that of *L. pinnatifida* (Gmelin) Lamouroux (cf. Kylin, 1923), *L. nipponica* Yamada (cf. Saito, 1960) and *L. intermedia* Yamada (cf. Saito, 1961). The branching of the central axis of each antheridium is dominantly alternate.

2. The cystocarp is ovoid in shape. The carpogonial branch is still naked

when the auxiliary cell is formed, whereas it is described in *Laurencia pinntifida* by Kylin (1923, Fig. 79 e) to be covered by a thick pericarp.

3. The tetrasporangia are formed on the upper lateral of the stichidium being arranged parallel to its central axis as seen in the longitudinal section. The tetrasporangium-initial arises from a pericentral cell. This evidence is established for the first time by the present study in the *Laurencia*. The only previous description on the origin of the tetrasporangium in the *Laurencia* is that which was given in *L. pinnatifida* by Kylin (1923) who stated, "Hier sind es beliebige, junge Rindenzellen im unteren Teil der Scheitelgrube, welche die Mutterzellen der Tetrasporangien darstellen."

Literature

Cribb, A. B. (1958). Records of marine algae from Southeastern Queensland III. *Laurencia* Lamx. *Univ. Queensl. Press* **3** (19), 159–191, pls. 1–13.

Kylin, H. (1923). Studien über die Entwicklungsgesichte der Florideen. *Kungl. Sv. Vet.-Akad. Handl.* **63** (11), 1–139, figs. 1–82.

Okamura, K. (1931). On the marine algae from Kôtôsho (Botel Tobago). *Bull. Biogeog. Soc. Jap.* **2** (2), 95–122, pls. 10–12.

——— (1936). *Nippon Kaiso-shi* [*Marine algal flora of Japan*]. 964 p. (In Japanese). Tokyo.

Saito, Y. (1956). List of the marine algae from Nou, Echigo Province, and its vicinity. *Bull. Fac. Fish., Hokk. Univ.* **7** (2), 96–108, figs. 1–7. (In Japanese with English summary).

——— (1960). Notes on some marine algae from Nou, in Echigo, and vicinity (3). *Bull. Jap. Soc. Phyc.* **8** (3), 85–90, 1 pl., textfigs. 1–2. (In Japanese with English summary).

——— (1961). Ditto (5). *Ibid.* **9** (2), 41–47, figs. 1–4. (In Japanese with English summary).

——— (1963). On the arrangement of tetrasporangia in the stichidia of *Laurencia*. *Ibid.* **11** (3), 114–117, figs. 1–2. (In Japanese with English summary).

Takamatsu, M. (1939). Marine algae from the coast of Japan Sea in Northeastern Honshu, Japan. *Saito Ho-on Kai Mus. Res. Bull.* **17**, Bot. 6, 21–83, pls. 5–13, 1 textfig.

Yamada, Y. (1931). Notes on Laurencia, with special reference to the Japanese species. *Univ. Calif. Publ. Bot.* **16** (7), 185–310, textfigs. 1–20 (A–T).

——— (1932). Notes on some Japanese algae IV. *Jour. Fac. Sci., Hokk. Imp. Univ.* **2** (2), 267–276, pls. 3–9, textfigs. 1–3.

——— & Segawa, S. (1953). On some new or noteworthy algae from Hachijo Island. *Rec. Oceanog. Works Jap.* (*new series*) **1** (1), 109–114, figs. 1–7.

EXPLANATION OF PLATES

PLATE I

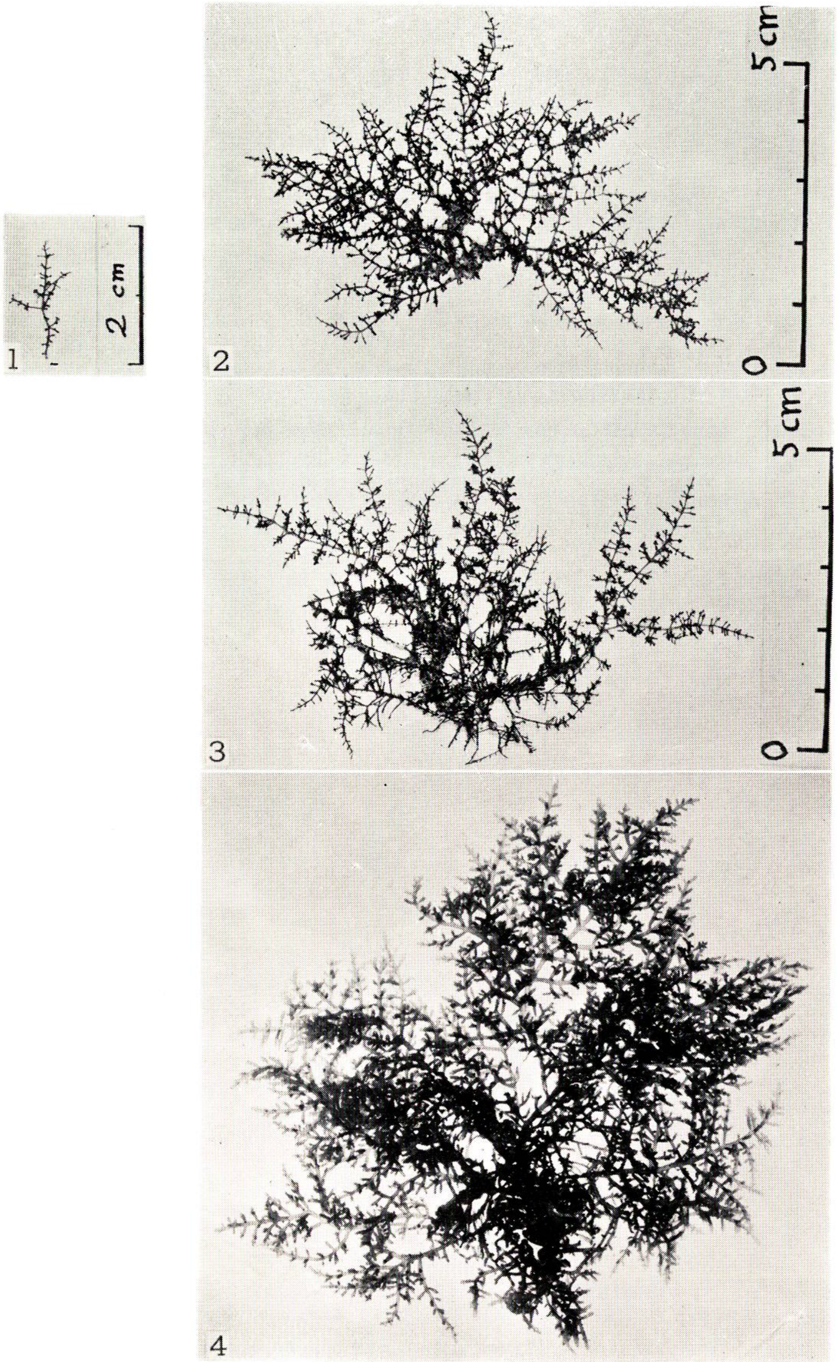
Laurencia venusta Yamada

Fig. 1. Fragment of a male specimen (All of the specimens shown in Pl. I and Pl. 2, Figs. 1–3 were collected at Moheji, Hokkaido, on September 13, 1963)

Fig. 2. Habit of a herbarium female specimen

Fig. 3. Habit of a herbarium tetrasporangial specimen

Fig. 4. Habit of a tetrasporangial plant preserved in formalin-seawater. ×9/10



Y. Saito: Morphology of the genus *Laurencia* of Japan. I

PLATE II

Lyurencia venusta Yamada

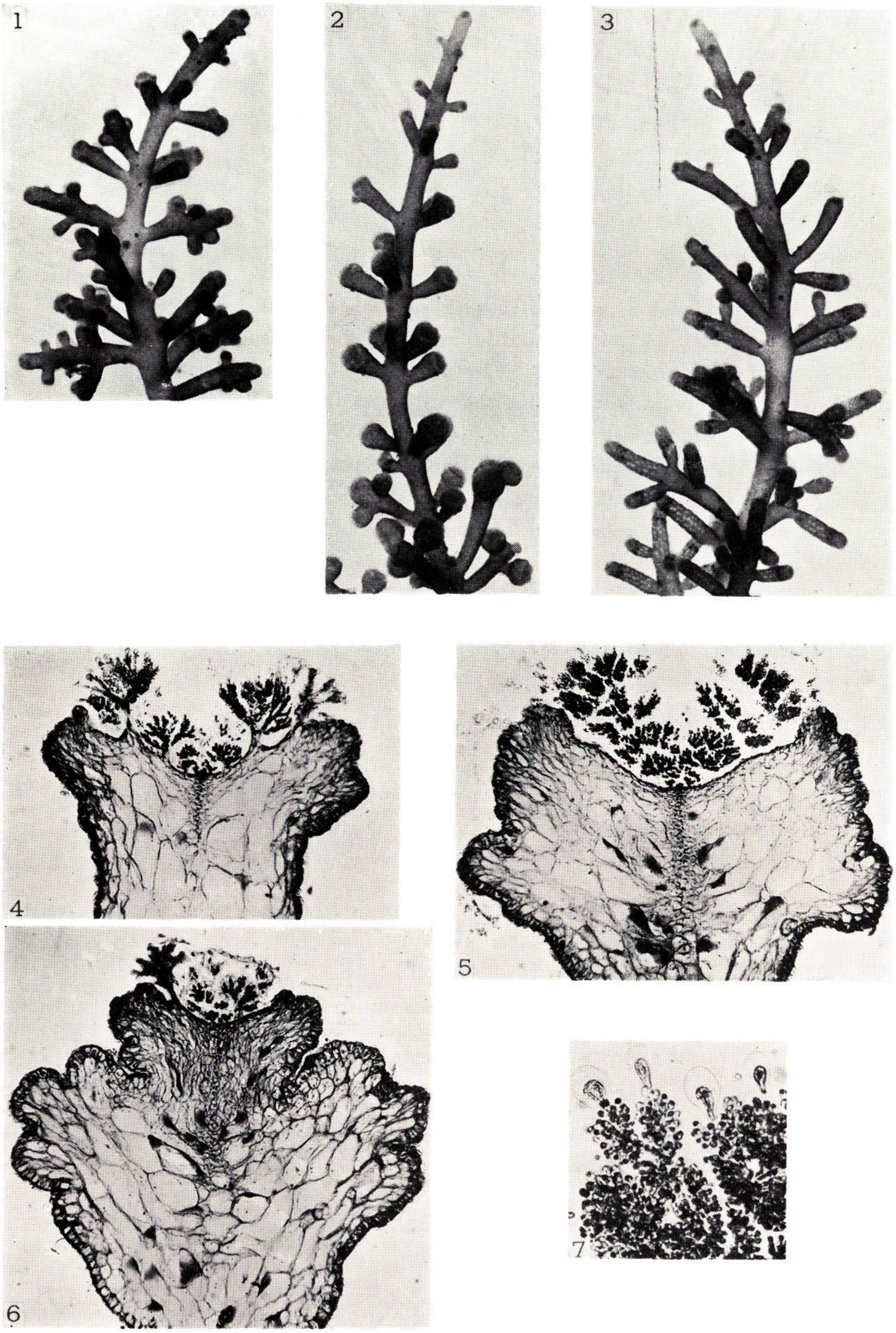
Fig. 1. Part of a female plant. ×6

Fig. 2. Part of a male plant. ×6

Fig. 3. Part of a tetrasporangial plant. ×6

Figs. 4–6. Longitudinal section through three antheridial receptacles to show various stages of their development. ×72

Fig. 7. A group of antheridia from a smeared preparation. ×256



Y. Saito: Morphology of the genus *Laurencia* of Japan. I

PLATE III

Laurencia vensta Yamada

Fig. 1. Part of apical portion of longitudinal section through a fertile branchlet of a female plant, showing the growing point (g) and a procarp (p). ×800 (cf. Pl. VII, Fig. 2)

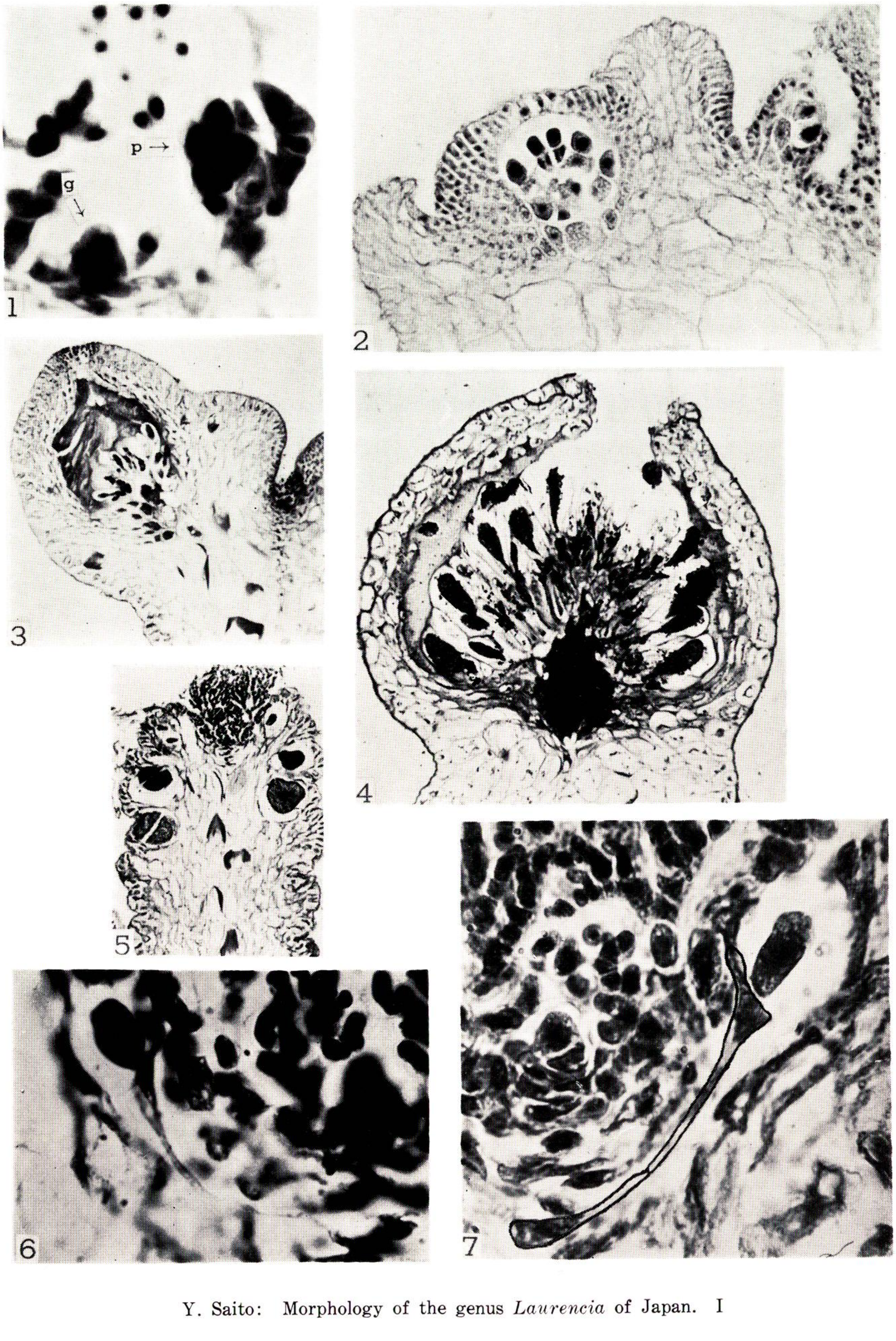
Fig. 2. Showing a procarp near the growing point in the apical depression and a young cystocarp removed towards the lateral of the fertile brachlet. ×320

Fig. 3. Longitudinal section through a fertile branchlet showing a young cystocarp. ×80

Fig. 4. Longitudinal section through a mature cystocarp. ×95

Fig. 5. Longitudinal section through a stichidial branchlet. ×80

Figs. 6 & 7. Part of apical portion of longitudinal section through a stichidial branchlet, showing a tetrasporangium-initial on an elongated pericentral cell which is connected with an elongated axial cell; the details were made clear by hard constrast in Fig. 6 (cf. Pl. VIII, Fig. 1) and by inking in Fig. 7. ×800



Y. Saito: Morphology of the genus *Laurencia* of Japan. I

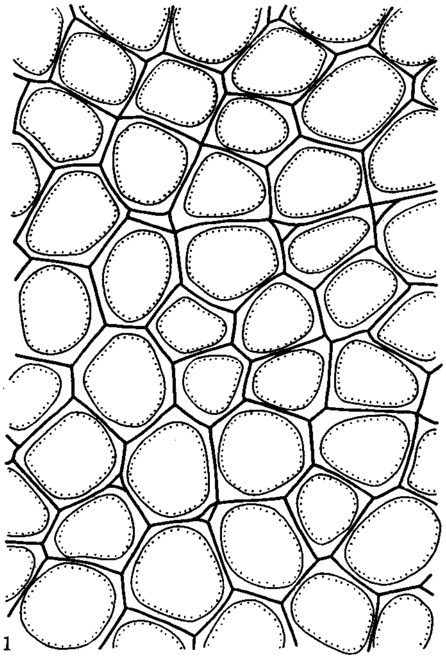
PLATE IV

Laurencia venusta Yamada

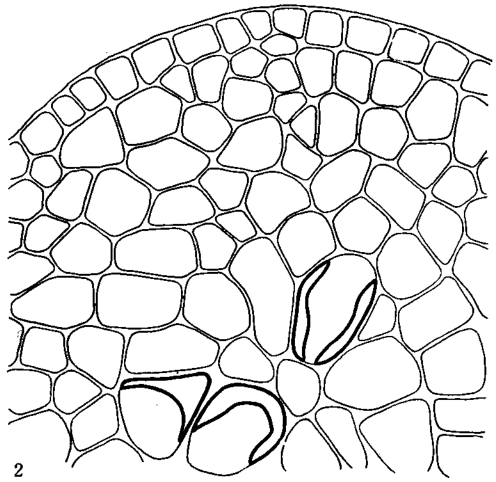
Fig. 1. Surface view of main axis

Fig. 2. Part of transverse section through a branchlet

Fig. 3. Part of longitudinal section through the apical portion of a branchlet



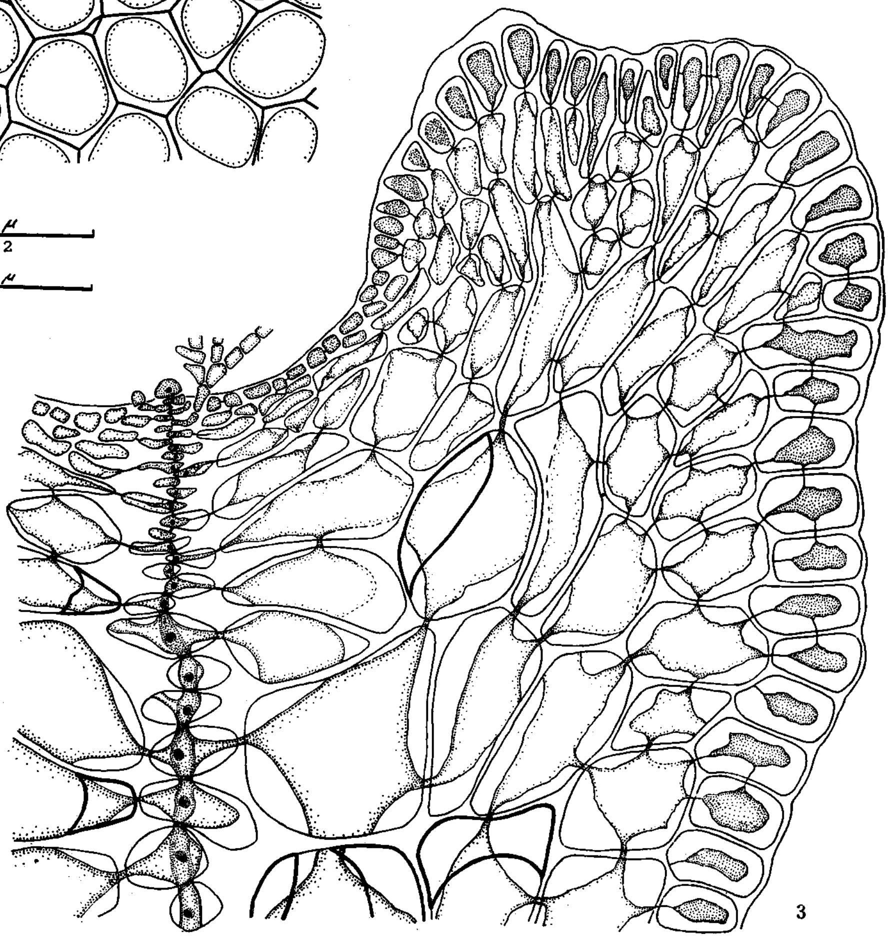
1



2

100 μ
1, 2

50 μ
3



3

Y. Saito: Morphology of the genus *Laurencia* of Japan. I

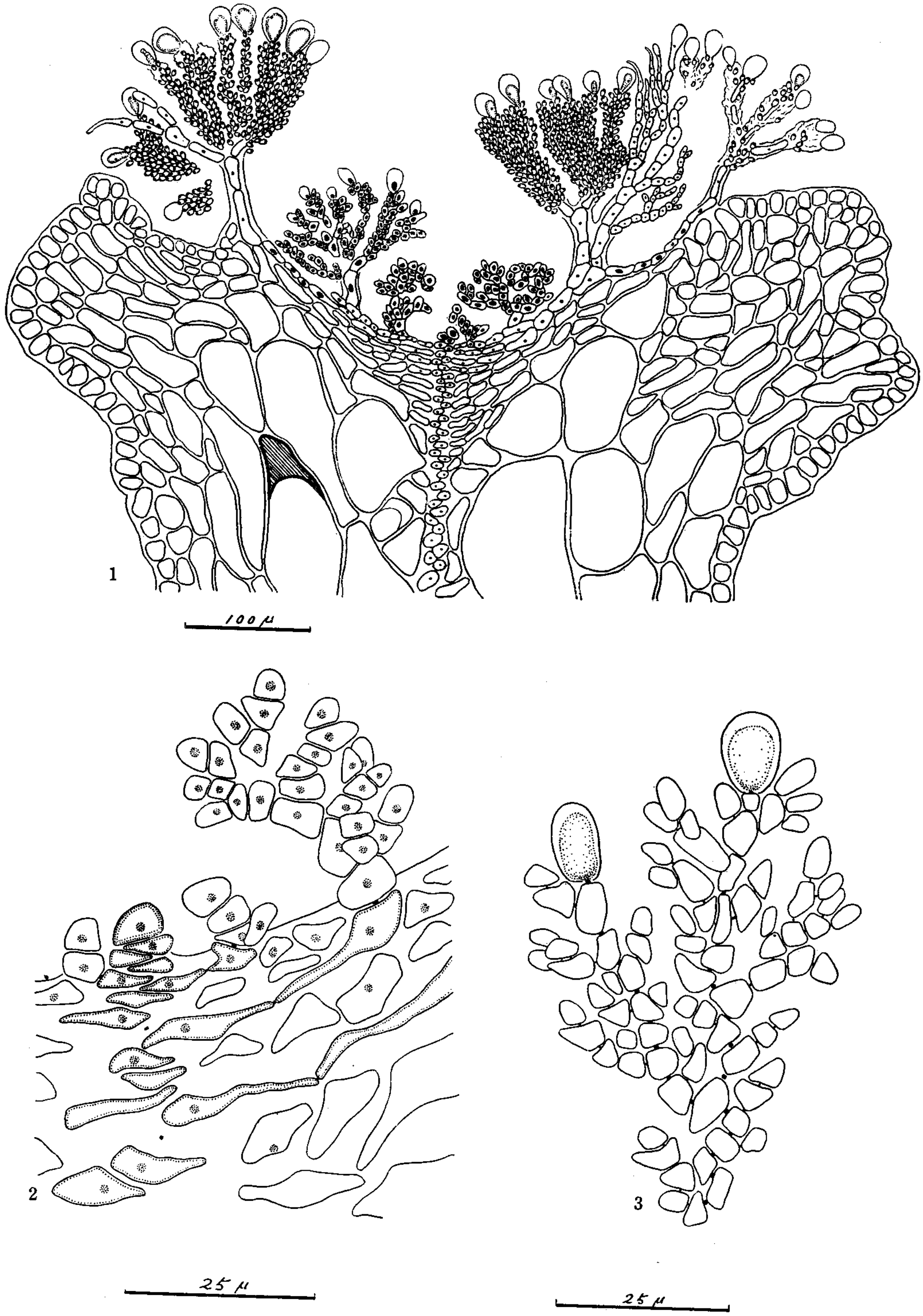
PLATE V

Laurencia venusta Yamada

Fig. 1. Longitudinal section through the apical portion of an antheridial receptacle

Fig. 2. Part of the apical portion of a longitudinal section through the antheridial receptacle, showing the growing point and an antheridium-initial

Fig. 3. A young antheridium



Y. Saito: Morphology of the genus *Laurencia* of Japan. I

PLATE VI

Laurencia venusta Yamada

Figs. 1 & 2. Apical portion of a mature antheridium in a smeared preparation

Fig. 3. Transverse section through an antheridium

Fig. 4. A young trichoblast

Y. Saito: Morphology of the genus *Laurenica* of Japan. I

PLATE VII

Laurencia venusta Yamada

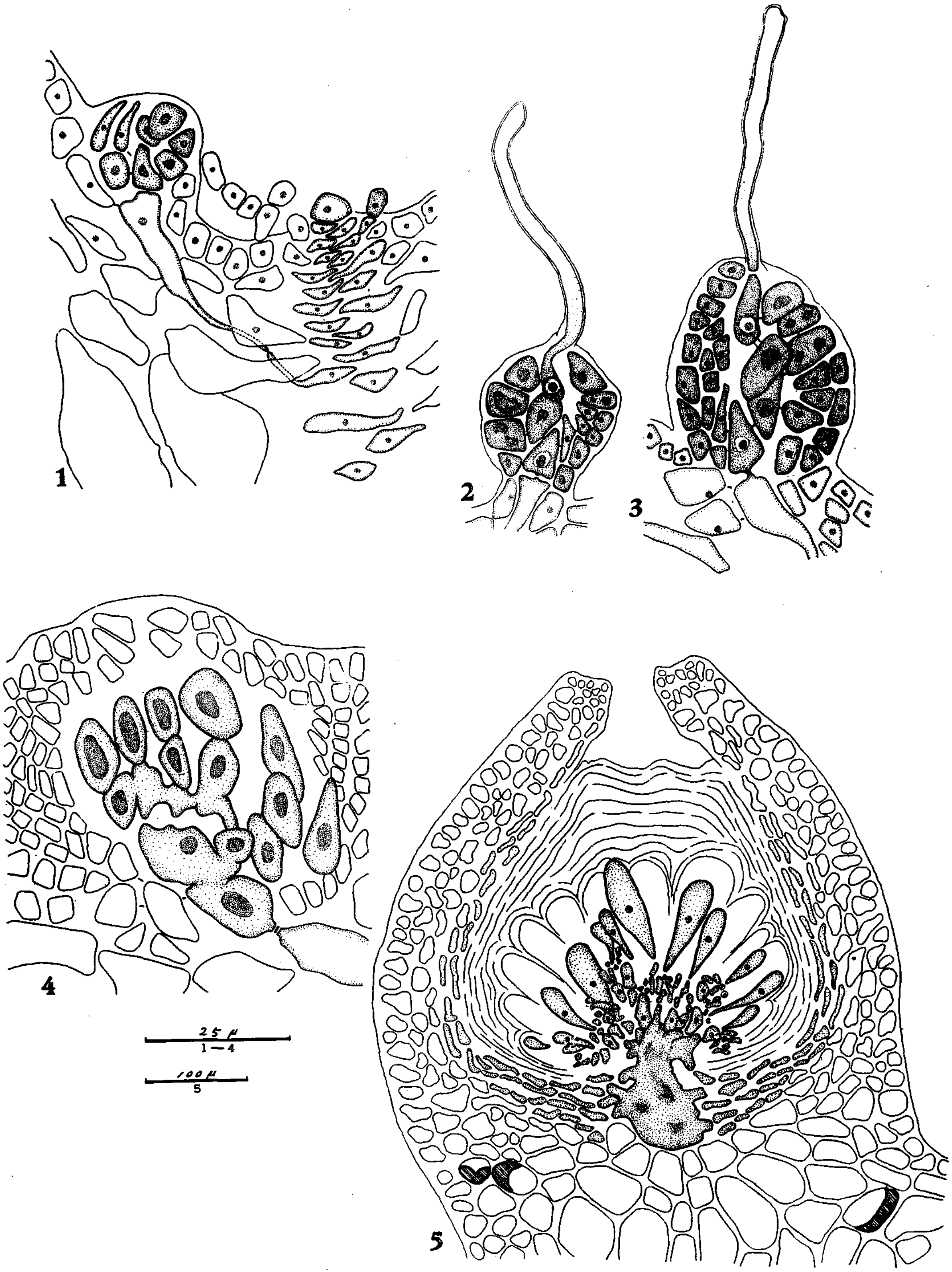
Fig. 1. Part of an apical portion of a longitudinal section through a fertile branchlet of a female plant, showing the growing point and a young procarp on an elongated pericentral cell

Fig. 2. Longitudinal section through a procarp which is ready for fertilization (cf. Pl. III, Fig. 1)

Fig. 3. Longitudinal section through a procarp after fertilization; carpogonium is fused with auxiliary cell

Fig. 4. Longitudinal section through a young cystocarp, showing fusion cell and gonimoblast-initials

Fig. 5. Longitudinal section through a ripe cystocarp



Y. Saito: Morphology of the genus *Laurencia* of Japan. I

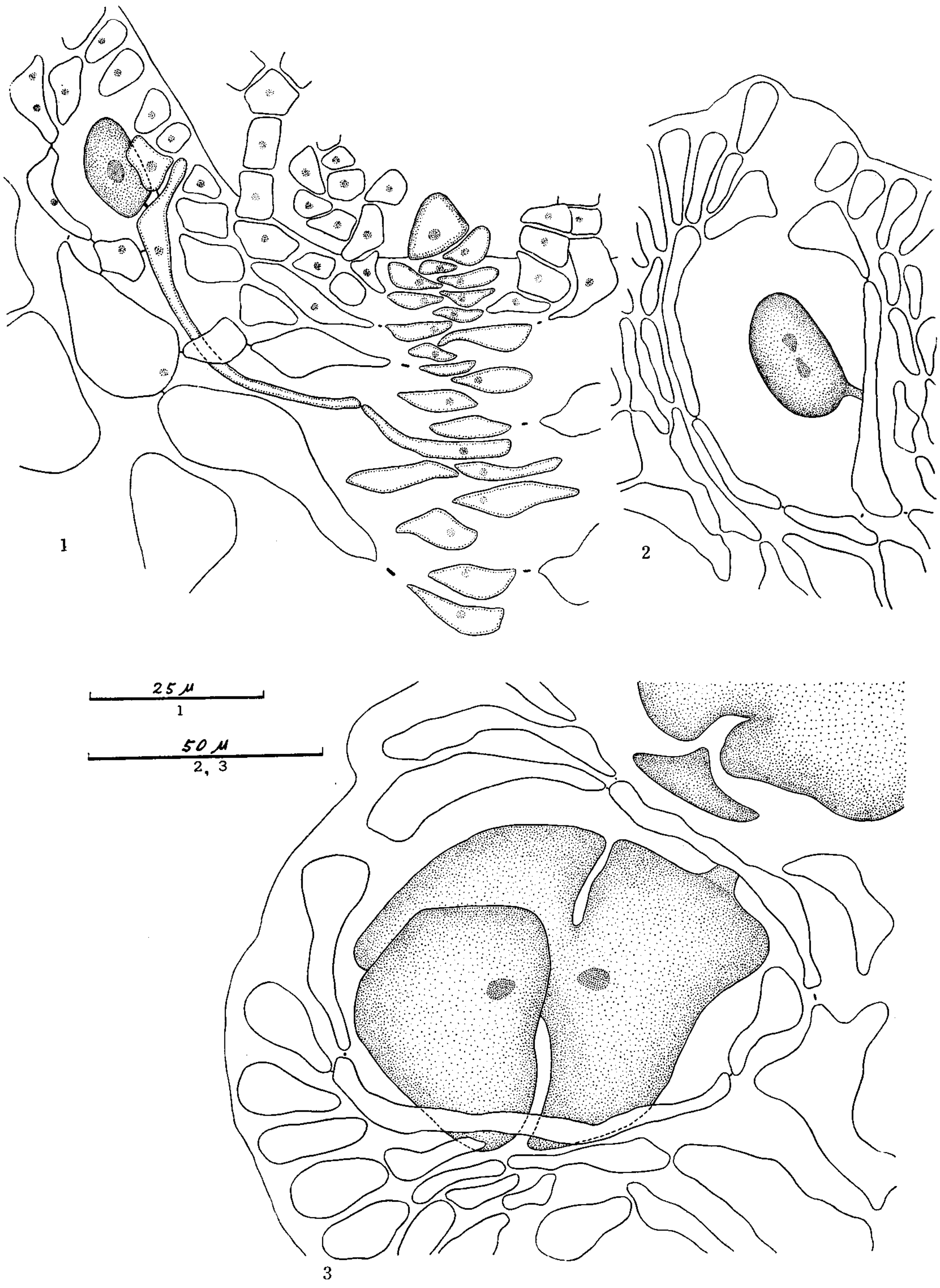
PLATE VIII

Laurencia venusta Yamada

Fig. 1. Part of a longitudinal section through a stichidial branchlet, showing the growing point and tetrasporangium-initial on an elongated pericentral cell (cf. Pl. III, Fig. 6)

Fig. 2. Ditto, showing a tetrasporangium near the periphery of the apical depression of the branchlet

Fig. 3. Ditto, showing a divided tetrasporngium on the lateral of the branchlet



Y. Saito: Morphology of the genus *Laurencia* of Japan. I