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Observations on *Vanvoorstia spectabilis* Harvey and *V. coccinea* Harvey (Delesseriaceae, Rhodophyta) from southern Japan

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The differences between *Vanvoorstia spectabilis* Harvey and *V. coccinea* Harvey (Delesseriaceae, Rhodophyta) were verified on Japanese materials. *V. spectabilis* has uncorticated blades consisted of smaller cells and tetrasporangial bladelets with 4 tetrasporangia in each segment, while in *V. coccinea* blades are corticated and tetrasporangial bladelets are terete and 5 tetrasporangia are produced in each segment. *V. spectabilis* is distributed in Yaeyama district of Okinawa Prefecture. The distribution range of *V. coccinea* is Okinawa Island to Kyushu and the Pacific coast of Honshu to Izu Islands.

Key Index Words: Delesseriaceae, Distribution, Morphology, Rhodophyta, Vanvoorstia coccinea, Vanvoorstia spectabilis, *Taxonomy.*

Vanvoorstia Harvey, a genus of the Delesseriaceae, is characterized by its intricate net-forming structure, with 2 species originally reported from Srilanka (Ceylon): *V. spectabilis* Harvey (1854: 144) and *V. coccinea* Harvey ex J. Agardh (1863: 1271). The third species, *V. bennetiana* (Harvey) Papenfuss, is known only from its type collection and morphological detail is yet unknown at present (Miller & Kraft, 1993). The genus has wide distribution range from Indian Ocean to warmer parts of Pacific Ocean through Indonesia.

Okamura (1900) reported a species of *Vanvoorstia* from Kashiwajima, Kochi Prefecture and identified it as *V. spectabilis*. He (1916) applied a name *Implicaria reticulata* Heydrich to the same species, but later he (1936) used again the name *V. spectabilis*, placing *Implicaria* as its synonym. After the detailed study on two species of *Vanvoorstia* by Papenfuss (1937), clarifying the difference between *V. spectablis* and *V. coccinea*, Segawa (1939) reexamined the materials from Izu Ooshima and Hachijyo Islands on the Pacific coast of central Honshu. He observed in his materials corticated blades and terete tetrasporangial stichidia-like bladelets characteristic to *V. coccinea*, and proposed to use this name for the Japanese plants. We noticed that another species of *Vanvoorstia* in the collections from Yaeyama district of Okinawa Prefecture, south Japan. Closer examination revealed that this species is attributable to *V. spectabilis*. New informations are given here on morphology of female structures in these two species.

Materials and Methods

Following specimens deposited in the herbarium of the Faculty of Science, Hokkaido University (SAP), as well as the fresh materials collected by the authors, were used for this study.

Vanvoorstia spectablis Harvey

Specimens examined: Miyakojima Island, Okinawa Pref., Oct. 1, 1984. Leg. Y. Nakajima. SAP slide. Miyakojima Island, Okinawa Pref., Apr. 10, 1935. Leg. T. Tanaka, SAP 058952,3. Ishigaki Island, Okinawa Pref., Apr. 13, 1935. Leg. T. Tanaka, SAP 058951. Kuroshima Island, Okinawa Pref., June 4, 1992. Leg. T. Waji-

ma, SAP 057853. Kerama, Okinawa Pref., no date, anonymous, SAP 059145.

Vanvoorstia coccinea Harvey

Specimens examined: Ooshima Island, Tokyo Pref., July 2, 1935. Leg. S. Segawa, SAP 031058. Hachijyo-jima, Tokyo Pref., July, 1930. Leg. Matsumoto, SAP 059157. Shirahama, Wakayama Pref., Apr. 7, 1957. Leg. T. Yamamoto, SAP 041978. Muroto, Kochi Pref., Mar. 30, 1930. Leg. K. Oshima, SAP 059158. Shimizu, Kochi Pref., June 20, 1954. Leg. I. Umezaki, SAP 035132. Kashiwajima, Kochi Pref., no date, anonymous, SAP herb. Okamura. Hyuga, Miyazaki Pref., no date, SAP 059148. Nomozaki, Nagasaki Pref., Apr. 28, 1977. Leg. T. Yotsui, SAP 035137. Tomioka, Kumamoto Pref., May 5, 1958. Leg. T. Yoshida, SAP 049906. Koshikijima Island, Kagoshima Pref., Aug. 1923. Leg. Y. Yamada, SAP 027175. Okinoerabu Island, Kagoshima Pref., July 26, 1979. Leg. M. Baba, SAP 056146. Henoko, Okinawa Pref., Mar. 9. 1990. Leg. T. Yoshida, SAP 055138-40. Ginoza, Okinawa Pref., Mar. 28, 1955. Leg. I. Nakata, SAP 045818.

Small pieces of the thallus were mounted in glycerin on a glass slide after soaking in water and being stained with aqueous aniline blue. Sections were made by hand with a razor blade.

Observations

Vanvoorstia spectabilis

Thallus (Fig. 1) is composed of several orders of blades. Long blades produce daughter blades from alternate central cells on the dorsal side. Short blades of next order are formed in a similar manner and they anastomose at their apices with the ventral surface of a blade to form a net-work.

Growth of the blades takes place by the activity of an apical cell dividing with transverse wall (Fig. 2). No intercalary cell division occurs in the cells of the first order. Apical cells of 2nd and 3rd order cell rows reach the margin. Margin of the blade is entire (Figs. 3, 6). The blades of all orders are uncorticated except midrib. Central cells or first order cells cut off ventral and dorsal pericentral cells after lateral pericentral cells are formed. Ventral pericentral cells are usually larger than dorsal ones. Alternate segments of central cells cut off a second pericentral cell on the dorsal surface. This second pericentral cell is the daughter blade primordium (dbp) to initiate daughter blades (Fig. 4). The daughter blade primordium soon divides to form initial cell (i_2) and basal segments (seg_1), which cuts off initial (i_2) of the second order cell row of the daughter blade (Fig. 3). Distal cells of short blades elongate forming filamentous cells (el) to prepare anastomosis (Fig. 3). Fig. 6 shows the disposition of 3 daughter blades produced acropetally. In Fig. 5, 4 orders of blades are illustrated in an optical longitudinal section.

Procarp is not observed in the materials at hand. Mature plants were collected in April. Cystocarps are developed on small bladelets of ultimate order. Apices of fertile bladelets are free from anastomosis. Cystocarps are spherical in shape, about 1 mm in diameter, and emergent from the mesh when fully grown up. In mature cystocarp (Fig. 9), a fusion cell is located at the base of gonimoblasts. Carposporangia are formed singly, terminal on the gonimoblast filaments. Carpostome is not protruded.

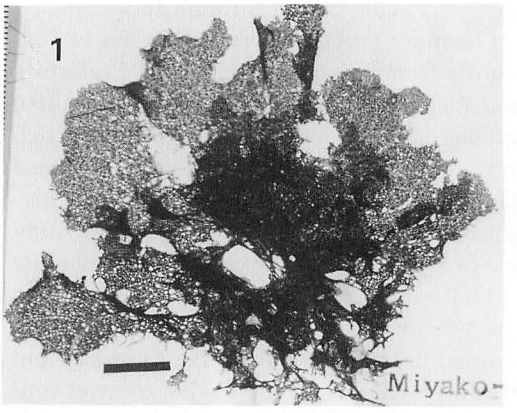
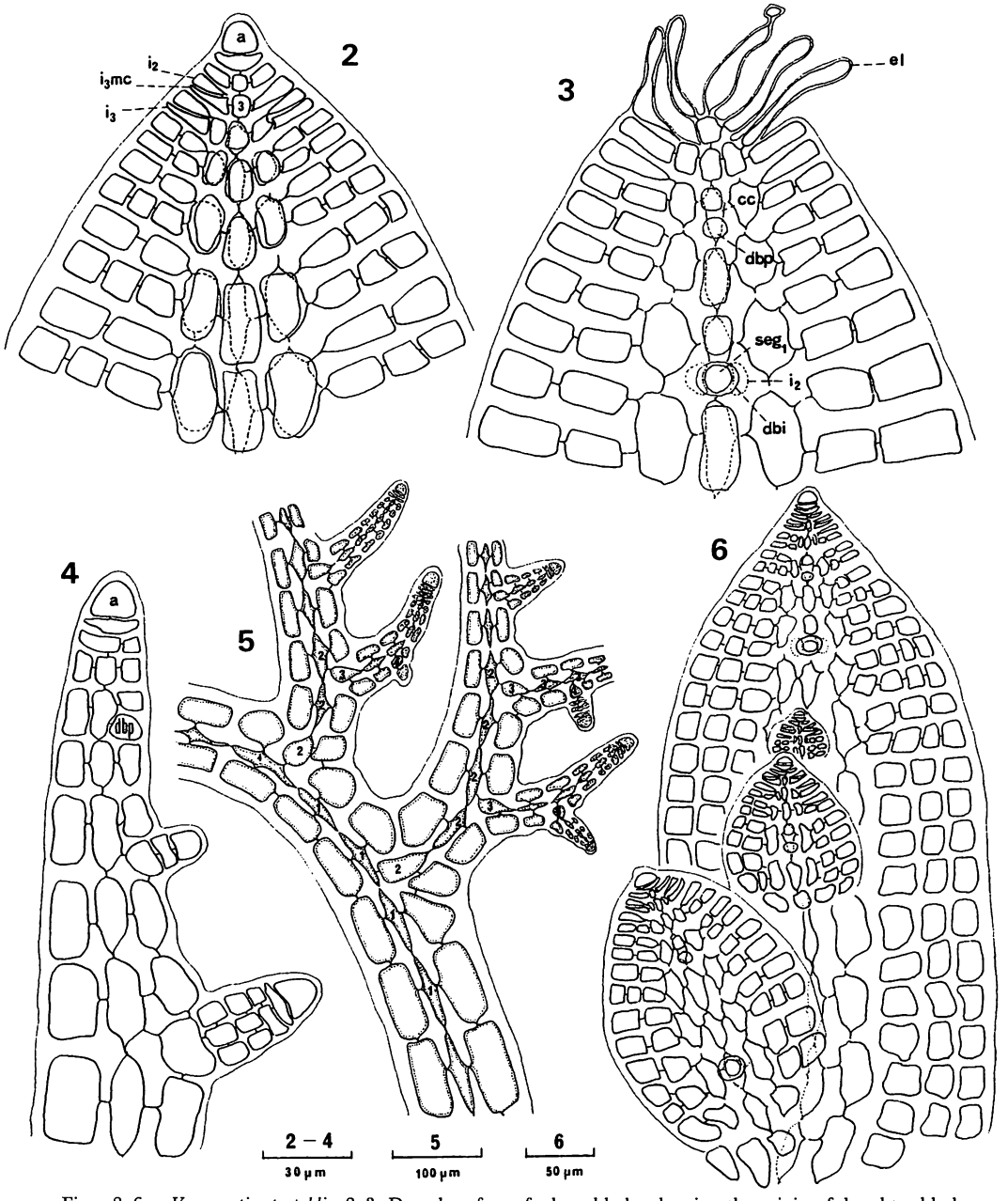
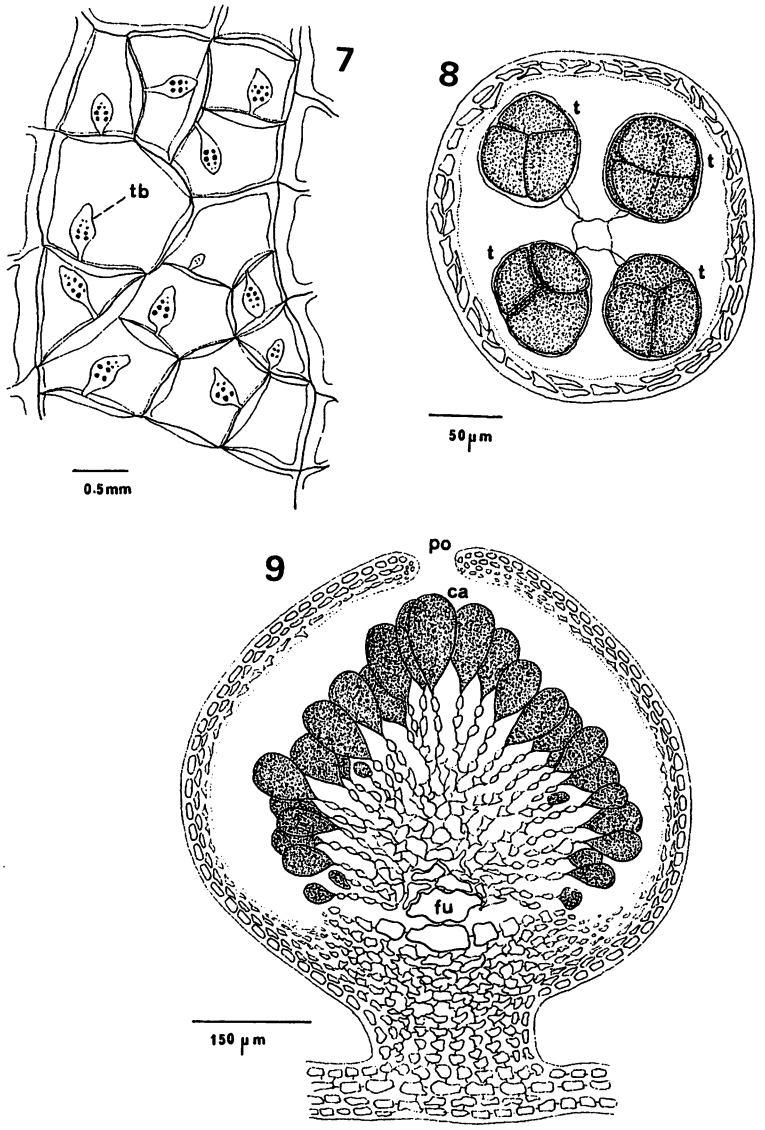


Fig. 1. *Vanvoorstia spectabilis* Harvey. A specimen collected at Miyakojima, Okinawa Pref., Apr. 10, 1935. Leg. T. Tanaka. SAP 058952.



Figs. 2–6. *Vanvoorstia spectablis*. 2–3. Dorsal surface of a long blade, showing the origin of daughter blades. a, apical cell; cc, central cell; dbp, daughter blade primordium; dbi, daughter blade initials; el, elongation of the distal cells; i_2, i_3, secondary and tertiary initials; i_3 mc, mother cell of tertiary initial; seg_1, basal segment of daughter blade; 3, third segment from apex. 4. Optical median longitudinal section of a long blade. 5. Optical median longitudinal section of four different orders (1–4) of the blades. 6. Dorsal surface of a long blade with daughter blades.



Figs. 7–9. *Vanvoorstia spectabilis*. 7. Portion of thallus bearing tetrasporangial bladelets (tb). 8. Cross section of tetrasporangial bladelet. t, tetrasporangium. 9. Median longitudinal section of an almost mature cystocarp. ca, carpospores; fu, fusion cell; po, aperture of cystocarp.

The short blades of ultimate orders are transformed into tetrasporangial bladelets, which are free at the apical part without forming anastomose with other blades (Fig. 7). In the early stage of development, the bladelets are slightly compressed, then they become thick and nearly terete in cross section (Fig. 8). Four tetrasporangia are produced in each segment, one from the dorsal, ventral and lateral pericentral cells.

Vanvoorstia coccinea

Thallus (Fig. 10), measuring up to 30 cm or more in diameter, is fine network constructed from several orders of blades. Mesh of the network becomes coarse when well grown up.

Apical organization and the mode of formation of network is similar to those of *V. spectabilis*, though the size of cells constructing the blade is nearly twice larger than the latter species. An apical cell divides with transverse

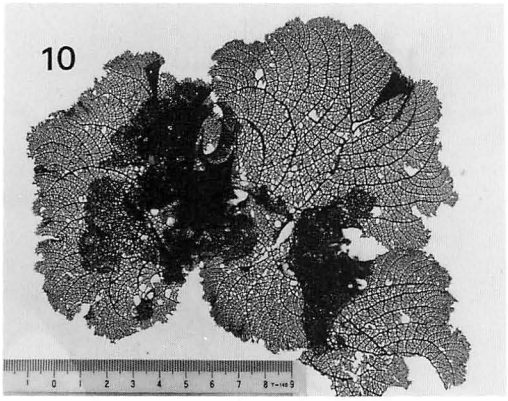


Fig. 10. *Vanvoorstia coccinea* Harvey. A specimen from Shirahama, Wakayam Pref., Apr. 6, 1957. Leg. Y. Tsuji. SAP 058996.

wall to form the cell row of the first order, in which no intercalary cell division takes place. Cells of the first order give rise to lateral pericentral cells that issue cell rows of second order, then in turn third order. Apical cells of the second and third order cell rows reach the margin. Rarely no third order cell row is produced (Fig. 11). Ventral and dorsal pericentral cells (dpc) are cut off from the cells of central cells. Primary cells of the blade give rise to cortical cells (cortc), and the blade become thickened with cortication (Fig. 15). Alternate central cells produce second dorsal pericentral cells from proximal part. This second dorsal pericentral cell is the primordium of daughter blade, and soon divides into basal segment (seg_1) and initial cell (dbi) of the daughter blade (Fig. 11, 13). The mode of net formation is the same as in *V. spectabilis*. Fig. 13 is an optical median longitudinal section showing daughter blade initial (dbi) and basal sagment (seg_1). Fig. 14 illustrates a case in development of successive order of blades forming net structure in the optical median section of through central cells.

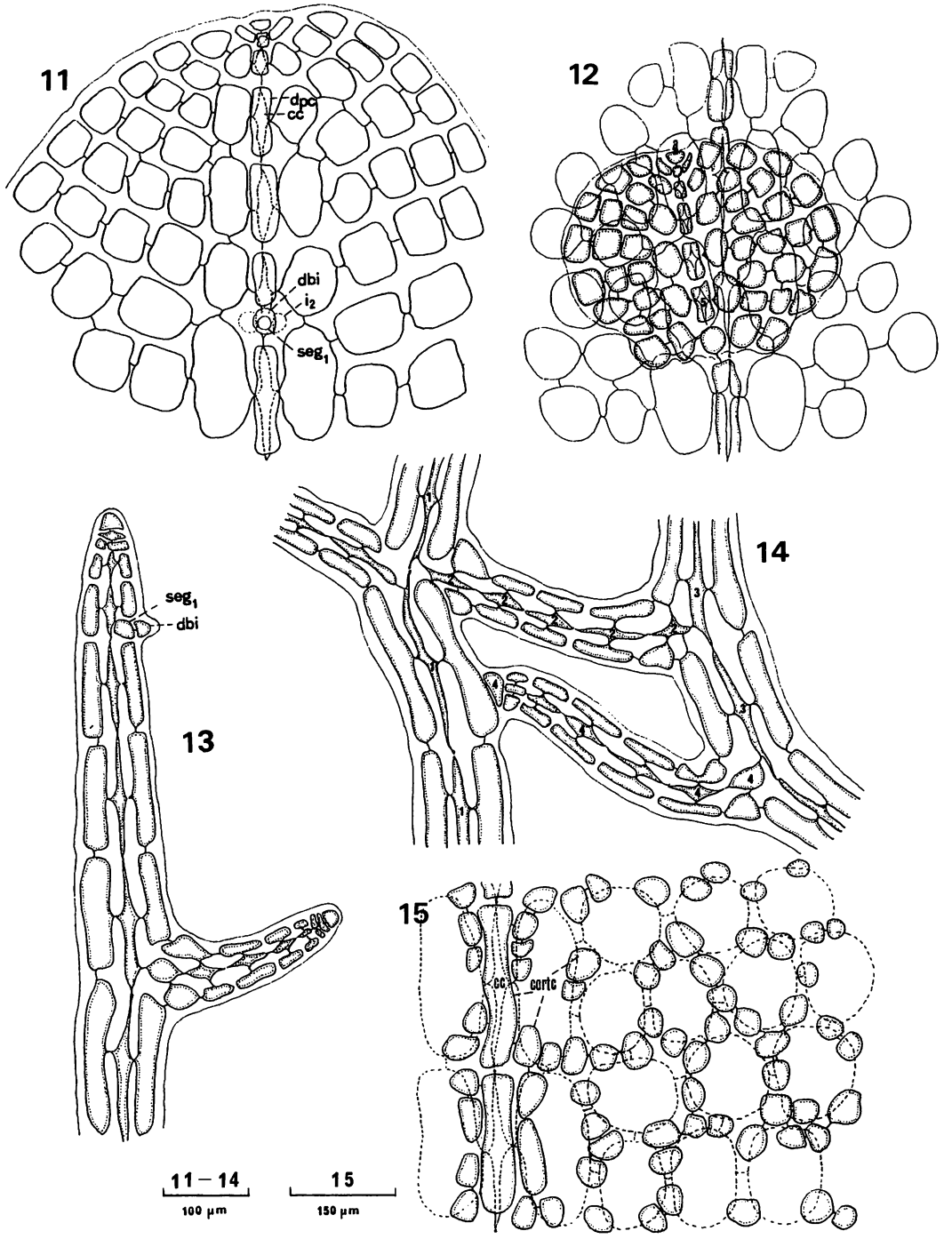
Mature materials were collected at Okinawa Island in March. Procarps are formed on the dorsal side of midrib of ultimate order bladelets. The procarp is composed of a 4-celled carpogonial branch and 2 groups of sterile cells on a supporting cell (Fig. 16). In the carpogonial branch, cb_2 is the largest and cb_3 is the smallest in size. First group of sterile cell divides into 2 cells before fertilization while second sterile cell remain undivided. Fig. 17 shows young cystocarp with short gonimoblast filaments (gon) growing from the auxiliary cell. Carposporangia are formed singly, terminal on the gonimoblast as seen in Figs. 18 and 19. In mature cystocarp, a large fusion cell (fu) is formed at the base of gonimoblasts. Cystocarps are spherical in shape. The apical part of the cystocarp is free from anastomosis and emergent from the mesh when mature. Carpostome is not protruded as in *V. spectabilis*.

Tetrasporangial bladelets are transformed from bladelets of ultimate order. They are terete even in early stage of development and have no wings. Fig. 21 is a longitudinal section including central cell, showing lateral pericentral cells (lpc) which give rise to a tetrasporangium in each segment. Dorsal surface view is shown in Fig. 22. Here, both of 2 dorsal pericentral cell (dpc) cuts off a tetrasporangium at each segment. From the ventral side (Fig. 23), a ventral pericentral cell (vpc) at each segment is seen with a tetrasporangium. In cross section of tetrasporangial bladelet (Fig. 24), five tetrasporangia are observed at each segment. They are composed of 2 on lateral pericentral cells, 2 on dorsal pericentral cells and one on ventral pericentral cell.

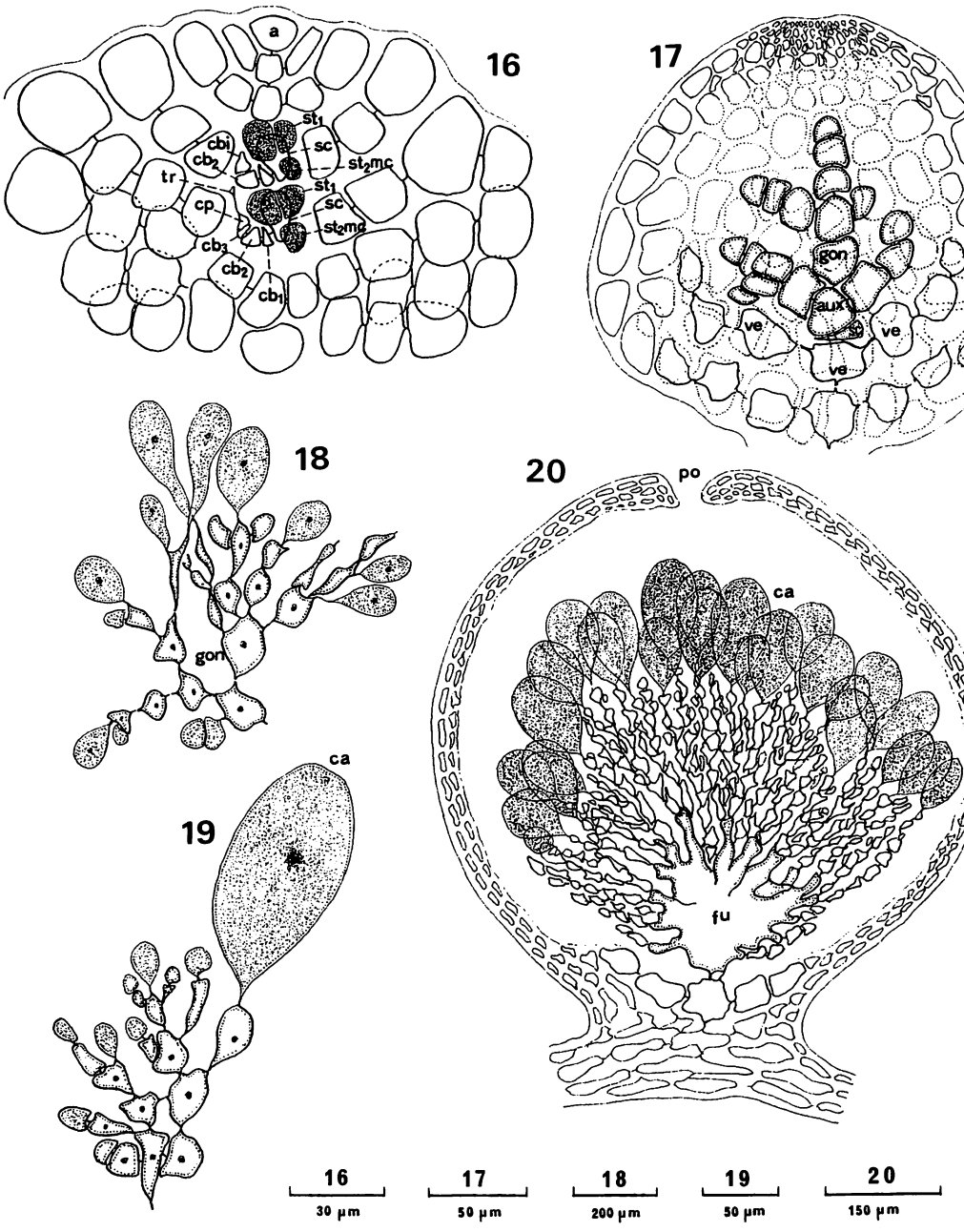
Remarks

Papenfuss (1937) gave a detailed description on the development of procarp and young cystocarp in *V. spectabilis*. We observed mature cystocarp in this species. Female reproductive structure was first given here for *V. coccinea*. Procarp structure is of a type with a carpogonial branch and 2 groups of sterile cells on a supporting cell, common in the family.

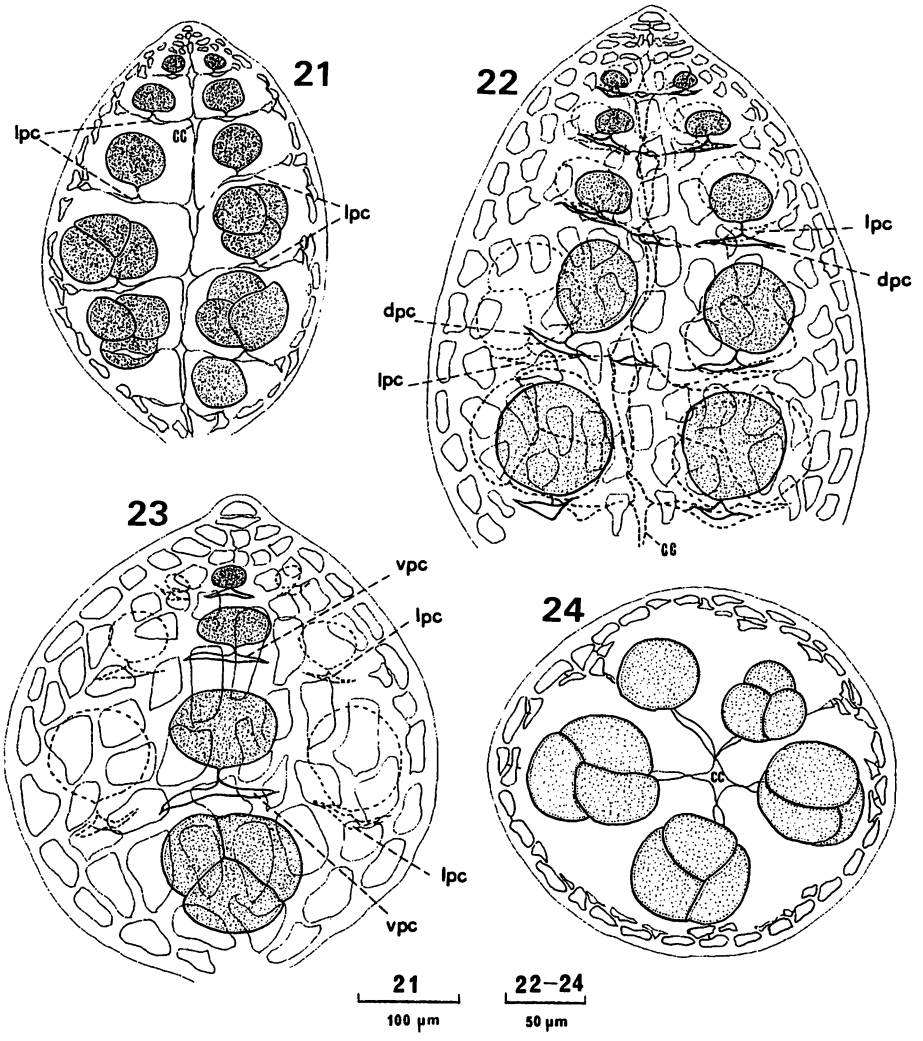
Tetrasporangial bladelets in *V. spectabilis* are slightly compressed at an early stage and become nearly terete without wings as shown in a figure given by Papenfuss (1937, fig. 55). His fig. 56 is much similar with our



Figs. 11–15. *Vanvoorstia coccinea*. 11–12. Dorsal surface of a long blade, showing the origin of daughter blades. For abbreviation see Figs. 2–6. 13. Optical median longitudinal section of a long blade. 14. Optical median longitudinal section of four different orders (1–4) of the blades. 15. Dorsal surface of blade, showing the mode of cortication. cortc, cortical cells.



Figs. 16–20. *Vanvoorstia coccinea*. 16. Dorsal surface of a blade, showing the procarp. cb_1–$_3$, first, second and third cells of carpogonial branch; cbi, carpogonial branch initial; cp, carpogonium: sc, supporting cell; st_1, first group of sterile cells; st_2 mc, mother cell of second group of sterile cells; tr, trichogyne. 17. Young cystocarp. aux, auxiliary cell; gon, gonimoblast; sc, supporting cell; ve, vegetative cells. 18–19. Gonimoblasts with terminal carposporangia. 20. Median longitudinal section of an almost mature cystocarp. ca, carpospores; fu, fusion cell; po, aperture of cystocarp.



Figs. 21–24. *Vanvoorstia coccinea*. 21. Optical median longitudinal section of a tetrasporangia-bearing bladelet. cc, central cell; lpc, lateral pericentral cells. 22. Dorsal surface of a tetrasporangia-bearing bladelet. dpc, dorsal pericentral cells. 23. Ventral surface of a tetrasporangia-bearing bladelet. vpc, ventral pericentral cells. 24. Cross section of tetrasporangia-bearing bladelet, showing five tetrasporangia.

materials at hand.

Segawa (1939) noted 4–6 tetrasporangia in each segment in *V. coccinea*. We observed 5 tetrasporangia in a segment in our materials.

In accordance with Okamura (1936) and Segawa (1939), we agree that the genus *Implicaria* Heydrich is synonymous with *Vanvoorstia*. As for species, however, it is difficult to conclude whether *I. reticulata* is conspecific with *V. spectabilis* or *V. coccinea*. Heydrich (1902) described his species basing on the specimens from Kerama Island, Loochoo (Okinawa Prefecture). Sizes of tetrasporangia (40 μm) and tetrasporangial stichidia (170 × 250 μm) given by Heydrich is nearing those of our materials of *V. spectabilis*. As shown above, our specimen from Kerama Island (SAP 059145) is referable to *V. spectabilis*.

Distribution of these 2 species of *Vanvoorstia* is shown in Fig. 25, compiled from the specimens deposited in SAP. *V. spectabilis* is distributed from Kerama Island to the west in Miyako, Ishigaki and Kuroshima islands.

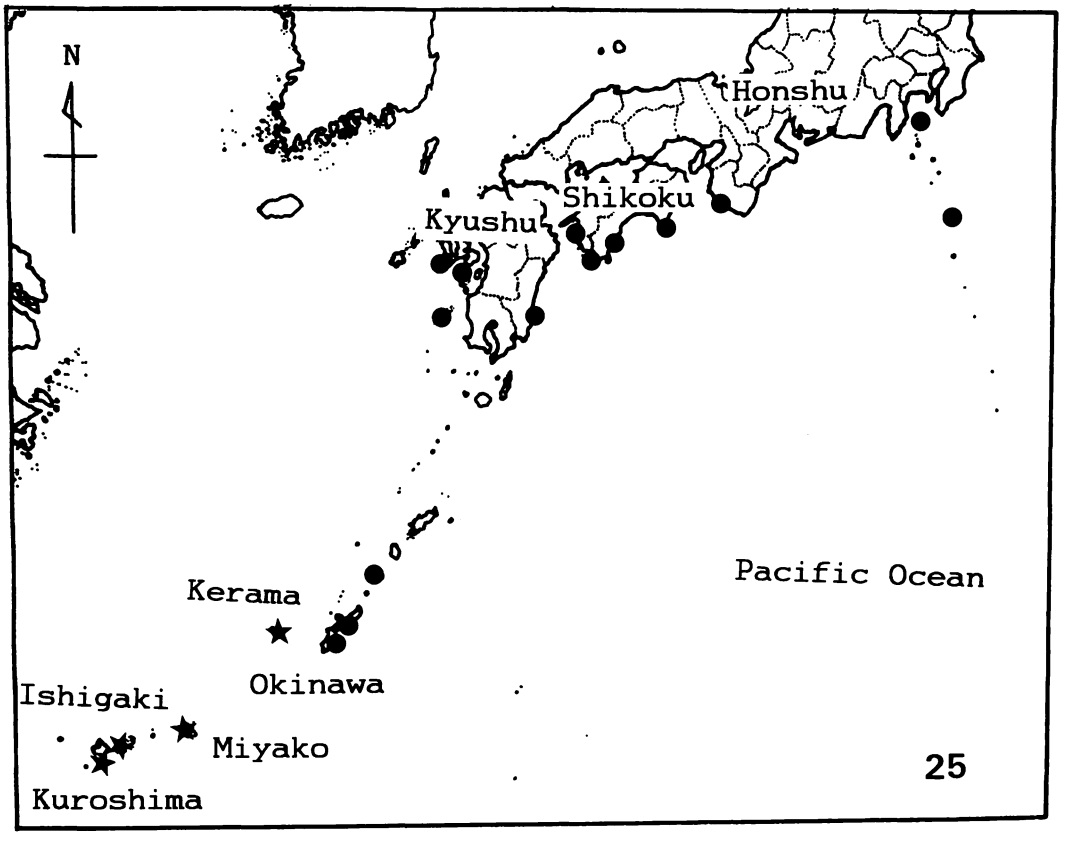


Fig. 25. Distribution of *Vanvoorstia* on the coast of Japan, as compiled from the specimens in SAP. Black circle: *V. coccinea*, Star: *V. spectabilis*.

This species was also recorded in the Philippines (Silva *et al.*, 1987). *V. coccinea*, on the other hand, from Okinawa Island to Ooshima, Tokyo Pref.

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吉田忠生・三上日出夫：ヒメカラゴロモ（新称）*Vanvoorstia spectabilis* とカラゴロモ *V. coccinea*（紅藻コノハノリ科）の形態について

これまで日本産のカラゴロモ属植物はカラゴロモ *Vanvoorstia coccinea* のみであるとされてきた。沖縄県八重山地方の宮古島，石垣島などの標本は葉片に皮層が形成されず，細胞は小形で，また四分胞子嚢は各節に4個づつ形成されるなど，*V. spectabilis* の特徴を持っていることが明らかとなった。この種類にヒメカラゴロモの和名を与えることにする。両種について嚢果形成過程も観察した。カラゴロモは伊豆大島から沖縄本島までの間に分布し，ヒメカラゴロモは慶良間諸島から西に分布することがわかった。（060 札幌市北区北10条西8丁目　北海道大学理学研究科生物科学専攻，062 札幌市豊平区3条7丁目　札幌大学）

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