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On the structure and reproductive organs of *Halosaccion glandiforme* (GMELIN) RUPRECHT, Rhodophyta*

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The vegetative structure and development of reproductive organs of *Halosaccion glandiforme*, the type species of the genus (type locality: Kamchatka), were investigated with materials from Kamchatka, Kurile Islands and Aleutian Islands. The species is characterized by 1) almost straight and rarely branched cortical cell rows in vegetative thallus, 2) bearing hairs, 3) tetrasporangia with a stalk cell occurring among almost straight sterile cell rows, 4) the cells divided from superficial cortical cell producing spermatangial mother cells, and 5) a mother cell producing two spermatangia. Cystocarps are not known. According to this investigation, *H. glandiforme* occurs in the Aleutian Islands from Unalaska to Attu Islands, Kamchatka and Kurile Islands. The ones growing in Pacific North America are known to be a different taxon.

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Halosaccion glandiforme (GMELIN)RUPRECHT, the type species of the genus (type locality: Kamchatka) was first introduced by GMELIN (1768) as *Ulva glandiformis*. RUPRECHT (1851), combining it with the genus *Halosaccion*, discussed precisely the validity of this basionym and the synonyms, *Fucus saccatus* sensu TURNER (1819, pl. 241, figs. a, a, b, c, d left only) and *Dumontia hydrophora* POSTELS et RUPRECHT (1840).

In spite of the early description and wide distribution of this alga, some significant taxonomic characters are still obscure. The nature of spermatangia and cystocarps are quite unknown up to now. Although tetrasporangia have been repeatedly reported (TURNER 1819, RUPRECHT 1851, SPARLING 1961, GUIRY 1974), their development, which may be one of the important characters to discern species (LEE, 1977, 1978), is still unclear.

This paper deals with the structure of the thallus and the development of tetrasporangia and spermatangia of *H. glandiforme*. The procarps and cystocarps are not known as in this genus.

Materials examined

The plants were collected from the Bay of Kronotskiy, Kamchatka on July-August, 1970. The materials from Baby Island of the Aleutian Islands, Alaska, were collected by the members of the Aleutian Expedition

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of Hokkaido University-1975, on August, 1975. Some other herbarium specimens from Kamchatka and Kurile Islands were also examined. Parts of them were preserved in the herbaria, Department of Botany, Faculty of Science, Hokkaido University (SAP) and Faculty of Agriculture, Hokkaido University (SAPA). They were summarized as below:

Kamchatka: Ozernaya, July 29, 1930 (by B. UMENO), 2, sterile plants (SAPA.), Kronotskiy, July 29, 1970, 3 plants (⊕ & sterile), Aug. 2, 1970, 2 plants (⊕), Aug. 4, 1967 (by L.PERESTENKO), 13 plants (sterile), Aug. 1970 (by H. KLOGIOVA), several plants (♂, ⊕ & sterile).

Aleutian Islands: Baby Isl., Aug. 24, 1975 (by S. SATO & K. USHIDA), SAP 032370 (⊕), 032371 (♂), 032373-4 (⊕). Attu Isl., Aug. 17, 1975 (by N. MASUDA), 1 plant (sterile). Atka Isl., May-June, 1931 (by Y. KOBAYASHI), 5 specimens.

Kurile Islands: Paramushiru Isl., Aug. 8, 1932 (by M. NAGAI), several plants. Onnekotan Isl., Aug. 15, 1935 (by M. NAGAI), several plants (SAPA, max. 10 cm high, ⊕ & sterile). Harumukotan Isl., Aug. 16, 1935 (by M. NAGAI), several plants (sterile). Ketoi Isl., Aug. 12, 1935 (by TATEWAKI & TAKAHASHI), several plants (⊕, ♂ & sterile). Simushiru Isl., Aug. 22, 1930 (by M. NAGAI), several plants (⊕ & sterile), Aug. 16 & 22, 1967 (by L. PERESTENKO), 17 plants (⊕, ♂ & sterile). Uruppu Isl., SAP 021981 and 15149 (except for upper left).

Observation

Vegetative thallus: The plants at hand are up to 10 cm high. They are membranaceous, simple and oblong to elongate elliptical with entire margin. Young thalli are mostly spatulate or broadly elliptical. The plant erects one to several fronds from a small discoid holdfast. The stipe is scarcely discernible or, if present, very short. The frond expands cuneately from the base and is broadly obtuse at apex. The regeneration of new saccate fronds from the ruptured margin of old thalli is not rare. In drying the plant becomes dark purple and scarcely adheres to paper (Fig. 25).

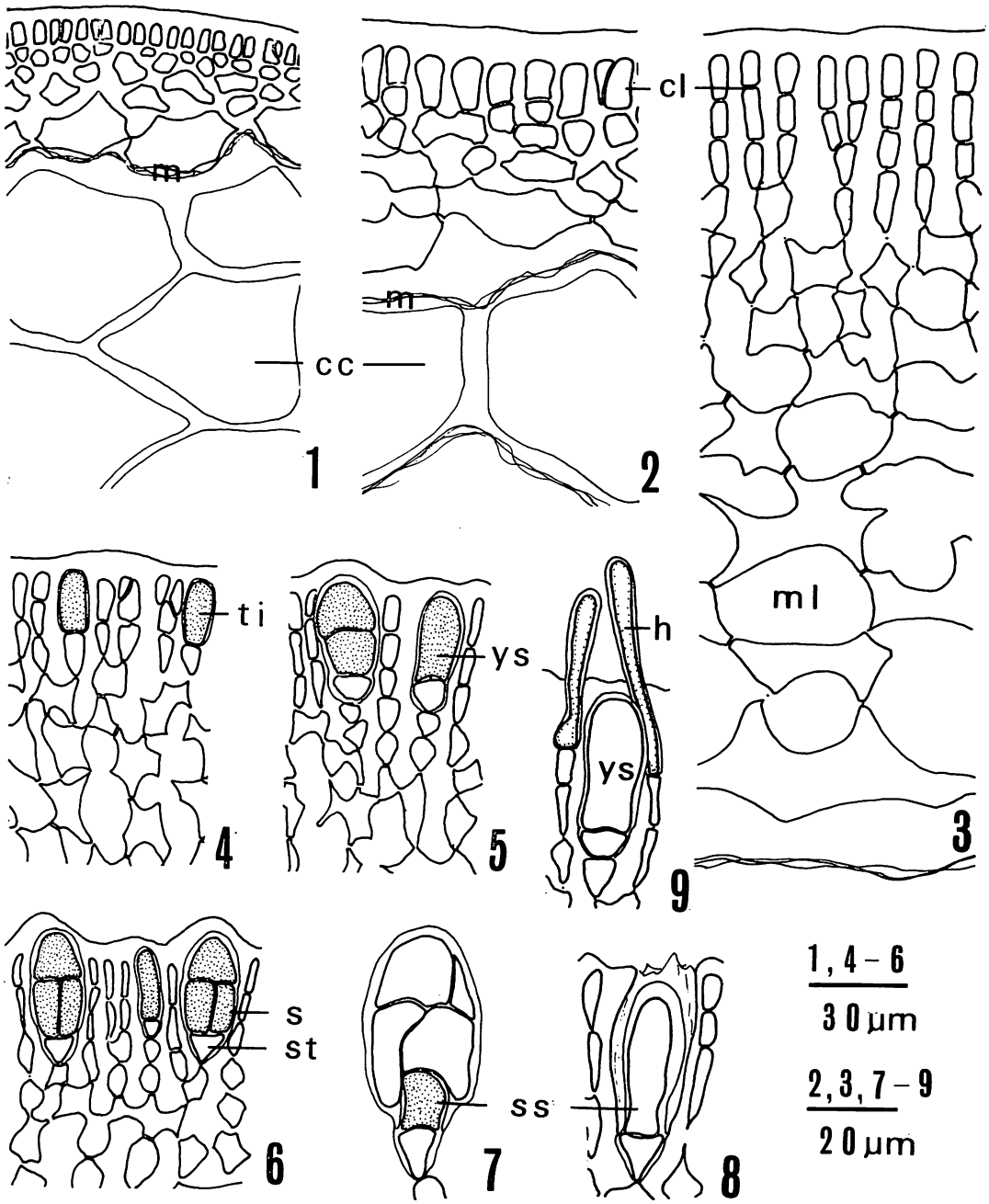
The mature thallus is composed of cortical and medullary layers (170–200 μm thick) and central cavity. The cortical layer comprises three to four celled straight and rarely divided branches arranged perpendicularly to the outer surface (Fig. 3). The cells are elongated oblong and densely pigmented. Secondary pit-connections with adjacent cells are not seen. The superficial cortical cells are sometimes spatulate in form, 4.5–5.5 μm broad and 5–10 μm long.

The medullary layer comprises five to eight irregularly arranged rows of cells which are somewhat compressed and larger in the inner layer. The outer one or two subcortical cells are originally round to oblong but become irregular after fusing with adjacent cells. The protoplasm is modified into characteristic stellate forms connected radially with adjacent ones. The innermost cells are 50–80 μm in diameter.

In young plants, 2 mm high, the cortical layer is a single row of oblong cells (5–6 μm × 10–13 μm in size), and the frond is solid. The medullary layer comprises outer firm medullary and inner soft central cells showing clear margins (Fig. 1), The central cells are ruptured later, leaving a central cavity (Fig. 2).

Unicellular hairs are present occasionally from the superficial cortical cells. Sometimes, they are found within both tetrasporangial and spermatangial sori, too (Figs. 9, 14).

Tetrasporangia: Tetrasporangial sori cover almost the whole frond except for the uppermost and lowermost portions. They originate from superficial cortical cells. Tetrasporangium initials are more enlarged both in width and height than the adjacent sterile cells (Fig. 4). When the initials become about 20 μm long, the sporangium and the stalk cell are formed by an unequal periclinal division (Fig. 5). The sporangium

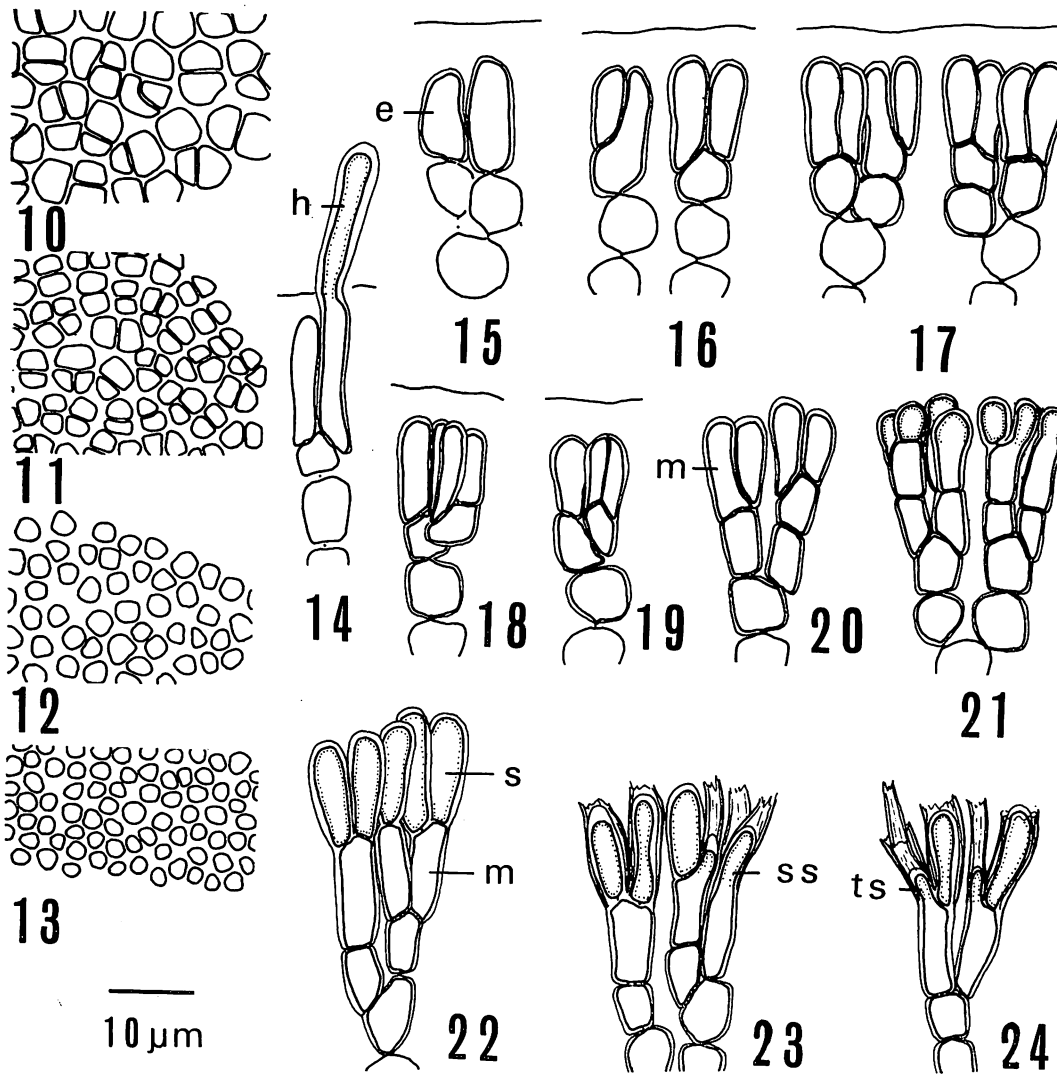


Figs. 1-9 Vegetative structure and tetrasporangia of *Halosaccion glandiforme* (GMELIN) RUPRECHT.

1. Transverse section of 2 mm high frond in upper portion, showing the central portion filled with large cells. Irregular lines show the position of margins in the future central cavity. 2. Middle portion of the same plant, showing rupture of large cells. 3. Transverse section of 8 cm high frond. 4-6. Development of tetrasporangia. 7-8. Development of secondary tetrasporangia. 9. Hairs within tetrasporangial sori (m: margin, between medullary and central cells, cc: central cell, cl: cortical layer, ml: medullary layer, ti: tetrasporangium initial, ys: young sporangium, s: sporangium, st: stalk cell, ss: secondary sporangium).

when about 27 μm high is divided into tetraspores. The mature tetrasporangium is elliptical, 18–22 μm broad and 35–43 μm long, whereas the stalk cell is acetabuliform and about 15 μm broad.

Sterile cortical cells in tetrasporangial sori elongate at the same time as the tetrasporangium initials. They become slender and straight filament later. Sometimes, the filaments divide dichotomously at the basal portion and are shorter than the mature sporangia with a stalk cell (Fig. 6).



Figs. 10–24 Spermatangium formation of *Halosaccion glandiforme* (GMELIN) RUPRECHT.

10–13. Development of spermatangia from surface view. 14. Hair within spermatangial sorus. 15. Elongation of superficial cortical cell. 16–20. Formation of mother cells from superficial cortical cells. Cells originated from superficial cortical cell are figured with double lines. 21–22. Development of spermatangia from mother cells. 23–24. Formation of secondary and tertiary spermatangia (h: hair, e: superficial cortical cell, m: mother cell, s: spermatangium, ss: secondary spermatangium, ts: tertiary spermatangium).

Fig. 25 *Halosaccion glandiforme* (GMELIN) RUPRECHT.

Tetrasporangial plants collected from the Bay of Kronotskiy, Kamchatka (August 2, 1970).

The internal proliferation of secondary sporangia is common from stalk cells (Fig. 8). More often the secondary sporangium protrudes while the spores are still within the sporangial wall (Fig. 7).

Spermatangia: Spermatangial sori develop in a manner similar to the tetrasporangial sori. The spermatangium is originated from the superficial cortical cell. The cortical cell elongates until about 10–13 μm long and divides obliquely into two to three outer cells and one lower cell (Figs. 10–11, 15–16). The outer cells elongated nearly in 15 μm long are divided again into two spermatangial mother cells outwards and one basal cell below (Figs. 17–18). Sometimes, one of the mother cells formed by an especially oblique division divides once again into upper two mother cells and one lower basal cell (Figs. 19, 20 right). Thus, about six to ten mother cells are formed from a single cortical cell.

The spermatangial mother cell protrudes two spermatangia subterminally almost simultaneously (Figs. 12–13, 21–22). A secondary spermatangium is formed commonly within the empty cavity, and the tertiary one is observed rarely (Figs. 23–24). The mature spermatangium is oblong to elongate elliptical, 3.4–4.5 μm broad and 12–14 μm long, and the mother cell is 3–5 μm broad and 10–15 μm long. The superficial culticle over the sorus is shed when the spermatangial mother cells are formed.

Discussion

Our plants are in accord with RUPRECHT's description (1851) quite well both in outer appearance and vegetative structure. They are characterized by membranaceous texture, perpendicularly arranged cortical cells, stellately modified protoplasm of the medullary cells, and hairs from superficial cortical cells. Another noticeable character of this species is that sterile cells among tetrasporangial sori remain narrow rarely branching and never developing into paraphyses. Most of the spermatangial mother cells are formed from the cells divided from a cortical cell.

J. AGARDH (1876), YENDO (1909) and DE TONI (1924) questioned the adoption of *Ulva glandiformis* GMELIN (1768) as the basionym of this species. In Japan and adjacent regions, therefore, this plant had been known as *H. saccatum* KÜTZING sensu YENDO on the basis of YENDO's insistence (1909). Further discussion on the nomenclature was given by LEE (1978). According to LEE (1977, 1978), however, the so called *H. saccatum* in Japan and adjacent regions is comprised of such heterogeneous members as *H. glandiforme* (GMELIN) RUPRECHT, *H. yendoi* I. K. LEE, and *H. minjaii* I. K. LEE, while true *H. glandiforme* was not found along the coasts of Japan.

Comparing *H. glandiforme* with other members of the genus, it resembles *H. minjaii* in vegetative structure by the arrangement of cortical cell (LEE 1977), whereas it is similar to *H. yendoi* and possibly *H. ramentaceum* in spermatangium formation. The spermatangial mother cells are formed from the cells which are divided

from the cortical cell (LEE & KUROGI 1968, as *H. saccatum*, GUIRY 1974).

So far as the present investigation is concerned, the plants occur in the Aleutian Islands from Unalaska to Attu Islands, Kamchatka, and Kurile Islands. *H. glandiforme*, as known in Pacific North America, is a taxon distinct from the species described here and will be the subject of a later paper.

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李仁圭*・V. F. マキエンコ**・黒木宗尚***: *Halosaccion glandiforme* (GMELIN) RUPRECHT の体構造と生殖器官の発達に就いて

Halosaccion glandiforme はダルス目に属する紅藻で RUPRECHT (1851) により *Halosaccion* 属に移された type species であるが，その分類学的特徴が明らかにされていない。著者等は本種の type locality である Kamchatka 及び Aleutian 列島，Kurile 列島から採集された材料をもとにし，種の分類学的特徴を体構造と生殖器官の発達から追跡した。その結果，本種は 1) 皮層細胞が表面に対し直角に配列し，2) 単細胞性の毛を持ち，3) 四分胞子嚢は stalk cell を持って，真直ぐにならぶ sterile cell 列の中に形成され，4) 精子器母細胞は表皮細胞から分裂した細胞により作られ，5) 各母細胞は 2 個の精子器を形成する。しかし，本属のいずれ種のにもみられない雌性体は本種にも発見出来なかった。本研究により本種は Aleutian 列島から Kamchatka, Kurile 列島中部まで分布していることが明らかになった。したがって北米太平洋岸に生育し，本種と同定されているものは *H. glandiforme* と別の taxon であることが明らかになり，この問題は後日のべることにする。

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