Isamu UMEZAKI*: The life history of *Hyalosiphonia caespitosa* (Dumontiaceae, Rhodophyta)**

梅崎 勇*: 紅藻イソウメモドキの生活史**

Hyalosiphonia caespitosa, the type and the only species of the genus, was described by Okamura in 1909 and was placed in the Dumontiaceae, Cryptonemiales by him. The species is known from Kyushu, Shikoku, the Japan Sea and Pacific coasts of Honshu and also in Korea and China.

Chihara and Yoshizaki (1971), studying the structure of the thallus of the species and the developmental mode of the carposporophyte, reported this alga should be included in the Dumontiaceae, confirming Okamura's classification. Observing the germination mode of tetraspores and carpospores of the species, Ohmori (1970) reported it to show Inoh's immediate discal type. However, he did not try to follow the further development.

Although tetrasporophytes and gametophytes (female) are known to occur in the sea, the life history of the species has not been studied yet. Culture studies of *Hyalosiphonia caespitosa* was undertaken by the writer at Maizuru, where this plant grew unexpectedly during the spring of 1969 when the present work started. From these studies, it has been shown that carpospores released from the cystocarpic plants upon germination develop into tetrasporophytes similar in their habit to gametophytes and then the tetraspores from the culture material give rise to young plants similar to gametophytes and tetrasporophytes.

Materials and Methods The specimens of *Hyalosiphonia caespitosa* used grew on rocks a little below the low tide level, and were slightly shaded by a pier. The alga appeared on rocks in the beginning of April, 1969 and its cystocarpic plants matured by the middle to the end of May and were collected on May 16, 1969. After withering the species was not found again on the shore.

Micropipette method was employed for the unialgal culture of released carpospores. Enriched sea-water medium, SWII solution, was used for

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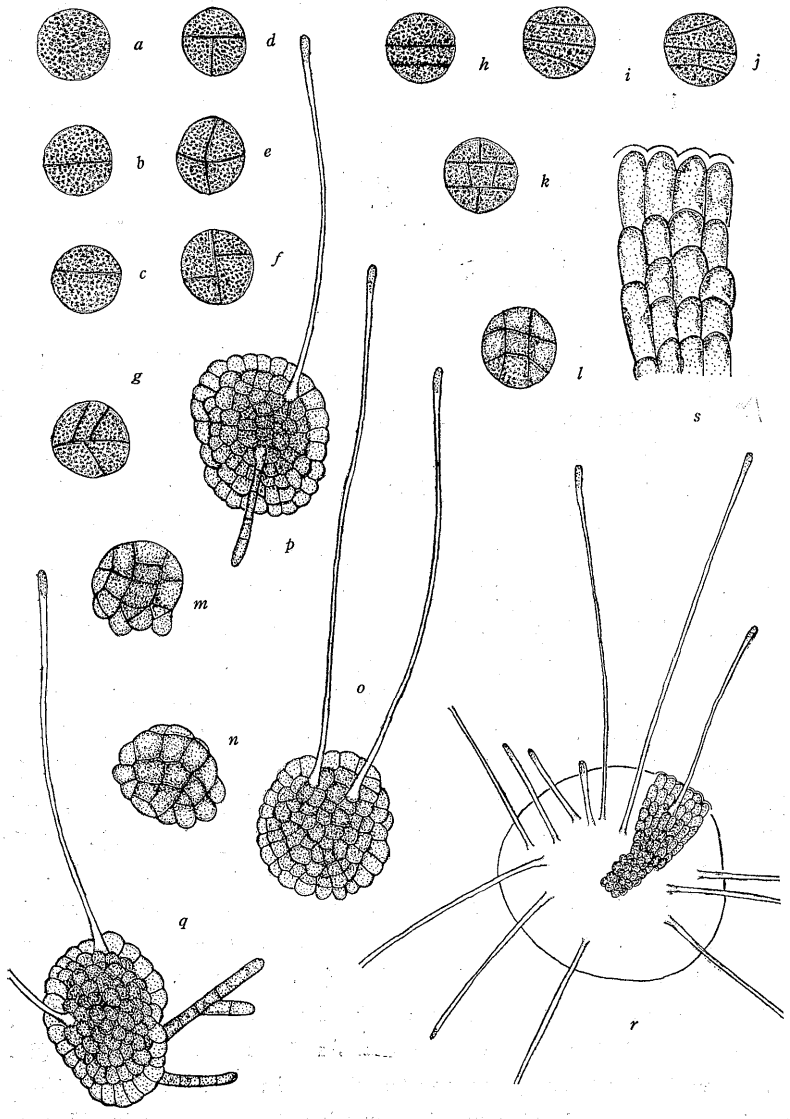
** Dedicated to Prof. Shoichiro Usami celebrating his sexagenary birthday.

culture throughout the life cycle and was changed once a week or every ten days. Cultures were placed under 1500 lux illumination with continuous photoperiod using Toshiba cool white fluorescent lamps, at room temperature, except for the summer months when they were kept at 10–15°C under 500–700 lux illumination. To induce the plants to become fertile they were controlled under a photoperiod of 7 hours light and 17 hours dark.

Observations Carpospores discharged from cystocarps move for a while like amoeba and soon become spherical with a colorless thin membrane, fastening to the substratum. The spores are (45)–53–55–(58) μ in diameter and contains densely packed deep red granules. The spore, one day after fastening to the substratum, divides into two cells by a plane running through the center or a little to one side (fig. 1 b, c; fig. 2 b). Then, the second or third planes run at right angles to the first to divide it into three or four cells (fig. 1 d–f; fig. 2 b). Sometimes, the second or third planes run nearly parallel with the first, resulting in three or four cells (fig. 1 h, i). Three or four days after germination the germlings become 5–10 cells in surface view, increasing their size slightly (fig. 1 g–i). After one week, the marginal cells of the germling divide towards its periphery, resulting in the production of a round monostromatic disc (fig. 1 m–n). At that time, cells located at the middle of the disc are divided by a plane parallel to the substratum, forming two layers of cells. Afterwards, further divisions occur at the central part of the disc resulting in the formation of a several-layered disc. After two months, the germling becomes a disc 70–100 μ broad, although remaining a single layer of cells at the margin (fig. 2 c). The surface cells of the disc are polygonal in surface view, 7–15 μ in diameter and with a lobed parietal chromatophore (fig. 3 h). At that time, single-celled hairs come out from some surface cells of the disc. The disc continues to issue hairs afterwards, sometimes even after their upright shoots are formed. The hairs are 3–6.5 μ in diameter and up to 1000 μ in length, and have protoplast at their apices (fig. 1 o–r; fig. 2 d, e).

Rarely, some marginal or surface cells of a disc form abnormal rhizoidal outgrowths, consisting of one row of cells and branched sometimes (fig. 1 p–q). Even during the summer months when cultures were kept at 10–15°C under 500–700 lux illumination, the discs continued to grow slowly. However, under those conditions the discs did not issue upright shoots. After six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months the germlings became pulvinate discs measuring 1–2 mm broad and 1–2 mm high and consisting of ten or more layers of cells throughout even at the margins (fig. 3 a–d). At that time upright shoots were formed from the upper central part of the disc (fig. 3 e–g; fig. 4); more shoots followed successively, later each disc having several, ten, or more (fig. 4; fig. 5 a, b). Late in November they rapidly elongated, resulting in a length of about 10 cm. (fig. 4; fig. 5 c).

Cultures, which had been placed under continuous illumination daily, were changed to a condition of 7 hrs. light–17 hrs. dark photoperiod, in the middle of December, 1969. About three months later, from the middle to late March, 1970, the upright shoots of the culture became fertile, producing tetrasporangia on them (fig. 4; fig. 5 d). The fertile plants are similar in their habit to cystocarpic plants derived from the spores. A little later they discharged tetraspores. On the other hand, upright shoots on discs kept under continuous illumination did not become fertile, but continued to grow vegetatively. Tetraspores released from one plant were measured 35–42 μ in diameter and those from the other one 30–35 μ. These measurements are a little smaller than those of carpospores (45–58 μ). Tetraspores discharged soon fastened to the substratum and were enveloped with a thin colorless membrane. After that, the spores germinated in the same pattern as in case of carpospores to develop into germling discs within one month. When the discs were cultured under the same condition as the culture of carpospore germlings employed in the preceeding year, they issued upright shoots identical in their habit with young gametophytes in the sea or with young tetrasporophytes in culture. After that, the culture experiment was

Fig. 1. Carpospores of *Hyalosiphonia caespitosa* and their developmental stages after germination. a. Carpospore. b. Two-celled germling which is devided by one plane running through the center of the spore. c. Two-celled germling which is divided by one plane running through a little one-side of the spore. d. Three-celled germling whose second division plane is running at right angle to the first. e. and f. Four-celled germlings whose second and third division planes are running at right angle to the first. g. Five-celled germling whose second, third, and fourth planes are running a little obliquely to the first. h. Three-celled germling whose second division plane is running in parallel with the first. i. Four-celled germling whose second and third division planes are running in nearly parallel with the first. j. Five-celled germling. k. Seven-celled germling. l. Nine-celled germling. m and n. Germlings whose marginal cells are dividing toward their outside. o. Disc having two colorless hairs. p and q. Discs having colorless hairs and abnormal rhizoidal filaments. r. Well-developed disc having numerous colorless hairs. s. Showing chromatophores of the marginal cells of a disc. a–n ×300; o–q ×150; r ×70; s ×250.

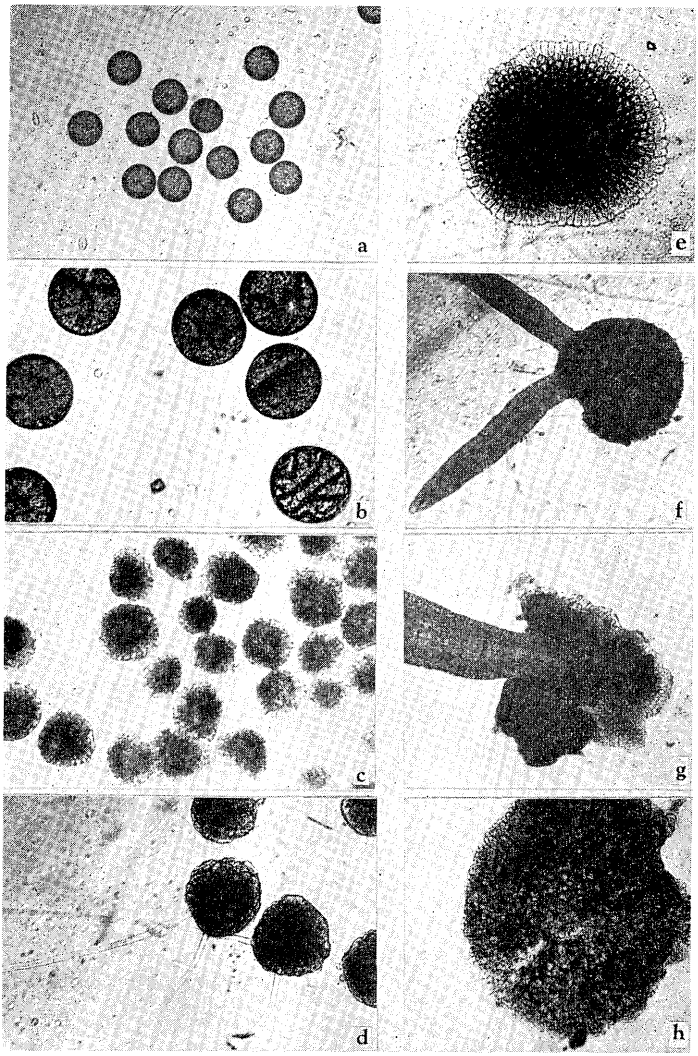

Fig. 2. a. Discharged carpospores. ×200. b. Two-, three-, four-, and six-celled germlings. ×350. c. One-month-old germling discs. ×150. d. Discs having colorless hairs. ×150. e. Polystromatic disc whose margin is composed of one layer of cells. ×70. f. Disc having two upright shoots. ×20. g. Part of an upright shoot and disc in vertical section. ×25. h. Cross section of a disc. ×50.

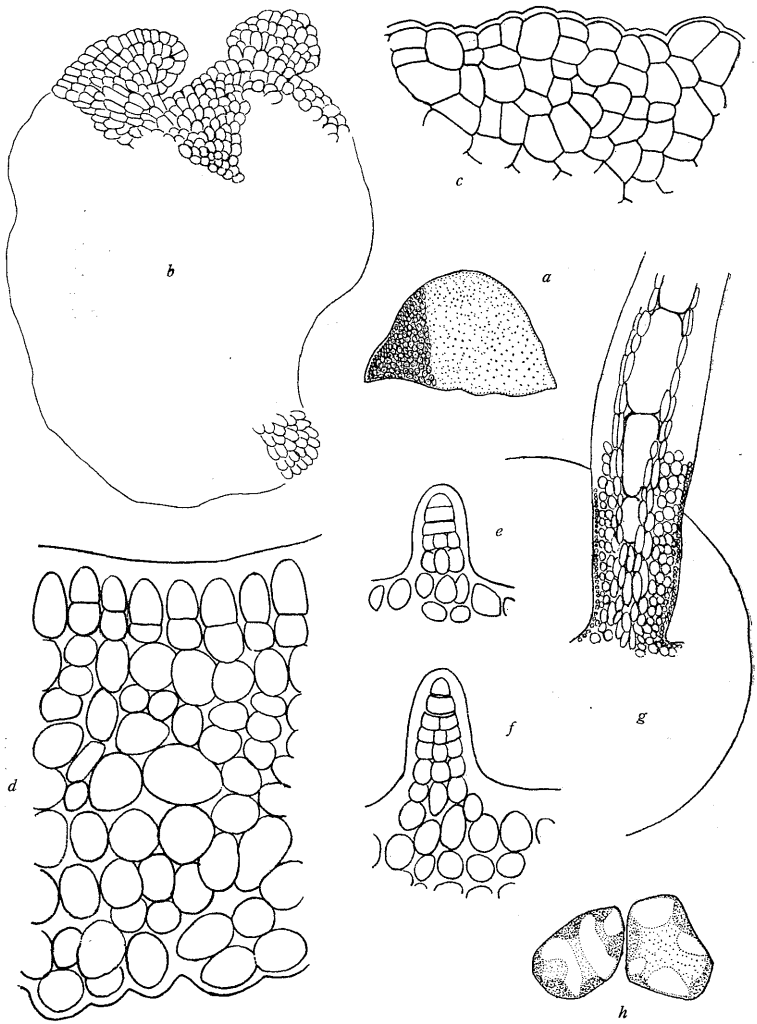

Fig. 3. a. Vertical section of a disc. ×30. b. Cross section of a disc. ×70. c. Part of the margin of a disc in cross section. ×280. d. Part of a disc in vertical section. ×400. e and f. Young upright shoots issuing from their discs. ×400. g. Part of an upright shoot issuing from the disc in vertical section. ×50. h. Two cells of an upright shoot showing chromatophores. ×500.

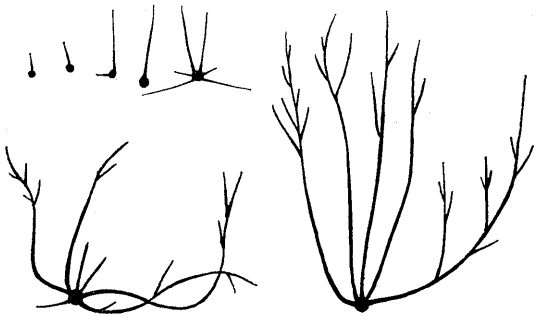

Fig. 4. Showing various stages in development of upright shoots which are issued from their discs. ×1.5.

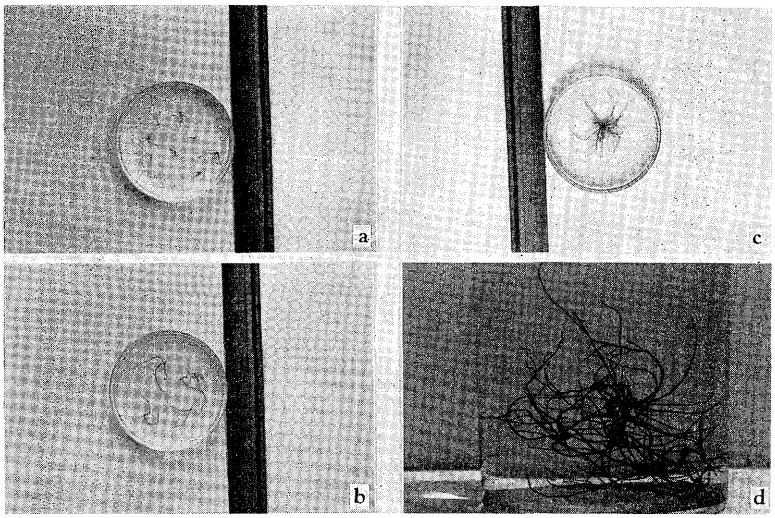

Fig. 5. Various stages in development of upright shoots. a. Six-month-old plants. ×1/3. b. Six- and a half-month-old plants. ×1/3. c. Seven-month-old plants. ×1/3. d. Plants having mature tetrasporangia. ×1/5.

stopped due to withering of the plants.

Discussion In the Dumontiaceae are two types of spore germination, i. e. the immediate discal type to which *Dumontia contorta* (Kylin 1917, as *Dumontia filiformis;* Rosenvinge 1917, as *D. incrassata*) belong and the diplocellular one to which *Dudresnaya* sp. (Killian 1914) and *D. japonica*

(Umezaki, 1968) belong. Recently, Ohmori (1970) reported that the spore germination of *Hyalosiphonia caespitosa* was of the immediate discal type. The present work confirmed Ohmori's observation. According to Inoh (1947) the immediate discal type is known in the Nemaliales (Chihara 1962), Cryptonemiales, Gigartinales, and Rhodymeniales and excepting only the Gelidiales and Ceramiales.

Germling discs of *Hyalosiphonia caespitosa* issued colorless hairs on them as *Dudresnaya japonica* (Umezaki l. c.) does. Such colorless hairs are also known to occur on discs of *Grateloupia elliptica* and *Carpopeltis flabellata* belonging to the Cryptonemiales and *Iridaea cornucopiae* (Inoh 1947, as *Iridophycus cornucopiae*) and *Rhodoglossum japonicum* f. *japonicum* (Inoh, as *Rhodoglossum pulcherum*) (Gigartinales), according to Inoh (1947). However, other species in the Florideophycidae showing the immediate discal type have no colorless hairs on their germling discs. From these facts it seems that the production of colorless hair is not always a distinct character of germling discs showing the type, and may be only a character of species. Ohmori's discs on which he did not find colorless hairs must have been too young to produce them.

Ohmori (l. c.) found carpospores of *Hyalosiphonia caespitosa* to be a little larger than tetraspores. The same result was also gained in the present work. The difference in diameters between tetrapores and carpospores has been shown in *Chondrus yendoi* f. *yendoi* (Nakamura 1947), in several species of Ceramiaceae (Nakamura 1947, 1954) and *Digenea simplex* (Tanaka 1953).

According to Kylin (1956), 14 genera are known in the Dumontiaceae. However, studies of life history in culture have been done only in three species: *Thuretellopsis peggiana* showing the *Bonnemaisonia*-type (Chihara's *Asparagopsis*-type) (Dixon & Richardson 1969; Richardson & Dixon 1970); *Dudresnaya* sp. (Killian 1914) and *D. japonica* (Umezaki 1968), although their complete life cycles have not been studied, are considered to have the *Polysiphonia*-type; Japanese *Pikea californica* is of the *Polysiphonia*-type (Chihara 1969) and the same species from the Pacific coast of North America has a life history with morphologically dissimilar gametangial and tetrasporangial phases (Scott & Dixon, 1971).

In the present work the carpospore germlings developed into tetrasporophytes on which tetrasporangia were produced. The tetraspores released

from the plant gave rise to juvenile plants superficially similar to young gametophytes and tetrasporophytes. From this result it seems that the life history of *Hyalosiphonia caespitosa* is of the *Polysiphonia*-type.

In the Dumontiaceae there are two types of germling discs derived from carpospore germination. The discs of *Dudresnaya* sp. (Killian l. c.) and *D. japonica* (Umezaki l. c.), *Thuretellopsis peggiana* (Dixon & Richardson 1968) and *Pikea californica* (Chihara 1969, Scott & Dixon 1971) are usually monostromatic, rarely distromatic, being superficially *Hymenoclonium*-like. On the other hand, those of *Hyalosiphonia caespitosa* are pulvinate and polystromatic, although their margins are monostromatic at their juvenile stages. Two types of germling discs are also known in the Bonnemaisoniaceae, Nemaliales. *Delisea fimbriata* has a polystromatic disc (Chihara 1962), while the disc of *Ptilonia okadai* is *Hymenoclonium*-like (Chihara 1962). However, there is no great difference between the two types of this family, because the carpospores of *Delisea fimbriata* sometimes develop into *Hymenoclonium*-like discs consisting of one layer of cells.

Upright shoots of *Hyalosiphonia caespitosa* were issued always from the polystromatic portion of the disc. There was no such a *Hymenoclonium*-like disc as seen in abnormal development of carpospores of *Delisea fimbriata* (Chihara 1962).

Summary

1. The life history of *Hyalosiphonia caespitosa* has been studied using unialgal cultures from the carpospores.

2. The germination mode of carpospores and tetraspores is of the immediate discal type. Upon germination the carpospores give rise to pulvinate discs composed of multilayers of cells with colorless hairs on them.

3. The pulvinate discs issued upright shoots which always originated from the polystromatic central portion of the disc.

4. The upright shoots developed into tetrasporophytes superficially similar to the cystocarpic plants.

5. Tetraspores released from the tetrasporophytes gave rise to new plants similar to juvenile gametophytes in the sea or tetrasporophytes in culture.

6. The life cycle of *Hyalosiphonia caespitosa* is of the *Polysiphonia*-type.

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紅藻イソウメモドキ（カクレイト目—リュウモンソウ科）の果胞子を発芽させ培養

してその生活史を研究した。果胞子の発芽体は生長して嚢果体と同じ四分胞子体になった。その四分胞子体が成熟して四分胞子を放出した。その四分胞子が発芽して嚢果体および四分胞子体の幼体と同じものに生長した。このことから，本種の生活史はイトグサ型であることが明らかにされた。本種の果胞子の大いさは (45)-53-55-(58) μ で四分胞子 (30-42 μ) より大きかった。さらに四分胞子および果胞子の発芽体は多層盤状体となりその多層部より直立体が発出生長した。

○ハイスグリ本州中部で発見（杉本順一）　Jun-ichi SUGIMOTO: *Ribes procumbens* Pallas newly found in middle Honshu, Japan

栃木市の古瀬義氏から，山梨県の北岳中腹において1967年7月21日に採集した，花のついたスグリ属の良い標本を頂いた。日本で未知のものらしいので，調べたところ，東北アジア大陸とサハリンに分布するハイスグリ *Ribes procumbens* Pallas であることが判明した。いくつかの文献の記載文を当ってみると，著者によって少しづつの形態上の相違があるが，この相違は同一種内の変異の範囲内のものであると思う。最も信頼のおける文献の一つに中井博士の朝鮮森林植物編15ユキノシタ科がある。この標本をその記載文と図とに対照してみると，大体の形態は一致する。葉の表面に毛がないこと，花序が長いことの違いがあるだけで，明かに同一種と断定できる。参考のため古瀬氏の標本の形を記しておく。

茎は細長く這い，枝はあまり出ない。3年目の部分は褐紫色，2年目の部分は少し稜角があり，外皮がはげやすい。当年の枝は無毛で，全体に刺は全くない。葉は短枝の先に4～6枚づつ集ってつく。葉柄は長さ 2～4 cm で基部の辺縁に長毛を列生する。上端に微毛あるも中部は無毛。葉身は腎形で心脚，径 4～6.5 cm, 3～5 浅裂する。裂片は圧扁された広三角形で，裂片間の彎入も浅い。鈍鋸歯がある。表面は無毛で腺点もない。裏面は腺点を欠き，ただ諸脈上に細毛を散生する。花芽は枝に側生し1個の総状花序を斜上ないし横出し，長さ 4～4.5 cm, 約8～10花つく。中軸と総梗部は細毛がある。苞は宿存性で長さ 3 mm，小花梗は長さ 4 mm，微毛がある。花は両性淡黄緑色で径 4～4.5 mm. 萼片は広円形で隣同士相接している。子房近くまで切れて各萼片は平開する。花弁は小形倒卵形，雄芯も花弁と同長ぐらい。花柱は2浅裂する。子房部は腺毛がない。この標本には果実がない。

Ribes procumbens Pallas, Fl. Ross. 1-2: 35, t. 65 (1788).

Hab. Honshu: Prov. Kai, Mt. Kitadake (Y. Furuse, July 21, 1967, no. 168).

Distr, Amur, Dahuria, Manchuria, N. Korea, Sachalin & Middle Honshu.

(静岡市八幡5-14-3)