

## Four taxa of the sections *Moniliformia*, *Hybrida* and *Setacea* of the genus *Batrachospermum* (Rhodophyta, Nemalionales) from temperate Japan

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This paper deals with a collection of the genus *Batrachospermum* from temperate Japan. One species is described here as a new taxon; *Batrachospermum turgidum* KUMANO differs from the other taxa of the *Moliniformia* in having a swollen carpogonium with an irregularly cylindrical and sometimes twisted trichogyne. Three taxa are recorded here for the first time from Japan; *B. macrosporum* MONTAGNE of section *Moniliformia*, *B. virgato-decaisneanum* of section *Hybrida* and *B. atrum* (HUDSON) HARVEY var. *tenuissimum* SIRODOT of section *Setacea*.

*Key Index Words:* *Batrachospermum*; *Batrachospermum turgidum*; *Rhodophyta*; section *Hybrida*; *taxonomy*; *temperate Japan*.

SAIDA (1887) confirmed that the carpospores of *Batrachospermum coerulescens* grew into the *Chantransia*-stage for the first time in Japan. OHNO (1899) reported *B. moniliforme* and OISHI (1901) *B. gallaei* from Senju Hachiman and Inogashira in Tokyo in Japan. OKAMURA (1916, 1936) and OKADA (1939) reported *B. virgatum*, *B. moniliforme* and *B. gallaei* from Japan. MORI (1975) recognized eighteen taxa of the genus *Batrachospermum* including three new species and KUMANO (1977) eight species. Recently, KUMANO (1982) described two new taxa of the section *Contorta* of the genus *Batrachospermum* from subtropical Japan. The present paper deals with four taxa of this genus for the first time in Japan including one new species.

### Descriptions and Observations

**1. *Batrachospermum macrosporum***  
MONTAGNE 1850, p. 293; Sirodot 1884, p. 268; Flint 1948, p. 428, figs. 1-5. (Fig. 1)

Frond dioecious, 3-5 cm high, 270-400  $\mu\text{m}$  wide, abundantly and more or less irregularly branched, mucilaginous, olive-green in color. Axial cells cylindrical, 30-60  $\mu\text{m}$  wide, 180-400  $\mu\text{m}$  long. Whorls globular or ellipsoidal, more or less distant from each other. Primary branchlets abundantly branched, consisting of 8-12 cell-stories; cells of fascicles lanceolate-ellipsoidal; hairs rare. Secondary branchlets rare. Male plants not observed yet. Carpogonium bearing branch arising from the basal cell of the primary branchlets, 55-100  $\mu\text{m}$  long, consisting of 5-7 cylindrical or barrel-shaped cells; carpogonium 5-7  $\mu\text{m}$  wide at the base, 7-12  $\mu\text{m}$  wide at the apex, 30-40  $\mu\text{m}$  long; trichogyne egg- or balloon-shaped indistinctly stalked. Gonimoblasts single or couple, globular, 90-150  $\mu\text{m}$  in diameter, inserted within a whorl. Carposporangia ovoid, very big, 16-23  $\mu\text{m}$  wide, 23-27  $\mu\text{m}$  long.

Specimen examined: Hansei, Obama, Fukui, Japan (UMEZAKI, 21/V 1974).

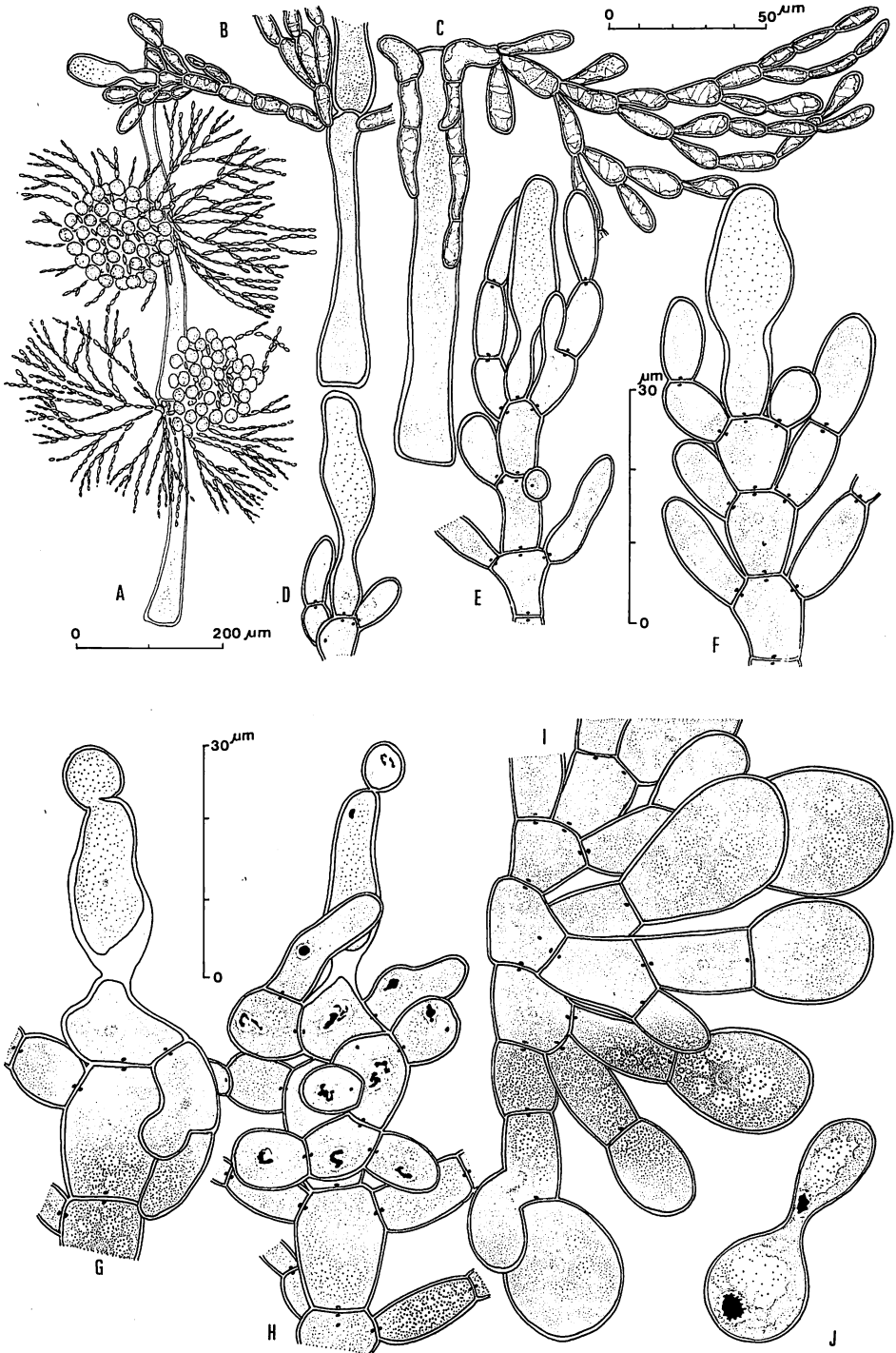


Fig. 1. *Batrachospermum macrosporum* MONTAGNE. A. The structure of whorls showing primary branchlets and gonimoblasts; B. A carpogonium bearing branch; C. The structure of a whorl showing a primary branchlet and cortical filaments; D-F. An unfertilized carpogonium; G-H. A fertilized carpogonium and gonimoblast filaments at an early stage; I. Carposporangia terminal on the gonimoblast filaments; J. A germinating carpospore.

Habitat: This species grows in running freshwater in coastal regions.

Distribution: French Guiana, North America and Japan.

This species was first described from French Guiana by MONTAGNE (1850), who stated that sporae maturae deorsum acuminatae, 5 ad 6 centimillim. (50–60  $\mu\text{m}$ ). Judging from FLINT's figures (1948), the carposporangia of this species is about 35  $\mu\text{m}$  long. SIRODOT (1884) and SKUJA (1933) described this species without giving the dimension and the figures. Japanese specimens are identical with the above-mentioned descriptions and figures, however, different from the French Guianan and American specimens in the size of carposporangia. This species was assigned to the section *Aristatae* by SKUJA (1933) or the section

*Helminthoidea* by FLINT (1948). But it is proposed that this species is better placed in the section *Moniliformia* rather than in the above two sections.

2. *Batrachospermum turgidum* KUMANO, sp. nov. (Figs. 2, 3)

Frons trioica, 3–5 cm alta, 400–470  $\mu\text{m}$  crassa, abundanter irregulariterque ramosa, parum mucosa, olivaceo-fusca. Cellulae axiales cylindricae, 30–46  $\mu\text{m}$  crassae, 230–430  $\mu\text{m}$  longae. Verticilli vel distantes et ellipsoidei vel contigui et plus minusve compressi. Ramuli primarii abundanter ramificantes, ex 8–15 cellulis constantes; cellulae fasciculorum lanceolato-ellipticae, fusiformes vel obovoideae; pili rari. Rmuli secundarii sparsi. Antheridia globosa, 5–7  $\mu\text{m}$  diametro, in ramulis primariis et secundariis terminalia.

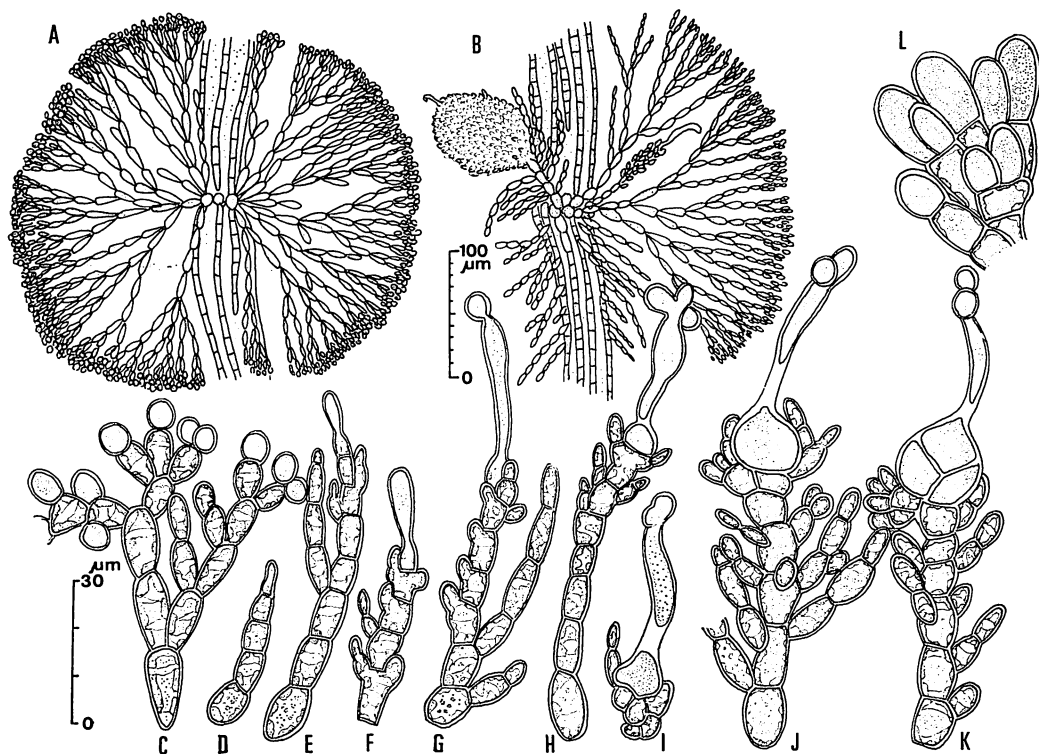


Fig. 2. *Batrachospermum turgidum* KUMANO, sp. nov. A. A part of a male plant showing primary branchlets and cortical filaments; B. A part of a female plant showing primary branchlets, cortical filaments, a carogonium bearing branch and a gonimoblast; C. Antheridia terminal on primary branchlets; D-F. The early development of the carogonium; G. A fertilized carogonium; H-K. The early development of the gonimoblast; L. Carposporangia terminal on gonimoblast filaments.

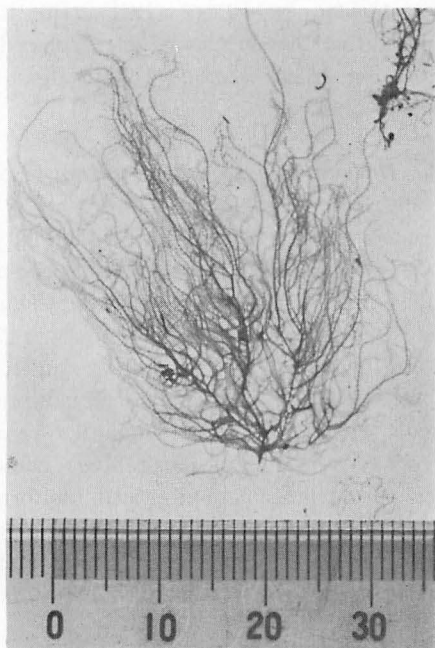


Fig. 3. *Batrachospermum turgidum* KUMANO, sp. nov. Holotype specimen.

Ramuli carpogoniferi e cellulis basi ramulorum primariorum orientes, 40–60  $\mu\text{m}$  longi, ex cellulis 5–8 doliiformibus constantes; carpogonium basi 4–5  $\mu\text{m}$  crassum, apice 3–6  $\mu\text{m}$  crassum, 35–50  $\mu\text{m}$  longum; trichogyne indistincte pedicellata, irregulariter cylindrica, tortuosa; carpogonium turgidum post fecundationem. Bracteae numerosae et brevissimae. Gonimoblasti singuli vel duo, globosi, 120–210  $\mu\text{m}$  diametro, in peripheria verticilli inserti. Carposporangia ovoidea, 9–13  $\mu\text{m}$  crassa, 16–20  $\mu\text{m}$  longa.

Frond trioecious, 3–5 cm high, 400–470  $\mu\text{m}$  wide, abundantly and irregularly branched, not very mucilaginous, olive-brown. Axial cells cylindrical, 30–46  $\mu\text{m}$  wide, 230–430  $\mu\text{m}$  long. Whorls ellipsoidal and separated or touching each other and more or less compressed. Primary branchlets abundantly branched, consisting of 8–15 cell-stories; cells of fascicles lanceolate-ellipsoidal, fusiform or obovoidal; hairs rare. Secondary branchlets sparse. Antheridia globose, 5–7  $\mu\text{m}$  in diameter, terminal on primary and secondary branchlets. Carpogonium bearing branch arising from the basal cell of the primary

branchlet, 40–60  $\mu\text{m}$  long, consisting of 5–8 barrel-shaped cells; carpogonium 4–5  $\mu\text{m}$  wide at the base, 3–6  $\mu\text{m}$  wide at the apex, 35–50  $\mu\text{m}$  long; trichogyne indistinctly stalked, irregularly cylindrical and twisted; carpogonium swollen after fertilization and divided endogenously. Bracts numerous and very short. Gonimoblast single or couple, globular, 120–210  $\mu\text{m}$  in diameter, inserted periphery of a whorl. Carposporangia ovoidal, 9–13  $\mu\text{m}$  wide, 16–20  $\mu\text{m}$  long.

Holotypus: Kita Dani, Gozaisho Dake, Mie, Japan (SETO, 11/V 1958, Herbarium of Faculty of Science, Kobe University). Isotypus: Herbarium of Faculty of Science, Hokkaido University, SAP.

Habitat: This species grows on rocks in mountain streams.

Distribution: Known from the type locality and Aka Zawa, Kiso, Gufu, Japan (HIROKI, 6/VIII 1974).

*Batrachospermum turgidum* seems to belong to the section *Moniliiformia*, but is very different from the other taxa of this section in the features of the carpogonium; the trichogyne is slender, irregularly cylindrical and twisted, moreover, the basal portion of the carpogonium becomes swollen and divided endogenously after fertilization.

During the development, the terminal portion of the carpogonium sticks out (Fig. 2 D) and turns into a club-shaped initial of the trichogyne (Fig. 2 E–F), which matures to become an irregularly cylindrical and twisted trichogyne with an indistinct stalk (Fig. 2 G), sometimes forked. After fertilization, the carpogonium becomes swollen and divided endogenously (Fig. 2 H–K) as mentioned above.

**3. *Batrachospermum virgato-decaisneanum* SIRODOT 1884, p. 290, tab. 23, figs. 1–10; Hamel 1925, p. 85. (Fig. 4)**

Frond dioecious, 2–4 cm high, 300–420  $\mu\text{m}$  wide, abundantly and irregularly branched, very mucilaginous, green with bluish tinge. Axial cells cylindrical, 27–60  $\mu\text{m}$  wide, 250–500  $\mu\text{m}$  long. Whorls barrel- or pear-shaped, separated or compressed. Primary branchlets

well-branched, consisting of 5-9 cell-stories; cells of fascicles barrel-shaped; hairs rare. Cortical filaments well-developed. Secondary branchlets sparsely formed. Antheridia globular, 4-5  $\mu\text{m}$  in diameter, terminal on primary branchlets. Carpogonium bearing branch arising from the basal cell of the primary branchlet, short, consisting of 1-5 disc- or barrel-shaped cells; carpogonium somewhat lateral on the terminal portion of the carpogonium bearing branch, asymmetrical, 6-9  $\mu\text{m}$  wide at the base, 6-8  $\mu\text{m}$  wide at the apex, 15-25  $\mu\text{m}$  long; trichogyne arising laterally from the carpogonium, balloon-shaped, distinctly stalked. Bracts numerous, short, consisting of ellipsoidal cells. Gonimoblasts single or rarely couple, globular, 160-200  $\mu\text{m}$  in diameter, inserted centrally. Carposporangia obovoidal, 8-10  $\mu\text{m}$  wide, 10-14  $\mu\text{m}$  long.

Specimen examined: Oh-ike, Kobe, Japan (OKA, 12/VI 1976).

Habitat: This species lives on the shells

of *Cipangopaludina japonica* (gastropod) growing in marshes and ditches.

Distribution: France and Japan.

SIRODOT (1884) assigned this species to the section *Hybrida* and mentioned that this species is found often on the shells of Lymnaeidae and Planorbidae, sometimes on roots of aquatic plants in France. In Japan, as mentioned above, this species grows on the living shells of *Cipangopaludina japonica* in the paddy fields and ditches at Oh-ike in Kobe.

As SIRODOT (1884) has shown in his plate 23, fig. 6, the carpogonium of this species is borne somewhat laterally on the terminal portion of the carpogonium bearing branch (Fig. 4 F). The side portion of the carpogonium sticks out and turns into a cylindrical initial of the trichogyne (Fig. 4 A), which becomes rounded (Fig. 4 B), then club-shaped (Fig. 4 C) and finally balloon-shaped (Fig. 4 E-F). Thus, the carpogonium of this species becomes asymmetrical and orientated side-

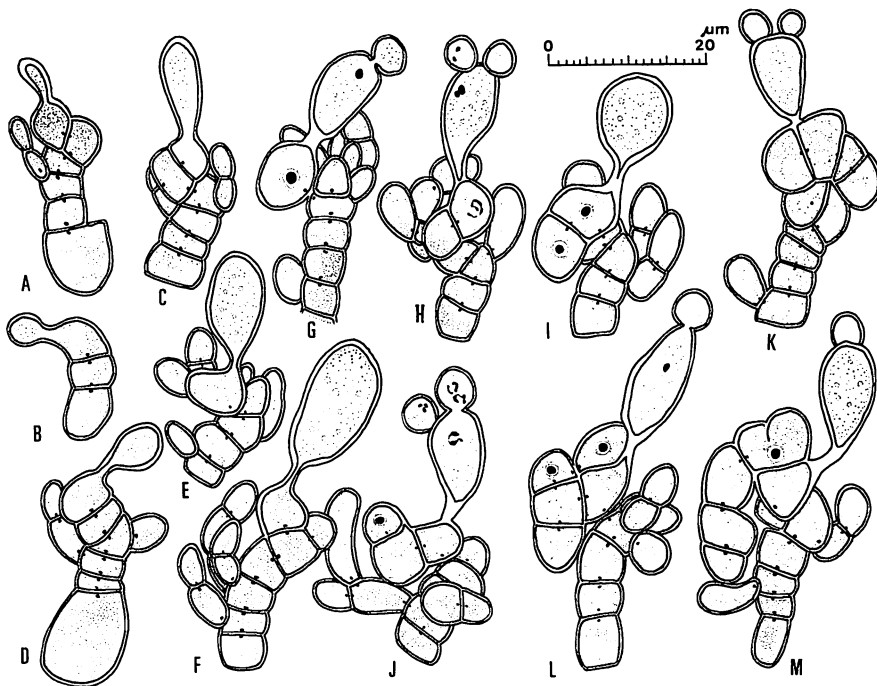


Fig. 4. *Batrachospermum virgato-decaisneanum* SIRODOT. A-E. The development of the carpogonium; F. A mature carpogonium somewhat lateral on the terminal portion of a carpogonium bearing branch; G. A fertilized carpogonium; H-M. The early development of the gonimoblast filaments.

ways on the terminal cell of the carpogonium bearing branch (Fig. 4 F). This type of carpogonium bearing branch development is found only in the taxa of the sections *Contorta* and *Hybrida* of the genus *Batrachospermum*. After fertilization the connection between the trichogyne and the carpogonium is closed (Fig. 4 G). The carpogonium extends a lateral outgrowth and cuts off the first initial of the gonimoblast filament (Fig. 4 H-I), which divides itself to form radially branched gonimoblast filaments (Fig. 4 J-M).

**4. *Batrachospermum atrum* (HUDSON) HARVEY var. *tenuissimum* SIRODOT 1884, p. 256, tab. 20, figs. 3-4, tab. 21, figs. 13-16. (Fig. 5)**

Frond monoecious, 2-7 cm high, 80-110  $\mu\text{m}$  wide, abundantly and irregularly branched, slightly mucilaginous, greyish or olive-green. Axial cells cylindrical, 25-75  $\mu\text{m}$  wide, 200-500  $\mu\text{m}$  long. Whorls very small, inconspic-

uous. Primary branchlets sparsely branched, consisting of 2-4 cell-stories; cells of fascicles barrel-shaped or ovoidal; hairs sparsely formed, varying in length. Cortical filaments well-developed. Secondary branchlets infrequent, very short. Antheridia globular or ovoid, 5-6  $\mu\text{m}$  wide, 4-7  $\mu\text{m}$  long, terminal or lateral on primary branchlets. Carpogonium bearing branch arising from the basal cell of the primary branchlet and from certain cells of cortical filaments, consisting of 1-3 disc-shaped cells; carpogonium 5-7  $\mu\text{m}$  wide, 20-30  $\mu\text{m}$  long; trichogyne urn-shaped. Gonimoblasts single or couple, semiglobular, 80-130  $\mu\text{m}$  wide, 40-120  $\mu\text{m}$  high, forming wart-like protuberances on the central axis. Carposporangia globular or ovoid, 8-12  $\mu\text{m}$  wide, 11-14  $\mu\text{m}$  long.

Specimen examined: Suzuran-dai, Kobe, Japan (KUMANO, 14/VI 1977).

Habitat: This variety grows on stones and roots of higher plants in a pond.

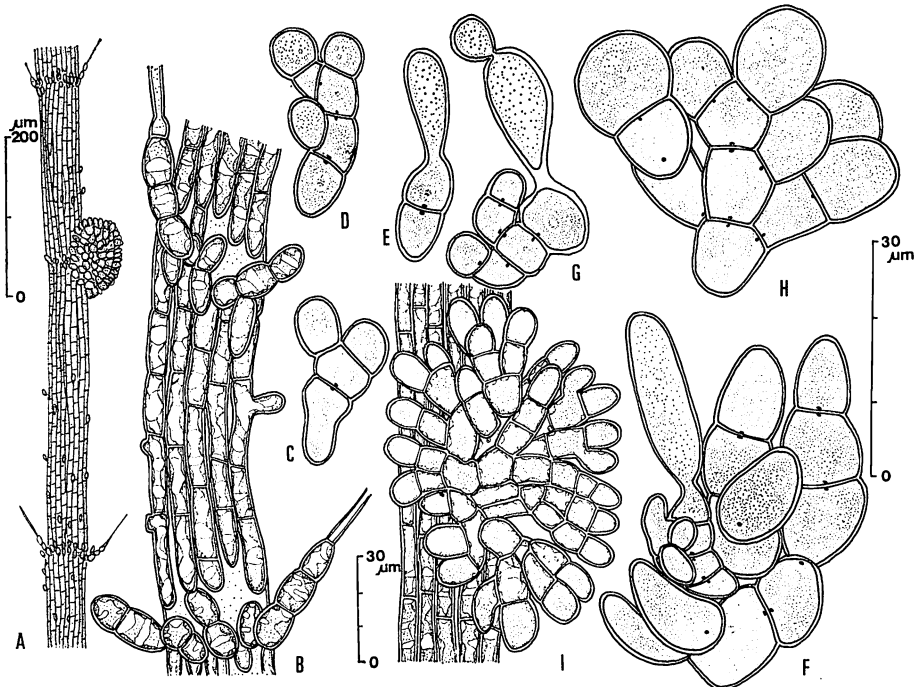


Fig. 5. *Batrachospermum atrum* (HUDSON) HARVEY var. *tenuissimum* Sirodot A. A part of a frond showing the reduced whorls and a wart-like gonimoblast; B. The reduced primary branchlets and the well-developed cortical filaments; C-D. Antheridia terminal on primary branchlets; E-F. A carpogonium; G. A fertilized carpogonium; H. Carposporangia terminal on gonimoblast filaments; I. A wart-like gonimoblast.

Distribution: France and Japan.

SIRODOT (1884) did not describe the dimensions of the thallus of *B. atrum* var. *tenuissimum*. Judging from the figures given by him, thalli of this variety are 70–100  $\mu\text{m}$  wide and axial cells are about 50  $\mu\text{m}$  wide and 240  $\mu\text{m}$  long. The Japanese specimens are identical with *B. atrum* var. *tenuissimum*, although they are a little larger in size than those given by SIRODOT.

## Discussion

The shape of the trichogyne is either ovoidal or balloon-shaped in the section *Hybrida* and urn- or club-shaped in the section *Setacea*, and the size of the trichogyne is small and moderately elongated in both sections. In the species of the section *Hybrida*, the carpogonium bearing branch is well-differentiated from the vegetative branchlets and consists of one to five barrel- or disc-shaped cells and the gonimoblasts are semi-globular, single and inserted centrally at the axis. Between the sections *Hybrida* and *Helminthoidea* there are considerable differences, for example, the trichogyne is formed asymmetrically in the former. However, the *Hybrida* is thought by the author to be derived from the *Helminthoidea* by means of the differentiation of the carpogonium bearing branch without any evolutionary change in shape and size of the trichogyne. Accompanying the differentiation of the carpogonium bearing branch, the number of cells consisting of the primary and the secondary branchlets is decreased, while the cortical filaments develop more frequently. In the *Hybrida-Setacea* evolutionary line, the section *Setacea* is regarded as the most advanced because its carpogonium bearing branch is most differentiated, consisting of only two to four disc-shaped cells; the gonimoblast is generally single, forming a wart-like protuberance at the central axis; and the cortical filaments are well-developed, finally covering the internodes like a pseudoparenchyma. *B. macrosporum* has big carposporangia, which is one of the largest

carposporangia among the section *Moniliformia*. The largest carposporangium ever reported is that of *B. hypogynum* (RATNASABAPATHY and KUMANO 1982, KUMANO and RATNASABAPATHY 1982). These species are also regarded as the advanced forms among the section *Moniliformia*.

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熊野 茂：温帯日本産カワモヅク属モニリフォルミア節，ヒブリダ節およびセタケア節  
(紅藻ウミゾウメン目) の3種1変種

温帯日本からモニリフォルミア節の1新種が記載された：*Batrachospermum turgidum* KUMANO は本節の他の種とは受精後球形に肥大する造果器と不規則な円柱形で時としてねじれる受精毛を持つ点で区別できる。また、モニリフォルミア節の *B. macrosporum* MONTAGNE, ヒブリダ節の *B. virgato-decaisneanum* SIRODOT およびセタケア節の *B. atrum* (HUDSON) HARVEY var. *tenuissimum* SIRODOT が日本新産として報告された。さらにヘルミントイデア節，ヒブリダ節とセタケア節の類縁が考察された。(657 神戸市灘区六甲台町 1-1 神戸大学理学部生物学教室)

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