

## Taxonomy of the family Batrachospermaceae (Batrachospermales, Rhodophyta)

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In this review some reappraisals of the classification system of the family Batrachospermaceae are introduced. An aspect of morphological relationships among the sections and the genera and a check list of the hitherto-described 104 taxa of the family Batrachospermaceae are given with taxonomic notes. This review deals with four genera, namely, genus *Batrachospermum* (91 taxa), genus *Sirodotia* (9 species), genus *Tuomeya* (1 species) and genus *Nothocladus* (3 species). The genus *Batrachospermum* (91 taxa) consists of two subgenera, namely, subgenus *Acarposporophytum* (1 species) and subgenus *Batrachospermum* (90 taxa) including 8 section, namely, section *Helminthoidea* (4 taxa), section *Batrachospermum* (18 taxa), section *Setacea* (3 taxa), section *Turfosa* (5 taxa), section *Virescentia* (14 taxa), section (*Hybrida* (3 taxa), section *Aristatae* (8 taxa) including 2 subsections, namely, subsection *Aristatae* and subsection *Macrosporum* and section *Contorta* (35 taxa) including 5 subsections, namely, subsection *Intortum*, subsection *Torridum*, subsection *Procarpum*, subsection *Kushiroense* and subsection *Ambiguum*.

*Key Index Words:* Batrachospermum—Batrachospermaceae—Rhodophyta—Nothocladus—Sirodotia—Tuomeya—taxonomy

The family Batrachospermaceae (as familia Batrachospermae) was established by C. Agardh (1824) including four genera, namely, the genus *Mesogloia*, the genus *Batrachospermum*, the genus *Thorea* and the genus *Draparnaldia*.

Kuetzing (1857) described *Baileya americana* based on the specimen collected by Bailey. Harvey (1858) established the genus *Tuomeya* and described the same plant under the binomial *Tuomeya fluviatilis* based on the specimen collected by Tuomey and Bailey.

Harvey (1858) treated the family Batrachospermaceae as the order Batrachospermeae, which grouped into two suborders: suborder Batrachospermeae (*Batrachospermum*) and suborder Lemanieae (*Lemanea* and *Tuomeya*), placed in the class Chlorospermeae, "green algae". Rabenhorst (1868) first removed the family Batrachospermaceae together with some other freshwater taxa from "green algae" to the Rhodophyceae.

Kylin (1912) established the genus *Sirodotia* based on the type species, *S. suecica*, then Skuja (1934) established the genus *Nothocladus* based on the type species, *N. nodosus*.

The above-mentioned four genera are delineated primarily on the basis of the development of gonimblast filaments, the size of carpogonia and the vegetative structures of thallus (Kylin 1956).

Recently, some reappraisals were made on the taxonomic frame work of the genus *Batrachospermum* (Necchi 1990a, Compère 1991) and of the family Batrachospermaceae (Necchi & Entwisle 1990).

The aim of this paper is to review such reappraisals, to consider an aspect of morphological relationships mainly among the sections of the family Batrachospermaceae, and to show a check list of the hitherto-described 104 taxa of the family with taxonomic notes.

### Type elements of the genus *Batrachospermum*

The genus *Batrachospermum* was established by Roth (1797) for an unnamed species, for which he cited the synonyms, *Conferva nodosa* L., *Chara batrachosperma* Weiss and *Chara gelatinosa* (L.) Roth. The first of these names is a typographical error by Roth, the second name would result in a tautonym, not allowed under the art. 55.1 (a) of ICBN (Greuter et al. 1988), and the third name was transferred to the genus *Batrachospermum* by De Candolle (1802). Roth (1800) described *Batrachospermum moniliforme*, the first species formally assigned to the genus, which includes *Chara gelatinosa* and *Conferva gelatinosa* as synonyms.

As corroborated by Skuja in Farr et al. (1979), Roth did not propose a new species but only a new name for *Conferva gelatinosa*. *Batrachospermum moniliforme* is illegitimate and a superfluous name for *Batrachospermum gelatinosum* under the art. 63.1 of ICBN, because Roth cited as synonym the earlier, validly published *Conferva gelatinosa* L. Therefore, the correct name of this species is *Batrachospermum gelatinosum* (L.) DC. as stated by Necchi (1990a) and Compère (1991).

The type element of *Conferva gelatinosa* L. and of the genus *Batrachospermum* Roth could be the specimen from Sweden described by the phrase "*Conferva filis ramosis moniliformibus, articulis globosis gelationosis*" (Linnaeus 1753), because the same phrase was used by Linnaeus (1755) in *Flora Suecica*. Unfortunately, the specimen labeled *Conferva gelatinosa* in the Linnean Herbarium would have been included since 1753 and therefore can neither be the holotype nor the lectotype (Compère 1991).

Among the other elements cited in the protologue, an available lectotype could be associated with the illustration from Dillenius' *Historia Muscorum* for *Conferva fontana nodosa spermatis ranarum instar lubrica, major et fucosa* (Dillenius 1741, pl. 7, fig. 42), which has always been associated with *Conferva gelatinosa* and *Batrachospermum moniliforme*.

Compère (1991) examined the specimen on

which Dillenius' drawing was based, deposited in the Dillenius' Herbarium of Oxford University (OXF), and found the characteristic carposporophytes and trichogynes of *Batrachospermum moniliforme*. Therefore, Compère chose the Dillenius' specimen of *Conferva fontana nodosa spermatis ranarum instar lubrica, major et fucosa* (Dillenius 1741, pl. 7, fig. 42) as the lectotype specimen for *Conferva gelatinosa* [= *B. gelatinosum* (L.) DC].

Another illustration from Dillenius' *Historia Muscorum* (1741, pl. 7, fig. 43) cited by Linnaeus is referred by Bory (1808) to his *Batrachospermum ludibonda stagnilis*. Compère (1991) examined the specimen illustrated by Dillenius and found the gonimoblasts inserted in the whorls, not exerted as *Batrachospermum stagnale* [= *B. ectocarpum*], so that this specimen agreed rather well with the current concept of *Batrachospermum gelatinosum* [= *B. moniliforme*].

Sirodot (1884) proposed the subdivision of the genus *Batrachospermum* into six sections in his monograph, "Les Batrachospermes", in which all the section names were not written in Latin but French, for example, *Helminthoides*, *Moniliformes*, *Setaces*, *Turficoles*, *Vertes* and *Hybride*. Most authors such as Hamel (1925), Israelson (1942), Bourrelly (1970), Reis (1974) and Starmach (1977) have agreed with a somewhat enlarged version of the subdivision of the genus into the sections proposed by Sirodod (1884), generally translating the French section names into the Latin names.

Compère (1991) pointed out that, before the publication of "Les Batrachospermes" (1884), Sirodod (1873, 1875) had proposed a first sketch of his subdivisions of *Batrachospermum* into sections and subsections and the Latin names published there have priority on the French names of "Les Batrachospermes". Compère (1991) did a reappraisal of section names of the genus *Batrachospermum* and showed the correct names.

Since then, four sections, namely, section *Contorta* Skuja (1931a), section *Aristatae* Skuja (1933), section *Claviformia* Reis (1973) and section *Carpocontorta* Sheath et al. (1986) were successively proposed.

Moreover, the subgenus *Acarposporophytum* Necchi (1987) was proposed to accommodate *B. brasiliense* Necchi, a species without gonimoblasts and carposporangia but with direct formation of the filaments of *Chantransia*-phase from the fertilized carpogonium.

### An aspect of phylogenetic relationships among the sections of the family Batrachospermaceae.

The carpogonia of the taxa of the section *Helminthoidea* are small and with ovoid or ellipsoidal trichogynes. Carpogonium-bearing branches are not differentiated from primary branchlets. Carposporophytes are small and numerous often more than ten in each whorl. Judging from these characteristics, the section *Helminthoidea* is considered as the most primitive section among the family Batrachospermaceae.

Placing the section *Helminthoidea* on the main trunk of the phylogenetic tree, other genera and sections of the family Batrachospermaceae fall into the following six evolutionary lines: 1) *Batrachospermum* line, 2) *Hybrida-Setacea* line, 3) *Aristatae-Acarposporophytum* line, 4) *Virescentia* line, 5) *Turfosa-Sirodotia* line and 6) *Contorta* line.

#### 1. *Batrachospermum* line.

One of the most primitive taxa among the section *Batrachospermum* is considered to be *B. stagnale*, for which carpogonia are with ovoid or club-shaped trichogynes, carpogonium-bearing branches are differentiated after fertilization, carposporophytes are numerous and scattered on periphery of a whorl.

The degree of the differentiation of carpogonium-bearing branches from primary branchlets is considered to reflect the degree of the phylogenetic changes. The more highly differentiated taxa are regarded as the more highly advanced ones. With the comparison of the differentiation of carpogonia and carpogonium-bearing branches from laterals of the whorl, it may be considered that *B. stagnale* [= *B. arcuatum*] is rather primitive, *B. gelatinosum* is more advanced (Kumano et al.

1970).

Among the section *Batrachospermum*, *B. nova-guineense* is regarded as such an advanced taxon, for which carpogonium-bearing branches are short, more differentiated, slightly curved. Some taxa of the section *Contorta* such as *B. tortuosum* have curved carpogonium-bearing branches. Therefore, *B. nova-guineense* is regarded as one of the connecting links between the both sections (Kumano & Johnstone 1983).

There is another trend toward the reduction of laterals of long carpogonium-bearing branches. In the early stage of development, long carpogonium-bearing branches of *B. cylindro-cellulare* closely resemble those of *B. cayennense* of the section *Aristatae*. Therefore, the former is regarded as an intermediate taxon between the section *Batrachospermum* and *Aristatae* (Kumano 1984a).

Sheath & Cole (1990) assigned *B. heterocorticum* to the section *Batrachospermum*, because of straight carpogonium-bearing branches, large lateral whorls and the presence of several carposporophytes in middle to outer portion of the whorl. However, the shape of trichogyne of this species is similar to that of *B. sirodotii* (section *Virescentia*). So that *B. heterocorticum* is regarded as an intermediate taxon between the section *Batrachospermum* and the section *Virescentia*.

#### 2. *Hybrida-Setacea* line

Carpogonium-bearing branches of *B. virgato-decaisneanum* of the section *Hybrida* are short and well-differentiated, one or two carposporophytes are semiglobular and inserted central within a whorl. Carpogonium-bearing branches of *B. atrum* of the section *Setacea* are very short and composed of a few cells; a carposporophyte develops a wart-like protuberance on central axis; cortical filaments are well-developed like a pseudoparenchyma. So that, *B. atrum* is regarded as one of the most advanced taxa on the *Hybrida-Setacea* line.

#### 3. *Aristatae-Acarposporophytum* line

As mentioned above, some members of the

section *Aristatae* are thought to be derived from some taxa of the section *Batrachospermum*. In *B. hypogynum* (Kumano & Ratnasabapathy 1982) and *B. macrosporum* (Kumano & Necchi 1990) with large carpospores germinating within carposporangia, the protoplasmic connections between carpogonia and rosette-like hypogynous cells are observed. These characteristics of the above-mentioned two taxa indicate that both taxa are regarded as more advanced taxa.

*B. brasiliense* of the subgenus *Acarposporophytum* (Necchi 1990a), in which a carposporophyte is reduced only one-celled zygote (Necchi 1987), is considered to be derived from some taxa of the section *Aristatae* and regarded as one of the most advanced taxon on the *Aristatae-Acarposporophytum* line.

#### 4. *Virescentia* line

Concerning to *B. sirodotii* of the section *Virescentia*, a carpogonium with a cylindrical large trichogyne, a carpogonium-bearing branch is short and differentiated, one or two carposporophytes are inserted centrally within a whorl and bigger than those found in the section *Batrachospermum*.

*B. bakarensis*, in which a short carpogonium-bearing branch is composed of two to five cells and slightly curved, resembles that of some taxa of the section *Contorta*. This fact suggests that there is a close relationship between the section *Virescentia* and the section *Contorta* (Kumano & Ratnasabapathy 1984).

#### 5. *Turfosa-Sirodotia* line

Concerning to *B. turfosum* var. *undulato-pedicellatum* (Kumano & M. Watanabe 1983), *B. periplocum* (Skuja 1969) and *B. orthostichum* (Skuja 1931a) of the section *Turfosa*, gonimoblast filaments spread along the central axis and carposporangia are developed in a similar mode as in the taxa of the genus *Sirodotia* (Kumano 1982c). Concerning to *B. tapirensis*, two types of gonimoblast filaments are observed; one is the erect (*Batrachospermum*) type, another is the diffused (*Sirodotia*) type (Kumano & Phang 1987). Because of these characteristics, the above-mentioned taxa are

considered as apparently intermediate taxa linking the genus *Batrachospermum* and the genus *Sirodotia*.

#### 6. *Contorta* line

As mentioned previously, *B. tortuosum* having a slightly curved carpogonium-bearing branch (Kumano 1978) is thought to be derived from taxa such as *B. nova-guineensis* (Kumano & Johnstone 1983) of the section *Batrachospermum* and *B. bakarensis* (Kumano & Ratnasabapathy 1984) of the section *Virescentia*. Among this evolutionary line, a carpogonium-bearing branch of *B. gibberosum* of the section *Contorta* is composed of thick-walled cells and differentiated very much, cortical filaments and secondary branchlets stick to axial cells and develop into pseudo-parenchymatous structures (Kumano 1978). Therefore, *B. gibberosum* is regarded as one of the most advanced taxa on the *Contorta* line and seems to be an intermediate taxon linking the genus *Batrachospermum* and the genus *Tuomeya* (Kumano 1978, 1986).

### A check list of the hitherto-described 104 taxa in the family Batrachospermaceae.

A check list is compiled of the hitherto-described 104 taxa with taxonomic notes.

Family Batrachospermaceae Agardh 1824

Genus *Batrachospermum* Roth 1800

I. Subgenus *Acarposporophytum* Necchi 1990a  
Type: *B. brasiliense* Necchi 1987.

Gonimoblast filaments and carposporangia absent. A carposporophyte reduced to only one cell, a zygote. Filaments of the *Chantransia*-phase developed directly from fertilized carpogonium.

1) *B. brasiliense* Necchi 1987

II. Subgenus *Batrachospermum* Necchi 1990a  
Type: *B. gelatinosa* (L.) DC. 1802

Syn.: genus *Batrachospermum* Roth 1800

Carposporophyte, gonimoblast filaments and carposporangia, present. Filaments of the *Chantransia*-phase developed from the germination of carpospores.

1. Section *Helminthoidea* De Toni 1897

Type: *B. confusum* (Bory) Hassal 1845 [= *B. helminthosum* Sirodot 1884, non Bory 1808]

Syn.: section *Helminthosa* Sirodot 1873, section "*Helminthoides*" Sirodot 1884.

Fronds not saturate green. Carpogonium-bearing branches not so differentiated, arising from the cells of the fascicles or from pericentral cells of primary branchlets. Laterals of carpogonium-bearing branches short. Carpogonia small in size, with ellipsoidal or ovoid trichogynes. Carposporophytes pedunculate, small, globular, numerous, scattered in the outer half to the whorl.

Compère (1991) pointed out that the name *Helminthosa* Sirodot (1873) could not be applied to this section, though it includes the same taxa, because Sirodot (1873) cited as type *B. helmentosum* Bory (1808) which was included in section "*Verts*" in 1884, under the new illegitimate name *B. coeruleascens* Sirodot (1884). The section name "*Helminthoides*" first published in a French name by Sirodot (1884) could not be taken into account under the art. 18.4 of ICBN. De Toni (1897) was the first to treat this section name as the Latin name and has to be accepted as author of the name of section *Helminthoidea*.

The section *Helminthoidea* was included in the section *Batrachospermum* by Necchi and Entwisle (1990), however, I prefer to keep separated the above both sections.

- 1) *B. confusum* (Bory) Hassal 1845  
[= *B. ludibonda* Bory var. *confusa* Bory 1808, *B. helminthosum* Sirodot 1884, non *B. helmentosum* Bory 1808, *B. crouanianum* Sirodot 1884]

According to Compère (1991), the species

name proposed by Sirodot (1884) was illegitimate for two reasons, 1) as a superfluous later renaming of the previous *B. confusum* Bory (1808), 2) as a later homonym (orthographic variant) of the earlier *B. helmentosum* Bory (1808).

Compère (1991) found that the Bory's holotype specimen had carpogonia with ovoid trichogynes and spermatangia occurred on the same specimen (monoecious species).

- 2) *B. boryanum* Sirodot 1884

[= *B. anatinum* Sirodot 1884]

- 3) *B. boryanum* var. *distensum* (Kylin) Israelson 1942

[= *B. distensum* Kylin 1912]

- 4) *B. szschwanense* Jao 1941

Jao (1941) stated that this species has resemblances of *B. boryanum* Sirodot, but differs from the latter chiefly in having male and female plants being similar in general appearance, an internodal filament entirely wanting and a curved trichogyne. It should be compared with the monoecious *B. distensum* Kylin (1912) and the polygamous *B. anatinum* Sirodot (1884).

2. Section *Batrachospermum*

Type: *B. gelatinosa* (L.) DC. 1802 [= *B. moniliforme* Roth 1800]

Syn.: section *Moniliformia* Sirodot 1873; section *Moniliformes* Sirodot 1884.

Fronds not saturate green. Carpogonium-bearing branches somewhat differentiated, usually arising from the cells of the fascicles, sometimes from the pericentral cells of the primary branchlets. Carpogonia small to large, with club- or finally often urn-shaped trichogynes. Carposporophytes pedunculate, globular, small, numerous, scattered within the whorl at various distances from the center. Laterals of carpogonium-bearing branches elongate, usually embracing the carpogonia and carposporophytes.

- 1) *B. gelatinosum* (L.) DC. 1802  
[=*Conferva gelatinosa* L. 1753, *B. moniliforme* Roth 1800, *B. corbula* Sirodot 1884, *B. decaisneanum* Sirodot 1884, *B. gelatinosum* var. *decaisneanum* (Sirodot) Reis 1969, *B. radians* Sirodot 1884, *B. Moniliforme* f. *lipsiensis* Roth 1800, *B. moniliforme* var. *scopula* Sirodot 1884]
- 2) *B. gelatinosum* f. *pyramidale* (Sirodot) Compère 1991  
[=*B. pyramidale* Sirodot 1884, *B. moniliforme* f. *pyramidale* (Sirodot) Israelson 1942, *B. pygmaeum* Sirodot 1884]
- 3) *B. gelatinosum* var. *obtrullatum* Kumano et M. Watanabe 1983
- 4) *B. durum* C. A. Agardh 1824  
[=*B. densum* Sirodot 1884, *B. moniliforme* f. *densum* (Sirodot) Israelson 1942, *B. gelatinosum* f. *densum* (Sirodot) Compère 1991]

Starmach (1982) stated that the species name *B. durum* must be used, because the reason given by Sirodot (1884) for rejecting C. A. Agardh's specific name and for proposing a new name for this species are not accepted by ICBN.

- 5) *B. helminthoideum* (Sirodot) Mori 1975  
[=*B. moniliforme* var. *helminthoideum* Sirodot 1884]
- 6) *B. sporulans* Sirodot 1884
- 7) *B. godronianum* Sirodot 1884
- 8) *B. reginense* Sirodot 1884
- 9) *B. stagnale* (Bory) Hassal 1845  
[=*B. ludibonda* Bory var. *stagnalis* Bory 1808, *B. ectocarpum* Sirodot 1875, 1884, *B. arcuatum* Kylin 1912]

(1991), the Bory's specimens (PC), clearly show the exerted gonimoblasts characteristic of *B. ectocarpum*. Sirodot himself (1884) considered both names as synonyms but did not accept Bory's epithet. Reis (1973), working on Portuguese material, distinguished *B. stagnale* as dioecious from the monoecious *B. ectocarpum*.

Sheath and Burkholder (1983) synonymized *B. ectocarpum* Sirodot with the dioecious *B. boryanum* Sirodot because of the variability of trichogynes in populations from Rhode Island, and included the section *Helminthoidea* into the section *Batrachospermum*.

However, Compère (1991) observed a few spermatia on the specimens bearing carpogonia in Bory's holotype (PC) and preferred to keep *B. boryanum* of the section *Helminthoidea* and *B. ectocarpum* of the section *Batrachospermum* separated on the basis of the exerted gonimoblasts in the monoecious *B. stagnale* (Bory) Hassal 1845 [= *B. ectocarpum* Sirodot 1884].

- 10) *B. sinense* Jao 1941

Jao (1941) assigned this species to the section *Turfosa*. A young trichogyne of this species is cuneate, but the mature one becomes round or obovate, sometimes inflated like a balloon, and a carpogonium-bearing branch is composed of barrel-shaped cells and provides many elongated laterals. These characteristics are also observed in the taxa of the section *Batrachospermum*, so that, this species resembles more closely those of the section *Batrachospermum* rather than those of the section *Turfosa* (Kumano 1984b).

- 11) *B. arcuatoideum* Reis 1973

- 12) *B. sporiferum* Mori 1975

- 13) *B. japonicum* Mori 1975

- 14) *B. polycarpum* Mori 1975

- 15) *B. cylindro-cellulare* Kumano 1978

According to Compère's observation

The early stage of development of a carpogonium-bearing branch of this species is similar to that of *B. caynneense* Montagne of the section *Aristatae*.

- 16) *B. nova-guineense* Kumano et Johnstone 1983

Johnstone et al. (1980) assigned this species to the section *Hybrida*, however, I prefer to assign this species to the section *Batrachospermum*.

- 17) *B. heterocorticum* Sheath et Cole 1990

Sheath & Cole (1990) mentioned that this species was assigned to the section *Batrachospermum*, because of straight carpogonium-bearing branches, large lateral whorls and presence of several carposporophytes in middle to outer portion of the whorl, on the other hand, the shape of trichogyne of this species was similar to that of *B. sirodotii* Skuja ex P. Reis (1974) of the section *Virescentia*.

[Section *Carpocontorta* Sheath et al. 1986]

Type: *B. carpocontortum* Sheath et al. 1986

Sheath et al. (1986) established a monotypic section *Carpocontorta* based primarily on the presence of protrusions and bends in a trichogyne, and on the size and localization of carposporophytes. However, other species have a similar shaped trichogyne (Sirodot 1884, Reis 1969, Mori 1975), and in these cases, the shape of the trichogyne has been treated as a characteristics at species rank. So that, *B. carpocontortum* Sheath et al. can be readily included in the section *Batrachospermum* as pointed out by Necchi and Entwisle (1990).

- 18) *B. carpocontortum* Sheath et al. 1986

### 3. Section *Setacea* De Toni 1897

Type: *B. dillenii* Sirodot 1884 [= *B. atrum* (Huds.) Harvey 1841]

Syn.: section *Moniliformia* subsection *Capillacea* Sirodot 1873, section *Monili-*

*formia* subsection *Setacea* Sirodot 1875, section *Setaces* Sirodot 1884

Fascicles reduced and very short. Carpogonia with club- or urn-shaped trichogynes. A carpogonium-bearing branch well-differentiated and reduced to a few cells. Carposporophytes appearing as wart-like protuberances on the central axis.

Compère (1991) stated that the French name of this section given by Sirodot (1884) was first treated as the Latin name by De Toni (1897). The earlier epithet *Capillacea* Sirodot (1873) has priority only at the subsection rank; at the section rank, *Setacea* Sirodot (1875) is illegitimate as a later superfluous synonym of *Capillacea* Sirodot (1873) according to the art. 63.1 of ICBN and cannot be considered as a basionym for the section *Setacea*. At the section rank, however, *Setacea* is the correct epithet.

The section *Setacea* is included in the section *Viridia* [= *Virescentia*] by Necchi and Entwisle (1990), however, I prefer to keep the above both sections separated.

- 1) *B. atrum* (Huds.) Harvey 1841  
[= *Conferva atra* Hudson 1798, *B. gallaei* Sirodot 1884, *B. dillenii* Sirodot 1884, *B. tenuissimum* Bory, *B. angolense* W. West & G. S. West 1897, *Sirodotia angolensis* (W. West & G. S. West) Skuja in Reis 1960]
- 2) *B. puiggarianum* Grunow in Wittrock et Nordstedt 1883  
[= *B. atrum* var. *puiggarianum* (Grunow) Necchi 1989, *B. schwackeanum* Moebius 1892, *B. nigrescens* W. West et G. S. West 1897, *Sirodotia nigrescens* (W. West & G. S. West) Skuja in Reis 1960]
- 3) *B. diatyches* Entwisle 1992  
[= *B. nothogaeae* Skuja, nom. nud.]
4. Section *Turfosa* Sirodot 1873  
Type: *B. vagum* (Roth) Ag. 1824 [= *B. turfosum* Bory 1808]

Syn.: section *Turficola* De Toni 1897;  
section *Turficoles* Sirodot 1884.

Fronds pseudo-dichotomously branched. Carpogonium-bearing branches straight, short and arising from pericentral cells of fascicles. Carpogonia sessile or indistinctly stalked elongate conical trichogyne with the largest diameter distal. Carposporophytes big, globular or semiglobular, single (sometimes couple, central within a whorl. Gonimoblast filaments of two types of erect and diffused.

In the section *Turfosa* emended by Necchi (1990a), the following taxa was recognized as possessing two types of gonimoblast filaments (erect and diffused), namely *B. orthostichum* Skuja, *B. periplocum* (Skuja) Necchi, *B. turfosum* Bory, *B. tapirensense* Kumano et Phang. Originally classified taxa in the section *Turfosa* such as *B. vogesiacum* T. G. Schults ex Skuja and *B. gombakense* Kumano et Ratnasabapathy must be transferred to the section *Virescentia*, as redefined in Kumano and Phang (1987) and Necchi (1990a), because these taxa have only an erect type of gonimoblast filament.

- 1) *B. turfosum* Bory 1808  
[=*Chara batrachosperma* var. *vaga* Roth 1797, *Batrachospermum moniliforme* var. *vagum* (Roth) Roth 1800, *B. vagum* (Roth) Ag. 1824, *B. keratophytum* Bory 1808, *B. vagum* var. *keratophytum* (Bory) Sirodot 1884]

Compère (1991) mentioned that at the species rank, the name *B. turfosum* Bory (1808) antedated *B. vagum* (Roth) Ag. (1824) and has to be used, even though the epithet *vagum* is older at the variety rank.

According to Compère's observation (1991), the Bory's type specimen has a few carpogonia with elongated, club-shaped trichogynes and spherical spermatia; it belongs to a monoecious species, but the reproduction is ensured by ovoid or elliptical monospores.

- 2) *B. turfosum* var. *undulato-pedicellatum*

Kumano et M. Watanabe 1983

- 3) *B. orthostichum* Skuja 1931a

Although Skuja (1931a) originally assigned this species with *atrum*-like fascicles to the section *Setacea*, it seems better to assign it to the section *Turfosa* based on the shape of trichogyne and a little long carpogonium-bearing branch. Skuja (1931a) observed some diffused gonimoblast filaments extending out from a globular carposporophyte of this species.

- 4) *B. periplocum* (Skuja) Necchi 1990a  
[=*B. vagum* var. *periplocum* Skuja 1969]

Skuja (1969) observed some diffused gonimoblast filaments extending out from a globular carposporophyte of this species.

- 5) *B. tapirensense* Kumano et Phang 1987

This species resembles *B. bakarensense* Kumano et Ratnasabapathy of the section *Virescentia* in having a short carpogonium-bearing branch and a carpogonium with club-shaped trichogyne. However, the former differs from the latter in having the carpogonium-bearing branch growing toward the same direction that cortical filaments are formed, moreover, in having both the radially branched and the diffused gonimoblast filaments.

5. Section *Virescentia* Sirodot 1873, 1875

Type: not designated in 1875, but only one species cited by Sirodot 1875, *B. helmetosum* Bory 1808 [= *B. coeruleascens* Sirodot 1884]

Syn.: section *Viridia* De Toni 1897;  
section *Vertis* Sirodot 1884.

Fronds saturate green. Carpogonium-bearing branches differentiated, short, arising from the pericentral cells. Carpogonia with distinctly pedunculate, cylindrical trichogynes. A carposporophyte big, globular, single (rarely in couple), central within a whorl.



- 1) *B. helmentosum* Bory 1808  
[=*B. coerulescens* Sirodot 1884, non *B. helminthosum* Sirodot 1884]

Compère (1991) stated that the reason given by Sirodot (1884) for rejecting Bory's specific name and for proposing a new name for this species are not accepted under ICBN and the former name must be used. The Bory's holotype specimen (PC) is a female plant, with a big carposporophyte in the center of a whorls and carpogonium with a stalked trichogyne.

- 2) *B. sirodotii* Skuja ex P. Reis 1974  
[=*B. virgatum* Sirodot 1884 nom. illeg., non *B. moniliforme* var. *virgatum* Kuetzing]

According to Compère (1991), when published the species name *B. virgatum* Sirodot (1884) cited the earlier *B. julianum* (Memegh.) Arc. as a synonym, therefore this species name is illegitimate as superfluous according to the art. 63 of ICBN. It cannot be considered as a new combination based on *B. moniliforme* var. *virgatum* Sirodot (1884), as suggested by Necchi (1989, 1990a) because Sirodot indicate by a question mark that he was not sure that his name could apply to Kuetzing's taxon. Skuja indicated that *B. virgatum* Sirodot was different from *B. moniliforme* var. *virgatum* Kuetzing. Consequently, Skuja proposed, but did not publish, the new name *B. sirodotii* for the illegitimate *B. virgatum* Sirodot. This name was accepted and validly published by Reis (1974) with a full and direct reference to the replaced name.

The lectotype of this species was chosen by Compère (1991) among the specimens cited by Sirodot (1884), which was determined by Sirodot and examined by Skuja.

- 3) *B. graibussoniense* Sirodot 1884  
4) *B. bruziense* Sirodot 1884  
5) *B. testale* Sirodot 1884

- 6) *B. lochmodes* Skuja 1938  
7) *B. vogesiacum* T. G. Schultz ex Skuja 1938  
[=*B. vagum* var. *flagelliforme* Sirodot 1884, *B. flagelliforme* (Sirodot) Necchi 1989]

Compère (1991) mentioned that this species name was proposed by Skuja (1938a) as a new name, at the species rank, for *B. vagum* var. *flagelliforme*, which was not a nomen nudum as stated by Necchi (1989, 1990a), but a nomen novum and validated before 1953, by the mere reference to the validly published *B. vagum* var. *flagelliforme* according to the art. 32.3, 33.2 of ICBN.

According to Compère (1991) the type specimen of this species is not the Schultz's specimen, not cited in the protologue, but one of the specimens cited by Sirodot (1884) for this variety. Among these specimens, Compère (1991) designated the specimen in Herbier Thuret (PC) as the lectotype of this species; this specimen bears the determination "*B. vagum* variete *flagelliforme* Sirodot fructifie" and has been determined by Skuja as "*Batrachospermum vogesianum* F. G. Schultz".

- 8) *B. gulbenkianum* Reis 1965b  
9) *B. transtaganum* Reis 1970  
10) *B. crispatum* Kumano et Ratnasabapathy (Ratnasabapathy and Kumano 1982a)  
11) *B. bakareense* Kumano et Ratnasabapathy 1984

Although this species resembles some taxa such as *B. tortuosum* of the section *Comtorta* in having a slightly curved carpogonium-bearing branch, it resembles more closely species of the section *Virescentia* in having a short carpogonium-bearing branch and a carpogonium with a club-shaped trichogyne.

- 12) *B. gombakense* Kumano et Ratnasa-

bapathy  
(Ratnasabapathy and Kumano 1982b)

Ratnasabapathy and Kumano (1982b) assigned this species to the section *Turfosa*. However, this species had better to be assigned to the section *Virescentia* based on the characteristics; a carpogonium with an indistinctly stalked and inverted conical trichogyne and a single large carposporophyte inserted centrally in a whorl.

[Section *Claviformia* Reis 1973]

Type: *B. azeredoi* Reis 1967

The section *Claviformia* was established by Reis (1973) by having basically a carpogonium with a sessile and club-shaped trichogyne and central carposporophytes.

According to these circumscription, I agree with Necchi's opinion (1990a) that the section *Claviformia* can be merged in the section *Virescentia*, whose members have a stalked or sessile, cylindrical or club-shaped trichogyne and sessile or central carposporophytes.

13) *B. azeredoi* Reis 1967

14) *B. ferreri* Reis 1967

#### 6. Section *Hybrida* De Tni 1897

Type: *B. virgato-decaisneanum* Sirodot 1884

Syn.: section *Hybride* Sirodot 1884

Fronds saturate green. Carpogonium-bearing branches short and arising from the basal cells of the primary branchlets. Carpogonia with trichogynes somewhat asymmetric, sessile or indistinctly stalked, ellipsoidal. Carposporophytes globular, big, single (or couple), central within the whorl.

This section name was first treated as the Latin name by De Toni (1897).

1) *B. virgato-decaisneanum* Sirodot 1884

2) *B. abili* Reis 1965a

3) *B. mikrogyne* Flint et Skuja in Flint 1953

#### 7. Section *Aristatae* Skuja 1933

Lectotype: *B. cayennense* Montagne in Kuetzing 1849 designated by Necchi (1990a).

Fronds irregularly branched. Carpogonium-bearing branches straight, long and differentiated from the fascicles. Carpogonia symmetrical. Carposporophytes pedunculate, spherical.

Skuja (1933) proposed the section *Aristatae* to include *B. macrosporum* Montagne, *B. cayennense* Montagne, *B. aristatae* Skuja sp. nov. and probably *B. breutelii* Rabenhorst, however, he did not designate the type species of this section, which presumably would be *B. aristatum*, which was not formally described. The earliest effectively and valid published species in the section *Aristatae* is *B. cayennense* Montagne is Kuetzing (1849). Thus, this species was designated as the lectotype of the section *Aristatae* by Necchi (1990a).

It is proposed that this section is divided into the following two subsections based on the occurrence of the hypogynous cells forming the rosette-like laterals.

#### 7-1. *Aristatae* subsect. nov.

Typus: *B. cayennense* Montagne in Kuetzing 1849

Frons plus minusve irregulariterque ramosa. Ramuli carpogoniferi stricti, longi, e cellulis pericentralis orientes, sine cellulis hypogynis rosulatis. Trichogyne indistincte pedicellata. Carposporophytum in peripherias verticilli insertum, aux ex verticillis exertum.

#### Subsection *Aristatae*

Fronds more or less irregularly branched. Carpogonium-bearing branches straight, long, arising from pericentral cells, without rosette-like hypogynous cells. Trichogyne indistinctly stalked. Carposporophytes spherical, inserted within or exerted from the periphery of a whorl.

- 1) *B. cayennense* Montagne in Kuetzing 1849
- 2) *B. turgidum* Kumano 1982b
- 3) *B. longiarticulatum* Necchi 1990a
- 4) *B. beraense* Kumano 1978

The taxa of the family Batrachospermaceae exhibited the primitive characteristics in the absence of any fusion of a fertilized carpogonium with a hypogynous cell and in the formation of the gonimoblast filaments produced directly from the undivided fertilized carpogonium. However, the gonimoblast filaments of *B. beraense* Kumano were developed from the divided carpogonium, the lower cell of which did not fuse with the hypogynous cell, as in certain members of the family Helmintho-cladiaceae (Kumano and Ratnasabapathy 1982).

- 5) *B. breutelii* Rabenhorst 1855  
[= *B. dimorphum* Kuetzing 1857]

*B. breutelii* firstly described without illustrations by Rabenhorst (1855) based on the specimen collected by Breutel from Gnadenthal near Cape of Good Hope in South Africa. Kuetzing (1857) described *B. dimorphum* with illustrations based on the specimen collected by Pfarrwe Wenck from the same locality, Gnadenthal in South Africa. Skuja (1933) examined the both type specimens of *S. breutelii* Rabenhorst (1855) and *B. dimorphum* Kuetzing (1857) and pointed out that the latter was regarded as conspecific with the former, which was validly published.

Skuja (1933) examined this species and found the unusual gonimoblast filaments developed into the large gemmae, "Brutkoerper".

#### 7-2. *Macrosporum* subsect. nov.

Typus: *B. macrosporum* Montagne 1850

Frons plus minusve irregulariterque ramosa. Ramuli carpogoniferi stricti, longi, e cellulis pericentralis orientes. Cellulae

hypogynae rosulatae, lateraliter prolatae, magnae. Carpogonia symmetrica, trichogyne indistincte pedicellata, urniformis. Carposporophytum in peripherias verticilli insertum, aux ex verticillis exertum.

#### Subsection *Macrosporum*

Fronds more or less irregularly branched. Carpogonium-bearing branches straight, long, arising from pericentral cells. Hypogynous cell in rosette, laterally elongate, large. Carpogonia symmetrical, trichogyne indistinctly stalked, urn-shaped. Carposporophytes spherical, inserted within or exerted from the periphery of a whorl.

- 6) *B. equisetifolium* Montagne 1850

Based on the examination of type specimen, Kumano (1990) stated that this species resembled *B. macrosporum* Montagne in having hypogynous cells forming rosette-like laterals, but differed from the latter in the size of the trichogyne.

- 7) *B. hypogynum* Kumano et Ratnasabapathy  
(Ratnasabapathy and Kumano 1982b)

The rosette-like nutritive hypogynous cell, connected with a carpogonium and the underlying cells of a carpogonium-bearing branch, took part an important role in the formation of a large carposporangia in this species (Kumano and Ratnasabapathy 1982).

- 8) *B. macrosporum* Montagne 1850  
[= *B. oxycladum* Montagne 1850, *B. macrosporum* var. *oxycladum* (Montagne) Sirodot 1884, *B. excelsum* Montagne 1850, *B. macrosporum* var. *excelsum* (Montagne) Sirodot 1884]

Kumano (1990) examined the type specimen of *S. oxycladum* Montagne and pointed out that this species was regarded as a synonym of *B. macrosporum* Montagne. This species had nutritive hypogynous cells which

formed rosette-like laterals and the largest carposporangia among the taxa of the genus *Batrachospermum* Roth.

#### 8. Section *Contorta* Skuja 1931a

Type: *B. procarpum* Skuja 1931a

Fronds irregularly or pseudo-dichotomously branched. Carpogonium-bearing branches curved or twinsted and coiled, differentiated from the fascicles. Carpogonia symmetrical. Carposporophytes sessile, semiglobular. Gonimoblast filaments of an erect type.

Skuja (1931a) proposed the division of the genus *Batrachospermum* into two subgenera, subgenus *Eu-Batrachospermum* and subgenus *Condea*, the latter with the single section *Contorta* to accommodate *B. procarpum* Skuja (1931a). The section *Contorta* as part of the genus *Batrachospermum* has been widely accepted and numerous species have been assigned to this section.

It is proposed that this section is divided into the following five subsections based on the occurrences of monosporangia, curved or spirally coiled carpogonium-bearing branches, loosely or compactly agglomerated carposporophytes.

#### 8-1. *Intortum* sect. nov.

Typus: *B. intortum* Jao 1941

Frons plus minusve irregulariterque ramosa. Ramuli carpogoniferi tortuosi, e cellulis pericentralis orientes. Trichogyne claviformis, indistincte pedicellata, ad basim saepe flexa. Carposporophytum globosus vel semiglobosus, in centro verticilli insertum. Monosporangia in ramulis carpogoniferiis, secundariis vel primariis terminalia.

#### Subsection *Intortum*

Frons irregularly branched. Carpogonium-bearing branches twisted, arising from pericentral cells. Trichogyne club-shaped, indistinctly stalked, often bent at the base. Carposporophytes globular or semiglobular,

inserted centrally. Monosporangia terminating laterals of carpogonium-bearing branches, primary and secondary branchlets.

#### 1) *B. intortum* Jao 1941

This taxon hitherto known only from China (Jao 1941) was found on several localities in the mountainous eastern part of Cuba, Prov. Oriente, by Rieth (1979).

#### 2) *B. pseudocarpum* Reis 1973

#### 3) *B. woiwapense* Kumano 1983c

#### 4) *B. lusitanicum* Reis 1965a

#### 8-2. *Torridum* sect. nov.

Typus: *B. torridum* Montagne 1850 [= *B. vagum* var. *torridum* (Montagne) Sirodot 1884]

Frons plus minusve irregulariterque ramosa. Ramuli carpogoniferi plus minusve curvi, e cellulis pericentralis orientes. Trichogyne indistincte pedicellata, claviformis, ad basim saepe flexa. Carposporophytum semiglobosi, breves, centro verticillii inserti.

#### Subsection *Torridum*

Fronds more or less irregularly branched. Carpogonium-bearing branches more or less curved, arising from pericentral cells. Trichogyne club-shaped, indistinctly stalked, often bent at the base. Carpogonia asymmetrical. Carposporophytes semiglobular, big, inserted centrally.

#### 5) *B. tortosum* Kumano 1978

#### 6) *B. tortosum* var. *majus* Kumano 1982a

#### 7) *B. torridum* Montagne 1850

[= *B. vagum* var. *torridum* (Montagne) Sirodot 1884]

Based on the examination of the type specimen, Kumano (1990) did not assign this species to the section *Turfosa* but to the section

*Contorta* and proposed to use Montagne's species name.

- 8) *B. doboense* Kumano et Borden-Kerby 1986
- 9) *B. feroense* Kumano et Borden-Kerby 1986

8-3. *Procarpum* sect. nov.

Typus: *B. procarpum* Skuja 1931a

Frons plus minusve irregulariterque ramosa. Ramuli primarii audouinelloidei, alterne vel unilaterliter ramificantes. Ramuli carpogoniferi tortuosi, e cellulis pericentralis orientes. Trichogyne indistincte pedicellata, ellipsoidea vel claviformis. Carposporophytum semiglobosi, breves, centro verticillii inserti. Fila gonimoblastorum longa, plus minusve laxe agglomerata.

#### Subsection *Procarpum*

Frons more or less irregularly branched. Primary branchlets *Audouinella*-like, alternately or unilaterally branched. Carpogonium-bearing branches twisted or spirally coiled, arising from pericentral cells. Trichogyne indistinctly stalked, ellipsoidal or club-shaped. Carposporophytes semiglobular, big, centrally inserted. Gonimoblast filaments long, more or less loosely agglomerated.

- 10) *B. procarpum* Skuja 1931a
- 11) *B. procarpum* var. *americanum* Sheath et al. 1992
- 12) *B. equisetoidium* Kumano et Necchi 1985
- 13) *B. cipoense* Kumano et Necchi 1985

Sheath et al. (1992) stated that this species was considered to be a synonym of *B. globosporum* Israelson (1942) because ellipsoidal cells were found in the outer portion of fascicles of the type material and the graduation of cell

shapes was found from the basal portion to the outer portion of fascicles in the original figures by Israelson (1942). However, I do not agree with the opinions of Sheath *et al.* because the characteristics of the audouinelloid fascicles of this species were different from those of *B. globosporum* Israelson (1942).

- 14) *B. jolyi* Necchi 1986

Sheath et al. (1992) considered that this species was a synonym of *B. globosporum*, because ellipsoidal and ovoid cells of fascicles were found in the type materials and also in the original figures by Necchi (1986). However, I agree with Necchi's opinion (1986, 1990a) that this species is classified with *B. procarpum* having audouinelloid fascicles.

- 15) *B. densiverticillatum* Necchi 1990a

8-4. *Kushiroense* subsect. nov.

Typus: *B. kushiroense* Kumano et Ohsaki 1983

Frons plus minusve irregulariterque ramosa. Ramuli carpogoniferi valde tortuosi, e cellulis pericentralis orientes. Trichogyne indistincte pedicellata, urnformis, ad basim saepe flexa. Carposporophytum globosi vel semiglobosi, centro verticillii inserti. Fila gonimoblastorum longa, laxe agglomerata.

#### Subsection *Kushiroense*

Fronds irregularly branched. Carpogonium-bearing branches strongly twisted, arising from pericentral cells. Trichogyne indistinctly stalked, often bent at the base. Carposporophytes globular or semiglobular, centrally inserted. Gonimoblast filaments long, loosely agglomerated.

- 16) *B. kushiroense* Kumano et Ohsaki 1983

- 17) *B. guyanense* (Montagne) Kumano 1990 [= *B. vagum* var. *guyanense* Montagne 1850]

Based on the examination of the type specimen, Kumano (1990) did not assign this species to the section *Turfosa* but to the section *Contorta* and proposed a new combination.

- 18) *B. tabagatense* Kumano et Borden-Kerby 1986  
 19) *B. nechochoense* Kumano et Borden-Kerby 1986  
 20) *B. nonocense* Kumano et Liao 1987  
 21) *B. iriomotense* Kumano 1982a  
 22) *B. globosporum* Israelson 1942

This species seemed better to be assigned to the section *Contorta* rather than to the section *Turfosa* (Israelson 1942), because the carpogonium-bearing branch of this species was strongly curved and the trichogyne was formed asymmetrically (Kumano 1984a).

- 23) *B. breviararticulatus* (Necchi et Kumano) Necchi 1990a  
 [= *B. capense* Starmach ex Necchi et Kumano var. *breviararticulatum* Necchi et Kumano 1984]  
 24) *B. capense* Starmach ex Necchi et Kumano 1984  
 [= *B. capense* Starmach 1975, nom. illeg.]  
 25) *B. skujanum* Necchi 1986

8-5. *Ambiguum* subsect. nov.

Typus: *B. ambiguum* Montagne 1850 [= *B. bicudoi* Necchi 1986, *B. exsertum* Necchi 1986, *B. basilare* Flint et Skuja in Flint 1953].

Fronds plus minusve irregulariterque ramosa. Ramuli carpogoniferi valde tortuosi, e cellulis pericentralis orientes. Trichogyne indistincte pedicellata, urnformis, ad basim saepe flexa. Carposporophytum globosi vel semiglobosi, centro verticillii inserti. Fila gonimblastorum langa, confertim agglomer-

ata.

Subsection *Ambiguum*

Fronds irregularly branched. Carpogonium-bearing branches strongly twisted. Trichogyne indistinctly stalked, often bent at the base. Carposporophytes globular or semiglobular, centrally inserted. Gonimoblast filaments compactly agglomerated.

- 26) *B. tiomanense* Kumano et Ratnasabapathy  
 (Ratnasabapathy and Kumano 1982a)  
 27) *B. omodoense* Kumano et Borden-Kerby 1986  
 28) *B. Hirosei* Ratnasabapathy et Kumano 1982b  
 29) *B. nodiflorum* Montagne 1850  
 [= *B. vagum* var. *nodiflorum* (Montagne) Sirodot 1884]

Based on the examination of the type specimen, Kumano (1990) stated that this species was not assigned to the section *Turfosa* but to the section *Contorta*, and proposed to use Montagne's species name.

- 30) *B. ambiguum* Montagne 1850  
 [= *B. bicudoi* Necchi 1986, *B. exsertum* Necchi 1986, *B. basilare* Flint et Skuja in Flint 1953].

Based on the examination of the type specimen Kumano (1990) stated that this species was assigned to the section *Contorta*, because of the occurrence of the spirally twisted carpogonium-bearing branch of this species.

- 31) *B. louisianae* Skuja in Flint 1949

Flint (1949) pointed out this species was assigned to the section *Contorta*. Based on the examination of the lectotype and other specimens, Sheath et al. (1992) confirmed a curved carpogonium-bearing branch.

- 32) *B. henriquesianum* Reis 1972
- 33) *B. mahlacense* Kumano et Borden-Kerby 1986
- 34) *B. gracillimum* W. West et G. S. West emend. Necchi 1989
- 35) *B. gibberosum* (Kumano) Kumano 1986 [= *Tuomeya gibberosa* Kumano 1978]

Kumano (1986) stated that this species differed from *Tuomeya americana* (Kuetzing) Papenfuss, the type species of the genus *Tuomeya*, in the presence of the secondary branchlets and the absence of the gonimoblast placenta, the latter of which was characteristic of the genus *Tuomeya*. Because this species is similar to the taxa of the genus *Batrachospermum* in the structure of thallus and the process of the fertilization, it was transferred from the genus *Tuomeya* to the genus *Batrachospermum*.

#### Genus *Sirodotia* Kylin 1912

Type: *Sirodotia suecica* Kylin 1912

Syn.: section *Sirodotia* (Kylin) Necchi et Entwisle 1990

Fronds irregularly branched. Carpogonium-bearing branches short, arising from pericentral cells and or cells of fascicles. Carpogonia asymmetrical with elongate conical or club-shaped trichogynes. Carposporophytes indefinite in shape, extend over along the cortical filaments. Gonimoblast filaments of a diffused type.

Necchi and Entwisle (1990) treated the genus *Sirodotia* Kylin 1912 as a section *Sirodotia* of the genus *Batrachospermum* Roth, however, I prefer to keep the above both genera separated, because the taxa of the genus *Sirodotia* is similar to those of the genus *Batrachospermum* in the vegetative structures but differs in the reproductive structures, in having a diffuse gonimoblast rather than a dense globular gonimoblast and a lobed rather than an isodiametric carpogonium base.

- 1) *S. suecica* Kylin 1912  
[= *Batrachospermum suecicum* (Kylin) Necchi et Entwisle 1990, *S. fennica* Skuja 1931b, *Batrachospermum fennicum* (Skuja) Necchi et Entwisle 1990, *S. acuminata* Skuja in Flint 1950]
- 2) *S. huilensis* (Welw., W. et G. S. West) Skuja 1931b  
[= *Batrachospermum huillense* Welwitsch ex W. et G. S. West 1897, *S. ateleia* Skuja 1938]
- 3) *S. delicatula* Skuja 1938  
[= *Batrachospermum delicatulum* (Skuja) Necchi et Entwisle 1990]
- 4) *S. sinica* Jao 1941
- 5) *S. segawae* Kumano 1982c

This species was reported from Japan without the Latin name and description by Segawa (1939), so that, a new species name was validly published by Kumano (1982c).

- 6) *S. yutakae* Kumano 1982c

This species was reported from Japan without the Latin name and description by Segawa (1939), so that, a new species name was validly published by Kumano (1982c).

- 7) *S. tenuissima* (Collins) Skuja in Flint 1948  
[*Batrachospermum vagum* (Roth) C. Agardh var. *flagelliforme* Sirodot f. *tenuissima* Collins 1895]

- 8) *S. gardneri* Skuja in Flint 1950

Based on the examination of the type specimen, Necchi et al. (1993) mentioned that *Sirodotia gardneri* could not be compared in all characteristics with the other species of *Sirodotia* because the type specimen was a male plants.

- 9) *S. polygama* Skuja in Flint 1948

According to Necchi et al. (1993), this species can be assigned to the section *Turfosa* sensu Necchi et Entwisle (1990).

Genus *Tuomeya* Harvey 1858

Type: *Tuomeya americana* (Harv.) Papenfuss 1958 [= *Baileya americana* Kuetzing 1857, *Tuomeya fluviatilis* Harvey 1858]

Syn.: section *Tuomeya* (Harvey) Necchi et Entwisle 1990.

Necchi and Entwisle (1990) treated the genus *Tuomeya* Harvey as a section *Tuomeya* of the genus *Batrachospermum* Roth, however, I prefer to keep the genus *Batrachospermum* and the genus *Tuomeya* separated.

- 1) *Tuomeya americana* (Harv.) Papenfuss 1958  
[= *Baileya americana* Kuetzing 1857, *Tuomeya fluviatilis* Harvey 1858, *Batrachospermum americanum* (Kuetzing) Necchi et Entwisle 1990]

Genus *Nothocladus* Skuja 1934

Type: *N. nodosus* Skuja 1934 [= *N. tasmanicus* Skuja 1934]

Syn.: section *Nothocladus* (Skuja) Necchi et Entwisle 1990

Necchi and Entwisle (1990) treated the genus *Nothocladus* Skuja as a section *Nothocladus* of the genus *Batrachospermum* Roth, however, I prefer to keep the above both genera separated, because *Nothocladus* differs from *Batrachospermum* in diffuse gonimblast filaments and from *Sirodotia* in symmetrical carpoconia.

- 1) *N. nodosus* Skuja 1934  
[= *N. tasmanicus* Skuja 1934, *Batrachospermum nodosum* (Skuja) Necchi et Entwisle 1990]
- 2) *N. lindaueri* Skuja 1944  
[= *Batrachospermum lindaueri* (Skuja) Necchi et Entwisle 1990]
- 3) *N. afroaustralis* Skuja 1964

**The taxa of the family Batrachospermaceae treated in this paper.**

Family Batrachospermaceae Agardh 1824

Genus *Batrachospermum* Roth 1800

- I. Subgenus *Acarposporophytum* Necchi 1990a
  - 1) *B. brasiliense* Necchi 1987
- II. Subgenus *Batrachospermum* Necchi 1990a [= genus *Batrachospermum* Roth 1800]
  1. Section *Helminthoidea* De Toni 1897 [= section *Helminthosa* Sirodot 1873, section "*Helminthoides*" Sirodot 1884]
    - 1) *B. confusum* (Bory) Hassal 1845  
[*B. ludibonda* Bory var. *confusa* Bory 1808, *B. helminthosum* Sirodot 1884, non *B. helmentosum* Bory 1808, *B. crouanianum* Sirodot 1884]
    - 2) *B. boryanum* Sirodot 1884  
[= *B. anatinum* Sirodot 1884]
    - 3) *B. boryanum* var. *distensum* (Kylin) Israelson 1942  
[= *B. distensum* Kylin 1912]
    - 4) *B. szschwanense* Jao 1941
  2. Section *Batrachospermum*  
[= section *Moniliformia* Sirodot 1873; section *Moniliformes* Sirodot 1884, section *Carpocontorta* Sheath et al. 1986]
    - 1) *B. gelatinosum* (L.) Dc. 1802  
[= *Conferva gelatinosa* L. 1753, *B. moniliforme* Roth 1800, *B. corbula* Sirodot 1884, *B. decaisneanum* Sirodot 1884, *B. gelatinosum* var. *decaisneanum* (Sirodot) Reis 1969, *B. radians* Sirodot 1884, *B. moniliforme* f. *lipsiensis* Roth 1800, *B. moniliforme* var. *scopula* Sirodot 1884]
    - 2) *B. gelatinosum* f. *pyramidale* (Sirodot) Compère 1991  
[= *B. pyramidale* Sirodot 1884, *B. moniliforme* f. *pyramidale* (Sirodot) Israelson 1942, *B. pygmaeum* Sirodot 1884]
    - 3) *B. gelatinosum* var. *obtrullatum* Kumano et Watanabe 1983
    - 4) *B. durum* C. A. Agardh 1824  
[= *B. densum* Sirodot 1884, *B. moniliforme* f. *densum* (Sirodot) Israelson 1942, *B. gelatinosum* f. *densum* (Sirodot) Compère 1991]



- 5) *B. helminthoideum* (Sirodot) Mori 1975  
[=*B. moniliforme* var. *helminthoideum* Sirodot 1884]
- 6) *B. sporulans* Sirodot 1884
- 7) *B. godronianum* Sirodot 1884
- 8) *B. reginense* Sirodot 1884
- 9) *B. stagnale* (Bory) Hassal 1845  
[=*B. ludibonda* Bory var. *stagnalis* Bory 1808, *B. ectocarpum* Sirodot 1875, 1884, *B. arcuatum* Kylin 1912]
- 10) *B. sinense* Jao 1941
- 11) *B. arcuatoideum* Reis 1973
- 12) *B. sporiferum* Mori 1975
- 13) *B. japonicum* Mori 1975
- 14) *B. polycarpum* Mori 1975
- 15) *B. cylindro-cellulare* Kumano 1978
- 16) *B. nova-guineense* Kumano et Johnstone 1983
- 17) *B. heterocorticum* Sheath et Cole 1990
- 18) *B. carpocontortum* Sheath et al. 1986.
3. Section *Setacea* De Toni 1897  
[=section *Moniliformia* subsection *Capillacea* Sirodot 1873, section *Moriliformia* subsection *Setacea* Sirodot 1875, section *Setaces* Sirodot 1884]
- 1) *B. atrum* (Huds.) Harvey 1841  
[=*Conferva atra* Hudson 1798, *B. gallaei* Sirodot 1884, *B. dillenii* Sirodot 1884, *B. tenuissimum* Bory, *B. angolense* W. West & G. S. West 1897, *Sirodotia angolensis* (W. West & G. S. West) Skuja in Reis 1960]
- 2) *B. puiggarianum* Grunow in Wittrock et Nordstedt 1883  
[=*B. atrum* var. *puiggarianum* (Grunow) Necchi 1989, *B. schwackeanum* Moebius 1892, *B. nigrescens* W. West et G. S. West 1897, *Sirodotia nigrescens* (W. West & G. S. West) Skuja in Reis 1960]
- 3) *B. diatyches* Entwisle 1991  
[=*B. nothogaeae* Skuja, nom. nud.]
4. Section *Turfosa* Sirodot 1873  
[=section *Turficola* De Toni 1897; section *Turficoles* Sirodot 1884]
- 1) *B. turfosum* Bory 1808  
[=*Chara batrachosperma* var. *vega* Roth 1797, *Batrachospermum moniliforme* var. *vagum* (Roth) Roth, *B. vagum* (Roth) Ag. 1824, *B. keratophyllum* Bory, *B. vegum* var. *keratophyllum* (Bory) Sirodot]
- 2) *B. turfosum* var. *undulato-pdeicellatum* Kumano et M. Watanabe 1983
- 3) *B. orthostichum* Skuja 1931a
- 4) *B. periplocum* (Skuja) Necchi 1990a  
[=*B. vagum* var. *periclocum* Skuja 1969]
- 5) *B. tapirensense* Kumano et Phang 1987
5. Section *Virescentia* Sirodot 1873, 1875  
[=section *Viridia* De Toni 1897; section *Vertis* Sirodot 1884, section *Claviformia* Reis 1973]
- 1) *B. helmentosum* Bory 1808  
[=*B. coerulescens* Sirodot 1884, non *B. helminthosum* Sirodot 1884]
- 2) *B. sirodotii* Skuja ex P. Reis 1974  
[=*B. virgatum* Sirodot 1884 nom. illeg., non *B. moniliforme* var. *virgatum* Kuetzing]
- 3) *B. graibussoniense* Sirodot 1884
- 4) *B. bruziense* Sirodot 1884
- 5) *B. testale* Sirodot 1884
- 6) *B. lochmodes* Skuja 1938
- 7) *B. vogesiacum* T. G. Schultz ex Skuja 1938  
[=*B. vagum* var. *flagelliforme* Sirodot 1884, *B. flagelliforme* (Sirodot) Necchi 1989]
- 8) *B. gulbenkianum* Reis 1965b
- 9) *B. transtaganum* Reis 1970
- 10) *B. crispatum* Kumano et Ratnasabapathy (Ratnasabapathy and Kumano 1982a)
- 11) *B. bakarensense* Kumano et Ratnasabapathy 1984
- 12) *B. gombakense* Kumano et Ratnasabapathy (Ratnasabapathy and Kumano 1982b)
- 13) *B. azeredoi* Reis 1967
- 14) *B. ferreri* Reis 1967
6. Section *Hybrida* De Toni 1897  
[=section *Hybride* Sirodot 1884]
- 1) *B. virgato-decaisneanum* Sirodot 1884
- 2) *B. abili* Reis 1965a
- 3) *B. mikroglyne* Flint et Skuja in Flint 1953
7. Section *Aristatae* Skuja 1933
- 7-1. Subsection *Aristatae* Kumano 1993
- 1) *B. cayennense* Montagne in Kuetzing 1849

- 2) *B. turgidum* Kumano 1982b  
 3) *B. longiarticulatum* Necchi 1990a  
 4) *B. beraense* Kumano 1978  
 5) *B. breutelii* Rabenhorst 1855  
 [= *B. dimorphum* Kuetzing 1857]
- 7-2. Subsection *Macrosporium* Kumano 1993  
 6) *B. equisetifolium* Montagne 1850  
 7) *B. hypogynum* Kumano et Ratnasabapathy  
 (Ratnasabapathy and Kumano 1982b)  
 8) *B. macrosporium* Montagne 1850  
 [= *B. oxycladum* Montagne 1850, *B. macrosporium* var. *oxycladum* (Montagne) Sirodot 1884, *B. excelsum* Montagne 1850, *B. macrosporium* var. *excelsum* (Montagne) Sirodot 1884]
8. Section *Contorta* Skuja 1931a
- 8-1. Subsection *Intortum* Kumano 1993  
 1) *B. intortum* Jao 1941  
 2) *B. pseudocarpum* Reis 1973  
 3) *B. weitapense* Kumano 1983c  
 4) *B. lusitanicum* Reis 1965a
- 8-2. Subsection *Torridum* Kumano 1993  
 5) *B. tortuosum* Kumano 1978  
 6) *B. tortuosum* var. *majus* Kumano 1982a  
 7) *B. torridum* Montagne 1850  
 [= *B. vagum* var. *torridum* (Montagne) Sirodot 1884]  
 8) *B. doboense* Kumano et Borden-Kerby 1986  
 9) *B. feroense* Kumano et Borden-Kerby 1986
- 8-3. Subsection *Procarpum* Kumano 1993  
 10) *B. procarpum* Skuja 1931a  
 11) *B. procarpum* var. *americanum* Sheath et al. 1992  
 12) *B. equisetoidium* Kumano et Necchi 1985  
 13) *B. cipoense* Kumano et Necchi 1985  
 14) *B. jolyi* Necchi 1986  
 15) *B. densiverticillatum* Necchi 1990a
- 8-4. Subsection *Kushiroense* Kumano 1993  
 16) *B. kushiroense* Kumano et Ohsaki 1983  
 17) *B. guyanense* (Montagne) Kumano 1990  
 [= *B. vagum* var. *guyanense* Montagne 1850]  
 18) *B. tabagatense* Kumano et Borden-Kerby 1986  
 19) *B. nechochoense* Kumano et Borden-Kerby 1986
- 20) *B. nonocense* Kumano et Liao 1987  
 21) *B. iriomotense* Kumano 1982a  
 22) *B. globosporum* Israelson 1942  
 23) *B. breviarticulatus* (Necchi et Kumano) Necchi 1990a  
 [= *B. capense* Starmach ex Necchi et Kumano var. *breviarticulatum* Necchi et Kumano 1984]  
 24) *B. capense* Starmach ex Necchi et Kumano 1984  
 [= *B. capense* Starmach 1975, nom. illeg.]  
 25) *B. skujanum* Necchi 1986
- 8-5. Subsection *Ambiguum* Kumano 1993  
 26) *B. tiomanense* Kumano et Ratnasabapathy  
 (Ratnasabapathy and Kumano 1982a)  
 27) *B. omodoense* Kumano et Borden-Kerby 1986  
 29) *B. nodiflorum* Montagne 1850  
 [= *B. vagum* var. *nodiflorum* (Montagne) Sirodot 1884]  
 30) *B. ambiguum* Montagne 1850  
 [= *B. bicudoi* Necchi 1986, *B. exsertum* Necchi 1986, *B. basilare* Flint et Skuja in Flint 1953].  
 31) *B. louisianae* Skuja in Flint 1949  
 32) *B. henriquesianum* Reis 1972  
 33) *B. mahlacense* Kumano et Borden-Kerby 1986  
 34) *B. gracillimum* W. West et G. S. West emend. Necchi 1989  
 35) *B. gibberosum* (Kumano) Kumano 1986  
 [= *Tuomeya gibberosa* Kumano 1978]
- Genus *Sirodotia* Kylin 1912  
 [= section *Sirodotia* (Kylin) Necchi et Entwisle 1990]
- 1) *S. suecica* Kylin 1912  
 [= *Batrachospermum suecicum* (Kylin) Necchi et Entwisle 1990, *S. fennica* Skuja 1931b, *Batrachospermum fennicum* (Skuja) Necchi et Entwisle 1990, *S. acuminata* Skuja ex Flint 1950]  
 2) *S. huillensis* (Welw., W et G. S. West) Skuja 1931b  
 [= *Batrachospermum huillense* Welwitsch ex W. et G. S. West 1897, *S. ateleia* Skuja 1938]

- 3) *S. delicatula* Skuja 1938  
[=*Batrachospermum delicatulum* (Skuja) Necchi et Entwisle 1990]
- 4) *S. sinica* Jao 1941
- 5) *S. segawae* Kumano 1982c
- 6) *S. yutakae* Kumano 1982c
- 7) *S. tenuissima* (Collins) Skuja ex Flint 1948  
[=*Batrachospermum vagum* (Roth) C. Agardh var. *flagelliforme* Sirodot f. *tenuissima* Collins 1895]
- 8) *S. gardneri* Skuja in Flint 1950
- 9) *S. polygama* Skuja in Flint 1948
- Genus *Tuomeya* Harvey 1858  
[=section *Tuomeya* (Harvey) Necchi et Entwisle 1990]
- 1) *Tuomeya americana* (Harv.) Papenfuss 1958  
[=*Baileya americana* Kuetzing 1857, *Tuomeya fluviatilis* Harvey 1858, *Batrachospermum americanum* (Kuetzing) Necchi et Entwisle 1990]
- Genus *Nothocladus* Skuja 1934  
[=section *Nothocladus* (Skuja) Necchi et Entwisle 1990]
- 1) *N. nodosus* Skuja 1934  
[=*N. tasmanicus* Skuja 1934, *Batrachospermum nodosum* (Skuja) Necchi et Entwisle 1990]
- 2) *N. lindaueri* Skuja 1944  
[=*Batrachospermum lindaueri* (Skuja) Necchi et Entwisle 1990]
- 3) *N. afroaustralis* Skuja 1964
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### 熊野 茂：カワモズク科（カワモズク目，紅藻植物）の分類

この総説では、カワモズク科の分類に関する最近の改変、形態学的観点から見た属・節間の類縁関係、及び、現在までに記載された104分類群のリストを、分類学的ノートを付して紹介した。この総説で取り扱った分類群はカワモズク科の4属である、即ち、カワモズク属(91分類群)、ユタカカワモズク属(9種)、ツオメヤ属(1種)、及びノトクラズ属(3種)。カワモズク属(91分類群)は2つの亜属からなる、即ち、無果孢子体亜属(1種)とカワモズク亜属(90分類群)。カワモズク亜属は次の8つの節から構成される、即ち、ヘルミントイデア節(4分類群)：カワモズク節(18分類群)：セタケア節(3分類群)：ツルフォサ節(5分類群)：ヴィレンセンチア節(14分類群)：ヒブリダ節(3分類群)：2つの亜節、即ち、マクロスポルム亜節とアリスタタエ節亜節からなるアリスタタエ節(8分類群)：5つの亜節、即ち、イントルタ亜節、トリズム亜節、プロカルプム亜節、クシロエンシス亜節及びアムビグウム亜節からなるコントルタ節(35分類群)。(657 神戸市灘区六甲台1-1 神戸大学理学部生物学教室)

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