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Studies on the freshwater Rhodophyta of Brazil II. Two new species of *Batrachospermum* ROTH from States of Amazonas and Minas Gerais

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Although there are minor differences among *Batrachospermum procarpum* SKUJA, *B. equisetoideum*, sp. nov. and *B. cipoense*, sp. nov., concerning vegetative characteristics these three species are distinguished from the other taxa of the genus *Batrachospermum* in having the audouinelloid fascicles. A key for the above-mentioned three species of *Batrachospermum* is as follows:

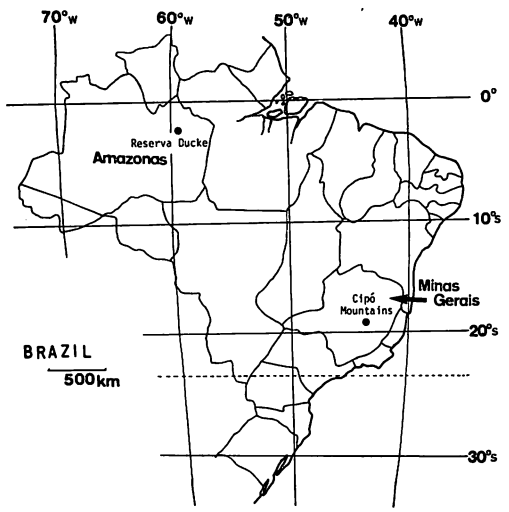
1. Gonimoblast 100-300 μm in diameter—*B. procarpum* SKUJA
1. Gonimoblast 300-900 μm in diameter.
   2. Carposporangia 13-19 μm long—*B. cipoense* KUMANO et NECCHI, sp. nov.
   2. Carposporangia 19-30 μm long—*B. equisetoideum* KUMANO et NECCHI, sp. nov.

Key Index Words: *Audouinelloid fascicle*; B. cipoense *sp. nov.*; B. equisetoideum *sp. nov.*; *Brazil*; *freshwater Rhodophyta*; *taxonomy*.

As regards the freshwater Rhodophyta, especially the genus *Batrachospermum*, of Brazil, SKUJA (1931) described *Batrachospermum orthostichum* and *B. procarpum* from Santa Teresa in State of Espírito Santo as a new species and SKUJA (1969) described *B. vagum* (ROTH) C. AGARDH var. *periplocum* from Rio Negro in State of Amazonas as a new variety. Recently, NECCHI and KUMANO (1984) reported three taxa of the genus *Batrachospermum* including *B. cayennense*, *B. orthostichum* and a new variety of *B. capense* from Itabaiana Mountains, Município of Areia Branca in State of Sergipe. The present paper deals with two new species of the genus *Batrachospermum* based on the specimens collected from States of Amazonas and Minas Gerais.

Specimens Examined

The specimens examined in the present study were deposited in the Herbarium of Institute of Botany, São Paulo, Brazil (SP), and in the Herbarium of Faculty of Science, Kobe University, Kobe, Japan. The specimens of *Batrachospermum equisetoideum* were collected on Feb. 22 in 1978 by C. PAPE (SP-152530), on Sept. 30 in 1982 by O. YANO (SP-176239) and on Jan. 31 in 1984 by O. NECCHI Jr. (SP-187177) from Igarapé Acará, Reserva Florestal Adolfo Ducke at about 25 km from Manaus to Itacoatiara (Route AM-10), ca. 100 m alt. and situated at 2°54'S, and 59°56'W, Município of Manaus, State of Amazonas. The specimens of *B. cipoense* were collected on Feb. 7 in 1976 by L. SORMUS (SP-187192) and on Sept. 7 in 1974 by I. SAZIMA and M. SAZIMA (SP-



Map. 1. Map of Brazil showing the localities where specimens were collected.

187193) from Cipó Mountains, at about 126 km from Vespasiano to Conceição de Mato Dentro (Route MG-2), ca. 1,200 m alt. and situated at 19°10'S and 43°32'W, Município of Santana do Riacho, State of Minas Gerais. Two localities above-mentioned are shown in Map. 1.

Descriptions of Species

1. *Batrachospermum equisetoideum* KUMANO et NECCHI, sp. nov. (Figs 1-5, 6-16)

Frons monoica, ca. 6 cm alta, 300-800 μm crassa, abundanter irregulariteque ramosa, parum mucosa, atropurpurea. Cellulae axiales cylindricae, 30-80 μm crassae, 140-300 μm longae. Verticilli equisetoidei et distantes vel contigui. Cellulae basales globosae, cum 1 (-2) fasciculis. Ramuli primarii arcuati, audouinelloidei, unilateraliter, alterne vel opposite ramificantes, ex 7-15 cellulis constantes; cellulae fasciculorum cylindricae, 5-8.5 μm crassae, 16-48 μm longae; pili nuli. Fila corticalia bene evoluta. Ramuli secundarii rari vel sparsim evoluti. Spermatangia globosa vel obovata, 6-9 μm diametro, in ramulis primariis, rari in ramulis secundariis, lateralia vel terminalia. Ramuli carpogoniferi e cellulis basi ramulorum primariorum orientes, ex cellulis 5-7 disci- vel doliiformibus constantes, tortuosi; carpogonium 40-55 μm longum, basi 7-8 μm crassum, apice 10-13 μm crassum; trichogyne ellipsoidea vel urniformis, distincte pedicellata. Bracteae numerosae, breves, ex cellulis rotundatarum constantes. Gonimoblastus singulus, indefinitiforme, verticilliis crassiorus, 300-800 μm diametro, plus minusve diffusus; fila gonimoblastorum ex cellulis cylindratis vel longis constantes, laxa agglomerata. Carposporangia globosa vel obovoidea, 15-24 μm crassa, 19-30 μm longa.

Frond monoecious, ca. 6 cm high, 300-800 μm wide, abundantly and irregularly branched, slightly mucilaginous, blackish purple. Axial cells cylindrical, 30-80 μm wide, 140-300 μm long. Whorls *Equisetum*-like and separated or touching each other. Basal cell globose, with 1 (-2) fascicles. Primary branchlets curved, audouinelloid, unilaterally, alternately or oppositely branched, consisting of 7-15 cell-stories; cells of fascicles cylindrical, 5-8.5 μm wide, 16-48 μm long; hairs lacking. Cortical filaments well-developed. Secondary branchlets rare, sparsely developed. Spermatangia globose or obovoidal, 6-9 μm in diameter, lateral or terminal on primary branchlets, rarely on secondary branchlets. Carpogonium-bearing branch arising from the basal cell of primary branchlet, consisting of 5-7 disc- or barrel-shaped cells, twisted; carpogonium 40-55 μm long, 7-8 μm wide at the base, 10-13 μm wide at the apex; trichogyne ellipsoidal or urn-shaped, distinctly stalked. Bracts numerous, short, consisting of rounded cells. Gonimoblast single, indefinite-shaped, wider than whorls, 300-800 μm in diameter, more or less diffused; gonimoblast filaments with cylindrical and long cells, loosely aggregated. Carposporangia globose or obovoidal, 15-24 μm wide, 19-30 μm long.

Holotype: O. NECCHI JR., SP-187177, 31/I 1984, Herbarium of Institute of Botany, São Paulo, Brazil.

Other specimens examined: C. PAPE, SP-152530, 22/II 1978; O. YANO, SP-176239, 30/IX 1982; J.A. STEYERMARK & J.J. WURDACK, BMP 419, 21/I 1955.

Type Locality: Reserva Florestal Adolfo Ducke, Município of Manaus, Amazonas State, Brazil.

Distribution: Type locality and Tirica River, between "La Laja" and Base Camp, Chimantá Massif, Bolivar State, Venezuela.

Habitat: Epilithic in a rivulet with limpid and current water in shaded places.

Batrachospermum equisetifolium was described from French Guiana by MONTAGNE (1850), who supplied only a poor description and no figures with detail of structures as an aid to a precise identification. Although *B. equisetoideum* resembles *B. equisetifolium* in the Latin epithets and there is not enough information to judge securely, the former seems to be a different species from the latter, judging from the original description in MONTAGNE (1850) and that in SIRODOT (1884).

B. equisetoideum closely resembles *B. procarpum* SKUJA in having a twisted carpogonium-bearing branch, a large gonimoblast consisting of loosely aggregated filaments and fascicles which are unilaterally, alternately or oppositely branched and containing spiral and ribbon-shaped chromatophores. However, this species differs from *B. procarpum* in the shape and size of carposporangia and gonimoblasts. The carposporangia for this species are globose or obovoidal, 15-24 μm wide and 19-30 μm long, while those for *B. procarpum* are obovoidal or pear-shaped, 8.5-9.5 μm wide and 10-13 μm long (SKUJA 1931). The gonimoblasts for this species are more or less diffused and indefinite-shaped, 300-800 μm in diameter, while those for *B. procarpum* are semiglobular and up to 300 μm in diameter (SKUJA 1931).

2. *Batrachospermum cipoense* KUMANO et NECCHI, sp. nov. (Figs 17-21, 22-31)

Frons monoica, ca. 5 cm alta, 350-700 μm crassa, abundanter irregulariteque ramosa, parum mucosa, aeruginosa. Cellulae axiales cylindricae, 25-90 μm crassae, 70-200 μm longae. Verticilli distantes vel contigui et cylindratii vel obconici. Cellulae basales globosae, cum 1-2 fasciculis. Ramuli primarii audouinelloidei, alterne vel unilaterliter raminificantes, ex 9-19 cellulis proximalibus et distalibus constantes; cellulae distales fasciculorum doliiformes, 5.5-8 μm crassae, 12-16 μm longae; cellulae proximales cylindricae, 6.5-9 μm crassae, 20-28 μm longae; pili numerosi, unus vel duo in quoque cellula terminales. Fila corticalia bene evoluta. Ramuli secundarii abundi, in parte vetustiore frondis totum internodium obtegentes. Spermatangia globosa vel obovata, 5-8 μm diametro, in ramulis primariis et secundariis lateralia vel terminalia. Ramuli carpogoniferi e cellulis basi ramulorum primariorum orientes, ex cellulis 4-7 disci- vel doliiformibus constantes, tortuosi; carpogonium 33-48 μm longum, basi 5-10 μm crassum, apice 7-10 μm crassum; trichogyne ellipsoidea vel claviformis, plus minusve distincte pedicellata. Bracteae numerosae, breves, ex cellulis rotundatarum constantes. Gonimoblastus singulus, globosus vel semiglobosus, 400-900 μm crassus, 400-700 μm altus, verticillis crassiorus; fila gonimoblastorum longa, plus minusve laxe agglomerata. Carposporangia globosa vel obovoidea, 11-17 μm crassa, 13-19 μm longa.

Frond monoecious, ca. 5 cm high, 350-700 μm wide, abundantly and irregularly branched, slightly mucilaginous, green with a bluish tinge. Axial cells cylindrical, 25-90 μm wide, 70-200 μm long. Whorls obconical or cylindrical, separated or touching each other. Basal cell globose, with 1-2 fascicles. Primary branchlets audouinelloid, curved, alternately or unilaterally branched, consisting of 9-19 both distal and proximal cell-stories; distal cells of fascicles barrel-shaped, 5.5-8 μm wide, 12-16 μm long; proximal cells cylindrical, 6.5-5 μm wide, 20-28 μm long; hairs abundant, 1-2 on each terminal cell. Cortical filaments well-developed. Secondary branchlets abundant, covering all the internodes in older parts of

frond. Spermatangia globose or obovoidal, 5-8 μm in diameter, lateral or terminal on primary and secondary branchlets. Carpogonium-bearing branch arising from the basal cell of primary branchlets, consisting of 4-7 disc- or barrel-shaped cells, twisted; carpogonium 33-48 μm long, 5-10 μm wide at the base, 7-10 μm wide at the apex; trichogyne ellipsoidal or club-shaped, more or less distinctly stalked. Bracts numerous, short, consisting of rounded cells. Gonimoblast single, globular or semiglobular, wider than whorls, 400-900 μm wide, 400-700 μm high; gonimoblast filaments more or less loosely aggregated. Carposporangia globose or obovoidal, 11-17 μm wide, 13-19 μm long.

Holotype: L. SORMUS, SP-187192, 7/11 1976, Herbarium of Institute of Botany, São Paulo, Brazil.

Other specimens examined: I. SAZIMA and M. SAZIMA, SP-187193, 7/IX 1974.

Type Locality: Cipó Mountains, Município of Santana do Riacho, Minas Gerais State, Brazil.

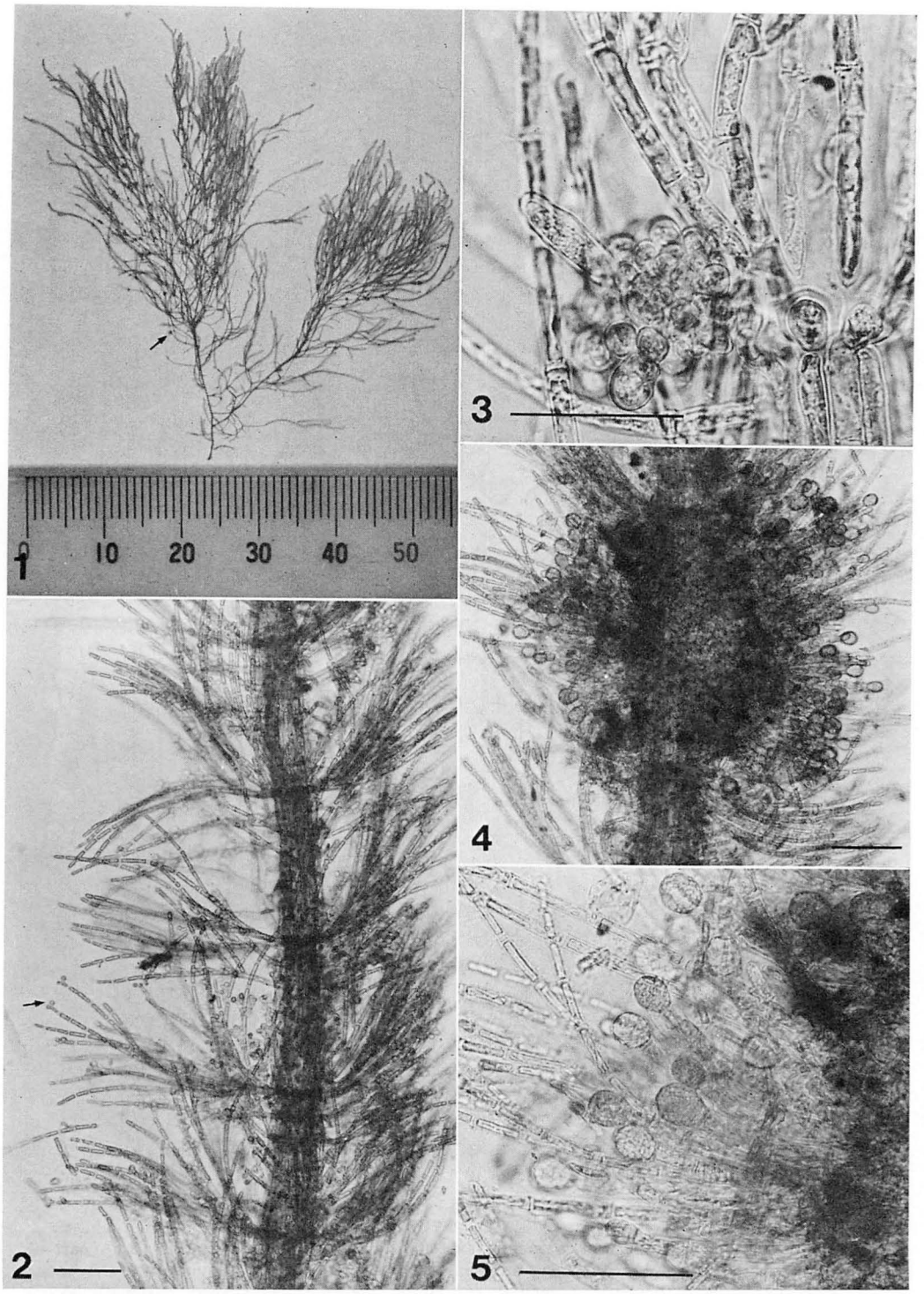
Distribution: Known only from the type locality.

Habitat: Epilithic in a mountain rivulet with limpid and current water in shaded places.

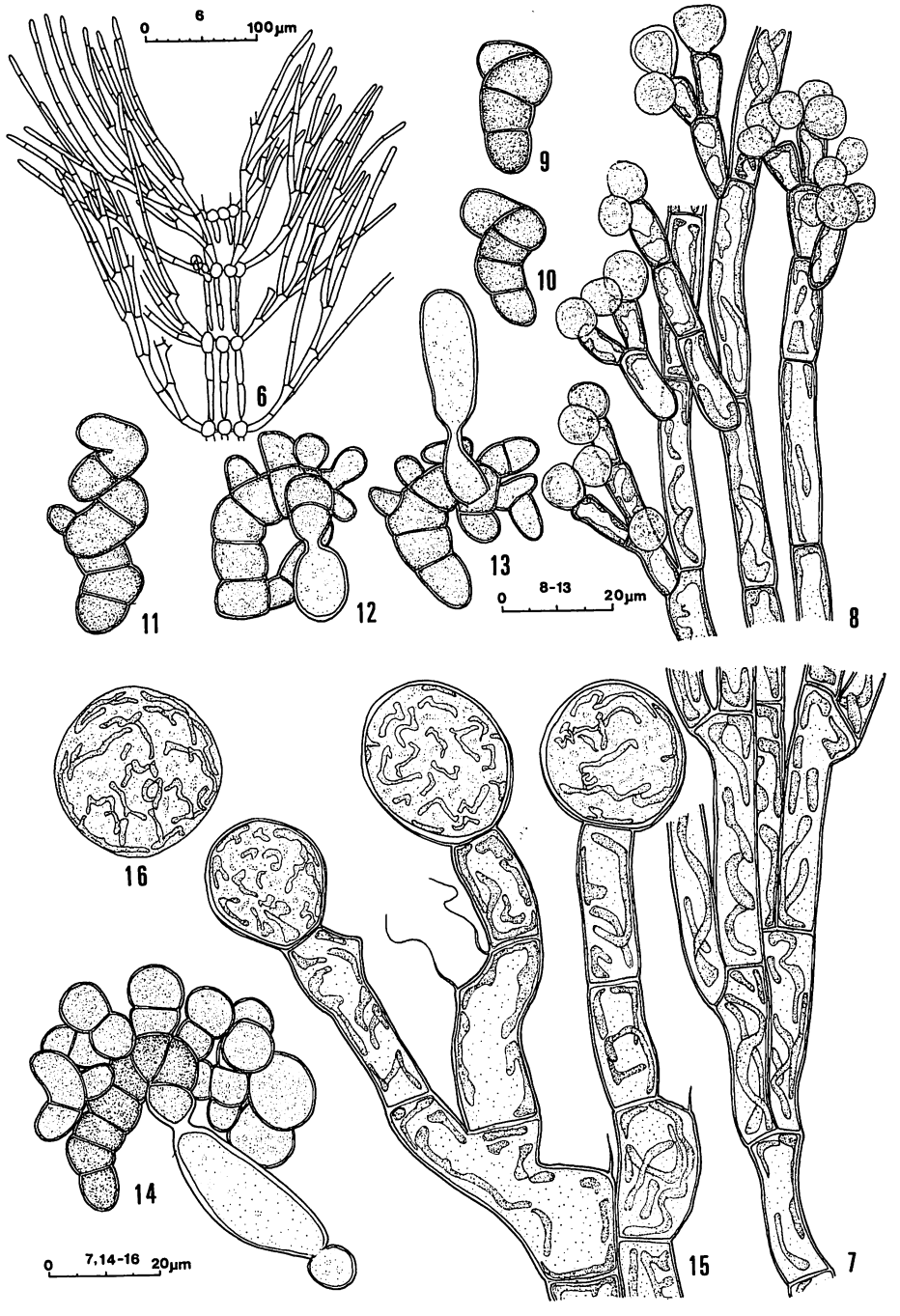
This species resembles *B. procarpum* and *B. equisetoideum* in general appearence. However, this species differs from *B. procarpum* in the shape and size of carposporangia and gonimoblasts; the carposporangia for *B. cipoense* are globose or obovoidal, 11-17 μm wide, 13-19 μm long and the gonimoblasts for *B. cipoense* are globular or semiglobular, 400-900 μm wide, while the carposporangia for *B. procarpum* are obovoidal or pear-shaped, 8.5-9.5 μm wide, 10-13 μm long and the gonimoblast for *B. procarpum* are semiglobular and up to 300 μm wide (SKUJA 1931). This species differs from *B. equisetoideum* in having secondary branchlets more abundantly developed, gonimoblasts more compactly aggregated and in the size of carposporangia; the carposporangia for *B. cipoense* are 13-19 μm long, while those for *B. equisetoideum* are 19-30 μm long.

Discussion

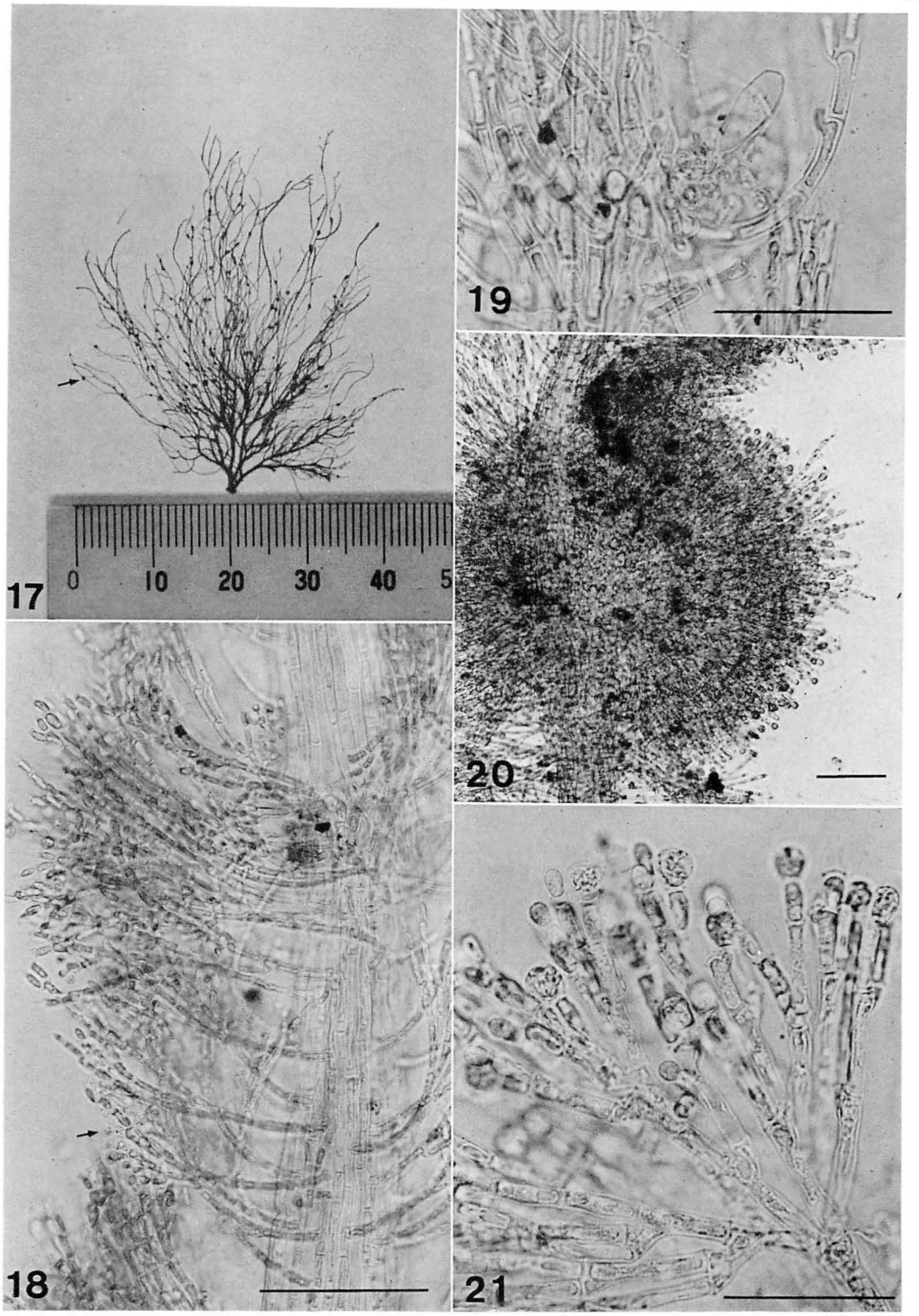
Most taxa of the genus *Batrachospermum* have the fascicles, which are di-, tri- or tetrachotomously branched laterals of limited growth, all of about the same length. These laterals are composed of small ellipsoidal or moniliform cells. However, *B. equisetoideum* presents some important characteristics, which are whorls of audouinelloid fascicles with alternate, opposite or unilateral branches. *B. equisetoidem* is compared with *B. procarpum*, which also has the audouinelloid branches, but is different from the latter in having the whorl of audouinelliod fascicles with opposite branches in addition to the alternate and unilateral ones found in *B. procarpum*, and strongly curved fascicles in contrast to the slightly curved ones found in *B. procarpum*. The cells of fascicles in *B. equisetoidem* are perfectly cylindrical without swellings or constrictions at the cross-walls as found in *B. procarpum*. *B. cipoense* is different from *B. equisetoideum* in having branches in the distal ends of the fascicles, the secondary branchlets more abundantly developed and hairs. Although there are minor differences among *B. procarpum*, *B. equisetoideum* and *B. cipoense*, concerning vegetative characteristic these three species are distinguished from the other taxa of the genus *Batrachospermum* in having the audouinelloid fascicles. In this respect, it is reasonable to consider them as a definite group of species named *Batrachospermum procarpum* complex, which has a geographical distribution restricted to the Americal Continent up to now. On the other hand, in relation to the reproductive characteristics, there are distinct differences among these three species as shown in the Table. However, these three species have the twisted or coiled carpogonium-bearing branches as found in taxa belonging to the section *Contorta*. This section is very heterogenous at the present, and consists of a miscellany of species that has the just mentioned



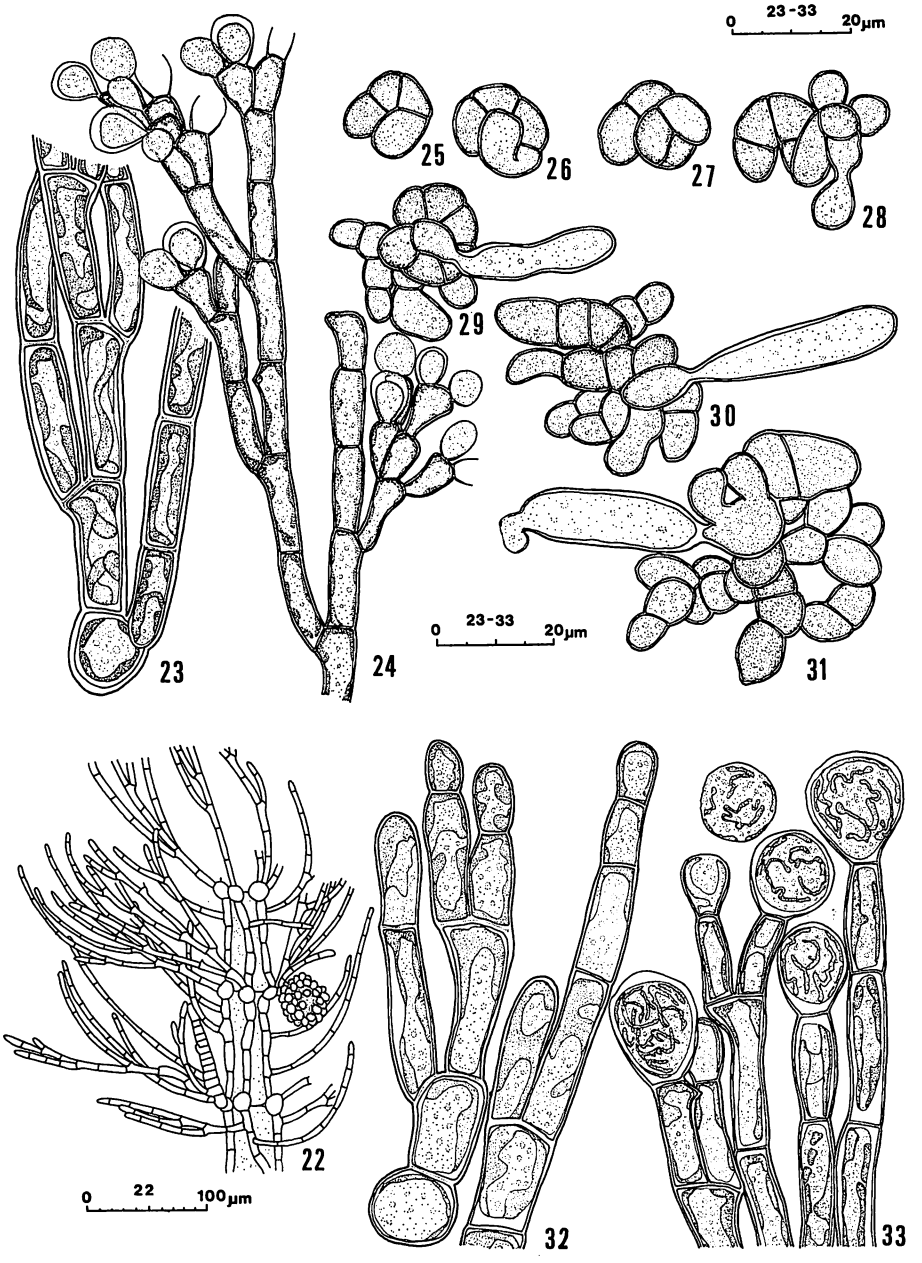
Figs 1–5. *Batrachospermum equisetoideum* KUMANO et NECCHI, sp. nov. 1. Holotype, leg. O. Necchi Jr., SP-187177, 31/I 1984, several gonimoblasts are recognized (arrow); 2. A part of thallus showing well-developed cortical filaments and many spermatangia terminal or lateral on primary and rarely secondary branchlets; 3. A part of whorl showing primary branchlets, cortical filaments and a carpogonium-bearing branch surrounded by rounded cells of bracts; 4. An indefinite-shaped gonimoblast; 5. Carposporangia terminal on loosely aggregated gonimoblast filaments. (Scale bar; 100 μm for Figs 2, 4 and 5; 50 μm for Fig 3).



Figs 6-16. *Batrachospermum equisetoideum* KUMANO et NECCHI, sp. nov. 6. A part of thallus showing axial cells, primary branchlet and a young carpogonium-bearing branch; 7. Proximal cells of primary branchlet containing spiral ribbon-shaped chromatophores; 8. Spermatangia terminal or lateral on primary branchlets; 9-11. Carpogonium-bearing branches at very early stage in development; 12. An early stage in development of a twisted carpogonium-bearing branch with a young carpogonium; 13. A carpogonium-bearing branch with a mature carpogonium; 14. A fertilized carpogonium with a spermatium; 15. Carposporangia terminal on gonimoblast filaments containing ribbon-shaped chromatophores; 16. A carpospore. (Scale bar; 100 μm for Fig. 6; 20 μm for Figs 7-16)



Figs 17-21. *Batrachospermum cipoense* KUMANO et NECCHI, sp. nov. 17. Holotype. leg. L. Sormus, SP-187192, 7/II 1976, several gonimoblasts are recognized (arrow); 18. A part of thallus showing well-developed cortical filaments and spermatangia terminal or lateral on primary and secondary branchlets (arrow); 19. A carpogonium with a trichogyne; 20. Semiglobular gonimoblast; 21. Carposporangia terminal on gonimoblast filaments. (Scale bar; 100 μm for Figs 18 and 20; 50 μm for Figs 19 and 21).



Figs 22-33. *Batrachospermum cipoense* KUMANO et NECCHI, sp. nov. 22. A part of thallus showing axial cells, cortical filaments, primary and secondary branchlets and a young carpogonium-bearing branch; 23. Proximal cells of primary branchlets containing parietal chromatophores; 24. Spermatangia terminal or lateral on secondary branchlet; 25-27. Carpogonium-bearing branches at very early stages in development; 28. An early stage in development of a coiled carpogonium-bearing branch with a young carpogonium; 29-30. Carpogonium-bearing branches with mature carpogonia; 31. A fertilized carpogonium with a spermatium; 32. Gonimoblast filaments at an early stage of development; 33. Carposporangia terminal on gonimoblast filaments. (Scale bar; 100 μm for Fig. 22; 20 μm for Figs 23-33)

	Gonimoblast	Carposporangia
B. procarpum	semiglobular up to 300 μm in diameter	obovoidal or pear-shaped 8.5-9.5 μm wide, 10-13 μm long
B. equisetoideum	more or less diffuse 300-800 μm in diameter	obovoidal or globose 15-24 μm wide, 19-30 μm long
B. cipoense	globular or semiglobular 400-900 μm in diameter	obovoidal or globose 11-17 μm wide, 13-19 μm long

characteristic in common. The other sections of the genus are generally identified mainly by reproductive characteristics, such as size and position of gonimoblasts, shape of trichogyne, size of carpogonium-bearing branches. So that, the present authors considered the reproductive characteristics as more important than the vegetative ones, and these three species should be assigned to the section *Contorta* for the present. The need for a more natural infrageneric arrangement is becoming greater every time a new species is described. Thus, a further rearrangement of the species at the infrageneric level with a review of the taxonomic criteria for those level is strongly desired.

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熊野 茂*・ネッシィ O., Jr.**: ブラジルの淡水産紅藻 II. アマゾナス州およびミナス ジエライス州のカワモヅク属2新種

ブラジル アマゾナス州 アドルフォ デュケ森林保護区の小流から *Batrachospermum equisetoideum* が，ミナス ジェライス州 シポ山地の小流から *Batrachospermum cipoense* がそれぞれ新種として記載された。上記2種と *Batrachospermum procarpum* SKUJA とは *Audouinella* 状に分枝する輪生枝をもつ点でカワモヅク属の他の種と区別できる。また上記3種を互いに区別するためのキィは次の通りである。

1. 嚢果の直径 100-300 μm—*B. procarpum* SKUJA
1. 嚢果の直径 300-900 μm
  2. 果胞子の長さ 13-19 μm—*B. cipoense* KUMANO et NECCHI
  2. 果胞子の長さ 19-24 μm—*B. equisetoideum* KUMANO et NECCHI

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