Article

Batrachospermum gombakense (Batrachospermaceae, Rhodophyta), new to Sabah, Malaysia

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Abstract

Batrachospermum gombakense Kumano et Ratnasabapathy (Batrachospermaceae, Rhodophyta) is reported for the first time from Sabah, Malaysia on the island of Borneo. This species was found attached to submerged rocks and boulders of clear stream waters of Sungai Tabin in the Tabin Wildlife Reserve, Lahad Datu. It is characterized by the following combination of features:(i) Plant dioecious, brownish dark purple, 1-3 cm high, 300-550 μm in diameter, more or less dichotomously branched, not very mucilaginous; (ii) Spermatangia spherical, in clusters on lateral short branchlets at the middle of fascicle or shortened branchlets; (iii) Carpogonium bearing branch arising from pericentral cell, consisting of 1-3 pentagonal cells; (iv) Trichogyne inversed conical or club-shaped, indistinctly stalked; and (v) Carposporophytes single, axial, spherical to ellipsoidal, and carposporangia ovoidal.

Batrachospermum gombakense is distributed in both Peninsular Malaysia and Sabah, Malaysia in Borneo. This finding contributes to efforts in mapping the distribution of species of the genus *Batrachospermum* in the Indo-Malaysian North Australian phycogeographical region (IMNAR).

Key Words: *Batrachospermum gombakense,* freshwater red algae, endemism, Sabah, Borneo, Indo-Malaysia North Australia phycogeographical region

Introduction

Borneo Island is situated in the center of the Indo-Malaysia North Australia phycogeographical region. West and West (1902) recognized that the region encompassing the Indian subcontinent, Sri Lanka, tropical Southeast Asia and northern Australia shared a number of characteristic desmid taxa. This was confirmed by Krieger (1932), based on the species composition of desmid flora, and the region was defined as the Indo-Malaysian North Australian phycogeographical region (IMNAR).

Vyverman (1996) reviewed the present knowledge of the freshwater algal flora, especially phytoplankton communities of lakes in the IMNAR and discussed some features of the geographic distribution of tropical freshwater phytoplankton. He recognized a much larger number of desmids and diatoms as regional endemics. These include the taxa which are confined to the IMNAR and the taxa which have their main distribution in the IMNAR but also occur further to the north and/or south.

Although little has been discussed about the geographic distribution of the taxa of freshwater red algae, which may be due to lack of information, the taxa of freshwater red algae are known to exhibit endemism. In fact, some taxa of the family Batrachospermaceae are thought to be endemics (Tyler, 1996); two species of the genus

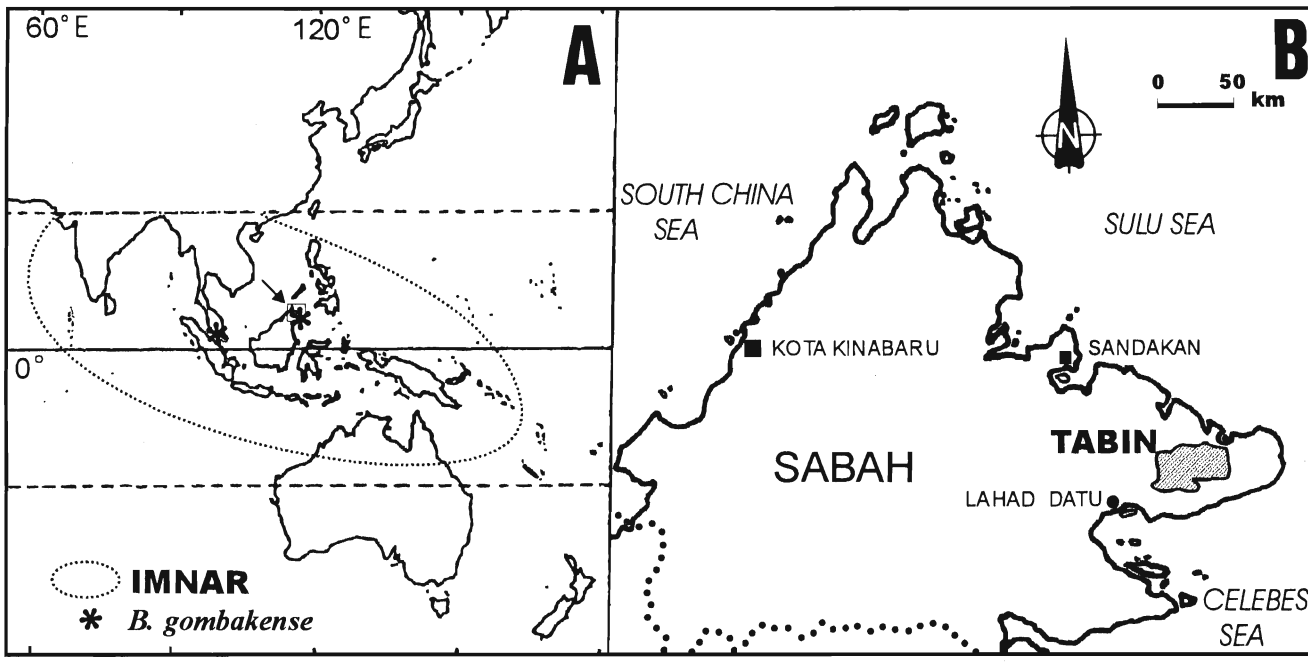

Fig.1. Location of the study area. Location of the Indo-Malaysian North Australian phycogeographical region (IMNAR) and Sabah on Borneo Island (marked by an arrow) are shown to the left (A). Distribution pattern of *Batrachospermum gombakense* (asterisks) is also shown in A. The Tabin Wildlife Reserve (TABIN), Sabah, Malaysian Borneo, is to the right (B).

Nothocladus are endemic to temperate Southeast Australia and Tasmania (Entwisle and Kraft, 1984), and *Batrachospermum diatyches* is endemic to Tasmania (Entwisle, 1992).

In the IMNAR, species of the genus *Batrachospermum* have been reported from the tropical regions, Peninsular Malaysia (Kumano, 1978; Ratnasabapathy and Kumano, 1982a, 1982b; Kumano and Ratnasabapathy, 1982, 1984; Kumano, 1984; Kumano, 1986; Kumano and Phang, 1987), Papua New Guinea (Kumano, 1983; Kumano and Johnstone, 1983; Kumano and Watanabe, 1983), the Philippines (Kumano and Liao, 1987) and India (Balakrishnan and Chaugule, 1980).

No taxa of the freshwater red algae have been reported from Sabah except for one record of a taxon of *Batrachospermum* from the Maliau River (Anton et al., 1998), which is the reason for this survey on freshwater algal flora at Tabin Wildlife Reserve in Lahad Datu, Sabah, a Malaysian state situated in North Borneo. In the present paper, *Batrachospermum gombakense* is reported new to Sungai Tabin, Sabah, Malyasia in Borneo and its implication for geographic distribution of species of the genus *Batrachospermum* is discussed.

Study area

The Tabin Wildlife Reserve of the Sabah Wildlife Department, covering an area estimated to be 122,539 hectares, is situated in the center of the Dent Peninsula, northeast of Lahad Datu (Fig.1). The Tabin Wildlife Reserve consists of a tropical rain forest area dominated by lowland dipterocarps almost totally surrounded by land alienated for planting of oil palm, *Elaeis guineensis*. It has seven of the protected areas of Tropical Rain Forest Reserves, thus providing small patches for particular scientific interests.

The joint Tabin Scientific Expedition 1 and Inventory 1998, organized by Universiti Malaysia Sabah and Sabah Wildlife Department, was conducted from 12-28 February and 12-30 March, 1998. The aim of this expedition was to document the flora and fauna of Tabin Wildlife Reserve in an effort to promote its conservation. The survey of freshwater algae was conducted in the Tabin Tropical Forest Reserve (5°10'N, 118° 40'E) which covers an area of about 122 hectares of lowland dipterocarp forests, including an area of mud volcanoes.

The specimens of *Batrachospermum gombakense* were collected in a tributary of Sungai Tabin at an altitude of about 150 meters. At this upper tributary of Sungai Tabin on March 9, 1998, the water was clear, with water temperature of 24.3-25.0°C and the conductivity of 668-751 μ S/cm at the sampling site.

Description of species

Batrachospermum gombakense Kumano &

Ratnasabapathy 1982b, Jpn. J. Phycol. 30:121, fig.2. (Figs.2-11)

Plant dioecious, brownish dark purple, 1-3 cm high, 300-550 μm in diameter, more or less dichotomously branched, not very mucilaginous. Axial cells cylindrical, 10-40 μm in diameter, 40-100 μm long. Whorls touching each other, more or less compressed. Primary fascicles unilaterally branched, consisting of 14-28 cell-stories; cells of fascicles cylindrical or barrel-shaped, 5-7 μm in diameter, 6-14 μm long, without terminal hairs. Cortical filaments well-developed. Secondary fascicles numerous, covering all internodes. Spermatangia spherical, 4-8 μm in diameter, in clusters on lateral short branchlets at the middle of fascicle or shortened branchlets. Carpogonium bearing branch arising from pericentral cell, consisting of 1-3 pentagonal cells. Carpogonium 3-5 μm in diameter at the base, 10-15 μm in diameter at the apex, 40-50 μm long; trichogyne inversed conical or club-shaped, indistinctly stalked. Involucral filaments arising from 1-2 pentagonal cells. Carposporophytes single, axial, spherical to ellipsoidal, 140-300 μm wide, 200-350 μm long. Carposporangia ovoidal, 8-12 μm in diameter, 15-25 μm long.

Specimens examined. One each of male and female specimens from an upper tributary of Sungai Tabin, Sabah, Malaysia (Sato, 9/III 1998).

Habitat. Attached to submerged rocks or boulders, 10-25 cm below the surface of clear stream waters in the upper tributary of Sungai Tabin which flow through the lowland dipterocarp forest in the Tabin Wildlife Reserve, Sabah, Malaysia.

Distribution. Selangor, Peninsular Malaysia and Sabah, Malaysia in Borneo.

Note. The specimens from Sungai Tabin are slightly different from those described by Ratnasabapathy and Kumano (1982b) in plant size and colour, in cell-story and cell size of primary fascicles, and in shape and size of carposporophytes; the latter showed green plants of 1-2 cm high and 200-400 μm wide in size, primary fascicles consisting of 9-15 cell-stories and 5-10 μm long in cell size, ellipsoidal carposporophytes of 140-210 μm wide and 185-330 μm long in size, and carposporangia of 8-11 μm in diameter and 20-25 μm long. However, the specimens from Sungai Tabin were identified as *B. gombakense* mainly based on the characteristics of reproductive structures.

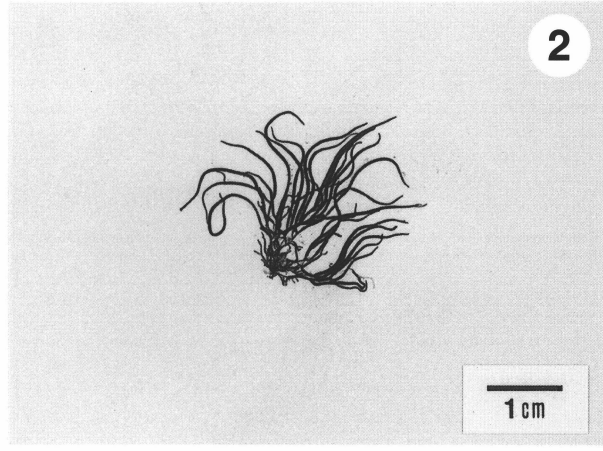

Fig.2. *Batrachospermum gombakense*. General habit of a male specimen from Sungai Tabin, Sabah, Malaysia.

Distribution of species of the genus *Batrachospermum* in the IMNAR

Freshwater red algae include regional endemics. According to Entwisle and Foard (1997), temperate regions of Australia and New Zealand yield many endemics while the tropical and subtropical climes have a more cosmopolitan algal flora. A red alga *Psilosiphon scoparium* from Southeast Australia is distinctive, because it brought new genus to the Batrachospermales (Entwisle, 1989). Moreover, two species of the genus *Nothocladus* are endemic to Southeast Australia and Tasmania (Entwisle and Kraft, 1984) and *Batrachospermum diatyches* endemic to Tasmania (Entwisle, 1992). Tasmania is particularly rich in algal endemics (Entwisle and Foard, 1997).

Eighteen species of the genus *Batrachospermum* have been reported from the IMNAR (Table 1). Among them, *B. cayennense* is distributed in tropical South America (Montagne, 1850; Necchi and Kumano, 1984) and Madagascar (Bourrelly, 1964). *B. gelatinosum* and *B. turfosum* have their distribution in the temperate regions (Kumano and Hirose, 1977; Kumano, 1980) and have been reported from the Papuan highlands (Kumano and Watanabe, 1983). Hence, fifteen species of *Batrachospermum* can be endemics to the IMNAR at the present. The present study shows that *B. gombakense* is distributed in both Peninsular Malaysia and Malaysia in Borneo, while the others have been reported only from each type locality. This finding suggests that some of the fifteen endemic species may have characteristic distribution reflecting the paleogeographical changes of the IMNAR.

The IMNAR has been defined by sharing a number of characteristic desmid species, and a large number of desmids and diatoms are considered as endemics in the IMNAR (Vyverman, 1996). It is, however, assumed that

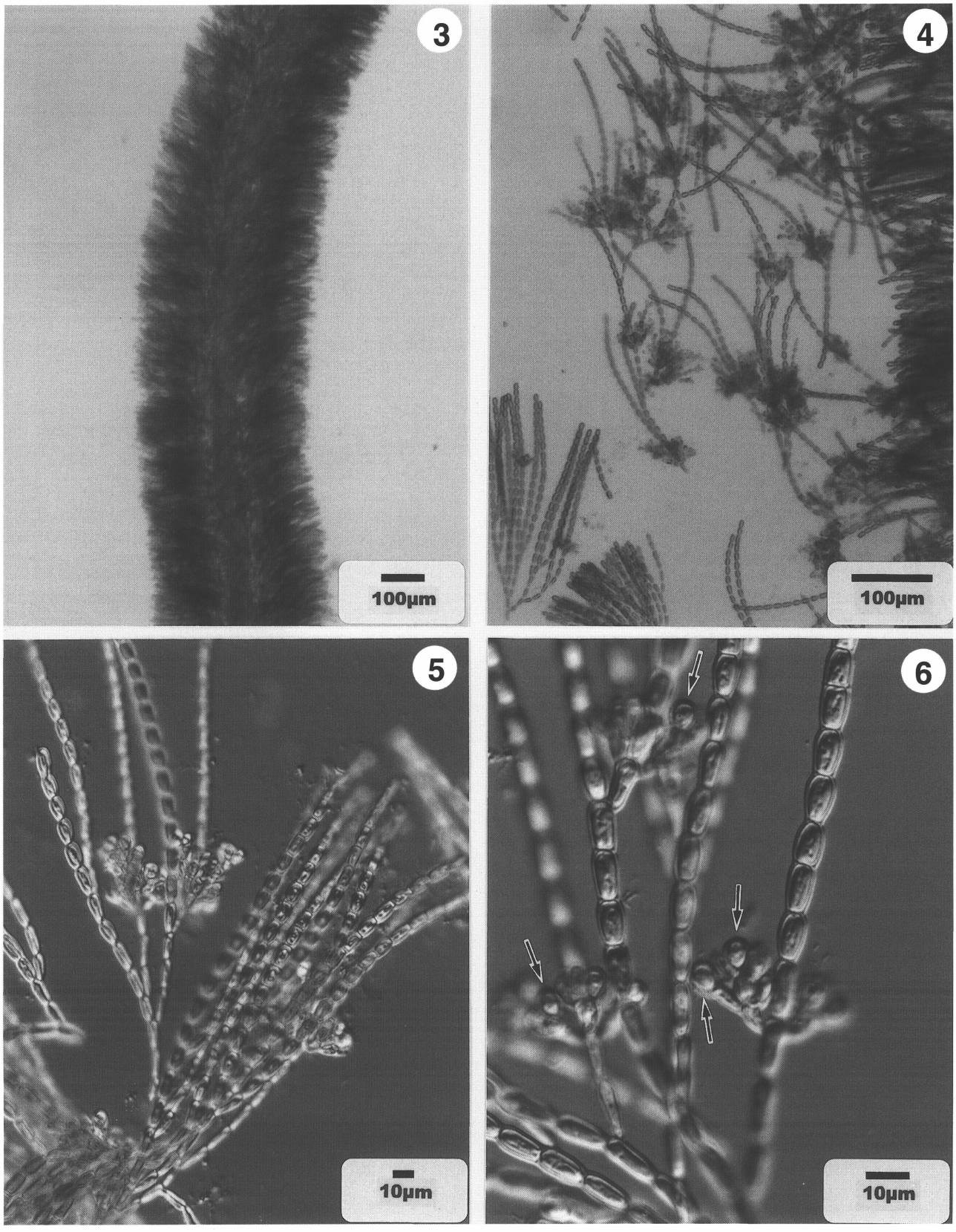

Fig.3-6. *Batrachospermum gombakense.* 3. Structure of whorls showing spermatangia. 4-5. Fascicles with spermatangia. 6. Spermatangia (arrows) in clusters, lateral on fascicles.

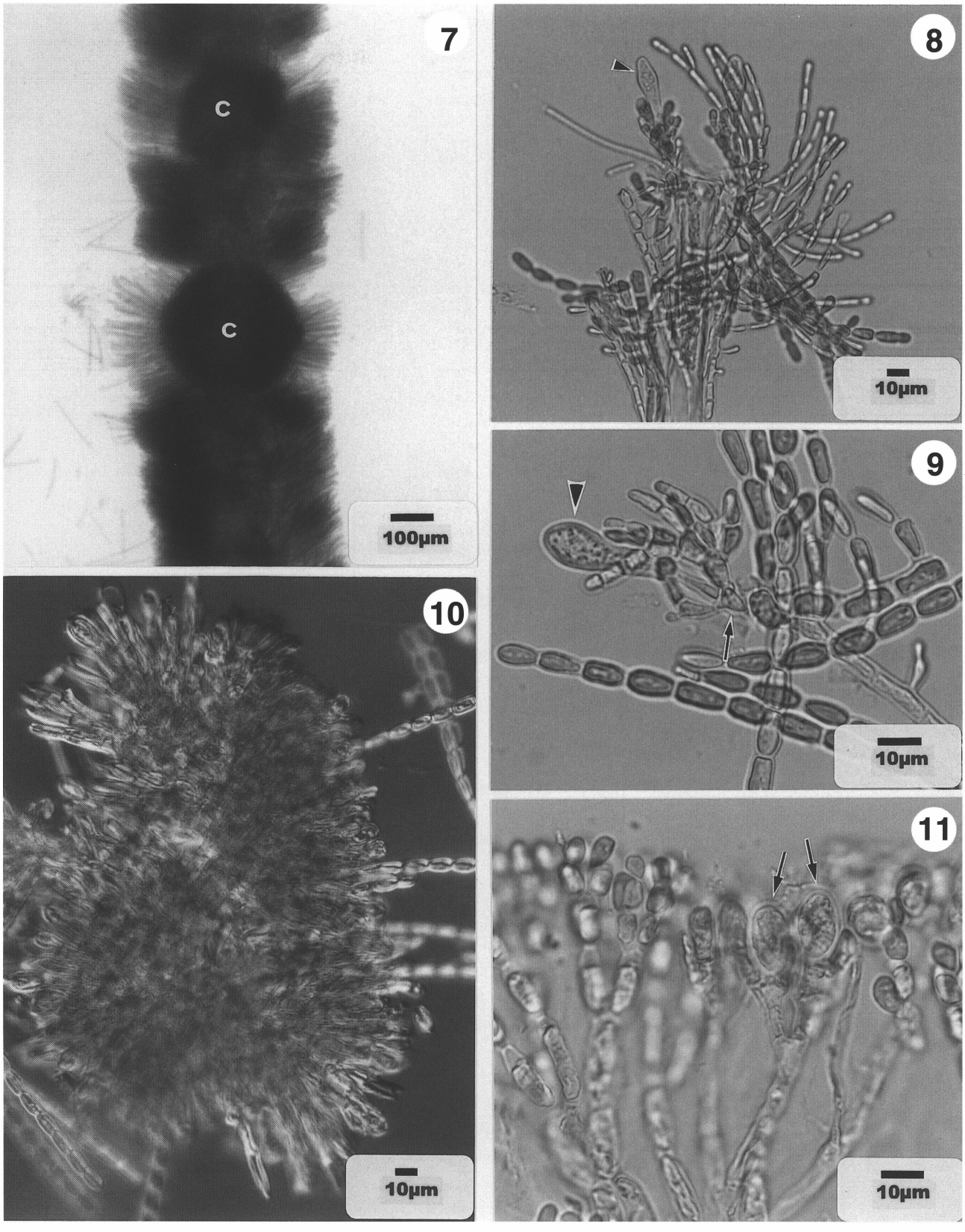

Fig.7-11. *Batrachospermum gombakense.* 7. A portion of a plant showing mature carposporophytes (c). 8-9. Carpogonium bearing branch consisting of only one pentagonal cell (an arrow); carpogonium with club-shaped trichogyne (arrowheads). 10. Carposporophyte with gonimoblast filaments. 11. Carposporangia (arrows) terminal on gonimoblast filaments.

Table 1. A selection of species of the genus *Batrachospermum* from the IMNAR.

Species	Known Distribution	Reference
1. *B. bakarense*	Peninsular Malaysia	Kumano and Ratnasabapathy, 1984
2. *B. beraense*	Peninsular Malaysia	Kumano, 1978; Kumano and Ratnasabapathy, 1982
3. *B. cayennense*	French Guiana Madagascar Peninsular Malaysia Brazil	Montagne, 1850 Bourrelly, 1964 Kumano and Ratnasabapathy, 1982 Necchi and Kumano, 1984
4. *B. crispatum*	Peninsular Malaysia	Ratnasabapathy and Kumano, 1982a
5. *B. cylindro-cellulare*	Peninsular Malaysia	Kumano, 1978; Kumano, 1984
6. *B. gelatinosum* (= - var. *obtrullatum*) (= *B. moniliforme*) (= *B. godronianum*)	 Papua New Guinea Japan* Peninsular Malaysia	 Kumano and Watanabe, 1983 Kumano and Hirose, 1977 Ratnasabapathy and Kumano, 1982a
7. *B. gibberosum*	Peninsular Malaysia	Kumano, 1986
8. *B. gombakense*	Peninsular Malaysia Sabah, Malaysia	Ratnasabapathy and Kumano, 1982b present study
9. *B. hirosei*	Peninsular Malaysia	Ratnasabapathy and Kumano, 1982b
10. *B. hypogynum*	Peninsular Malaysia	Ratnasabapathy and Kumano, 1982b
11. *B. mahabaleshwarensis*	India	Balakrishnan and Chaugule, 1980
12. *B. nonocense*	Nonoc Island, the Philippines	Kumano and Liao, 1987
13. *B. nova-guineese*	Papua New Guinea	Kumano and Johnstone, 1983
14. *B. tapirense*	Peninsular Malaysia	Kumano and Phang, 1987
15. *B. tiomanense*	Peninsular Malaysia	Ratnasabapathy and Kumano, 1982a
16. *B. tortuosum*	Peninsular Malaysia	Kumano, 1978; Kumano, 1984
17. *B. turfosum* (= - var. *undulato-pedicellatum*) (= *B. vagum*)	 Papua New Guinea Japan*	 Kumano and Watanabe, 1983 Kumano and Hirose, 1977
18. *B. woitapense*	Papua New Guinea	Kumano, 1983

*) widely distributed in the temperate regions

geographic distribution of species of the genus *Batrachospermum* should be different from that of desmids and diatoms, because freshwater red algae would be less tolerant to desiccation and cannot propagate by asexual reproduction.

Kristiansen (1996) considered four main types of dispersal of freshwater algae, namely by water, organisms, man, and by airborne dispersal. The possibility for successful dispersal depends on distance and the tolerance of the algae for the transported conditions. Although we have no information about dispersal factors for freshwater red algae, the genus *Batrachospermum* is considered to be less capable for transport than unicellular algae, such as desmids and diatoms. Among the possible factors, dispersal by freshwater, which takes place in running water and whenever there is a water connection between water bodies (Kristiansen, 1996), is the most natural and probable way for species of *Batrachospermum*.

During the Quaternary period of low sea levels, the geography of the earth was considerably altered (Williams et al., 1993). The shelves were exposed around the major continents, with new river courses being cut across them as the enlarged land areas drained to the more distant sea, and land bridges connected many areas now separated by straits. During the last glacial maximum, for example, many islands of Southeast Asia were linked and formed an extension of the Asian mainland (e.g. Peltier, 1994). The area emcompassing Southeast Asia, New Guinea and Australia is important for human and biotic migration (Pirazzoli, 1996). Most significant in this area is the changing complex of islands and straits that separated the continental shelves of Sunda and Sahul.

From the paleogeographical point of view, it is important to clarify the distribution patterns of species of the genus *Batrachospermum* in the IMNAR. Although our knowledge of freshwater red algal flora in the IMNAR is still fragmentary, the new record of *B. gombakense* from Borneo Island contributes to efforts in mapping the distribution of species of this genus in the IMNAR.

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