

OBSERVATIONS OF SPORE MORPHOLOGY  
OF SOME HEPATIC SPECIES (MARCHANTIOPHYTA) IN CHINA  
О МОРФОЛОГИИ СПОР НЕКОТОРЫХ ВИДОВ ПЕЧЕНОЧНИКОВ  
(MARCHANTIOPHYTA) В КИТАЕ

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Abstract

The spores of four genera and six species, *Porella ceaspitans* (Stephani) Hatt., *Frullania gaoligongensis* X.-L. Bai et C. Gao, *F. appendistipula* Hatt., *Riccia cavernosa* Hoffm., *R. frostii* Aust. and *Targionia hypophylla* L., were studied by light microscopy (LM) and scanning electron microscopy (SEM). The result shows that their spore morphological differences can be obviously distinguished. The information provided by SEM shows the significant character differences among species, which provides new materials for the further studies of the taxonomy of Hepaticae.

Резюме

Споры печеночников из четырех родов и шести видов, *Porella ceaspitans* (Stephani) Hatt., *Frullania gaoligongensis* X.-L. Bai et C. Gao, *F. appendistipula* Hatt., *Riccia cavernosa* Hoffm., *R. frostii* Aust. и *Targionia hypophylla* L., были изучены с помощью световой и сканирующей электронной микроскопии. Результаты наблюдений показывают, что есть существенные морфологические отличия между видами. Данные СЭМ позволяют выявить важные диагностические признаки, что является основой для уточнения таксономии печеночников.

KEYWORDS: Spore, ornamentation, Hepaticae, SEM

INTRODUCTION

A taxonomical arrangement of Hepaticae and separation of the families were made mostly on the basis of gametophytic characters. However, due to morphological simplicity of some species, their taxonomically useful characters are rather scarce; moreover many gametophytic diagnostic characters show a considerable variability, as they are affected by environmental conditions (Pandé, 1924; Abeywickrama, 1945). The spore ornamentation has been occasionally used for clarifying some problems involving closely related species. However, additional study is needed concerning hepatic species in China.

In present study, the detailed spore morphological structures of *Porella ceaspitans*, *Frulla-*

*nia gaoligongensis* and *F. appendistipula* were examined for the first time with the SEM. SEM spore micrographs of *Riccia cavernosa* have been previously published by Na-Thalang (1980), Jovet-Ast (1986), Perold (1989), Jia et al. (2002), Zhang & Wu (2006) and Dirkse & Losada-Lima (2011); spore structure of *R. frostii* was examined with SEM by Kumar et al. (1987) and Jia et al. (2002), as well as that of *Targionia hypophylla* was investigated by other authors. We have studied spores from other collections of these three species. The purpose of this study is to characterize the spore morphology of four genera and six species of the Hepaticae as an aid for studies in taxonomy and paleopalynology.

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## MATERIALS AND METHODS

This study was based on the collections preserved at the College of Life Science of Inner Mongolia University Herbarium (HIMC). Measurements of spores were made under the LM. Scanning electron micrographs were taken using H-7000 SEM. Before scanning, spores were washed in a drop of distilled water on a microscope slide and allowed to air dry for two days and then coated with gold.

In descriptions of the spore morphology, the terms as defined and used by Duthie & Garside (1936, 1939), Erdtman (1969), Taylor et al. (1974), Na-Thalang (1980), Gupta & Udari (1986) and Perold (1989) were adopted.

The Chinese specimens studied for the spore of morphology are as follow:

*Porella caespitans*: Yunnan Prov., Weixi County, 7.V.1982, X. Hao 117.

*Frullania gaoligongensis*: Yunnan Prov., Gaoligong Mt., 29.VII.1978, M. Zang 5620.

*Frullania appendistipula*: Yunnan Prov., Yulong Mt., 31.VIII.1957, W.-X. Xu 0646.

*Targionia hypophylla*: Inner Mongolia Prov., Ningcheng County, 26. VII.2000, X.-L. Bai 419.

*Riccia cavernosa*: Inner Mongolia Prov., Eergunayouqi, 8.IX.1986, X.-L. Bai 146.

*Riccia frostii*: Inner Mongolia Prov., Eergunayouqi, 8.IX.1986, X.-L. Bai 146.

## RESULTS

***Porella caespitans* (Stephani) Hatt.** (Fig. 1: a, b, c).

Spores 31.2–37.7  $\mu\text{m}$  in diameter, globular or subglobular, apolar; wing and triradiate mark absent, without pores; ornamentation densely papillose, the same on both spore faces; papillae blunt, smooth, rounded and discrete.

In China, *P. caespitans* is confirmed to be present in Guizhou, Sichuan, Yunnan, Gansu, Shaanxi, Xizang, Zhejiang, Taiwan (Bai, 2000). Elsewhere it is distributed from Japan to India through China and other countries where the climate is temperate to warm (Hattori, 1976).

As pointed out by Hattori (1975, 1976), *P. caespitans* is closely related to *P. subobtusa*, *P. acutifolia* and *P. campylophylla*, while it is very difficult to distinguish them by gametophyte characters due to high plasticity of these taxa. At present there is no published data on spore mor-

phology of other three species; in this study we provide a study of spore morphology of *P. caespitans* as an aid for future studies.

***Frullania gaoligongensis* X.-L. Bai et C. Gao** (Fig. 1: d, e, f).

Spores 35.4–43.6  $\mu\text{m}$  in diameter, globular or subglobular, apolar; wing and triradiate mark absent, without pores; ornamentation the same on both spore faces, with low convoluted, dense, smooth and vermiculate papillae, adjacent papillae frequently fused or joined to form cupulate projections.

*F. gaoligongensis* is an endemic of China (Bai & Gao, 1999).

On the basis of spore morphology, *F. gaoligongensis* is characterized by cupulate projections on spore surface; it is clearly distinct from another species of *Frullania*, *F. appendistipula* (Fig. 1: g, h, i). Furthermore, our results also support the suggestion of Gupta and Udari (1986) to distinguish different *Frullania* species by two types of spore ornamentation, namely rosette and cupulate.

***Frullania appendistipula* Hatt.** (Fig. 1: g, h, i).

Spores 42.9–48.4  $\mu\text{m}$  in diameter, globular or subglobular, apolar; wing and triradiate mark absent, without pores; ornamentation densely papillose on the both spore faces; papillae blunt, smooth, rounded and indiscrete, adjacent papillae frequently fused or joined to form rosette pattern.

In China, *F. appendistipula* has only been found in Yunnan. Elsewhere it is known from New Guinea (Bai, 2000).

Zhang & Wu (2006) and Wu et al. (2008) have observed spores of ten *Frullania* species from China. In their results, five species, *F. muscicola*, *F. yuennanensis*, *F. physantha*, *F. ericoides* and *F. sinosphaerantha*, have rosette pattern, which is quite similar to those of *F. appendistipula* found in present study; however, these species cannot be distinguished from each other by the ornamentation of spore surface.

Our results support the opinion that the spore surface of *Frullania* has an ornamentation unique for the genus but similar between its species (Wu et al., 2008); therefore, not all *Frullania* species can be separated by spores only.

***Riccia cavernosa* Hoffm.** (Fig. 2: a, b, c).

Spores 43.6–55.6  $\mu\text{m}$  in diameter, triangu-

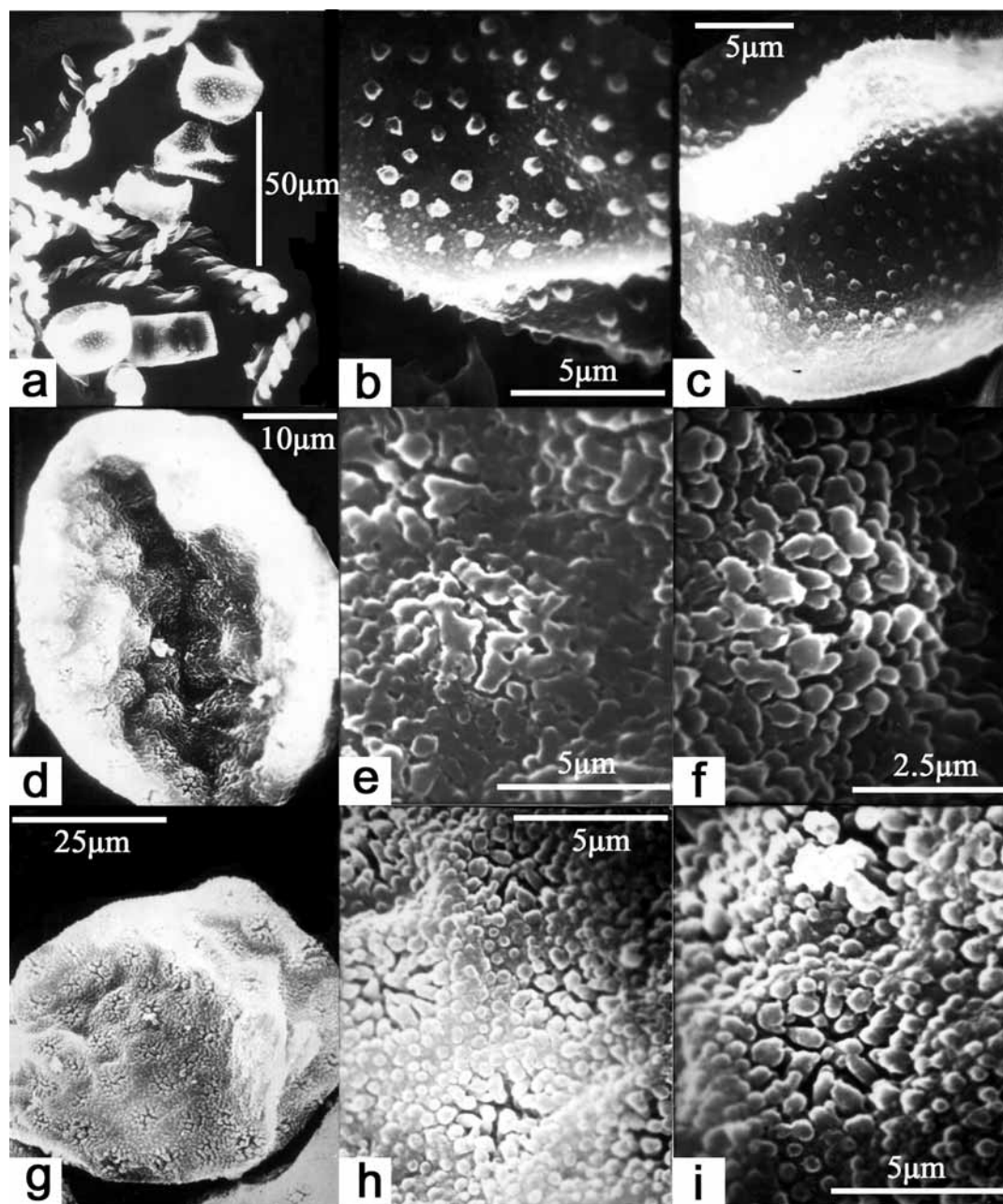


Fig. 1. a-c – *Porella caespitans* spores. a: spores and elaters; b, c: spore surface, shows dense papillae; d-f – *Frullania gaoligongensis* spores. d: spore view; e, f: spore surface, shows cupulate projections; g-i. *Frullania appendistipula* spores. g: spore view; h, i: spore surface, shows rosette pattern.

lar-globular, polar; wing narrow, margin finely crenulate, without pores; ornamentation dissimilar on both spore faces and often incompletely reticulate: distal face convex, with smooth, irregular low ridges, forming an intricate pattern,

widely spaced or crowded and occasionally with a nearly continuous ridge running along periphery at inner side of wing; proximal face with apex blunt, triradiate mark distinct, often granulate; covered with simple or branching ridges, some-

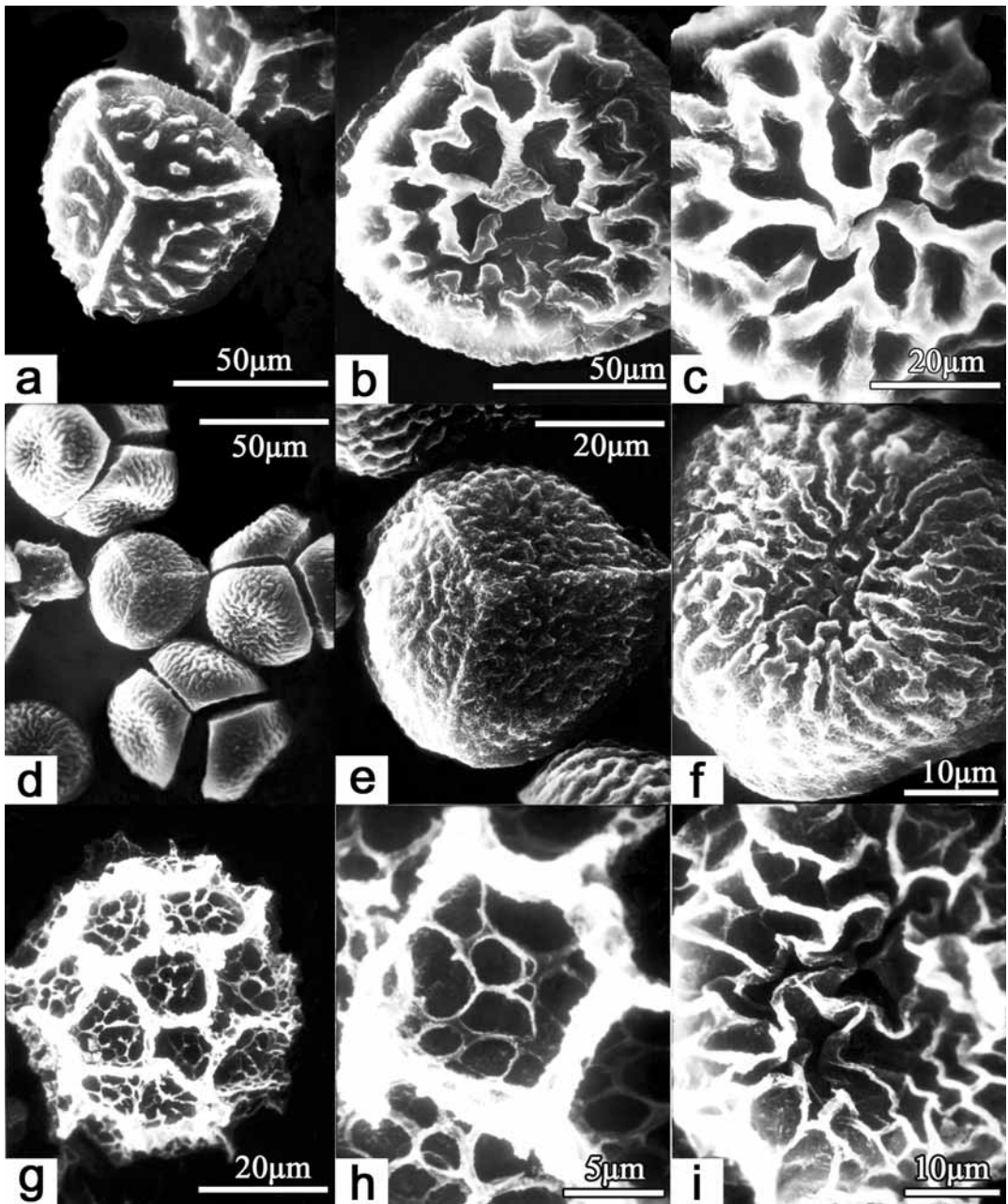


Fig. 2. a-c – *Riccia cavernosa* spores. a: proximal face; b, c: distal face; d-f – *Riccia frostii* spores. d: proximal view; e: proximal face; f: distal face; g-i – *Targionia hypophylla* spores. g, h: distal face; i: proximal face.

times forming irregular and imperfect lumina.

In China, the presence of *R. cavernosa* is confirmed for Inner Mongolia and Beijing. Apart from China, it is known from India, Mongolia, Russia, Europe, North America, Australia, and Africa (Zhang & Wu, 2006).

Jia et al. (2002) and Zhang & Wu (2006) published SEM spore micrographs of *R. cavernosa* based on the same Chinese sample, which correspond closely to those in the present study. These authors describe spores of this specimen being 70–90  $\mu\text{m}$  in diameter which is greater than in our observation.

**Riccia frostii** Aust. (Fig. 2: d, e, f)

Spores 44.2–49.4  $\mu\text{m}$  in diameter, in tetrads, triangular-globular; ornamentation with simple or branched undulate ridges, similar on both spore faces; distal face highly convex, with 6–8 usually complete, round or oval areolae across diameter of spore, areolar walls thin and low, raised at nodes into truncate processes; proximal face with apex blunt, trilete mark distinct.

In China, *R. frostii* is distributed in Gansu, Inner Mongolia, Liaoning, Shandong and Yunnan. Elsewhere it is known from Russia, Europe and North America (Zhang & Wu, 2006).

Spores of *R. frostii* have been repeatedly illustrated in drawings and described by several authors. This species has an unique and distinctive spore ornamentation which is easy to identify and it is usually not confused with other *Riccia* species.

**Targionia hypophylla** L. (Fig. 2: g, h, i)

Spores 48.1–52.0  $\mu\text{m}$  in diameter, globular, polar; wing present, with small pores; ornamentation dissimilar on both spore faces: distal face forms the double network pattern, the large networks consist of strongly elevated rounded ridges which form polygonal walled enclosures. A reticulum of smaller ridges is superimposed on and between these large ridges; proximal face is less rounded, with stereo pair and has long, sinuous, closely set, reticulated ridges.

In China, *T. hypophylla* is confirmed to be present in Heilongjiang, Jilin, Liaoning, Hebei, Henan, Hubei, Sichuan and Taiwan. Elsewhere it is known from Japan, Europe, North America and Oceania (Zhang & Wu, 2006).

The spore cross-sectional morphology was studied by Denizot (1971), Zigliara (1972), Steinkamp (1973), Taylor et al. (1974) and Zhang & Wu (2006). Zigliara's SEM of spore ornamentation for European populations, and those of Steinkamp for American populations, as well as those of Taylor et al. for New Zealand populations, are similar to Zhang & Wu and our micrographs for Chinese populations.

## DISCUSSION

*Porella* and *Frullania* are genera of leafy liverworts in order Jungermanniales, while *Targionia* and *Riccia* are genera of thallose liverworts in order Marchantiales. Our results confirm the

existing knowledge that the spore morphology is different in these two types of liverworts (Zhang & Wu, 2006). The Jungermannialean spores of three studied species are apolar and small (31.2–48.4  $\mu\text{m}$ ), their surface is covered by low papillae on the both spore faces. On the other hand, spores of Marchantiales represented in our study by three species, are polar and relatively larger (43.6–52.0  $\mu\text{m}$ ), their surface is covered by raised areolae or network formed by ridges.

Of the China liverwort flora alone, we have obtained SEM micrographs of spores of four genera and six species. The results show that the ornamentation pattern of the spores is of taxonomic importance, as is evident from the distribution of the different spore types among the species, thus making it possible to distinguish species based on these features alone.

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