

Spore Morphology of Some Bryaceae Schwägr. Species (Bryophyta) from Turkey

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Abstract

The spores of *Bryum caespiticium* Hedw., *B. capillare* Hedw., *B. creberrimum* Taylor, *B. imbricatum* (Schwägr.) Bruch & Schimp. and *B. subelegans* Kindb. were studied by light and scanning electron microscopy for the first time. The apertural region consists of a leptoma in all spores. Two spore types, characterized by their surface ornamentation, are established, reflecting the species taxonomic relationships. While surface ornamentation is of a piloid type in *Bryum imbricatum*, it is of granuloid type in *B. caespiticium*, *B. capillare*, *B. creberrimum* and *B. subelegans*. The spore wall of the family Bryaceae includes sclerine (the distinction between exine and perine may be difficult to define) and intine. The taxonomy of the genera *Bryum* is discussed on the basis of their spore morphology.

Key words: Bryophyta, Bryaceae, Spore morphology, LM, SEM

INTRODUCTION

The Bryaceae Schwägr. Family is mainly distributed through Europe, Asia, North America, Greenland, Australia and New Zealand. The genus of *Bryum* Hedw. is a very large cosmopolitan, taxonomically difficult genus of ca 1050 mainly terrestrial or saxicolous species of the Bryaceae family. The Bryaceae species are tufted plants that spread amongst other mosses on basic rock crevices, walls, old buildings, tree trunks, patches on soil, and cliffs in montane habitats [1].

Both the division of Bryaceae and the separation of the genera were made according to gametophytic and sporophytic characters. Some of these characters were: the leaf shape, laminal cells, leaf marginal cells, the structure of peristome teeth, and gemmae shape [1]. Spore morphology is an important taxonomic character. While there has been a recent increase in studies of bryophyte spores [2-10], there is still, however, a lot of research needed into this area.

In this study, the detailed spore morphological structures of some Bryaceae were studied for the first time with light microscope (LM) and scanning microscope (SEM). The aim of this study is to characterize the spore morphology of five species of the family Bryaceae in order to provide an aid for studies in taxonomy and paleopalynology.

MATERIALS AND METHODS

Spores material used in the study was obtained from the Herbarium of the Faculty of Science and Arts of Osmangazi University (OUFE). The external surface was observed with LM and SEM. Untreated spores were prepared with glycerine-jelly onto microscope slides [11], and the acetolysis method [12] was employed for the LM. Measurements of the shortest and the largest diameters (in polar view), and the polar axis and

the equatorial diameter (in equatorial view) were taken in 25 randomly selected spores. Following this, the mean, standard deviation, standard error and range were established. Sclerine thickness, as well as the largest length of the apertural region, was based on 25 measurements and only the mean is presented. For scanning electron microscopy (SEM) investigations, the unacetolyzed spores were directly placed on stubs, sputter-coated with gold plate, and examined with a Jeol 5600 LV scanning electron microscope. The first exsiccate listed under the "Specimens examined" is termed the reference specimen and the others are the comparisons. The terminologies for spore morphology proposed by Erdtman [12], Boros & Járαι-Komlódi [4], Blackmore & Barnes [7], Punt et al. [13] and Kapp et al. [14] were used.

Abbreviations

P: polar axis in equatorial view. E: equatorial diameter in equatorial view. D_M : largest diameter in polar view. D_m : shortest diameter in polar view. st: sclerine thickness. a: largest length of the apertural region. X: mean. s.d.: standard deviation. S_x : standard error. R: range. SEM: scanning electron microscopy. LM: light microscopy. W: Wodehouse. E: Erdtman.

RESULTS

General Remarks

The sporoderm of the family Bryaceae consists of perine, exine and intine. The separation between exine and perine may be difficult to define, and sclerine is a more appropriate term.

Ornamentation is different in each genus and sometimes it is possible to distinguish species based on these features. The apertural region consists of an aperture, surrounded by one or more rings of ornamentation elements. The spores can be separated into two groups on the basis of their morphological

types: (1) the granuloid type and (2) the piloid type. The range of measurements found in the reference specimens was in accordance with those of the comparison specimens, but the

mean may be somewhat different. This reflects the occurrence of intraspecific variation. All the morphometric data of the spores are presented in Tables 1-3..

Table 1. Morphometric data of the Bryaceae spores studied, in equatorial view.

Measurements Taxa	P				E			
	R (µm)	X±S _x (µm)	s (µm)	V (%)	R (µm)	X±S _x (µm)	s (µm)	V (%)
<i>Bryum caespiticium</i> (W)	7.0-14.0	10.3-0.3	1.5	2.4	10.0-17.0	13.5-0.3	1.8	3.5
<i>Bryum caespiticium</i> (E)	6.0-11.0	8.5-0.2	1.4	2.0	11.0-15.0	12.7-0.2	1.3	1.7
<i>Bryum capillare</i> (W)	6.0-12.0	9.3-0.2	1.3	1.7	11.0-16.0	13-0.2	1.3	1.7
<i>Bryum capillare</i> (E)	7.0-12.0	9.5-0.2	1.2	1.5	11.0-15.0	13.6-0.2	1.1	1.2
<i>Bryum creberrimum</i> (W)	6.0-13.0	9.2-0.3	1.6	2.7	11.0-15.0	12.6-0.2	1.0	1.0
<i>Bryum creberrimum</i> (E)	5.0-9.0	7.2-0.2	1.0	1.1	10.0-14.0	11.2-0.1	0.8	0.7
<i>Bryum imbricatum</i> (W)	10.0-18.0	13.4-0.3	1.8	3.5	15.0-22.0	18.4-0.3	1.7	2.9
<i>Bryum imbricatum</i> (E)	10.0-16.0	12.6-0.3	1.6	2.6	15.0-19.0	16.9-0.2	1.3	1.8
<i>Bryum subelegans</i> (W)	7.0-12.0	9.24-0.26	1.3	1.7	11-14	12.6-0.1	0.9	0.8
<i>Bryum subelegans</i> (E)	6.0-9.0	7.2-0.2	1.0	1.0	10.0-12.0	11.0-0.1	0.8	0.6

Table 2. Morphometric data of the Bryaceae spores studied, in polar view.

Measurements Taxa	D _M				D _m			
	R (µm)	X±S _x (µm)	s (µm)	V (%)	R (µm)	X±S _x (µm)	s (µm)	V (%)
<i>Bryum caespiticium</i> (W)	10.0-17.0	12.8-0.4	2.2	4.9	9.0-17.0	12.2-0.4	2.1	4.7
<i>Bryum caespiticium</i> (E)	10.0-15.0	11.2-0.2	1.2	1.5	8.0-14.0	10.3-0.2	1.4	2.0
<i>Bryum capillare</i> (W)	10.0-15.0	12.6-0.2	1.2	1.4	10.0-14.0	11.6-0.2	1.1	1.2
<i>Bryum capillare</i> (E)	10.0-15.0	13.1-0.2	1.0	1.1	10.0-15.0	12.2-0.2	1.3	1.6
<i>Bryum creberrimum</i> (W)	10.0-14.0	12.5-0.2	1.0	1.0	10.0-14.0	12.1-0.1	0.8	0.7
<i>Bryum creberrimum</i> (E)	9.0-12.0	10.9-0.1	0.9	0.9	9.0-11.0	10.2-0.1	0.6	0.4
<i>Bryum imbricatum</i> (W)	16.0-22.0	19.1-0.2	1.3	1.8	16.0-20.0	18.3-0.2	1.3	1.8
<i>Bryum imbricatum</i> (E)	14.0-20.0	16.7-0.3	1.5	2.5	14.0-20.0	16.7-0.3	1.5	2.5
<i>Bryum subelegans</i> (W)	10.0-14.0	12.6-0.2	1.1	1.2	10.0-14.0	12.2-0.2	1.0	1.0
<i>Bryum subelegans</i> (E)	10.0-14.0	11.4-0.1	0.9	0.8	9.0-13.0	10.5-0.1	0.9	0.8

Table 3. Morphometric data of the sclerine and apertural region of the Bryaceae spores studied.

Measurements Taxa	st (µm)	a (µm)
<i>Bryum caespiticium</i> (W)	1	9.6
<i>Bryum caespiticium</i> (E)	0.8	7.6
<i>Bryum capillare</i> (W)	1	9.3
<i>Bryum capillare</i> (E)	0.8	9.6
<i>Bryum creberrimum</i> (W)	0.9	9.9
<i>Bryum creberrimum</i> (E)	0.9	8.0
<i>Bryum imbricatum</i> (W)	0.9	15.8
<i>Bryum imbricatum</i> (E)	0.9	12.9
<i>Bryum subelegans</i> (W)	0.9	9.0
<i>Bryum subelegans</i> (E)	0.9	8.9

Description of the spores

Granuloid type (Figs. 1-3). Taxa studied: *Bryum caespiticium* Hedw., *B. capillare* Hedw., *B. creberrimum* Taylor, and *B. subelegans* Kindb.

Small (inferior than 25 µm) sized spores (Tables I-III), bilaterally and sometimes radially symmetric to asymmetric; heteropolar; rounded to subrounded amb; plane-convex to

concave-convex in shape (Figs. 1-3). The surface is ornamented by garnule-like elements (Figs. 1c, f; 2c, f; 3c). The apertural region consists of a less resistant area in the majority of the taxa, which was interpreted as a leptoma (Figs. 1c, f; 2c, f; 3c). The granule-like elements are bigger and sparsely distributed; thus, in these taxa this area is interpreted as an aperture. SEM observations are useful for spore type characterization but do not permit a clear distinction of the taxa examined.

Besides the occurrence of an aperture or a leptoma, the most significant features permitting distinction of these spores were the measurements of their largest diameter (Table II). Some morphological variations observed in the granuloid elements (Figs. 1c, f; 2c, f; 3c) may occur in some taxa but, as far as we can see, it is not a safe constant with which to establish the distinction between species. This is because of the great intraspecific variation present due to these characteristics.

Piloid type (Fig 2). Taxon studied: *Bryum imbricatum* (Schwägr.) Bruch & Schimp.

Small (inferior than 25 µm) sized spores (Tables I-III), bilaterally symmetric; heteropolar; subcircular amb; concave-convex in shape (Figs. 2d-f). The surface presents elements resembling pila (Fig. 2f) The apertural region consists of a subtriangular elongate area which circles the aperture. The morphological variations observed in the piloid elements permit the distinction of the taxon in *Bryum imbricatum*, and in SEM, the elements show some roughness (Fig. 2f).

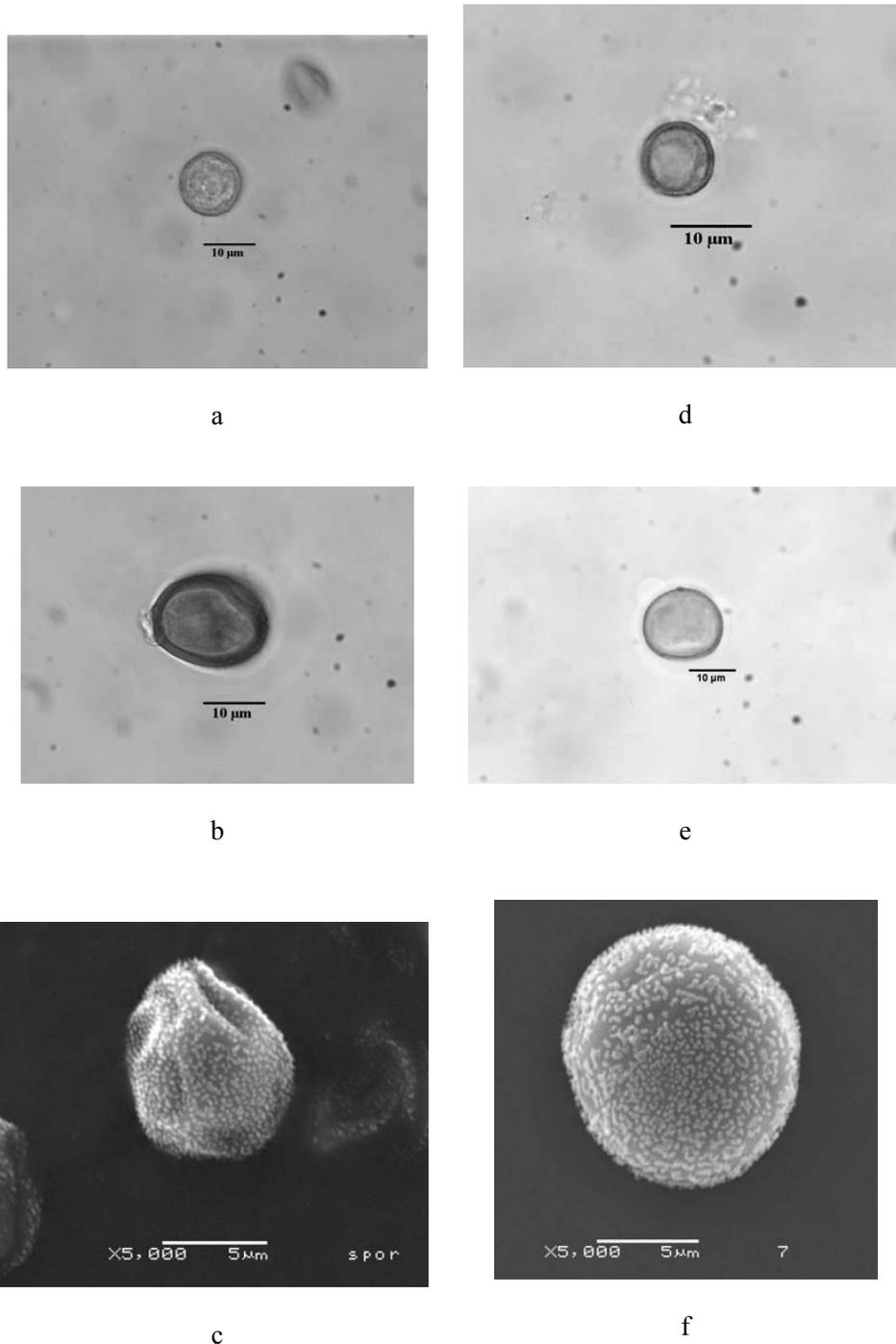


Figure 1. *Bryum caespitium* spores a) proximal view (W) b) equatorial view (E) c) proximal surface (SEM) *Bryum capillare* spores d) proximal view (W) e) equatorial view (E) f) distal surface (SEM)

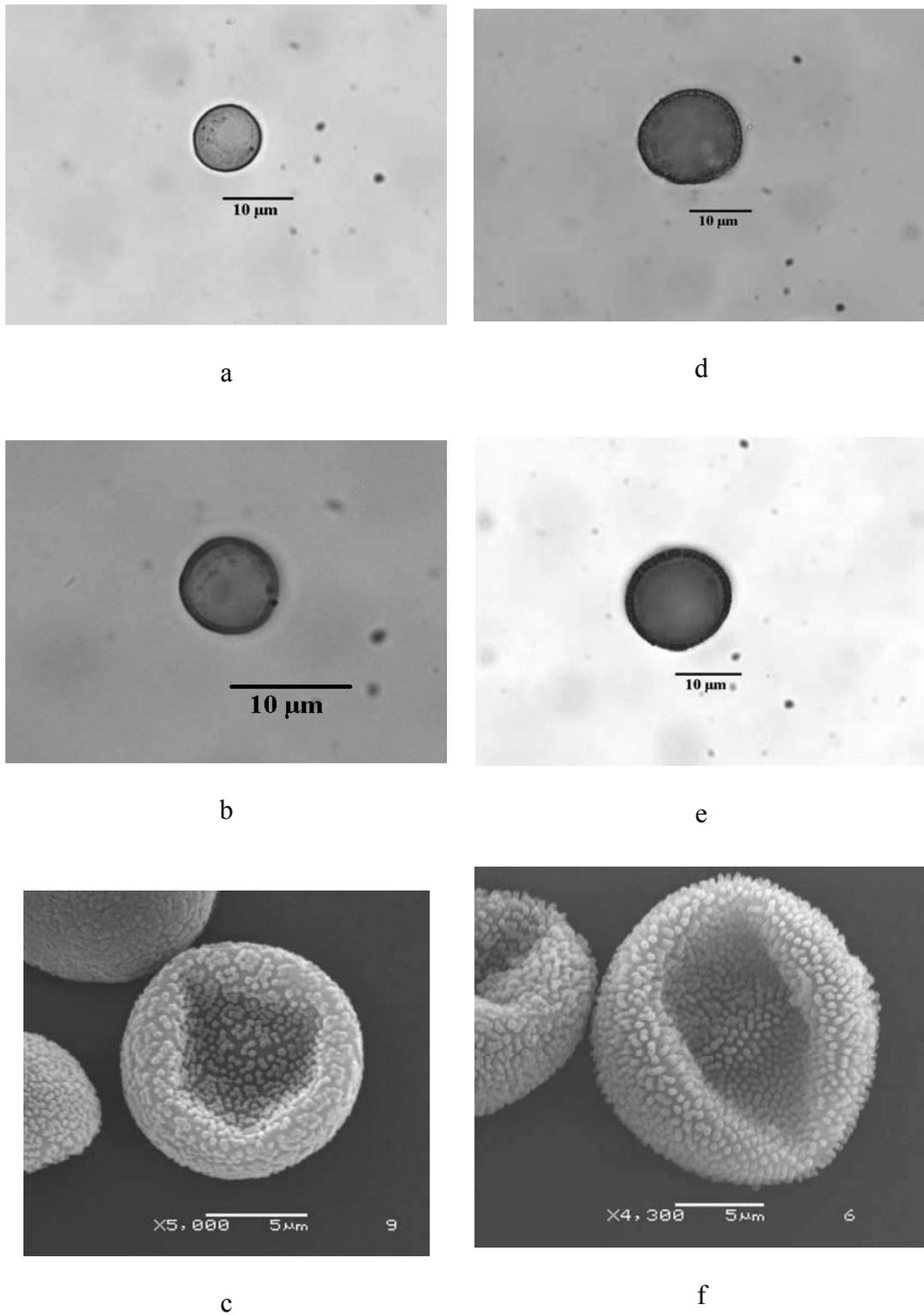


Figure 2. *Bryum creberrimum* spores a) proximal view (W) b) proximal view (E) c) proximal surface (SEM) *Bryum imbricatum* spores d) proximal view (W) e) proximal view (E) f) proximal surface (SEM)

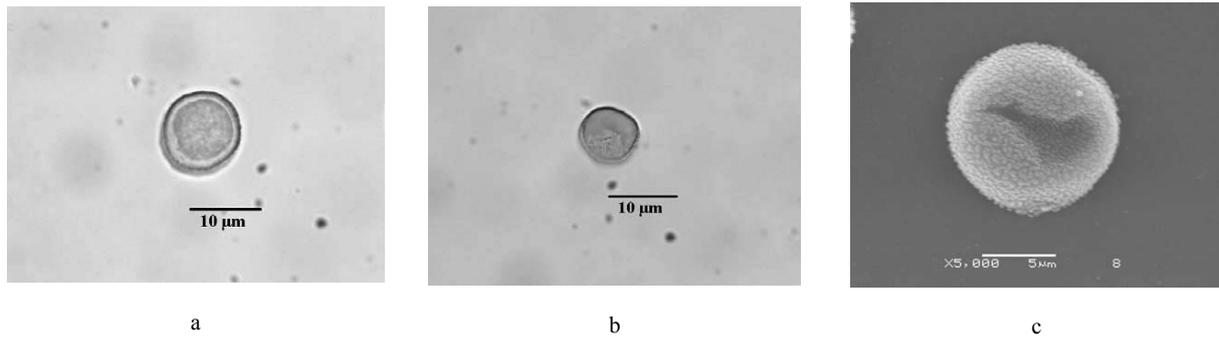


Figure 3. *Bryum subelegans* spores a) proximal view (W) b) proximal view (E) c) proximal surface (SEM)

DISCUSSION

The relatively simple spores of the moss family Bryaceae do not offer many morphological characters useful for distinguishing taxa. The ornamentation pattern of the spores is of taxonomic importance, as is evident from the distribution of the different spore types among the species [9,10]. Spores of the granuloid type are found in four species, while spores of the piloid type are found in one species. The spores of some species of Bryaceae genera were described by Erdtman [12], Boros & Járαι-Komlódi [4], Punt et al. [13] and Kapp et al. [14].

The results presented here are in accordance with those found by previous authors. However, discrepancies which have not previously been referred to in the literature, but were found in the present study, are related to surface ornamentation in *Bryum imbricatum*, *B. caespiticium*, *B. capillare*, *B. creberrimum* and *B. Subelegans*. Sometimes, there is some variability in the mean found in the different specimens analyzed for each taxon, but the range of measurements of the comparison specimens are always in accordance to the specimen reference. These results confirm those of Olesen & Mogensen [5]. They demonstrated the need to check more than one specimen to characterize the spore size of a taxon.

In conclusion, we agree with Sorsa & Koponen [2], Vitt & Hamilton [3], Boros & Járαι-Komlódi [4], Olesen & Mogensen [5], Brown & Lemmon [6], Blackmore & Barnes [7], Estebanez et al. [8] and Luiz-Ponzo & Barth [9,10], that spore morphology in the family Bryaceae and its relatives show distinguish characters which are important for taxonomic studies.

Specimens investigated

All specimens are from Türkiye.

Bryum caespiticium Hedw. B7 Eskişehir: Sündiken Mountains, Arıkaya, *Pinus nigra* subsp. *pallasiana*-*Quercus cerris* var. *cerris* forest, alt. 1230 m, on rock, 23 July 2000, Savaroğlu 479, 695.

Bryum capillare Hedw. B7 Eskişehir: Sündiken Mountains, north sides, Karakütük, *Pinus sylvestris* forest, alt. 1516 m, on rock, 15 October 2000, Savaroğlu 610.

Bryum creberrimum Taylor B7 Eskişehir: Sündiken Mountains, north sides, near Karakütük, monument forest, *Pinus sylvestris* forest, alt. 1420 m, on soil, 26 August 2000, Savaroğlu 581.

Bryum imbricatum (Schwägr.) Bruch & Schimp. B7 Eskişehir: Sündiken Mountains, near Yukarı Danişment, alt. 1270 m, on wet soil, 11 June 2000, Savaroğlu 345.

Bryum subelegans Kindb. B7 Eskişehir: Sündiken Mountains, Bozdağ, *Quercus cerris* var. *cerris* forest, alt. 1240 m, on soil, 10 May 2000, Savaroğlu 77.

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