

SPORE MORPHOLOGY OF SOME *WEISSIA* SPECIES (POTTIACEAE) FROM TURKEY

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ABSTRACT. In this study, spore morphology of *Weissia controversa* Hedw., *W. condensata* (Voit) Lindb. and *W. brachycarpa* (Nees & Hornsch.) Jur. were examined by the light microscopy (LM) and the scanning electron microscopy (SEM). All spores are small, the length of the polar axis (P) is between 13.39 μm and 15.0 μm , equatorial diameter (E) is between 17.56 μm and 18.38 μm . The smallest spores observed in *W. condensata* and the biggest spores in *W. controversa*. The shapes of all spores were determined as suboblate. Ornamentations are differing on leptoma and on distal pole. Baculate, baculate-clavate, pilate-baculate and ecinate ornamentation types were observed on the distal pole. The ornamentations are diluted on the leptoma. In addition to spore morphology, capsule structures were examined and photographed with SEM. As a result, the spore size, shapes, ornamentation types and the capsule structures show some differences among these species and these differences can be used as a distinctive character in the identification of the species.

1. INTRODUCTION

The Pottiaceae Hampe is the most common and large moss family, with around 1.400 species in 83 genera. This family members show a major variety of morphological, physiological and genecological adaptations [1]. Pottiaceae is one of the lineages in which most exchanges in sporangium shape [2].

Weissia Hedwig, belonging to Pottiaceae family, is one of the most notable genus where a shift in both sporangium shape and habitat is seen [2]. *Weissia* is a large genus with about 100 species worldwide and generally contains widely spread species whose relationships have been much debated [1, 3]. The genus is presented with 12 taxa in Turkey; *Weissia brachycarpa* (Nees & Hornsch.) Jur., *W. breutelii* Mull.Hal., *W. condensata* (Voit)Lindb. var. *condensata*, *W. condensata* var. *armata* (Thér.&Trab.) M.J.Cano, Ros & J.Guerra, *W. controversa* Hedw. var. *controversa*, *W. controversa* var. *crispata* (Nees&Hornsch.) Nyholm, *W. leptocarpa* Schimp. ex Besch., *W. levieri* (Limpr.) Kindb., *W. longifolia* Mitt., *W. rutilans* (Hedw.) Lindb., *W. squarrosa* (Nees&Hornsch.) Mull.Hal., *W. wimmeriana* (Sendtn.) Bruch& Schimp. [4, 5]. In many species of *Weissia*, the gametophyte characters such as the

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leaf length, width, and degree of margin involution are remarkably uniform, while the sporophyte characters such as seta length, operculum and peristome teeth development are strikingly variable [3]. These conclusions show the potential for the genus to be used as a model organism for examining morphological variation in moss sporophyte. Spore, which is an important sporophytic characters, has also been useful in solving taxonomic problems. Some recent studies have proved that spore external morphology is useful in characterizing moss taxa at the generic and specific levels [6-14]. For this reason, in this study, the

detailed spore morphological structures of some Turkish *Weissia* species were studied with light microscope (LM) and scanning electron microscope (SEM), in order to contribute to the taxonomy and palynology works. In addition to spore morphology, capsule structures were examined and photographed with SEM.

2. MATERIAL AND METHODS

The spore and capsule materials were obtained from the bryophyte herbarium of Ankara Hacı Bayram Veli University Polatlı Science and Arts Faculty. List of spores examined are given in the Table 1. The external surfaces of the spores were observed using light microscopy (LM) and scanning electron microscopy (SEM). The spores were prepared by the Wodehouse [15] method for LM photographs. The measurements of the polar axis (P) and the equatorial diameter (E) were taken from 20 randomly selected spores. The Simpson and Roe graphical test was used for graphical calculations [16]. The capsules were observed using stereo microscopy and scanning electron microscopy. The mouth diameter, length and width in 20 randomly selected capsules were measured. Olympus SZX7 model light microscope, BX47 model stereo microscope and SC 100 Model image analysis system were used to photograph and measurements the spores and the capsules.

For scanning electron microscopy, the spores and the capsules were directly placed onto stubs which have double-sided carbon band. The stubs were coated with gold-palladium alloy at voltage of 40 mV for 60 seconds in a vacuum evaporator and examined with Quanta Feg 250 scanning electron microscopy in Kastamonu University Central Research Laboratory.

The terminology for spore morphology was proposed by Erdtman [17], Boros and Járαι-Komlódi [18], Blackmore and Barnes [19], Punt et al. [20] and Kapp et al. [21].

TABLE 1. The details of specimens and localities.

Species	Localities
<i>Weissia controversa</i>	Sakarya (Karapürçek); on soil, <i>Pinus nigra</i> J.F.Arnold, <i>Quercus</i> L., <i>Juniperus</i> L. forest, 1005 m alt., 40°35'45"N, 30°32'37"E, 12.05.2018.
<i>Weissia condensata</i>	Yalova (Central); on soil, <i>Carpinus betulus</i> L., <i>Fagus orientalis</i> Lipsky, <i>Tilia tomentosa</i> Moench forest, 485 m alt., 40°32'02"N, 29°12'40"E, 11.05.2018.
<i>Weissia brachycarpa</i>	Kocaeli (Başiskele); on soil, <i>Carpinus betulus</i> L., <i>Cornus mas</i> L., <i>Juglans regia</i> L., <i>Erica arborea</i> L. forest, 182 m alt., 40°40'01"N, 29°58'42"E, 12.05.2018.

3. RESULTS

***Weissia brachycarpa*:** Spores are small, suboblate, heteropolar and katalept. The length of the polar axis is average 14.76 µm, equatorial diameter is average 18.38 µm in diameter, the ratio of polar axis to equatorial diameter is ~0.80 (Table 2, Figure 1). The sclerine surface is ornamented by regular baculate-clavate elements. Baculas have papillae. Both elements are irregular in size, between 0.5-1.0 µm long.

The aperture consists of irregular leptoma. Leptoma boundaries are not clear, monolete (Figure 2, 3). The capsules are erect, ovoid, symmetrical, average 0.48 mm wide and 1.26 mm long, ~2.6 times as long as wide. The capsule mouth narrowed and is average 0.22 mm in diameter. Peristome absent (Figure 4).

TABLE 2. The spore morphological parameters (values in µm).

Species	P			E			P/E	Shape	Ornamentations
	min	max	mean	min	max	mean	(mean)		
<i>W. brachycarpa</i>	13.57	15.93	14.76	17.03	19.84	18.38	0.80	Suboblate	Baculate-clavate
<i>W. condensata</i>	12.03	14.68	13.39	17.03	17.75	17.56	0.76	Suboblate	Baculate
<i>W. controversa</i>	13.89	16.77	15.0	16.57	18.21	18.21	0.82	Suboblate	Pilate-baculate, microechinate

***Weissia condensata*:** Spores are small, suboblate, heteropolar and katalept. The length of the polar axis is average 13.39 µm, equatorial diameter is average 17.56 µm in diameter, the ratio of polar axis to equatorial diameter is ~0.76 (Table 2, Figure 1). The sclerine surface is ornamented by irregular baculate elements with papillae. Baculas are irregular in shape and size, between 0.3-1.0 µm long. The aperture consists of a concave leptoma. The ornamentations are diluted on leptoma (Figure 2,

3). Capsules are erect, oblong-ellipsoid, symmetrical, average 0.29 mm wide and 0.82 mm long, ~ 2.8 times as long as wide. Capsule mouth distinctly narrowed and is average 0.13 mm in diameter. Peristome absent (Figure 4).

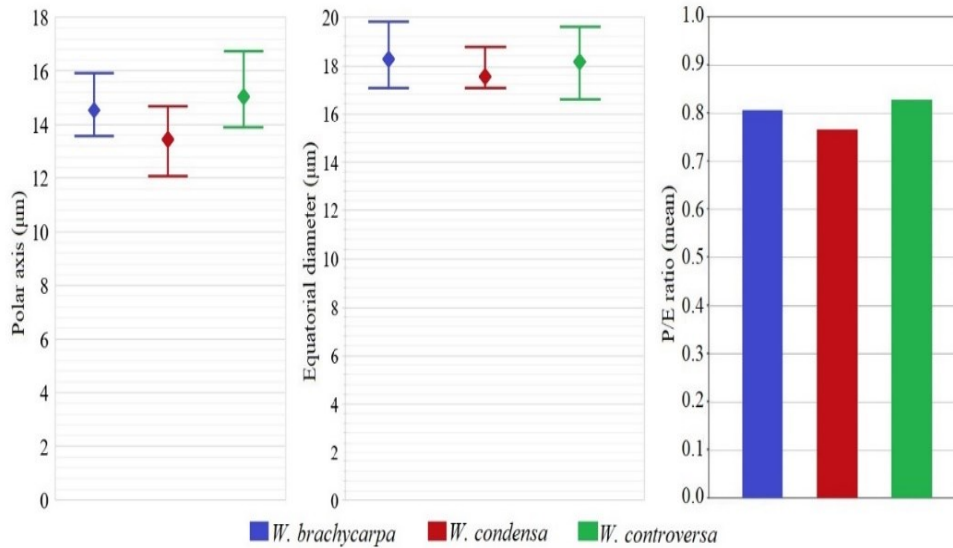


FIGURE 1. Graphical comparison of the length of polar axis (P), equatorial diameter (E) and P/E ratios (minimum, maximum and mean values).

***Weissia controversa*:** Spores are small, suboblate, heteropolar and katelept. The length of the polar axis is average 15 μm , equatorial diameter is average 18.21 μm in diameter, the ratio of polar axis to equatorial diameter is ~ 0.82 (Table 2, Figure 1). The sclerine surface is ornamented by pilate-baculate and microechinate elements. These elements are irregular in shape and size, between 0.2-2.0 μm long. The aperture consists of an undistinct, slightly concave to plano-convex leptoma. Leptoma surface is ornamented with microecinate elements. The ornamentations are diluted on leptoma (Figure 2, 3). Capsules are erect, ovoid, symmetrical, average 0.51 mm wide and 1.14 mm long, ~ 2.2 times as long as wide. The capsule mouth narrowed slightly and is average 0.31 mm in diameter. Peristome present, teeth rudimentary, lanceolate, slightly papillose, striate, $\sim 55 \mu\text{m}$ long (Figure 4).

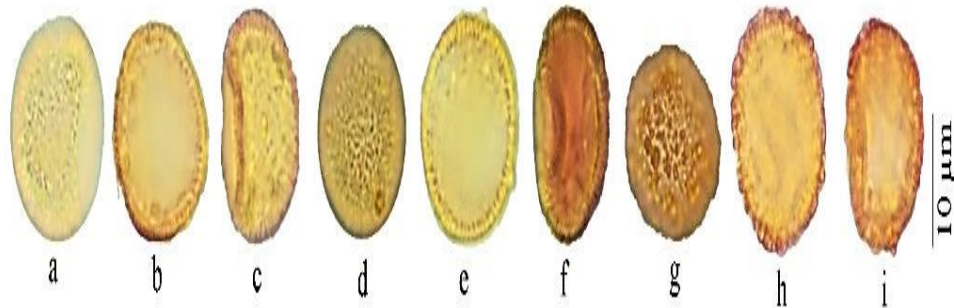


FIGURE 2. LM spore microphotograph. a-c: *W. brachycarpa*; d-f: *W. condensa*; g-i: *W. controversa* (a, d, g: distal view; b, e, h: proximal view; c, f, i: equatorial view).

4. DISCUSSION

The spore morphology of Turkish *Weissia controversa*, *W. condensa* and *W. brachycarpa* species studied by LM and SEM. Among them, the spores of *W. controversa* have previously been described by Boros et al. [22]. The results presented here are in accordance with this study. However, discrepancies that have not previously been referred to in the literature, specifically relating to surface ornamentation in *W. condensa* and *W. brachycarpa*, were observed during the present study.

The species have small sized spores and common sporophytes that increase chance of successful dispersal and occupying new localities [23]. The length of the polar axis (P) is between 13.39 μm and 15 μm , equatorial diameter (E) is between 17.56 μm and 18.38 μm . The smallest spores of them are *Weissia condensa* and the biggest spores of them are *W. controversa*. The shapes of all spores were determined as suboblate. Spore walls are thick on distal pole, tapers to proximal pole and forms leptoma. All spores are katelept and heteropolar. While *W. brachycarpa* has monoete spores, *W. controversa* and *W. condensa* have alete spores. Apertures are in the form of a leptoma on the proximal pole. The shape of leptoma varies from concave to plano-convex. The ornamentations are differing on leptoma and on distal pole. Baculate, baculate-clavate, pilate-baculate and ecinate ornamentation types

were observed on the distal pole. The ornamentations show some differences in all species. The ornamentations are diluted on the leptoma.

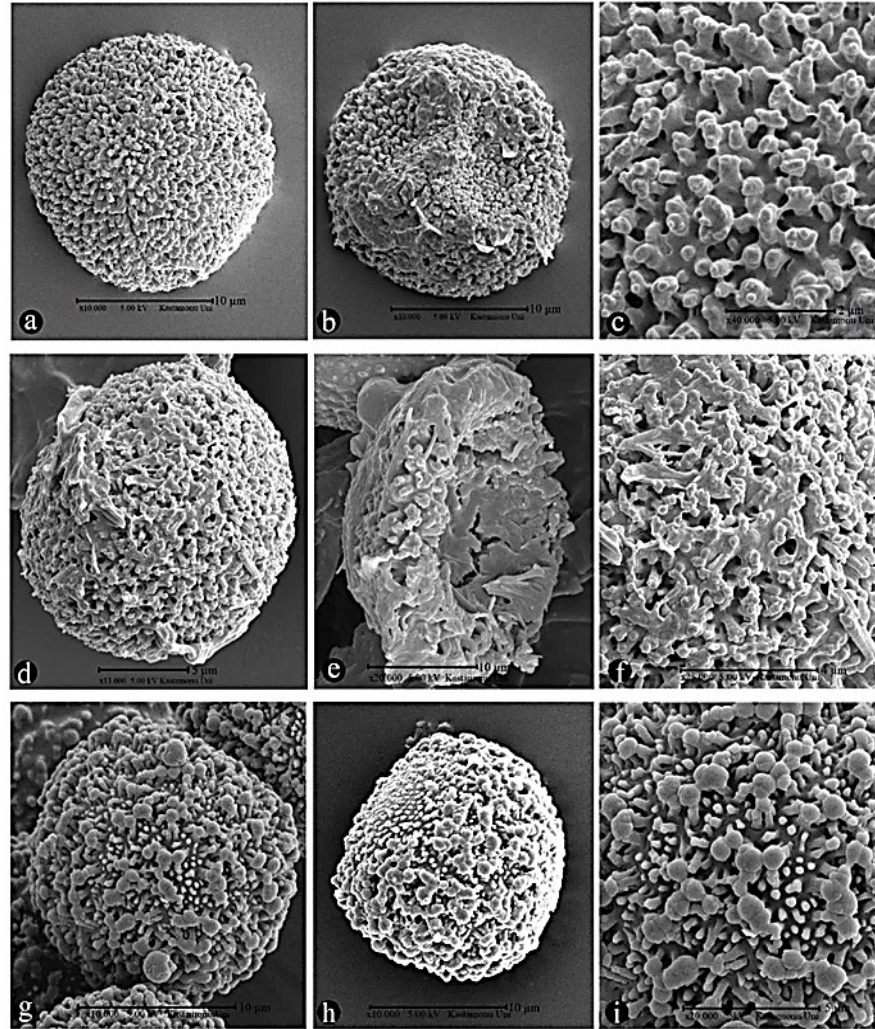


FIGURE 3. SEM spore photograph. a-c: *W. brachycarpa*, d-f: *W. condensata*; g-i: *W. controversa* (a, d, g: distal view; b, e, h: proximal view; c, f, i: spore ornamentation).

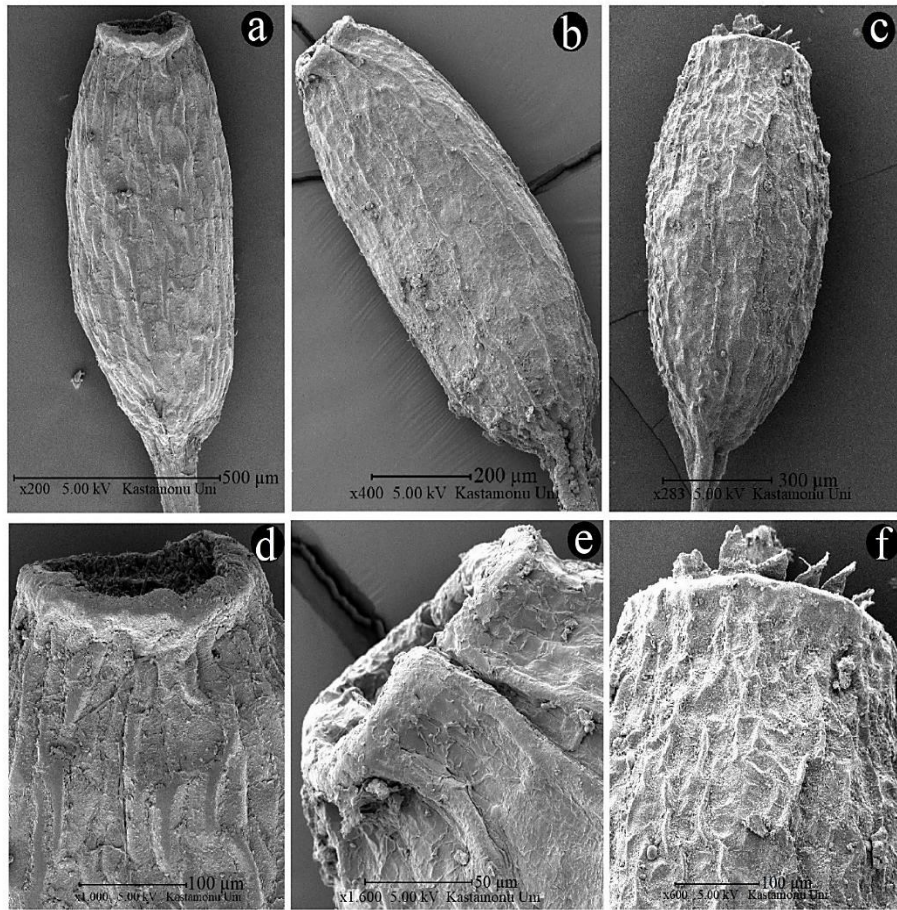


FIGURE 4. SEM capsule photograph a, d: *W. brachycarpa*, b, e: *W. condensata*; c-f: *W. controversa*.

There is some relationship between exine surface ornamentations and the vegetation substratum [6, 13]. Examined moss species are belonging to only one habitat; terricolous that inhabited on soil. In this study, the species, which have baculate exine surfaces, prefer terricolous habitats.

The shapes and sizes of the capsules have some minor differences. The widths of the capsules are between 0.29 mm and 0.51 mm, length of capsules are between 0.82

mm and 1.26. mm. The smallest capsules are in *Weissia condensa*. All capsules are erect and symmetrical. While *W. controversa* has rudimentary, lanceolate, slightly papillose peristome teeth, *W. condensa* and *W. brachycarpa* have not peristome. According to the results; scanning electron microscopy images are an important character in the differentiation of species, while light microscope images do not provide a precise distinction.

Consequently, the spore morphology and capsule structures in examined *Weissia* species show distinctive features which are important for taxonomic studies.

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