

Microstructural Morphology of *Opuntia* (Cactaceae) Species Based on Scanning Electron Microscopy

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ABSTRACT

Opuntia species can be difficult to delineate morphologically. They exhibit a high degree of phenotypic plasticity in macromorphology, which appears highly correlated with environmental variation. The micromorphological characteristics of three eastern *Opuntia* species were examined using scanning electron microscopy techniques. It was hoped that different taxa would demonstrate divergent characteristics in overall morphology based on areolar wool, glochid arrangement, pollen structure, and seed and spine surface patterns and microstructural morphology. *Opuntia humifusa* (Raf.) Raf. and *O. pusilla* (Haw.) Haw. were the most similar among all of the species investigated. A putative hybrid showed the same features as the proposed parental taxa, *O. humifusa* and *O. pusilla*. *Opuntia* aff. *grandiflora* Engelm. was dissimilar to *O. humifusa* or *O. pusilla* in having larger pollen grains with more germinal pores. Also, *O. aff. grandiflora* spine tips lacked the degree of retrorse barbs present in the other two.

SPINE TIPS

Retrorse barbs are one common feature of certain *Opuntia* spines. They are produced when epidermal cells overgrow underlying cells of developing spines (Rehman & Pinkava 2001; Figure 1). These barbs are easily felt by rubbing the spine from the base upwards. It is difficult to feel the retrorse barbs produced by *O. aff. grandiflora* (Figure 2), however, immature spines of *O. humifusa* (Figure 3), and *O. pusilla* (Figure 4) have readily evident barbs. Barbs of *O. aff. grandiflora* are clearly evident under high magnification.

GLOCHID ARRANGEMENT

Glochids, like spines, are retrorsely barbed (Figure 5). They generally are produced in fascicles. There is a typical arrangement for glochids among all 3 species. Several tiers are formed by glochids of different lengths from most areoles. The shortest glochids (1) fill the areole margins (Figure 6 & 7). The next in length (2) are borne directly in front of the short glochids; then the longest glochids (3) exert from the middle of the areole. This lengthening process generally occurs with the aging of the plant and can be related to particular environmental variables. Oftentimes, this gradation of glochid lengths is not easily recognized and glochid arrangement is seen as a mixture of several different size classes rather than a delineated grouping by length. Marginal areoles (those produced from the margins of the pads) produce, in age, glochids that show a star-like radiation (or pin cushion-pattern) from the center of the areole (Figure 8) instead of glochids showing length segregation. This also typically occurs as the plant ages and can be seen in areoles produced from basal cladodes as well. "Wool" (Figure 7) is produced from areoles along with spines and glochids, but no differences were seen in wool among the three species studied here.

Fig. 5; Close-up of glochids showing retrorse barbs; *O. grandiflora*

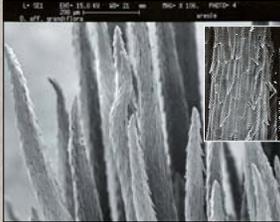


Fig. 6; *O. aff. grandiflora* glochids in 3 levels

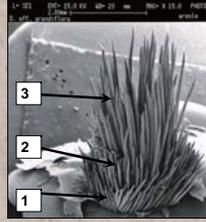


Fig. 7; *O. humifusa* wool (indicated in circle below)

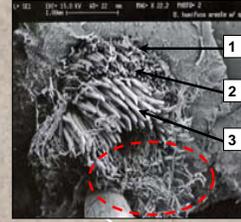


Fig. 8; *O. pusilla* marginal areole



Fig. 15; *O. aff. grandiflora* pollen



Fig. 16; *O. humifusa* pollen

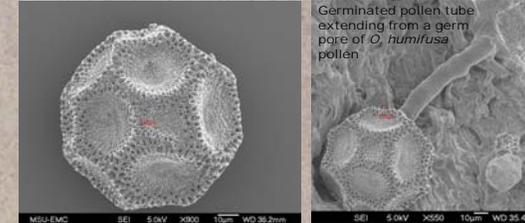


Fig. 17; *O. pusilla* pollen

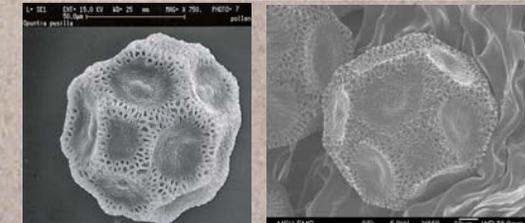
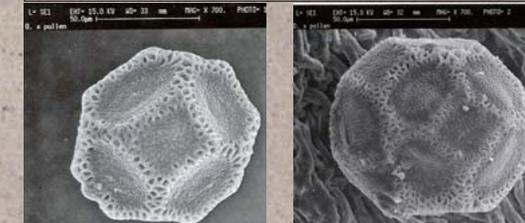
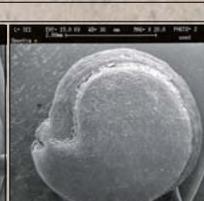
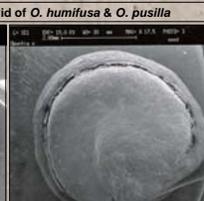
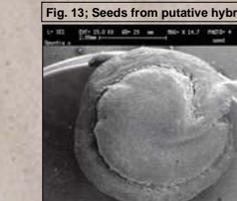
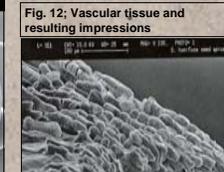
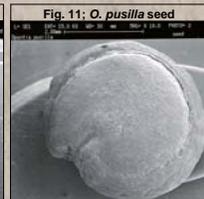
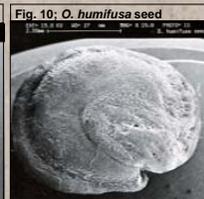
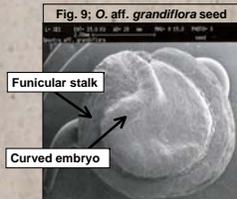


Fig. 18; Pollen of putative hybrid between *O. humifusa* & *O. pusilla*



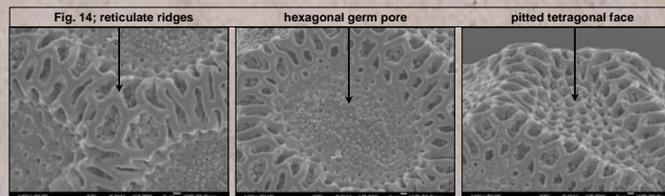
SEED MORPHOLOGY

The seeds of *Opuntia* have different features based on species. *Opuntia* aff. *grandiflora* exhibits a large median ridge (part of the curved embryo) that extends from the hilum to the proximal end of the seed and a wider funicular stalk than the other taxa (Figure 8). *Opuntia humifusa* shows the same median ridge, but it is much less pronounced (Figure 9). *Opuntia pusilla* on the other hand has a relatively smooth surface (or lack of ridge; Figure 10). A putative hybrid between *O. humifusa* and *O. pusilla* shows characteristics intermediate between the 2 species (Figure 11). Microstructural patterns of seeds are correlated to the type of parenchymatous cells occurring around the seed as it develops. This can be seen as rectangular impressions left by these cells on the seed surface (Fig. 12).



POLLEN TOPOLOGY

Opuntia pollen has an interesting surface structure. The surface (exine) is made up of a series of reticulate ridges, which surround hexagonal germ pores, and pitted tetragonal faces, which occur between series of pores (Figure 14). *Opuntia* aff. *grandiflora* pollen was slightly larger than the other taxa (by 10-20µm), generally had more germ pores, was more spherical, and its tetragonal faces tended to be more irregular (Figure 15). *Opuntia humifusa* (Figure 16), *O. pusilla* (Figure 17), and the putative hybrid (Figure 18) all were similar in pollen characteristics.



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