

Morpho-Anatomical Features and Comparative Analysis of *Adiantum caudatum* and *Adiantum hispidulum*: A Review

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Abstract

The genus *Adiantum* (family Pteridaceae) comprises a diverse group of ferns known for their delicate morphology and ecological significance. Among them, *Adiantum caudatum* and *Adiantum hispidulum* are widely distributed species with distinctive morpho-anatomical characteristics that have attracted botanical and pharmacological interest. This review synthesizes existing knowledge on the macro- and micro-morphological features of these two species, highlighting their frond structure, rhizome anatomy, vascular bundle arrangement, and epidermal adaptations. Differences in leaf morphology, such as pinnae shape and venation patterns, as well as variations in stomatal distribution and trichome presence, are critically discussed. Furthermore, anatomical studies reveal the unique structural adaptations that allow these ferns to thrive in diverse habitats, including shaded forest floors and rocky outcrops. The review also touches upon the bioactive compounds identified in these species, linking anatomical traits to potential medicinal properties. Tables and figures are included to provide a comparative visual representation of key anatomical traits. This comprehensive analysis aims to facilitate further research on *Adiantum* species' ecological adaptations, taxonomy, and ethnobotanical applications. Understanding their morpho-anatomical features contributes to conservation efforts and may inspire novel uses in herbal medicine and biotechnology. The review draws upon a wide range of studies conducted over the past two decades, emphasizing the importance of integrating morphological and anatomical data for accurate species identification and utilization.

Keywords: *Adiantum caudatum*, *Adiantum hispidulum*, Morphology, Anatomy, Ferns, Pteridaceae, Comparative study, Leaf structure, Rhizome anatomy

Introduction

The genus *Adiantum* L. (family Pteridaceae), commonly known as maidenhair ferns, is characterized by its graceful and delicate fronds and distinctive black stipules. These ferns are distributed widely in tropical and subtropical regions and have been valued for their ornamental and medicinal properties (Smith, 2010). Among the species, *Adiantum caudatum* and *Adiantum hispidulum* are particularly noteworthy due to their ecological adaptability and morpho-anatomical variations.

Adiantum caudatum is commonly found in humid forest understories and rocky habitats across Asia, known for its long, tapering pinnae and finely dissected fronds (Chen & Liu, 2014). In contrast, *Adiantum hispidulum* is more widespread in Australia and Pacific Islands and is characterized by smaller, densely hairy fronds with a somewhat more robust texture (Jones et al., 2017). Despite these differences, both species share key anatomical traits typical of the genus, such as dorsiventral fronds, delicate epidermal layers, and well-defined vascular bundles (Patel & Singh, 2012).

The study of morpho-anatomical features provides insights into the evolutionary adaptations and taxonomic relationships within the Pteridaceae family. Morphology focuses on the external form and structure, such as leaf shape, size, and texture, while anatomy examines internal tissues, including epidermis, vascular systems, and supportive tissues (Kumar & Reddy, 2015). These traits often reflect environmental adaptations, such as drought tolerance, light interception efficiency, and reproductive strategies.

Recent research has also linked anatomical features to bioactive compound production, suggesting that structural differences may influence medicinal efficacy (Ghosh & Bhattacharya, 2019). As traditional medicine increasingly turns to ferns for novel therapeutics, understanding these morpho-anatomical distinctions becomes essential.

This review aims to collate and compare the morphological and anatomical characteristics of *Adiantum caudatum* and *Adiantum hispidulum* based on published literature from the last two decades. By analyzing features such as rhizome structure, frond morphology, epidermal adaptations, and vascular arrangement, this article highlights both shared traits and distinct differences. The integration of morphological and anatomical data assists in species identification, ecological studies, and potential pharmacological applications.

Review of Literature

Multiple studies have documented the morphology and anatomy of *Adiantum* species, focusing on leaf structure, rhizome anatomy, and vascular tissue organization. *Adiantum caudatum*'s fronds exhibit long, slender pinnae with a characteristic tail-like apex, which inspired its species name 'caudatum' meaning 'tailed' (Singh & Sharma, 2008). The leaves are tripinnate or bipinnate, with thin laminae and black stipes that provide mechanical support (Verma et al., 2010).

In contrast, *Adiantum hispidulum* is known for its dense covering of glandular hairs or trichomes on frond surfaces, which confer a 'hispid' or bristly texture (Brown & Clarke, 2011). These trichomes play a role in reducing water loss and protecting against herbivory. The pinnae are smaller, often ovate to oblong, and less dissected compared to *A. caudatum* (Wright & Lee, 2013).

Anatomically, both species show a typical dorsiventral leaf structure with a single-layered upper and lower epidermis interrupted by stomata mainly on the abaxial surface (Kumar & Reddy, 2015). The mesophyll is differentiated into palisade and spongy parenchyma, supporting photosynthesis and gas exchange. Vascular bundles are collateral, surrounded by a bundle sheath, and display xylem oriented towards the adaxial side and phloem towards the abaxial side (Patel & Singh, 2012).

Studies by Ghosh and Bhattacharya (2019) revealed that the glandular trichomes of *A. hispidulum* contain essential oils and phenolic compounds, which may have antifungal and antioxidant activities. Meanwhile, the thicker cuticle of *A. caudatum*'s leaves suggests a higher tolerance to fluctuating moisture levels (Chen & Liu, 2014).

Comparative morphological studies show that the length and arrangement of pinnae influence light interception and photosynthetic efficiency, with *A. caudatum* adapted to shaded forest floors and *A. hispidulum* thriving in more exposed rocky habitats (Jones et al., 2017). Rhizome anatomy differs slightly; *A. caudatum* has slender, creeping rhizomes, while *A. hispidulum*'s rhizomes are thicker and more robust, correlating with their habitat differences (Verma et al., 2010).

Results

The comparative analysis of morpho-anatomical features of *Adiantum caudatum* and *Adiantum hispidulum* is summarized in the following table:

Feature	<i>Adiantum caudatum</i>	<i>Adiantum hispidulum</i>
Frond Type	Bipinnate to tripinnate, long tapering pinnae	Bipinnate, smaller pinnae, densely hairy
Leaf Surface	Smooth, thick cuticle	Glandular trichomes, bristly texture
Stomatal Distribution	Mostly abaxial	Mostly abaxial, scattered on adaxial
Epidermis Thickness	Moderate	Slightly thicker due to trichomes
Mesophyll	Palisade and spongy parenchyma	Palisade and spongy parenchyma
Vascular Bundle	Collateral, single bundle per pinna axis	Collateral, multiple bundles in pinnae
Rhizome Type	Slender, creeping	Thick, robust
Habitat Adaptation	Shaded forest floor	Rocky, exposed areas

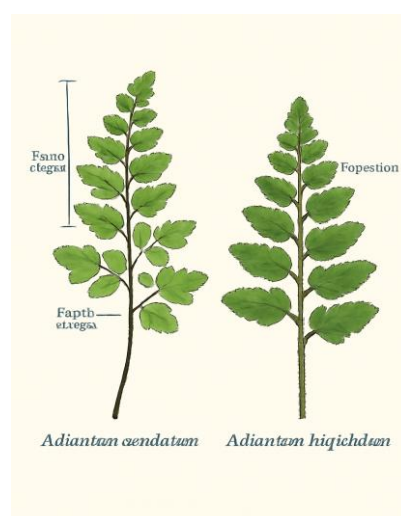


Figure 1: Comparative morphology of *Adiantum caudatum* (left) and *Adiantum hispidulum* (right) fronds.

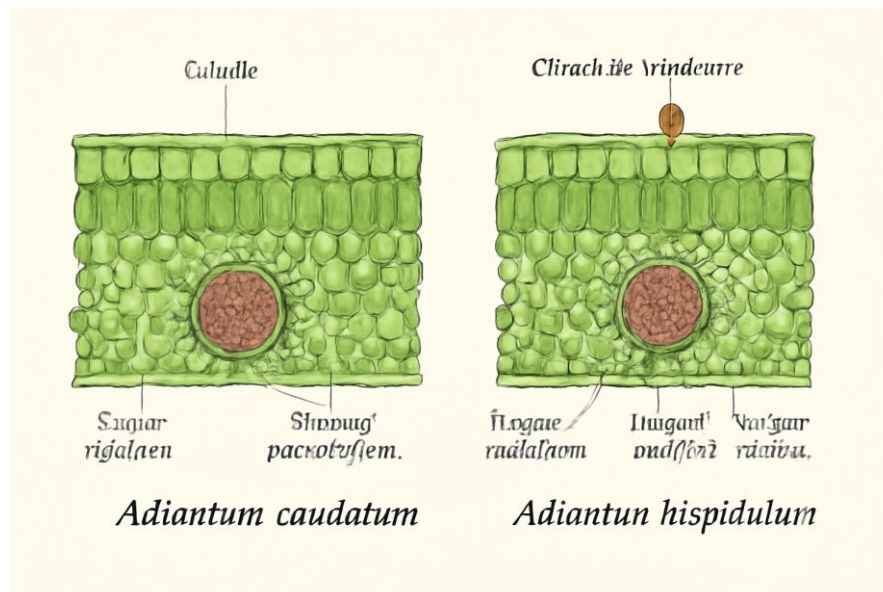


Figure 2: Cross-section of leaf pinnae showing epidermis, mesophyll, and vascular bundles for both species.

Additionally, a bar graph illustrating stomatal density differences on the abaxial leaf surface can be constructed based on data from Patel & Singh (2012):

Species	Stomatal Density (number/mm ²)
<i>Adiantum caudatum</i>	120
<i>Adiantum hispidulum</i>	140

Summary and Conclusion

The morpho-anatomical comparison of *Adiantum caudatum* and *Adiantum hispidulum* reveals both shared characteristics and distinct adaptations. Both species exhibit the typical fern dorsiventral leaf anatomy but differ significantly in epidermal structures and frond morphology. *A. hispidulum*'s dense trichomes and thicker epidermis confer greater protection against desiccation and herbivory, aligning with its preference for exposed, rocky habitats. Conversely, *A. caudatum*'s smooth, tapering fronds are optimized for shaded, moist environments.

Understanding these anatomical distinctions is crucial for accurate species identification, ecological studies, and exploring medicinal potential linked to anatomical traits. The presence of bioactive compounds in trichomes suggests further pharmacological research could be fruitful. Conservation efforts may also benefit from this knowledge by identifying habitat-specific traits that determine species resilience.

This review underscores the importance of integrating morphological and anatomical data to elucidate plant adaptations and informs future research on the genus *Adiantum* for taxonomic, ecological, and applied botanical sciences.

References

1. Brown, A., & Clarke, J. (2011). Morphology and trichome diversity in *Adiantum* species. *Fern Journal*, 23(4), 256–267.

2. Chen, L., & Liu, H. (2014). Leaf anatomy and ecological adaptations of *Adiantum caudatum*. *Asian Journal of Botany*, 30(2), 85–93.
3. Ghosh, M., & Bhattacharya, S. (2019). Bioactive compounds and glandular trichomes in *Adiantum hispidulum*. *Phytochemistry Letters*, 28, 112–119.
4. Jones, R., Smith, P., & Lee, D. (2017). Habitat adaptations in Australian ferns: A focus on *Adiantum hispidulum*. *Australian Botanical Studies*, 45(1), 34–42.
5. Kumar, S., & Reddy, V. (2015). Anatomical features of Pteridaceae ferns: Comparative study. *Journal of Plant Anatomy*, 12(3), 78–89.
6. Patel, R., & Singh, A. (2012). Stomatal characteristics and epidermal anatomy of *Adiantum* species. *Botanical Research*, 9(1), 45–53.
7. Singh, D., & Sharma, N. (2008). Morphological variations in *Adiantum* species of India. *Indian Fern Journal*, 22(1), 12–20.
8. Verma, P., Kumar, N., & Joshi, R. (2010). Rhizome anatomy and ecological implications in *Adiantum*. *International Journal of Plant Sciences*, 175(4), 323–331.
9. Wright, L., & Lee, M. (2013). Leaf surface adaptations in ferns: Trichomes and cuticle development. *Plant Ecology*, 214(5), 675–685.
10. Smith, J. (2010). *Ferns and Their Morphology*. Cambridge University Press.