BIOLOGY, MEDICINE, & NATURAL PRODUCT CHEMISTRY ISSN 2089-6514 (paper)
Volume 15, Number 1, April 2026 | Pages: 1231-1237 | DOI: 10.14421/biomedich.2026.151.1231-1237 ISSN 2540-9328 (online)

Phenetic Relationships of Ferns Based on Morphological Characteristics in an Oil Palm Plantation of Tampaure Hamlet

Tiara, Lestari M.P. Alibasyah, Yulia Windarsih, Musdalifah Nurdin, Manap Trianto, Vita Indri Febriani
Departement of Biology Education, Faculty of Teacher Training and Education, Tadulako University.
Jl. Soekarno Hatta No KM 9, 94148, Central Sulawesi, Tel./Fax. (0451) 422611, Indonesia.

Corresponding author*
yuliawindarsih@untad.ac.id

Manuscript received: 24 June 2026. Revision accepted: 28 June 2026, Published: 01 July 2026.

Abstract

Ferns (Pteridophyta) are a group of vascular plants that reproduce by spores and possess true roots, stems, and leaves, as well as xylem and phloem tissues. This study was conducted to investigate the phenetic relationships among fern species based on their morphological characteristics in an oil palm plantation located in Tampaure Hamlet, Bambaira District, Pasangkayu Regency, West Sulawesi, Indonesia. A field exploration method was employed, and samples were collected using a free-collection technique. Morphological data were compiled using Microsoft Excel and subsequently analyzed through Principal Component Analysis (PCA) and the Unweighted Pair Group Method with Arithmetic Mean (UPGMA) in PAST version 4.03. A total of 50 individuals representing 10 fern species were identified from both terrestrial and epiphytic habitats, namely *Sphaerostephanos heterocarpus*, *Diplazium dilatatum*, *Davallia denticulata*, *Asplenium nidus*, *Selaginella delicatula*, *Pityrogramma calomelanos*, *Stenochlaena palustris*, *Lygodium circinatum*, *Nephrolepis biserrata*, and *Pteris wallichiana*. The UPGMA analysis revealed that *Pteris wallichiana* and *Sphaerostephanos heterocarpus* exhibited the closest phenetic relationship, with a similarity index of 0.88. In contrast, the most distant relationship was observed between *Selaginella delicatula* and *Asplenium nidus*, with a similarity index of 0.63. The PCA biplot analysis demonstrated that the major variation distinguishing fern species in the study area was primarily influenced by meristic traits, particularly the number of fertile pinnae, as well as overall plant size. These morphological characteristics contributed substantially to species differentiation and the phenetic grouping pattern observed among the investigated fern species.

Keywords: Ferns; Morphological Characteristics; PCA Biplot; Phenetic Relationship; Oil Palm Plantation; UPGMA.

INTRODUCTION

Ferns (Pteridophyta) belong to the division Cryptogamae and are classified as cormophytes, characterized by well-differentiated true roots, stems, and leaves (Fahmi et al., 2025). Ferns are widely distributed across various habitats, ranging from primary forests and secondary forests to plantation ecosystems (Ulfa et al., 2023). These plants are commonly found in environments with high humidity, as such conditions favor their growth and reproductive processes (Majid et al., 2022). Environmental factors, including air humidity, light intensity, air temperature, soil temperature, and soil pH, play significant roles in determining fern diversity because they directly influence the survival and distribution of fern species (Yolla et al., 2022). Ferns can also serve as bioindicators of environmental conditions due to their sensitivity to ecological factors such as temperature, humidity, light intensity, and altitude. Variations in these environmental parameters may affect the occurrence, abundance, and distribution patterns of fern species. Consequently, the composition of fern communities can provide valuable information regarding habitat quality and environmental conditions (Adriati & Hutasuhut, 2025).

Ferns constitute an important plant group in maintaining ecosystem stability, particularly within tropical regions such as Indonesia (Windari et al., 2021). As a tropical country, Indonesia possesses exceptionally high plant diversity, supported by its humid climate, heterogeneous habitats, and favorable environmental conditions (Aldiansyah et al., 2024). It is estimated that approximately 1,250–1,500 fern species occur in Indonesia, making ferns one of the oldest extant groups of terrestrial plants (Pramudita et al., 2021). In plantation ecosystems, ferns contribute to ecosystem balance and vegetation stability while supporting ecological functions that ensure the sustainability of plantation landscapes (Irma & Herlina, 2013). Morphological characteristics of roots, stems, leaves, and reproductive structures vary among fern species and can be utilized as important taxonomic characters for species identification (Listiyanti et al., 2022). Furthermore, the degree of similarity and phenetic relationships among species can be assessed

through a phenetic approach based on shared morphological characteristics, where variations in morphological traits are used to evaluate species affinities (Danong et al., 2023).

A phenetic approach enables the assessment of relationships among plant species based on shared morphological characteristics (Qatrunnada & Susandarini, 2022). In phenetic analyses, species are grouped according to the degree of similarity in their morphological traits, where species exhibiting more shared characteristics are considered to have closer phenetic affinities (Palupi et al., 2023). The level of relatedness among organisms is determined by the extent of their common characteristics. Consequently, organisms with higher morphological similarity are clustered together, whereas those with fewer shared traits are considered more distantly related. Phenetic analyses are valuable for understanding patterns of species grouping and provide important support for taxonomic and biodiversity studies. Furthermore, relationship analyses contribute significantly to plant identification, classification, and taxonomic research by facilitating the evaluation of similarities and differences among species based on observable characters (Polihito et al., 2022; Hermawan et al., 2021).

The oil palm plantation in Tampaure Hamlet provides environmental conditions favorable for the growth and development of various fern species. Fern communities in this plantation ecosystem are influenced by canopy cover, air humidity, and light intensity beneath the oil palm stands. As an important component of understory vegetation and a potential environmental indicator, ferns play a crucial role in maintaining ecosystem functions. Although numerous fern species are found within the oil palm plantation of Tampaure Hamlet, scientific information regarding their phenetic relationships based on morphological characteristics remains unavailable. Previous studies in similar habitats have primarily focused on species inventories and diversity assessments, while analyses of species relationships based on morphometric, meristic, and qualitative characters remain limited.Therefore, further investigation is required to provide a comprehensive understanding of the phenetic relationships among fern species occurring in this area. This study aimed to investigate the phenetic relationships of fern species based on their morphological characteristics in the oil palm plantation of Tampaure Hamlet. The findings are expected to contribute valuable information to biodiversity databases and serve as a scientific basis for future taxonomic and ecological studies of ferns.

MATERIALS AND METHODS

Study area

This study was conducted in an oil palm plantation located in Tampaure Hamlet, Bambaira District, Pasangkayu Regency, West Sulawesi, Indonesia (Figure 1). Tampaure Hamlet covers an area of approximately 1,66 km², and the study site consisted of a 2 Ha oil palm plantation. The research was carried out from April to May 2026.

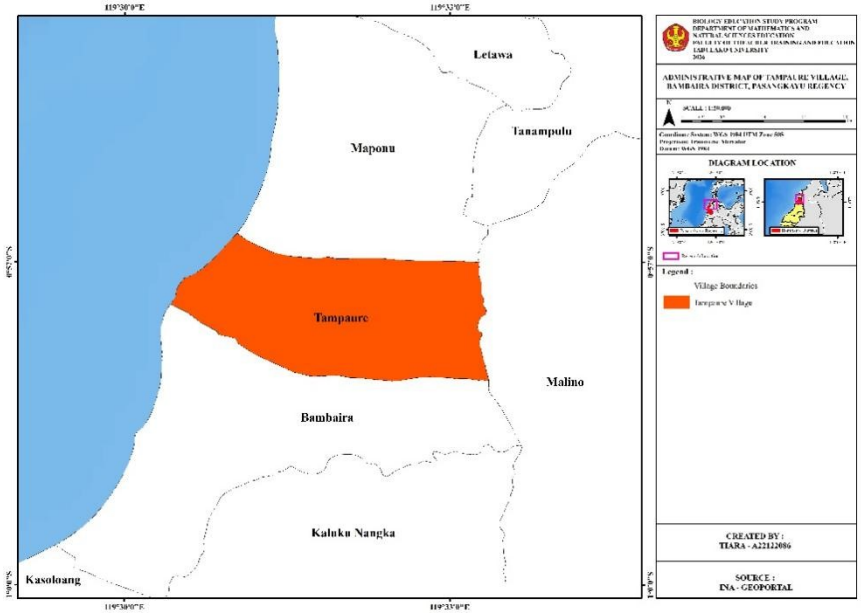

Figure 1. Map of the research location in Tampaure Hamlet, Bambaira Subdistrict, West Sulawesi, Indonesia.

Procedures

Data Collection Techniques

Data were collected using an exploration method with a free-collection sampling technique. The research began with the preparation of tools and materials. The initial stage involved collecting fern samples from their natural habitats in the oil palm plantation area of Tampaure Hamlet using the free-collection technique. The fern

species found at the study site were subsequently documented. The collected data were recorded on observation sheets and documented using a camera.

Identification of Fern Species

Fern species were identified using the identification book Eksplorasi Tumbuhan Paku (Pteridophyta) by Sianturi et al. (2020), which contains descriptions and illustrations that assist in species identification. Identification was conducted by examining the morphological characteristics of the ferns, which included three main categories of characters: morphometric, meristic, and qualitative characters, comprising a total of 40 characters.

Data Analysis

The data collected through direct field observations were organized into tables using Microsoft Excel. Subsequently, the compiled data were analyzed using PAST version 4.03 software to group fern species based on the similarity of their morphological characteristics. The Unweighted Pair Group Method with Arithmetic Average (UPGMA) was employed to classify taxonomic levels based on a high degree of similarity and to determine the relationships among fern species, which were presented in the form of a dendrogram showing the relationships among species.

RESULTS AND DISCUSSION

Fern Species

Ferns (Pteridophyta) belong to the division Cryptogamae and are classified as cormophytes because they possess true roots, stems, and leaves, as well as vascular tissues (Adlini et al., 2021). Based on the field observations, a total of 10 fern species comprising 50 individuals were recorded at the study site. Each species was represented by five individuals, reflecting the diversity of fern species found in the area (Figure 1).

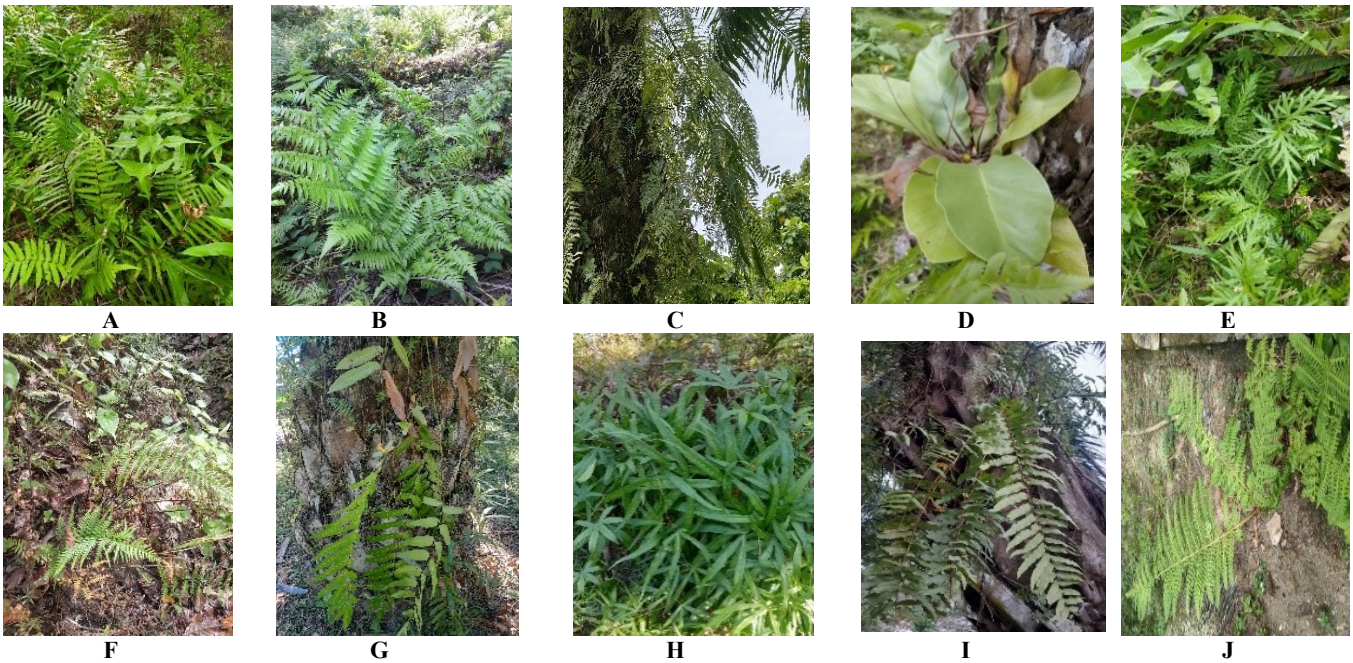

Figure 2. *Fern Species Sphaerostephanos heterocarpus* (A), *Diplazium dilatatum* (B), *Davallia denticulata* (C), *Asplenium nidus* (D), *Selaginella delicatula* (E), *Pityrogramma calomelanos* (F), *Stenochlaena palustris* (G), *Lygodium circinatum* (H), *Nephrolepis biserrata* (I), *Pteris wallichiana* (J).

Principal Component Analysis (PCA)

In this study, Principal Component Analysis (PCA) was used to analyze the data. The results were presented in the form of a dendrogram to illustrate the degree of similarity among samples based on the observed morphological characteristics. As shown in the dendrogram, Pteris wallichiana and Sphaerostephanos heterocarpus exhibited the closest relationship, with a similarity index of 0.88. In contrast, the most distant relationship was found between Selaginella delicatula and Asplenium nidus, with a similarity index of 0.63. This grouping generally indicates that species with similar morphological characteristics tend to be included in the same cluster. It should be noted that the relationships obtained in this study represent phenetic relationships based on morphological similarity (Figure 3).

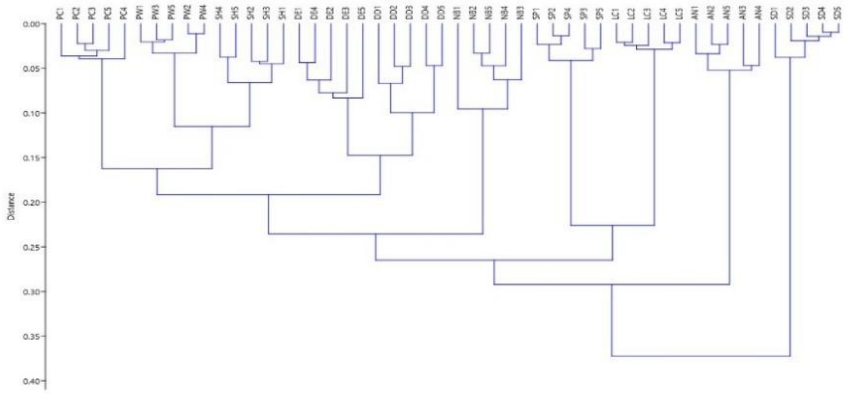

Figure 3. Dendrogram based on Principal Component Analysis (PCA).

Loadings Plot of PCA

The results of the Principal Component Analysis (PCA) were used to determine which morphological characteristics most clearly distinguished the 10 fern species. A total of 50 individuals were analyzed, representing the species *Sphaerostephanos heterocarpus, Diplazium dilatatum*, *Davallia denticulata*, *Asplenium nidus*, *Selaginella delicatula*, *Pityrogramma calomelanos*, *Stenochlaena palustris*, *Lygodium circinatum*, *Nephrolepis biserrata*, and *Pteris wallichiana*. The visualization presented is a PCA loading plot, which shows the contribution of each morphological variable in explaining the variation in characteristics among the species. In summary, PCA was used to simplify complex data, making it easier to identify the main morphological traits that distinguish one species from another (Figures 4 and 5).

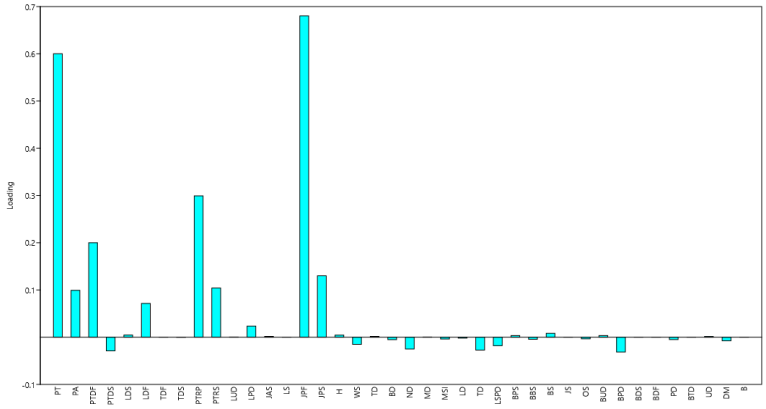

Figure 4. The loadings plot componen 1.

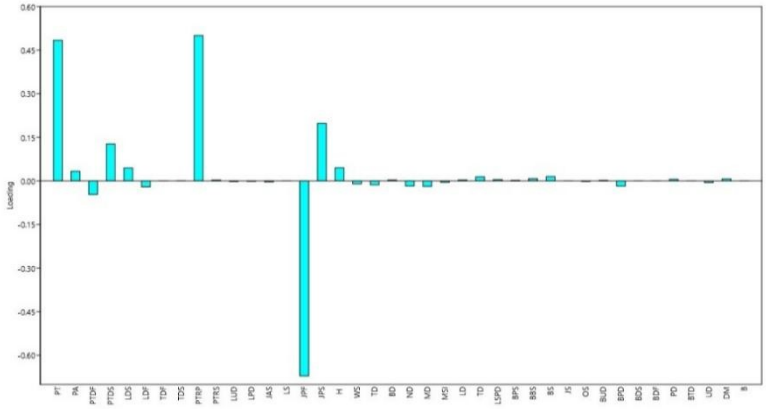

Figure 5. The loadings plot componen 2.

Biplot of PCA

The results of the Principal Component Analysis (PCA) showed that the morphological variation of the fern species examined in this study could be explained by two principal components, namely PC1 and PC2. Most of the identified morphological variation was represented by these two components. In the first principal component (PC1), the characters with the highest loading values were the number of fertile pinnae (JPF), total plant length (PT), primary stipe/rachis length (PTRP), total fertile frond length (PTDF), and the number of sterile pinnae (JPS). In the second principal component (PC2), the characters with high loading values were the number of fertile pinnae (JPF), primary stipe/rachis length (PTRP), total plant length (PT), the number of sterile pinnae (JPS), and total sterile frond length (PTDS). The major variation distinguishing fern species at the study site was dominated by meristic characters, particularly the number of fertile pinnae (JPF), as well as plant size dimensions (Figure 6).

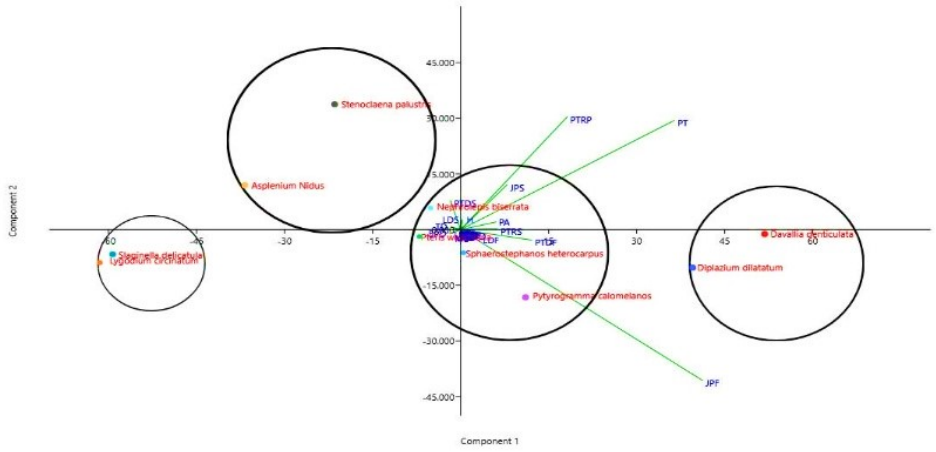

Figure 6. Biplot PCA.

Discussion

This study was conducted to determine the relationships among fern species based on morphological characteristics in Tampaure Hamlet, Bambaira District, Pasangkayu Regency, West Sulawesi. The results showed that fern species in the oil palm plantation area of Tampaure Hamlet exhibited considerable morphological diversity. Sampling was carried out using an exploration method with a free-collection sampling technique. Environmental conditions at the study site included an average temperature of 33.6 °C, air humidity of 79%, soil pH of 6.5, and light intensity of 997.8 lux. A total of 10 fern species were identified, namely Sphaerostephanos heterocarpus, Diplazium dilatatum, Davallia denticulata, Asplenium nidus, Selaginella delicatula, Pityrogramma calomelanos, Stenochlaena palustris, Lygodium circinatum, Nephrolepis biserrata, and Pteris wallichiana. The distribution and growth of ferns are mainly influenced by environmental factors such as temperature, air humidity, light intensity, and soil pH (Kirno et al., 2018). In addition, variations in microhabitat conditions determine the distribution of species found in the field (Arise & Sofiyanti, 2023).

Using the UPGMA method, cluster analysis was performed to group species based on shared morphological characteristics. The greater the number of similar characters shared among species, the closer their positions are in the resulting dendrogram (Rizanda et al., 2024). Studies of relationships based on morphological characteristics produce a dendrogram that illustrates species grouping according to the degree of morphological similarity. In general, species belonging to the same group share more characteristics than species from different groups, indicating closer phenetic relationships (Ramadhani & Purnomo, 2023). The dendrogram showed that the degree of relationship was determined by the similarity coefficient. The higher the similarity value between two species, the closer their relationship. Species pairs with a similarity coefficient of 0.77 were considered to have a very close relationship, whereas species with a coefficient of 0.64 exhibited a more distant relationship. Differences in similarity values reflect the number of morphological characters shared among the species (Pohlito et al., 2022).

Principal Component Analysis (PCA) can reduce a large number of variables into several principal components that account for most of the variation in the data, thereby facilitating the identification of the most important variables (Maulana et al., 2022). Morphological variation in ferns, such as frond shape, frond size, sorus type, and habitat, represents characteristics that are commonly used to distinguish species and explain patterns of variation among taxa (Rachman et al., 2025). PCA was used to reduce morphological characters into several principal components that explain the greatest variation among species. Based on studies of several fern species, PCA

has shown that morphological variation among fern species is mainly influenced by vegetative traits, including frond shape and size, stipe structure, and sorus characteristics (Sofiyanti et al., 2021). Morphological characteristics of fronds are particularly important in distinguishing fern species because considerable differences exist among taxa. Variations in the size, shape, and arrangement of secondary fronds can be used to explain patterns of morphological variation within a particular fern group (Aini et al., 2022).

PCA and biplot analyses identify morphological characters that contribute to species diversity, with a cumulative variation of 70.79%. This indicates that characteristics with high loadings in the principal components play a significant role in the formation of the groups, whereas characteristics with low loadings contribute less to the observed variability. PC1 and PC2 were used in the biplot interpretation because they were able to represent most of the information contained in the original data (Hetharie et al., 2018). The PCA results produced a biplot graph illustrating the distribution of measurement values based on morphological characteristics (Maulana et al., 2022). Based on PC1 and PC2, a biplot was constructed because these two components accounted for most of the variation and values, thereby representing the majority of the observed data variation. PC1 explained 51.56% of the variation, whereas PC2 explained 27.77% of the variation (Karuniawan et al., 2021). PC1 had the largest eigenvalue and explained most of the variance, while PC2 explained the next largest proportion of variance (Dwiana et al., 2025).

CONCLUSIONS

This study successfully identified ten fern species in Tampaure Hamlet, Bambaira District. The presence of various fern species indicates that the environmental conditions in the area provide suitable habitats to support fern diversity. Relationship analysis using the UPGMA method revealed differences in the degree of morphological similarity among species, which collectively formed several related species groups. The findings of this study demonstrate that morphological characteristics remain important for understanding the phenetic relationships among fern species.

Acknowledgements: The authors would like to express their sincere gratitude to Tadulako University for the institutional support and facilities provided during the conduct of this research.

Authors' Contributions: Conceptualization, Tiara, Lestari M.P. Alibasyah, and Yulia Windarsih; methodology, Yulia Windarsih and Lestari M.P. Alibasyah; formal analysis, Musdalifah Nurdin, Manap Trianto, and Vita Indri Febriani; writing original draft preparation, Tiara, Lestari M.P. Alibasyah, and Yulia Windarsih; writing review and editing, all authors. All authors have read and agreed to the published version of the manuscript.

Competing Interests: The authors declare that they have no competing.

REFERENCES

Adlini, M. N., Hartono, A., Khairani, M., Tanjung, I. F., & Khairuna, K. (2021). *Identifikasi Tumbuhan Paku (Pteridophyta) Di Universitas Islam Negeri Sumatera Utara*. *Biota: Jurnal Ilmiah Ilmu-Ilmu Hayati*, 6(2), 87–94. https://doi.org/10.24002/biota.v6i2.3842

Adriati, D., & Hutasuhut, M. A. (2025). Studi Ekologi Tumbuhan Paku (Pteridophyta) Di Taman Wisata Alam Danau Sicike-Cike Dan Hutan Desa Serdang Sumatera Utara. BIOEDUSAINS: *Jurnal Pendidikan Biologi Dan Sains*, 8(1), 72–88. https://doi.org/10.31539/bioedusains.v8i2.13159

Aini, S. Q., Ifadatin, S., & Zakiah, Z. (2022). Karakteristik Morfologi Pada Tumbuhan Paku *Nephrolepis Biserrata* (Sw.) Schott Dan *Nephrolepis Exaltata* (L.) Schott Di Kawasan Kampus Universitas Tanjungpura. *Jurnal Protobiont,* 11(1), 11–16. https://doi.org/10.26418/protobiont.v11i1.58226

Aldiansyah, R., Syamswisna, Prameswari, A. A., Ariyansyah, I., Anggini, P., & Diarsih, A. A. (2024). Studi Literatur: Keanekaragaman Tumbuhan Paku (Pteridophyta) Di Kalimantan Barat. *Biogenerasi: Jurnal Pendidikan Biologi, 9*(2), 1170–1176. https://doi.org/10.30605/biogenerasi.v9i2.3835

Arise, W. N., & Sofiyanti, N. (2023). Kajian Fenetik Tumbuhan Paku (Pteridofita) Di Kecamatan Benai Kabupaten Kuantan Singingi, Provinsi Riau. *Biota: Jurnal Ilmiah Ilmu-Ilmu Hayati, 8*(1), 59–67. https://doi.org/10.24002/biota.v8i1.4523

Danong, M. T., Ruma, M. T. L., Nono, K. M., Mauboy, R. S., Boro, T. L., & Etu, E. (2023). Hubungan Kekerabatan Fenetik Jenis-Jenis Tumbuhan Genus *Euphorbia* (Euphorbiaceae) Berdasarkan Ciri Morfologi. *Floribunda: Jurnal Sistematika Tumbuhan, 7*(2), 38–50. https://doi.org/10.32556/floribunda.v7i2.2023.387

Dwiana, V. N., Nurmayulis, & Millah, Z. (2025). Identifikasi Keragaman Morfologi Tanaman Sente (*Alocasia Macrorrhizos*) Di Kabupaten Pandeglang Provinsi Banten. *Syntax Literate: Jurnal Ilmiah Indonesia, 10*(7), 8886–8895. https://doi.org/10.36418/syntax-literate.v10i7.61092

Hetharie, H., Raharjo, S. H. T., & Jambormias, E. (2018). Pengelompokan Klon-Klon Ubi Jalar Berdasarkan Analisis Gerombol, Komponen Utama Dan Biplot Dari Karakter Morfologi. *Jurnal Agronomi Indonesia (Indonesian Journal Of Agronomy),* 46(3), 276–282. https://doi.org/10.24831/jai.v46i3.18215

Hermawan, R., Fusvita, L., Nugraha, N. H., & Amelya, M. P. (2021). *Morphological Characteristic And Phenetic Relationship Of Lysurus Periphragmoides Collected From West Java*. *Jurnal Biodjati*, 6(1), 102–110. https://doi.org/10.15575/biodjati.v6i1.10724

Hidayatussakinahi, El Fahmi, R., & Joko, J. (2025). Identifikasi Struktur Morfologi Paku Kijang (*Phegopteris Connectilis* (Michx.) Watt) Sebagai Bahan Ajar Morfologi Tumbuhan Di Lingkungan Universitas Pendidikan Muhammadiyah Sorong. *Biolearning Journal, 12*(1),64-67. https://e-

journal.unimudasorong.ac.id/index.php/biolearningjournal/article/view/1310

Irma, W., & Herlina, N. (2013). Keanekaragaman Hayati Tumbuhan Paku (Pteridophyta) Di Desa Gading Sari Kecamatan Tapung Kabupaten Kampar Provinsi Riau. *Photon: Jurnal Sain Dan Kesehatan,* 4(1), 65–70. https://doi.org/10.37859/jp.v4i1.171

Karuniawan, A., Maulana, H., Ustari, D., Dewayani, S., Solihin, E., Solihin, M. A., Amien, S., & Arifin, M. (2021). Yield Stability Analysis Of Orange-Fleshed Sweet Potato In Indonesia Using AMMI and GGE biplot. *Heliyon, 7*(4), e06881. https://doi.org/10.1016/j.heliyon.2021.e06881

Kirno, F., Astiani, D., & Ekamawanti, H. A. (2019). Keanekaragaman Jenis Tumbuhan Paku-Pakuan (*Pteridophyta*) Dan Kondisi Tempat Tumbuhnya Pada Hutan Rawa Gambut Sekunder Dan Lahan Gambut Terbuka. *Jurnal Hutan Lestari, 7*(1), 164–173. https://doi.org/10.18592/ak.v5i1.15967

Listiyanti, R., Indriyani, S., & Ilmiyah, N. (2022). Karakteristik Morfologi Jenis-Jenis Paku Epifit Pada Tanaman Kelapa Sawit Di Desa Tegalrejo Rindah. *Al Kawnu: Science and Local Wisdom Journal, 2*(1), 99–106. https://doi.org/10.18592/alkawnu.v2i1.7281

Majid, A., Ajizah, A., & Amintarti, S. (2022). Keragaman Tumbuhan Paku (Pteridophyta) Di Taman Biodiversitas Hutan Hujan Tropis Mandiangin. *Jurnal Al-Azhar Indonesia Seri Sains dan Teknologi, 7*(2), 103–113. https://doi.org/10.36722/sst.v7i2.1117

Maulana, H., Maxiselly, Y., Karuniawan, A., Purdianty, A., Zulaicho, Z., & Y.H., A. (2022). Diversitas Genetik *Dahlia Pinnata* Cav Berdasarkan Karakter Morfologi Di Jawa Dan Sumatera Dengan Menggunakan Analisis Komponen Utama (PCA). *Jurnal Zuriat, 33*(1), 10–15. https://doi.org/10.24198/zuriat.v33i1.52968

Palupi, D., Aryani, R. D., Sukarsa, S., & Lestari, S. (2023). Hubungan Kekerabatan Fenetik 6 Spesies Anggota Genus *Hibiscus* Berdasarkan Karakter Morfologi. *Bioscientist. Jurnal Ilmiah Biologi, 11*(1), 98–109. https://doi.org/10.33394/bioscientist.v11i1.6542

Polihito, R. A., Latjompoh, M., & Kandowangko, N. Y. (2022). Hubungan Kekerabatan Fenetik Lima Anggota Familia Araceae. *Biosfer: Jurnal Biologi dan Pendidikan Biologi, 7*(2), 128–133. https://doi.org/10.23969/biosfer.v7i2.6120

Pramudita, I., Triyanti, M., & Wardianti, Y. (2021). Keanekaragaman Tumbuhan Paku Di Bukit Botak Kabupaten Musi Rawas Sumatera Selatan. Jurnal Biosilampari: *Jurnal Biologi*, 4(1), 19–25. https://doi.org/10.31540/biosilampari.v4i1.1309

Qatrunnada, Q., & Susandarini, R. (2022). Keanekaragaman Dan Hubungan Kekerabatan Fenetik Spesies Anggota Famili Asteraceae Di Jalur Pendakian Gunung Lawu Berdasarkan Karakter Morfologis. *Bioma: Berkala Ilmiah Biologi, 24*(1), 43–53. https://doi.org/10.14710/bioma.24.1.43-53

Rachman, N. M., Rahmah, S., Amalia, A., Indriyani, S., & Norfajrina, N. (2025). Karakteristik Morfologi Jenis Tumbuhan Paku. *Al Kawnu: Science and Local Wisdom Journal, 5*(1), 29–43. https://doi.org/10.18592/ak.v5i1.15967

Ramadhani, A. S., & Purnomo, P. (2023). Variasi Dan Analisis Fenetik Bavoa (*Cleome Gynandra* L.) Di Sulawesi Tengah Berdasarkan Penanda Morfologis. *Jurnal Penelitian Saintek, 28*(2), 118–131. https://doi.org/10.21831/jps.v28i2.50830

Rizanda, N. H., & Susandarini, R. (2024). Hubungan Kekerabatan Fenetik Sembilan Spesies Anggota Myrtaceae Berdasarkan Morfologi Dan Karakter Anatomis Daun. *Berkala Ilmiah Biologi, 15*(3), 167–177. https://doi.org/10.22146/bib.v15i3.8235

Sofiyanti, N., Sari, A. K., Iriani, D., Mutrofin, R., Taufiq, I., Juliantari, E., & Pranata, S. (2021). Morphological And Anatomical Study Of Four *Pyrrosia* (Polypodiaeae) Species From Rumbai Forest, Riau Province, Indonesia. *Biodiversitas Journal of Biological Diversity*, 22(11), 4905–4914. https://doi.org/10.13057/biodiv/d221124

Ulfa, S. W., Ayunda, D. K., Hasibuan, S. A., & Harahap, A. A. (2023). Identifikasi Spora (Warna, Bentuk) Pada Tumbuhan Paku Yang Ada Di Beberapa Kecamatan Di Kota Medan. *Jurnal Ilmiah Wahana Pendidikan, 9*(17), 610–621. https://doi.org/10.5281/zenodo.8320899

Windari, Khotimperwati, L., & Murningsih. (2021). Keanekaragaman Jenis Tumbuhan Paku (Pteridophyta) di Kawasan Wisata Air Terjun Jurang Nganten Kabupaten Jepara. *Bioma* , *23*(2), 107–111. https://doi.org/10.14710/bioma.23.2.107-111

Yolla, A. S., Damayanti, F., & Gresinta, E. (2022). Keanekaragaman Tumbuhan Paku Terestrial Di Kawasan Hutan Pinus Gunung Pancar, Bogor. *EduBiologia: Biological Science and Education Journal, 2*(1), 63–71. https://doi.org/10.30998/edubiologia.v2i1.11844

THIS PAGE INTENTIONALLY LEFT BLANK