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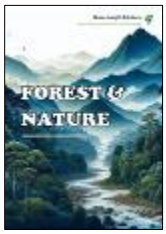

RESEARCH ARTICLE

Bibliometric Analysis and Preliminary Diversity Assessment of the Genus *Dillenia* in Sulawesi

Andhika Senatama[1,2], Melya Riniarti[1], Inggar Damayanti[1*], Irfan Martiansyah[3], Prima Wakyu Kusuma Hutabarat[2]

[1] Department of Forestry, Faculty of Agriculture, University of Lampung, Bandar Lampung, Indonesia
[2] Research Center for Biosystematics and Evolution, National Research and Innovation Agency, Bogor, Indonesia
[3] Research Center for Applied Botany, National Research and Innovation Agency, Bogor, Indonesia
* Corresponding author: inggar.damayanti@fp.unila.ac.id

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ABSTRACT

The genus *Dillenia* (Dilleniaceae) comprises approximately 100 species distributed across South Asia, Southeast Asia, and northern Australia. In Indonesia, research on *Dillenia* remains limited, particularly regarding updated data on its diversity and distribution. This research aims to know the research gap of the genus *Dillenia* globally and inventory *Dillenia* collection from Sulawesi at Herbarium Bogoriense (BO) and Bogor Botanical Garden (BBG). This study first conducted a bibliometric analysis using data from the Scopus database, followed by a descriptive approach through morphological observation of herbarium specimens from Sulawesi deposited in the BO and living collections in the BBG. The bibliometric analysis revealed five major research clusters in *Dillenia* studies: antibacterial activity and phytochemistry; ethnobotany and traditional uses; pharmacology and cytotoxicity; phytochemical analysis and plant extracts; and compound isolation and purification. Research on taxonomy, ecology, and conservation of *Dillenia* remains underexplored and offers substantial opportunities for further investigation. The inventory confirmed the presence of four endemic species in Sulawesi—*D. serrata*, *D. ochreata*, *D. celebica*, and *D. talaudensis*—and *D. pentagyna*, which is more broadly distributed. However, potential misidentification was observed in some specimens, notably the occurrence of *D. ptempoda* in the BBG collection, a species not listed in previous taxonomic revisions.

1. Introduction

The genus *Dillenia* (family Dilleniaceae) comprises approximately 100 species distributed across South and Southeast Asia to northern Australia. The genus was established by Linnaeus in 1753 with *Dillenia* indica as the type species and is named in honor of the German botanist Johann Jacob Dillenius (Yazan et al., 2014). Members of *Dillenia* are typically trees, although some species are shrubs, characterized by reddish-brown to gray bark, sympodial branching, and spirally arranged simple leaves with pinnate venation. The flowers are solitary or in inflorescences, large, with 4–5 sepals and five petals. Fruits are generally indehiscent when immature and dehiscent at maturity. Several species produce edible fruits. Seeds are arillate, bearing a fleshy to membranous aril and a dark brown to black outer coat (Hoogland, 1952; Sabandar et al., 2017).

Ecologically, *Dillenia* species exhibit fast growth, making them suitable candidates for reforestation and restoration initiatives (Siahaan et al., 2022). They also hold potential for carbon sequestration. A study by Rindyastuti (2017) on a 20-year-old *Dillenia* specimen at the Purwodadi Botanical Garden reported a carbon stock of up to 135.59 kg per plant. Although this is lower than values reported for Dipterocarpaceae, mangrove, or *Acacia* forests, it exceeds those of herbaceous plants, wild bananas (*Musa* spp.) (Danarto et al., 2015), and bamboo (Sujarwo, 2016). Economically, *Dillenia* wood is valued for construction, fuelwood, and furniture manufacturing (Shah et al., 2015).

Bibliometric analysis—a statistical method for evaluating books, articles, and other scientific literature—has been extensively applied across disciplines (Wulan, 2020). Bibliometrics has been used in biological sciences to assess publication trends and identify research gaps. Yang et al. (2017) highlighted the utility of bibliometric tools in mapping research contributions from academic institutions, industries, and other stakeholders. For example, a study by Abdullah (2022) analyzed six decades of biological research, examining publication volume, geographic distribution, citation impact, and journal metrics.

The distribution of *Dillenia* in Indonesia was last comprehensively reviewed by R.D. Hoogland (1952). According to Hoogland (1952), Global Biodiversity Information Facility (GBIF), and the Plants of the World Online (POWO) database, there are 23 *Dillenia* species in Indonesia, including 11 endemics—2 in Kalimantan, 4 in Sulawesi, and 5 in Papua. Since Hoogland's revision, five new species and one taxonomic revision have been described: *D. nalagi*, *D. insularum*, *D. cyclopensis* (Hoogland, 1959), *D. crenatifolia* (Hoogland, 1959), *D. tetrapetala* (Lee et al., 2012), and *D. tirupatiensis* (Swamy et al., 2020). Among these, only *D. cyclopensis* extends the genus's range in Indonesia. Other newly described species are confined to Papua New Guinea, Solomon Islands, Vietnam, or India.

Given the lack of updated data, it is necessary to inventory *Dillenia* specimens in the Bogoriense Herbarium (BO) and the living collections of Bogor Botanical Gardens, particularly those originating from Sulawesi. A bibliometric analysis of the genus is essential to evaluate current research progress and to identify critical knowledge gaps. With four endemic species, Sulawesi is the second richest island in Indonesia for *Dillenia* endemism. Its unique biogeography—situated at the convergence of the Indo-Australian, Eurasian, and Pacific tectonic plates—further underscores its importance for floristic and evolutionary studies.

2. Materials and Methods

2.1. Study Area

This study was conducted between January and March 2025, at two main locations: the Herbarium Bogoriense (BO) and the Bogor Botanical Garden (BBG).

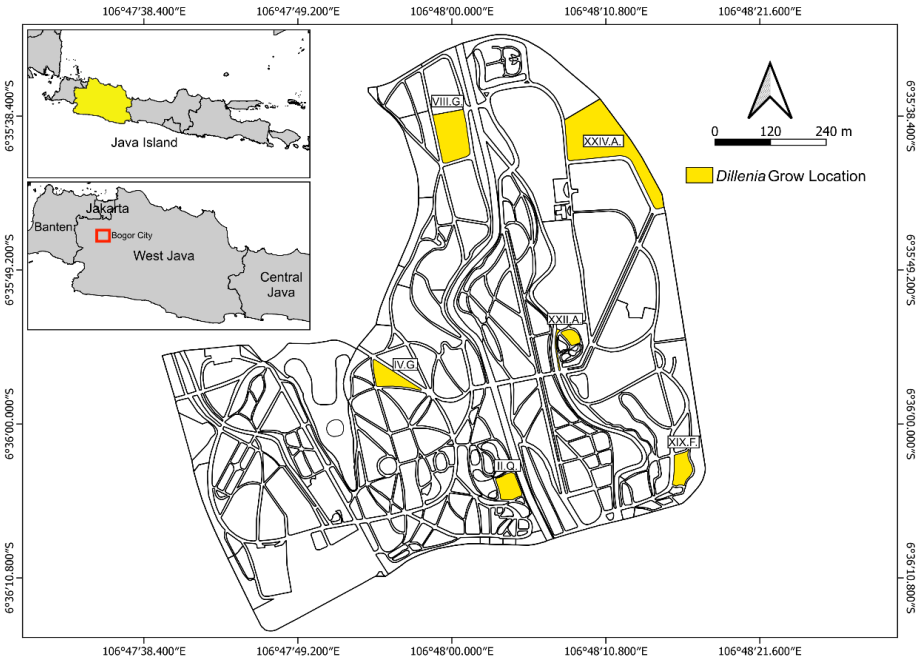

Fig. 1. Map of Bogor Botanical Garden showing the garden sections (vak) where the *Dillenia* collections are planted (highlighted in yellow).

2.2. Bibliometric

The bibliometric analysis in this study followed the approach outlined by Costa et al. (2024). Data were sourced from Scopus, a reputable academic database known for its rigorous indexing standards. A

comprehensive search was performed using the keyword Dillenia, and all related documents were downloaded in CSV format. The dataset included author names, titles, publication years, countries and regions, journal names, document types, subject categories, annual publication and citation counts, affiliations, author keywords, index terms, and document languages. For the analysis, we used VOSviewer, a software developed by van Eck and Waltman (2010), which is widely used for visualizing bibliometric networks.

2.3. Inventory

The inventory phase involved examining all *Dillenia* herbarium specimens from Sulawesi housed at the Herbarium Bogoriense (BO), as well as all *Dillenia* specimens in the living collection at Bogor Botanical Garden, based on the reference document "An Alphabetical List of Plant Species Cultivated in the Bogor Botanic Gardens" (Ariati et al., 2019).

Taxonomic identification was carried out using a descriptive approach, focusing on the morphological characteristics of each specimen. Each *Dillenia* specimen—both herbarium (BO) and living (BBG)—was recorded in a data matrix that included species name, local name, collection locality, and specimen number (for BO), and local name, collection origin, and specimen number (for BBG).

All identifications referred to R.D. Hoogland's foundational monograph, A Revision of the Genus *Dillenia* (1952), which remains the principal taxonomic reference for this genus.

3. Results and Discussion

3.1. Results

Scopus categorizes Dillenia-related publications into various subject areas (**Fig. 2**). The top ten fields include Agricultural and Biological Sciences (189), Pharmacology, Toxicology and Pharmaceutics (115), Biochemistry, Genetics and Molecular Biology (112), Medicine (90), Environmental Science (76), Chemistry (50), Chemical Engineering (25), Immunology and Microbiology (22), Earth and Planetary Sciences (22), and Materials Science (19).

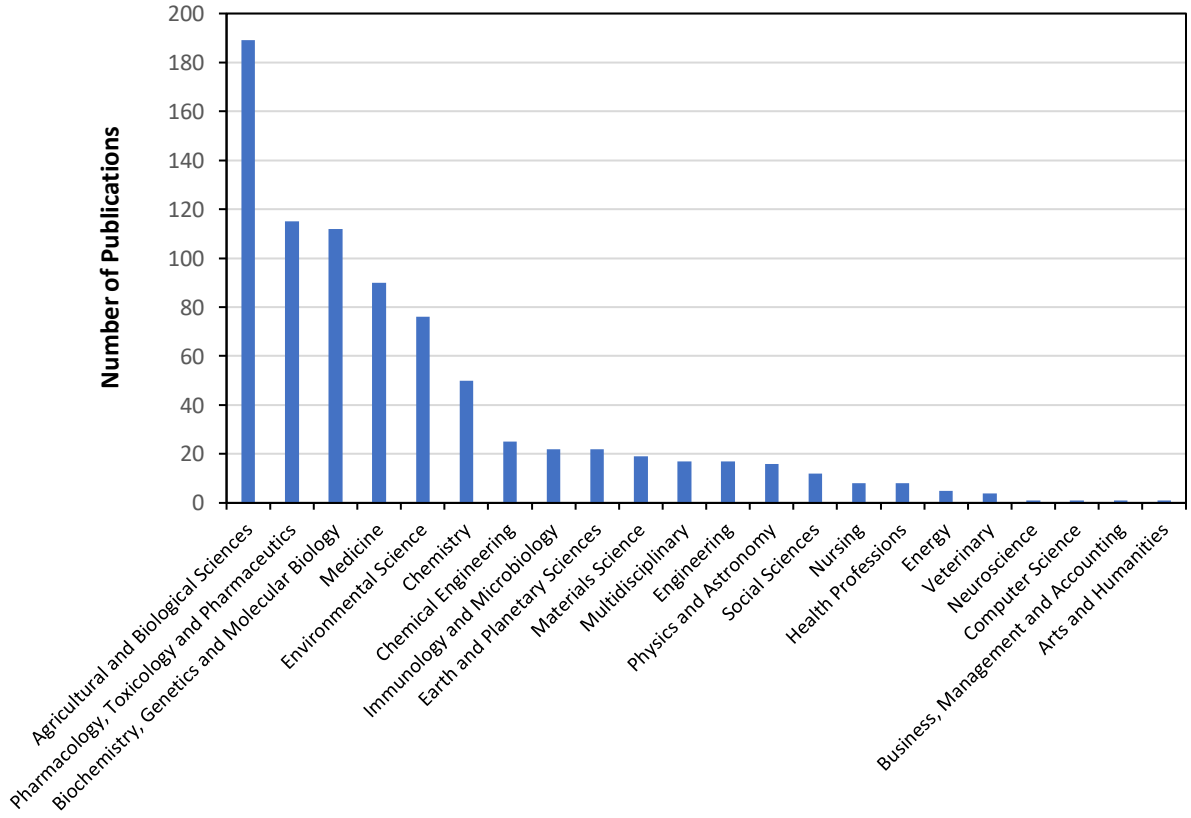

Fig. 2. *Dillenia* Research Numerical Details about Subject Areas Covered in Research Publications by Scopus.

Based on **Fig. 3**, research publications on *Dillenia* began in 1971. The number of publications has shown a steady increase each decade: 5 publications in 1970–1979, 16 in 1980–1989, 21 in 1990–1999, 27 in 2000–2009, followed by a sharp rise to 205 in 2010–2019, and 192 publications from 2020 to March 2025.

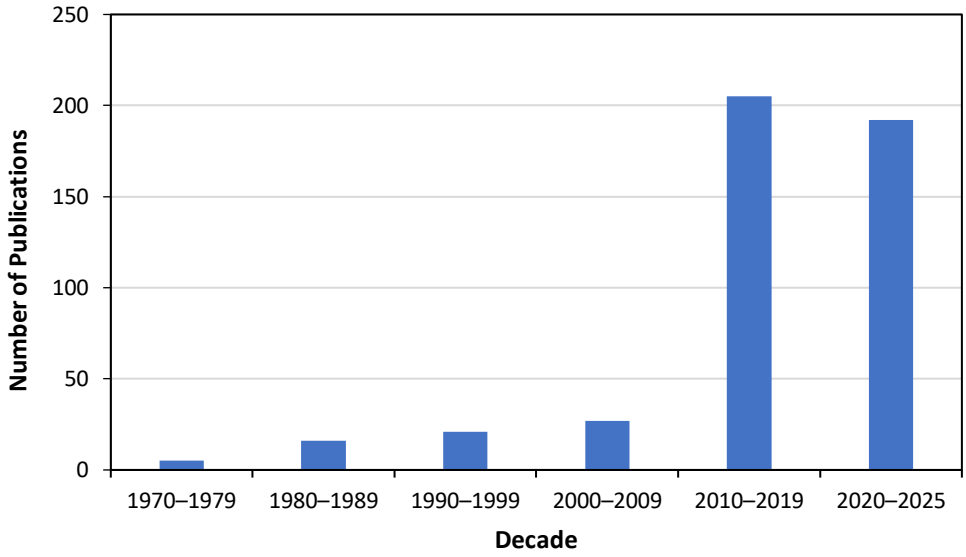

Fig. 3. List of Publications/Decade of *Dillenia* Research.

Based on **Fig. 4**, Bibliometric mapping of research publications by country. Node size represents the number of publications, while connecting lines indicate international collaborations. India dominates the output, followed by Malaysia, Indonesia, and Bangladesh, with active networks linking Asia, Europe, and North America.

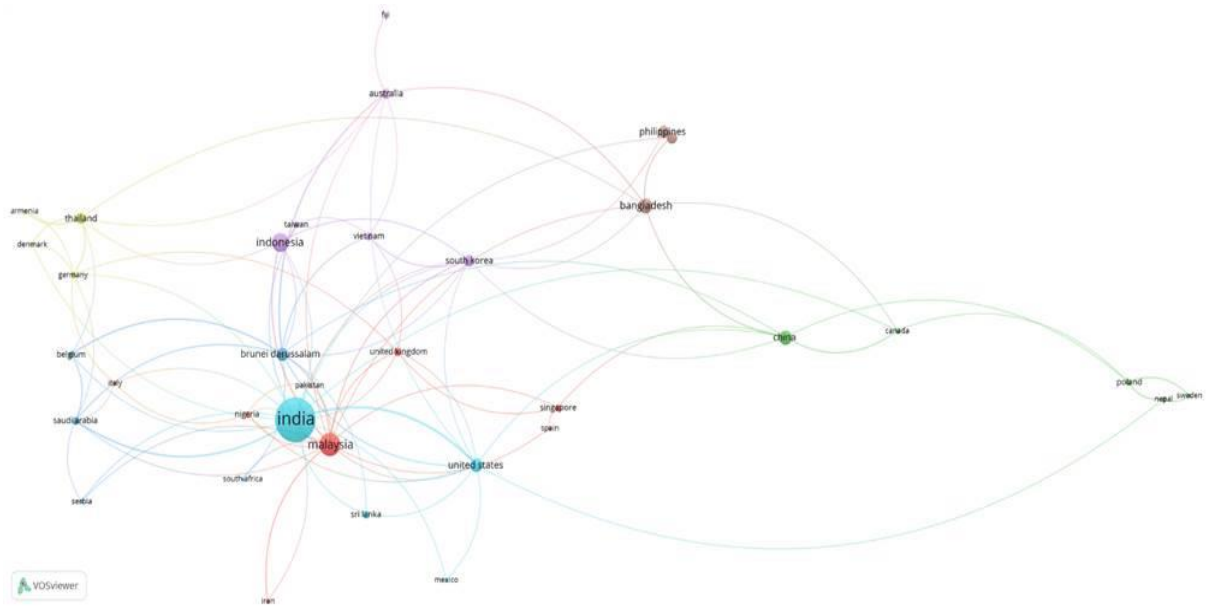

Fig. 4. Co-authorship network for countries with at least two (2) publications in *Dillenia* Research.

Based on **Fig. 5**, the Keyword Network for *Dillenia* has six clusters for *Dillenia* research. 1. red cluster: antibacterial and pharmacological activity, 2. blue cluster: ethnobotany and traditional uses, 3. green cluster: toxicity and cellular mechanisms, 4. yellow cluster: plant chemistry and bioactive compounds, 5. purple cluster: extract isolation and purification, 6. light blue cluster: compound analysis and characterization techniques.

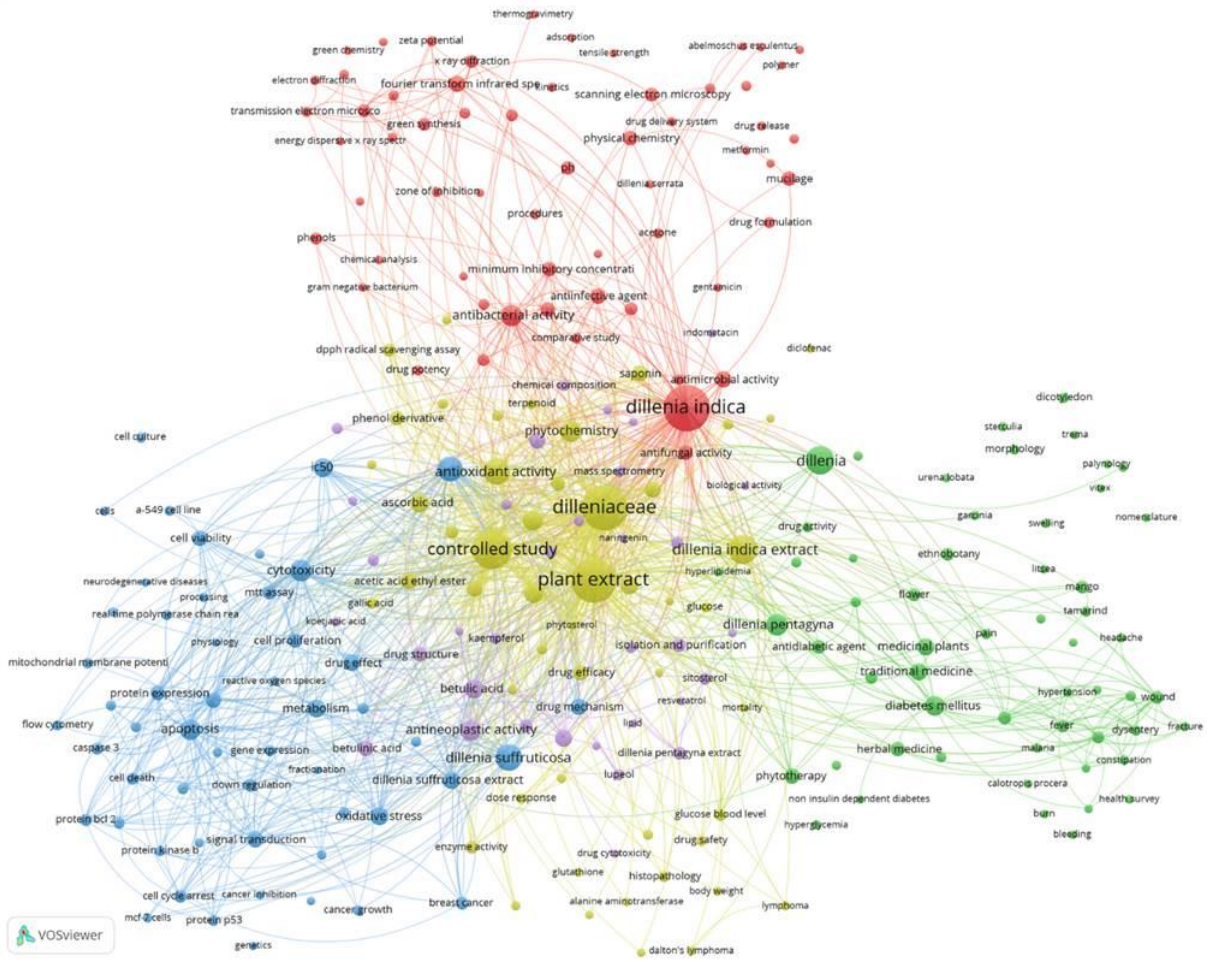

Fig. 5. Keyword Network for *Dillenia*.

The results of the inventory of *Dillenia* from Sulawesi in the Herbarium Bogoriense (BO) collection are presented in **Table 1** and **Table 2**. Inventory at BO showed that five species of Dillenia were collected from Sulawesi. These species include *D. celebica*, *D. ochreata*, *D. pentagyna*, *D. serrata* and *D. talaudensis*. Table 1 provides a detailed description of the *Dillenia* herbarium, including species name, local name, location of origin, and specimen collection number.

Inventory at BBG shows that three species of Dillenia collected from Sulawesi have been cultivated. These species are *D. ptempoda*, *D. ochreata*, and *D. serrata*. **Table 2** provides a detailed description of the live collection of *Dillenia*, including species names, locations of origin, and specimen collection numbers.

3.2. Discussion

3.2.1. Bibliometric of Genus Dillenia

Based on **Fig. 2** and **Fig. 3**, the dramatic rise in publication numbers, especially during the last two decades, reflects significant advancements in biological research. This growth is driven by increased access to scientific information through digital platforms, cutting-edge technologies such as DNA sequencing, imaging, and bioinformatics development, and enhanced international collaboration across disciplines (Stern, 2022). Clusters on **Fig. 5** indicate that current *Dillenia* research is still heavily focused on phytochemistry, particularly on a single species, *D. indica*. *D. indica* has become the main focus of *Dillenia* genus research due to its wide distribution and its well-established role as a source of traditional medicines. According to the Plants of the World Online (POWO) database, *D. indica* is naturally distributed across South Asia, South-Central China, Southeast China, and Southeast Asia. According to

Global Biodiversity Information Facility (GBIF, 2025), *D. indica* has occurrences in North Australia, South America and Latin America. Numerous studies have reported that D. indica exhibits significant antibacterial, anticancer, antioxidant, analgesic, and anti-inflammatory activities, attributed to its richness in polyphenols and flavonoids (Akter et al., 2022; Rahman et al., 2021; Song et al., 2022). This highlights a substantial opportunity for further exploration in other research fields and with other species within the genus.

Table 1. Inventory of *Dillenia* from Sulawesi in the Herbarium Bogoriense (BO) Collection

No.	Species	Local Name	Origin Location	Specimen Number Collection
1	*Dillenia celebica* Hoogland	Reses; Njehek	South Sulawesi; North Sulawesi	Dr. G. Kjellberg 2226; H. Wullus bb. 13755; Dr. J. G. Boerlage 5899; Dr. S. H. Koorders 19382 B
2	*Dillenia ochreata* (Miq.) Teijsm. & Binn. ex Martelli	Jonggi, kelemor, ngeher, kelemor, marePrer	North Sulawesi; Gorontalo	C. A. Wisse W. 97, W. 98; E. F. de Vogel 2448; S. H. Koorders 3240; S. H. Koorders 2094, 1510; Sutrisno 56; A. H. G. Alston 16538; Fegomam 5324; A. rnongula bb. 17. 563; Teysmann 5847; Hery Yanto xm-984 S. H. Koorders 16709 B, 16712 B, 16714 B; V. Balgooy 3770, 3771; T.C. Whitmore & K. Sidiyasa TCW 3494, TCW 3532; G. Baengkom bb. 7528; H. J. H. Walangitung bb. 12.657; H. Ficoalu bb. 18.085; Riedel 5339; J. J. Afriastini 2876 A
3	*Dillenia pentagyna* Roxb.		South Sulawesi; Central Sulawesi; Southeast Sulawesi	Noerkas 296, W. Meijer 10744, L. V. D. Pijil 733, Dr. A. Rant 433; 453; H. A. B. Bunnemeijer 12558; C. P. Bungkart bb. 5864
4	*Dillenia serrata* Thunb.	Dongi; Woea, dengi; dengilo, jonggi	South Sulawesi; Southeast Sulawesi; West Sulawesi; Central Sulawesi;	Agus Suyadi EAW 9115; Ramlanto Ram. 180; Boschproefstation No. Cel/IV - 89; A. G. Waturandang 10; Deden G D. 62; H. O. R. Gelsing, Mndgldi H. 73 - 10; W. Meijer 11212; H. N. Reppie Col./IV - 155; H. S. H. Walanggitang 26; A. G. Waturandang Col./III – 39; E. A. Widjaja & Agus Suyadi EAW 9416; A. Hidayat AH 4208; Agus Suyadi EAW 9115; Dr. G. Kjellberg 194, 579; S. Prawiroatmodjo & Maskuri 1368; Versteeg BB. 3924; A. G. Waturandang 10, 58; Sidiyasa, K. & Arifin, Z. 3998; "Elizabeth A. Widjaja, Megawati, Hamzah, Wahyudi Santoso" EAW 9642; H. O. R. Gelsing, Mndgldi H. 73 - 10; M. J. E. Coode Coode 6288; Ramlanto 118; Ramaghanil Pitopang RP.2153; Meijer 9517, 10056; E. F. De Vogel 5067; Kessler, P. J. A. PK 3076; T. Uji 4622; F. Roringpanday BB. 7505; Boschproefstation bb.13.747
5	*Dillenia talaudensis* Hoogland		South Sulawesi	H. J. Lam 3072

The red cluster centers on Dillenia's antibacterial and antimicrobial potential, with *D. indica* as the predominant species studied. Research in this cluster investigates phenolic, flavonoid, and tannin compounds, which contribute to antimicrobial activity against various pathogens. Previous studies have shown that *D. indica* possesses anticancer, antibacterial, antioxidant, analgesic, and anti-inflammatory properties (Song et al., 2022). Akter et al. (2022) reported that bark extracts of *D. indica* are rich in polyphenols and flavonoids, and have high antioxidant capacity. Additionally, other studies indicate that leaf and fruit extracts also show promise as natural antibacterial agents (Rahman et al., 2021).

The blue cluster highlights ethnobotanical and traditional uses of *Dillenia*. For instance, *D. pentagyna* is traditionally used by the Koch Rajbanshi people in Assam as a treatment for cancer (Yadav et al., 2015). Its bark is also used for treating diabetes, diarrhea, cuts, and burns (Saxena et al., 2022). In Indonesia, the Pinogu community utilizes *D. serrata* wood (locally known as dengilo) for stabilizing muddy roads and constructing trench bridges (Arini et al., 2019). In many parts of Asia, leaves and fruits of *D. indica* are used in traditional medicine for fever, indigestion, and inflammation (Mohona et al., 2016), while the fruits are often processed into syrups and herbal drinks. *Dillenia* wood is also utilized for furniture and construction materials.

Table 2. Inventory of Sulawesi-origin *Dillenia* in the Bogor Botanical Garden Collection (BBG)

No.	Species	Origin Location	Specimen Number Collection
1.	*Dillenia ptempoda* (Miq.) Hoogland	South Sulawesi	II.Q.86
2.	*Dillenia ptempoda* (Miq.) Hoogland	South Sulawesi	II.Q.86a
3.	*Dillenia ptempoda* (Miq.) Hoogland	South Sulawesi	II.Q.92
4.	*Dillenia serrata* Thunb.	Southeast Sulawesi	II.Q.103
5.	*Dillenia serrata* Thunb.	Southeast Sulawesi	II.Q.103a
6.	*Dillenia ptempoda* (Miq.) Hoogland	Southeast Sulawesi	II.Q.104
7.	*Dillenia ptempoda* (Miq.) Hoogland	Southeast Sulawesi	II.Q.104a
8.	*Dillenia ochreata* (Miq.) Teijsm. & Binn. ex Martelli	Central Sulawesi	II.Q.105a
9.	*Dillenia ochreata* (Miq.) Teijsm. & Binn. ex Martelli	North Sulawesi	IV.G.36
10.	*Dillenia ptempoda* (Miq.) Hoogland	South Sulawesi	IV.G.130
11.	*Dillenia ptempoda* (Miq.) Hoogland	South Sulawesi	IV.G.138
12.	*Dillenia ptempoda* (Miq.) Hoogland	South Sulawesi	IV.G.138a
13.	*Dillenia ptempoda* (Miq.) Hoogland	South Sulawesi	VIII.G.229
14.	*Dillenia ptempoda* (Miq.) Hoogland	South Sulawesi	XIX.F.120a
15.	*Dillenia ptempoda* (Miq.) Hoogland	South Sulawesi	XXII.A.12
16.	*Dillenia ptempoda* (Miq.) Hoogland	South Sulawesi	XXII.A.19
17.	*Dillenia ptempoda* (Miq.) Hoogland	North Sulawesi	XXIV.A.140

The green cluster focuses on cytotoxic and pharmacological activities, particularly the anticancer potential of *Dillenia*. Studies in this group examine how extracts from the leaf, fruit, and stem bark of *Dillenia* species induce cytotoxic effects through apoptosis, cell cycle inhibition, and oxidative stress modulation. Apoptosis is a controlled cell death mechanism that maintains cellular balance and, unlike necrosis, does not trigger inflammation, making it a desirable pathway in cancer therapy (Foo et al., 2015). This cluster features *D. suffruticosa*, a species traditionally used to treat fever and rheumatism (Yakop et al., 2020). Research indicates it exhibits stronger cytotoxic activity against human cancer cells than other medicinal plants (Yazan et al., 2015).

The yellow cluster investigates plant extracts and phytochemistry. It includes studies on various bioactive compounds found in various *Dillenia* species, such as flavonoids, triterpenoids, saponins, and phenolics. According to Saikia et al. (2023), *D. indica* contains numerous phytochemical compounds, including polyphenols, terpenoids, alkaloids, chromanes, dicarboxylic acids, fatty acids, anthraquinones, and ketones. These compounds exhibit antioxidant, anti-inflammatory, and antidiabetic activities, highlighting their potential in herbal medicine development. Gogoi et al. (2020) further emphasized the broad pharmacological activities of *D. indica* and the importance of toxicity assessments to ensure its safety before therapeutic applications.

The purple cluster is centered around the analysis and isolation of phenolic compounds. This research cluster emphasizes identifying and characterizing flavonoids and phenolics in *Dillenia* extracts. Flavonoids, a class of polyphenolic secondary metabolites, are widely found in fruits, vegetables, and grains (Wang et al., 2019). Studies have shown their antiproliferative and cytoprotective properties (Satari et al., 2021). Chromatographic techniques are frequently used in this cluster to determine the structure and purity of active compounds. Chromatography separates compound mixtures based on their interactions with a stationary and a mobile phase (Coskun, 2016).

While phytochemical and pharmacological studies dominate current *Dillenia* research, these findings highlight the vast untapped potential for multidisciplinary exploration, especially involving lesser-studied species and the genus's underexplored ecological or evolutionary aspects.

3.2.2. Inventory of Dillenia Specimens at Herbarium Bogoriense (BO) and Bogor Botanical Garden (BBG)

Based on Table 1, 114 herbarium sheets representing 72 collection numbers were examined at the Herbarium Bogoriense (BO). The inventory included 48 specimens of *Dillenia serrata* Thunb., 46

specimens of *D. ochreata* (Miq.) Teijsm. & Binn. ex Martelli, 13 specimens of *D. pentagyna* Roxb., 6 specimens of *D. celebica* Hoogland, and 1 specimen of *D. talaudensis* Hoogland.

The herbarium inventory confirmed the presence of four *Dillenia* species endemic to Sulawesi (*D. serrata, D. ochreata, D. celebica*, and *D. talaudensis*) and one species with a broader distribution that includes Sulawesi *(D. pentagyna*). In terms of geographical distribution, the Sulawesi-origin specimens were collected from the following provinces: North Sulawesi (48 specimens), South Sulawesi (22), Southeast Sulawesi (22), Central Sulawesi (6), unspecified localities within Sulawesi (12), West Sulawesi (1), and Gorontalo (1).

In addition to the above, five herbarium sheets labeled as *Dillenia ochreata* were found in the BO collection and reportedly originated from West Papua. However, *D. ochreata* is recognized by Hoogland (1952) as strictly endemic to Sulawesi and has never been recorded from West Papua. Preliminary morphological observations cast doubt on the identity of these specimens, leading us to exclude them from further analysis in this study.

A re-examination of morphological characters confirmed that 11 specimens at BO had been misidentified. These are accessioned under the following numbers: BO-0093906, BO-1869701, BO-1869700, BO-1876748, BO-0013157, BO-0013158, BO-1896778, BO-1896777, BO-1896797, BO-1896799, and BO-1875750. These specimens have been annotated accordingly, pending further taxonomic study.

Fig. 6 shows two herbarium specimens of *Dillenia* form Sulawesi at BO. A). Misidentification of the herbarium *Dillenia ochreat*a. Suspicion of misidentification arose when the wing characteristics of *D. ochreata* (**Fig. 6**) were inconsistent with the descriptions provided in the latest *Dillenia* monograph by Hoogland. Re-identification was subsequently conducted based on wing morphology, revealing that the specimen was correctly identified as *D. celebica*. B). *Dillenia talaudensis* type specimen. Herbarium type is the original specimen used to describe and name a new species formally.

Fig. 6. *Dillenia* Hebarium Collection at BO. A). Misidentification Herbarium *Dillenia ochreata*, B). *Dillenia talaudensis* Type Specimen.

According to **Table 2**, 17 accession numbers of *Dillenia* specimens collected from Sulawesi were examined at BBG. These included 14 specimens labeled as *D. ptempoda*, 2 as *D. serrata*, and 2 as *D. ochreata*. Geographically, these specimens originated from South Sulawesi (10), Southeast Sulawesi (4), North Sulawesi (2), and Central Sulawesi (1).

Dillenia ptempoda does not appear in major taxonomic databases, such as Plants of the World Online (POWO) and the International Plant Names Index (IPNI) (**Fig. 7**). Only two new species of *Dillenia* have been validly described in the last two decades—*D. tetrapetala* (Choudhary et al., 2012) and *D. tirupatiensis* (Swamy et al., 2020)—and neither corresponds to this name. *D. ptempoda* likely

represents a misspelling or misapplication of the name *D. pteropoda* (Miq.) Hoogland. However, *D. pteropoda* is native to the Philippines, Moluccas, and New Guinea, and has never been recorded from Sulawesi.

Fig. 7. *Dillenia* Collection at Bogor Botanical Garden. A). VIII.G.229 *Dillenia ptempoda*, B). XXIV.A.140 *Dillenia ptempoda*.

The *Dillenia ptempoda* predominance in BBG's Sulawesi-origin specimens raises important taxonomic questions. Are these truly *D. pteropoda* specimens with an undocumented range extension, or are they misidentified individuals of Sulawesi species? This ambiguity prompted a closer look at the morphology of these specimens, especially since 16 of them showed signs of potential misidentification. These are accessioned as: II.Q.86, II.Q.86a, II.Q.92, II.Q.103, II.Q.103a, II.Q.104, II.Q.104a, II.Q.105a, IV.G.130, IV.G.138, IV.G.138a, VIII.G.229, XIX.F.120a, XXII.A.12, XXII.A.19, and XXIV.A.140.

The high level of morphological similarity among *Dillenia* species, particularly when reproductive structures are missing, makes accurate identification challenging. These complexities reinforce the importance of detailed taxonomic work, guided by foundational revisions such as that of Hoogland (1952).

Importantly, misidentifications like these can have far-reaching implications for biodiversity conservation. According to the IUCN Red List, the conservation status of Sulawesi-endemic *Dillenia* species is as follows: *D. serrata* is classified as Least Concern (LC), *D. ochreata* and *D. celebica* as Endangered (EN), and *D. talaudensis* as Critically Endangered (CR). In contrast, the unrecognized *D. ptempoda* has no formal status, which highlights the risk of overlooking potentially threatened species due to taxonomic uncertainty.

4. Conclusion

Bibliometric analysis indicates that *Dillenia* research has predominantly focused on phytochemistry, pharmacology, compound analysis, and ethnobotany. In contrast, research in morphology, molecular systematics, and conservation remains limited, highlighting significant opportunities for future investigation. The herbarium inventory at Herbarium Bogoriense (BO) confirmed the presence of four *Dillenia* species endemic to Sulawesi (*D. celebica*, *D. ochreata*, *D. serrata*, and *D. talaudensis*), along with one species with a broader distribution that includes Sulawesi (*D. pentagyna*). However, the Bogor Botanical Garden (BBG) inventory yielded a different result, recording *D. ptempoda*, *D. serrata*, and *D. ochreata* as Sulawesi-origin species. The discrepancies between the BO and BBG collections, particularly the unrecognized name *D. ptempoda* in the latter, suggest potential misidentifications. This underscores the urgent need for taxonomic revision and

critical re-evaluation of *Dillenia* specimens, especially those originating from Sulawesi, to ensure accurate documentation and support effective conservation planning.

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References

Abdullah, K. H. (2022). Publication Trends in Biology Education: A Bibliometric Review of 63 Years. *Journal of Turkish Science Education*, *19*(2), 465-480.

Akter, M. J., Ali, S., Hasnin, I., Khatune, N. A., & Rahman, M. A. A. (2021). Cytotoxicity and Sedative Activity of Steam Bark of *Dillenia indica* L. *Bangladesh Pharmaceutical Journal*, *24*(2): 105-110.

Ariati, S. R., Astuti, R. S. Supriyatna, I., Yuswandi, A. Y., Setiawan, A., Saftaningsih, D., Pribadi, D. O. 2019. *An Alphabetical List of Plant Species Cultivated in The Bogor Botanic Gardens*. Indonesian Institute of Sciences, Bogor.

Arini, D. I. D., Yuliantoro, I. 2019. Perception of Local Community of Pinogu Toward Forest and Its Utilization. *Jurnal Wasian, 6*(2), 111-123.

Choudhary, R. K., Bach, T. T., Van Nong, L., Van Hai, D., Quang, B. H., Lee, Y.-M., Park, S.-H., Lee, C., & Lee, J. (2012). *Dillenia tetrapetala* (Dilleniaceae), a New Species from HonBa Nature Reserve, Vietnam. *Annales Botanici Fennici*, *49*(5/6), 369–376.

Coskun, O. (2016). Separation techniques: chromatography. *Northern clinics of Istanbul, 3*(2), 156.

Costa, A. R., Oliveira, C. V. B., da Silva, M. E. P., da Silva, P. A. G., Hassan, W., Zafar, M., & Barros, L. M. (2024). Bibliometric Analysis of The Species *Anacardium occidentale* L. Associated with Scientometric Networks. *Vegetos*, 1-11.

Danarto, S. A. and L. Hapsari. (2015). Biomass and Carbon Stock Estimation Inventory of Indonesian Bananas (*Musa* spp.) and Its Potential Role for Land Rehabilitation. *Biotropia, 22*(2), 102-108.

Foo, J. B., Yazan, L. S., Tor, Y. S., Wibowo, A., Ismail, N., How, C. W., & Abdullah, R. (2015). Induction of Cell Cycle Arrest and Apoptosis by Betulinic Acid-Rich Fraction from *Dillenia suffruticosa* Root in MCF-7 Cells Involved p53/p21 and Mitochondrial Signalling Pathway. *Journal of Ethnopharmacology, 166*, 270-278.

GBIF. (2025). *Dillenia* L. <https://www.gbif.org> (Feb. 28, 2025)

Gogoi, B., Sahariah, B. J., Patowary, P., Mawlieh, B. H., Deka, B., & Bordoloi, R. (2020). *Dillenia indica* Linn.-A Multipurpose Medicinal Plant of Assam. *British Journal of Medical and Health Research, 7*(05), 51-63.

Hoogland, R. D. (1952). A Revision of the Genus *Dillenia*. *Blumea, 7*(1), 1-145.

Hoogland, R. D. (1959). Additional Notes on Dilleniaceae 1-9. *Blumea, 9*(2), 577-589.

Mabberley, D. J. (1999). The Importance to Indopacific Botany of Baron Dumont de Courset's Botaniste Cultivateur. *Gardens' Bulletin, Singapore, 51*, 309-317.

Mohona, F. M., Hossain, M. M., Hasan, M. M., & Rony, S. R. (2016). Analgesic, CNS Depressant and Cytotoxic Activities of Leaves Extract of *Dillenia indica* Linn. *International Journal of Pharmaceutical Sciences and Research, 7*(1), 136.

Rahman, F. (2022). Pharmacological Properties & Phytochemical Constituents of *Dillenia indica* As A Potential Medicinal Tree: An Overview. *Barrister Shameem Haider Patwary, 12*(1), 38-49.

Renjana, E., Nikmatullah, M., Firdiana, E. R., Ningrum, L. W., & Angio, M. H. (2021). Potensi *Nephrolepis* spp. sebagai Tanaman Obat Koleksi Kebun Raya Purwodadi berdasarkan Kajian Etnomedisin dan Fitokimia. *Buletin Plasma Nutfah, 27*(1), 1-10.

Rindyastuti, R. (2017). Carbon Storage of Medium-Sized Tree: A Case Study on *Dillenia* Collection in Purwodadi Botanic Garden. *Berkala Penelitian Hayati Journal of Biological Researches, 22*(2), 74-80.

Sabandar, C. W., Jalil, J., Ahmat, N., Aladdin, N. A., Kamaruddin, H. S., & Wahyuningrum, R. (2020). Aktivitas Antioksidan dan Penghambatan Xantin Oksidase Kulit Batang Songi (*Dillenia serrata* Thunb.). *Jurnal Farmasi Galenika, 6*(1), 151-159.

Saikia, D., Kesavan, R., Stephen Inbaraj, B., Dikkala, P. K., Nayak, P. K., & Sridhar, K. (2023). Bioactive Compounds and Health-Promoting Properties of Elephant Apple (*Dillenia indica* L.): A Comprehensive Review. *Foods, 12*(16), 2993.

Satari, A., Ghasemi, S., Habtemariam, S., Asgharian, S., & Lorigooini, Z. (2021). Rutin: A Flavonoid as an Effective Sensitizer for Anticancer Therapy; Insights into Multifaceted Mechanisms and Applicability for Combination Therapy. *Evidence-Based Complementary and Alternative Medicine, 2021*(1), 9913179.

Shah, M. D., C. Gnanaraj, M. S. Khan, M. Iqbal. (2015). *Dillenia suffruticosa* L. Impedes Carbon Tetrachloride–Induced Hepatic Damage by Modulating Oxidative Stress and Inflammatory Markers in Rats. *Journal of Environmental Pathology, Toxicology and Oncology, 34*, 133-152.

Sholikhah, M. A., & Pratiwi, R. P. (2025). Tinjauan Literatur Augmented Reality pada Pembelajaran Biologi dalam Melatihkan Literasi Digital pada Artikel. *Berkala Ilmiah Pendidikan Biologi (BioEdu), 14*(1), 240-248.

Siahaan, E. N. R., Hatta, G. M., & Rudy, G. S. (2022). Potensi dan Prospek Pengembangan Tanaman Simpur (*Dillenia indica* L.) di KHDTK Kecamatan Kintap Kalimantan Selatan. *Jurnal Sylva Scienteae, 5*(3), 446-455.

Song, B. R., Alam, M. B., & Lee, S. H. (2022). Terpenoid-Rich Extract of *Dillenia indica* L. Bark Displays Antidiabetic Action in Insulin-Resistant C2C12 Cells and STZ-Induced Diabetic Mice by Attenuation of Oxidative Stress. *Antioxidants, 11*(7), 1227.

Stern, C. D. (2022). Reflections on The Past, Present and Future of Developmental Biology. *Developmental Biology, 488*, 30-34.

Sujarwo, W. (2016). Stand Biomass and Carbon Storage of Bamboo Forest in Penglipuran Traditional Village, Bali (Indonesia). *Journal of forestry research, 27*(4), 913-917.

Swamy, J., Rasingam, L., Nagaraju, S., & Mane, P. R. (2020). A New Species of *Dillenia* (Angiosperms: Dilleniaceae) from The Eastern Ghats of Andhra Pradesh, India. *Journal of Threatened Taxa, 12*(11), 16636-16640.

Wang, M., Firrman, J., Liu, L., & Yam, K. (2019). A Review on Flavonoid Apigenin: Dietary Intake, ADME, Antimicrobial Effects, and Interactions with Human Gut Microbiota. *BioMed Research International, 2019*(1), 7010467.

Wulan, S. (2020). Kiprah Peneliti Zoologi Pusat Penelitian Biologi-LIPI dan Kolaborasi Penelitian dalam Publikasi Internasional: Analisis Bibliometrik. *Media Pustakawan, 27*(2), 126-137.

Yadav, R. K., Srivastava, S. K., & Mishra, S. (2015). Review on Ethnopharmacognosy of *Dillenia pentagyna*: A Medicinally Important Plant. *International Journal of Latest Research in Science and Technology, 4*(1), 123-127.

Yakop, F., Hamid, M. H. S. A., Ahmad, N., Majid, M. A., Pillai, M. K., & Taha, H. (2020). Phytochemical Screening, Antioxidant and Antibacterial Activities of Extracts and Fractions of *Dillenia suffruticosa* Leaves. *Malaysian Applied Biology, 49*(1), 121-130.

Yang, G., & Wu, L. (2017). Trend in H2S Biology and Medicine Research—A Bibliometric Analysis. *Molecules, 22*(12), 2087.

Yazan, L. S., Ong, Y. S., Zaaba, N. E., Ali, R. M., Foo, J. B., & Tor, Y. S. (2015). Anti-Breast Cancer Properties and Toxicity of *Dillenia suffruticosa* Root Aqueous Extract in BALB/c Mice. *Asian Pacific Journal of Tropical Biomedicine*, *5*(12), 1018-1026.

Yazan, S., L., and Armania, N. 2014. *Dillenia* Species: A Review of The Traditional Uses, Active Constituents and Pharmacological Properties from Pre-clinical Studies. *Pharmaceutical Biology, 52*(7), 890-897.