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Review Article

Utilization of *Pteridophyta* species in Cyathea Park, Bali, as traditional medicine agents: A field study and meta-synthesis review

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Abstract

Pteridophytes have been studied and preserved in botanical gardens. However, only a few have discovered and documented the medicinal properties of Pteridophyta species. This study aims to promote the utilization of *Pteridophyta* species in Taman Cyathea, Bali, as traditional medicine agents by conducting a comprehensive literature review with a novelty of 15 years (2008-2022) on the ethnopharmacology and species diversity of the plant division. This research was conducted by directly exploring *Pteridophyta* species collected in Taman Cyathea, Bali, and a meta-synthesis was carried out related to the potential use of these species as traditional medicinal agents. The STARLITE principle was used for the article search, and ENTREQ was used for transparency in reporting meta-synthetic results. The study was conducted by searching the databases with keywords set according to the inclusion criteria. Findings in the field showed that there were as many as nine species of *Pteridophyta* identified as having benefits as traditional medicine agents, including *Cyathea contaminans* (Wall ex Hook) Copel., *Asplenium nidus* L., *Asplenium* sp., *Selaginella* sp., *Diplazium esculentum*, *Angiopteris evecta* (G.Forst.) Hoffm, *Cyathea* sp., *Nephrolepis hirsutula* (Forst) C. Presl and *Dicksonia blumei* (Kunze) Moore. The results of the meta-synthesis obtained 49 articles that met the study criteria; leaves, shoots, roots, stems, and hairs were used for various purposes, including restorative materials, planting media, crafts, game materials, and food ingredients. *Pteridophyta* species treat fever, cough, anticonvulsant, antibacterial, anti-inflammatory, antipyretic, antidiuretic, immunomodulatory, antioxidant, insecticide, larvicide, diabetes, and antiretroviral diseases, among others, so their potential use as traditional medicine agents and candidates for standardized herbs or phytopharmaceuticals have promising prospects in the future. However, its pharmacological, phytochemical, and toxicity properties must be investigated further.

Keywords: Cyathea; plant diversity; *Pteridophyta*; traditional medicinal agents; meta-synthesis

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Introduction

Regions with high rain intensity tend to have abundant flora diversity, including Indonesia (Atho *et al*., 2020). Tropical rainforests in the country can produce thousands of plants, including ferns (*Pteridophyta*) (Nabila *et al*., 2021). *Pteridophyta* generally lives in humid environments with temperatures ranging from 21–27 °C at varying altitudes and habitats in aquatic, terrestrial, and epiphytic areas (Lestari and Nindira, 2021, Nabila *et al*., 2021). *Pteridophyta* has kormus and spore bags on parts of their bodies and does not have seeds, so they are classified into the Cryptogamae (Yudianto, 1992; Silalahi, 2014). Indonesia's high diversity of nail plants is essential to the environment and humans (Jones *et al*., 2019). *Pteridophyta* for the environment has an ecological role, such as covering soil, protecting the soil from erosion, mixing litter for soil nutrient formation, and acting as producers in the food chain. Meanwhile, the role of *Pteridophyta* for humans is as a source of germplasm, including for consumption needs, raw materials for traditional medicine, ornamental plants, handicrafts, and fertilizers for soil improvement (Tungmunnithum *et al*., 2018; Ciawi *et al*., 2022; Sirichai *et al*., 2022). Nail plants indicate that the environment is still in good condition (Darma *et al*., 2018; Taslim *et al*., 2019; Wu *et al*., 2020).

People around the world have widely used Pteridophyta species. In addition to meeting daily needs in the form of vegetables, its widespread use has been trusted as a traditional medicine agent because it has a postuse therapeutic effect (Ho *et al*., 2011; Singh *et al*., 2020). Numerous studies have explored the biological and pharmacological activities of *Pteridophyta species.* The findings showed *that Pteridophyta* species contain various secondary metabolite compounds in terpenoids, phenolics, flavonoids, alkaloids, saponins, and anthraquinones, all known to have medicinal benefits. Studies conducted in India found that *Pteridophyta* species are widely used as candidates for herbal and traditional medicine and have been developed into standardized medicine (Sureshkumar *et al*., 2018). Furthermore, Ho *et al*. (2011) explained that *Pteridophyta* species are widely used as raw materials for medicine and candidates for traditional and modern medicines because they contain bioactive compounds and activities relevant to certain diseases and have been empirically proven to have pharmacological effects on human health. In Indonesia, the chemical content contained in the *Pteridophyta* plant part has been widely explored for further development as a traditional medicine agent (Cao *et al*., 2017; Tungmunnithum *et al*., 2018; Nikmatullah *et al*., 2020; Singh et al., 2020; Bailly, 2021; Taheri *et al*., 2021; Chaparro-Hernández *et al*., 2022). The high demand for healing materials for industrial use, the distribution of drugs in the community, and the rising standardization of raw materials for indigenous Indonesian traditional medicines used commercially all play a role in mediating this.

Traditional medicine in Indonesia is divided into three types: herbs, standardized herbal medicines, and phytopharmaceuticals. Nevertheless, until now, there have been no reports of the potential use of *Pteridophyta* species as more modern drug candidates, such as standardized herbal medicines (OHT) and phytopharmaceuticals, even though plant parts and bioactive compounds have been studied as traditional medicine agents and confirmed through empirical research. However, findings in the field show that the use of ferns is only limited to being introduced as vegetables or light drugs such as bleeding relievers, minor wounds, and other treatments in the form of herbal medicine (Rindita *et al*., 2020). Exploration and identification of *Pteridophyta* in various regions of Indonesia have been widely carried out *(Darma et al., 2018; Nikmatullah et al*., 2020; Nabila *et al*., 2021). It is included in the technical implementation unit of the Eka Karya Botanical Garden Plant Conservation Center, Bali. This botanical garden has duties and functions as a cultural heritage site, including a center for biodiversity research and plant conservation in eastern Indonesia. Cyathea Park covers an area of 2 ha and conserves *Pteridophyta* and Likofita plants (LIPI, 2022). Exploration conducted by previous research is limited to identifying the current types, quantities, identities, and conditions of *Pteridophyta* available to update collection data (Darma *et al*., 2018, 2021; Lestari and Nindira, 2021).

However, although reports of widespread use of Pteridophyta species in various parts of Indonesia have been reported, this has not been reported in Bali, which has yet to see much potential and utilization of *Pteridophyta* species as agents or candidates for traditional medicine; this is supported by the common public knowledge of *Pteridophyta* species that can be used as raw materials for traditional medicine. Thus, exploring, compiling, and identifying *Pteridophyta* species that can be used as raw materials for traditional medicine or candidates for standardized herbal medicines and phytopharmaceuticals in the community is essential. This study aims to promote the utilization of *Pteridophyta* species in Cyathea Park, Bali, as traditional medicine agents by conducting a comprehensive literature review with a 15-year recency (2008-2022) on the ethnopharmacology and species diversity of the said plant division. Hopefully, this research can contribute to the importance of conservation and further exploration of *Pteridophyta* species to be used as candidates for traditional medicine.

Materials and Methods

Field studies

Field studies were conducted by directly exploring and observing the types of *Pteridophyta* in Cyathea Park (-8.2759165, 115.1511926), Eka Karya Botanical Garden, Bali, which is located at Jalan Raya Kebun Raya Eka Karya number 2, Candikuning, Baturiti, Tabanan Regency, Bali 82191. *Pteridophyta* species collected in Ciathea Park, plot code XI. E is located at an altitude of 1,250-1,450 meters above sea level, with temperatures ranging from 18-20 °C and humidity ranging from 70-90%. Data were collected by identifying species types, families, and morphologies to be described qualitatively (Darwin *et al*., 2021). Collection of *Pteridophyta* species identity in this study by recording based on "plaque" or board identity consisting of access number "E" and marking number given by the manager of Catathea Park. Specific identity and validation of species correctness are performed online to determine classification, nomenclature, habitat data, and synonyms through the World Flora Online (WFO) Plant List with access code for pteridophytes (wfo-949999999997(WFO 2022)). Two independent authors performed identification, and if there were differences in the results, consensus was reached to obtain agreement equality. The exploration was conducted for two weeks, from November to December 2022. Instruments in this study include data recording sheets, Catathea Garden plans, stationery, and devices for documentation. Data analysis is carried out descriptively based on the collected data accompanied by a narrative review.

Meta-synthesis review

Meta-synthesis is carried out by identifying, exploring, and promoting the benefits of nail plant parts, bioactive ingredients that have therapeutic effects, and their potential as candidates for traditional medicine, herbs, standardized herbal medicines, and phytopharmaca. The results of identifying *Pteridophyta* species recorded in Taman Cyathea, Bali, were then analyzed in depth, focusing on ethnobotanical and ethnopharmacological utilization. In conducting a meta-synthesis, six stages are passed by emphasizing the principle of completeness and accuracy of qualitative research presented in Figure 1 and described as follows.

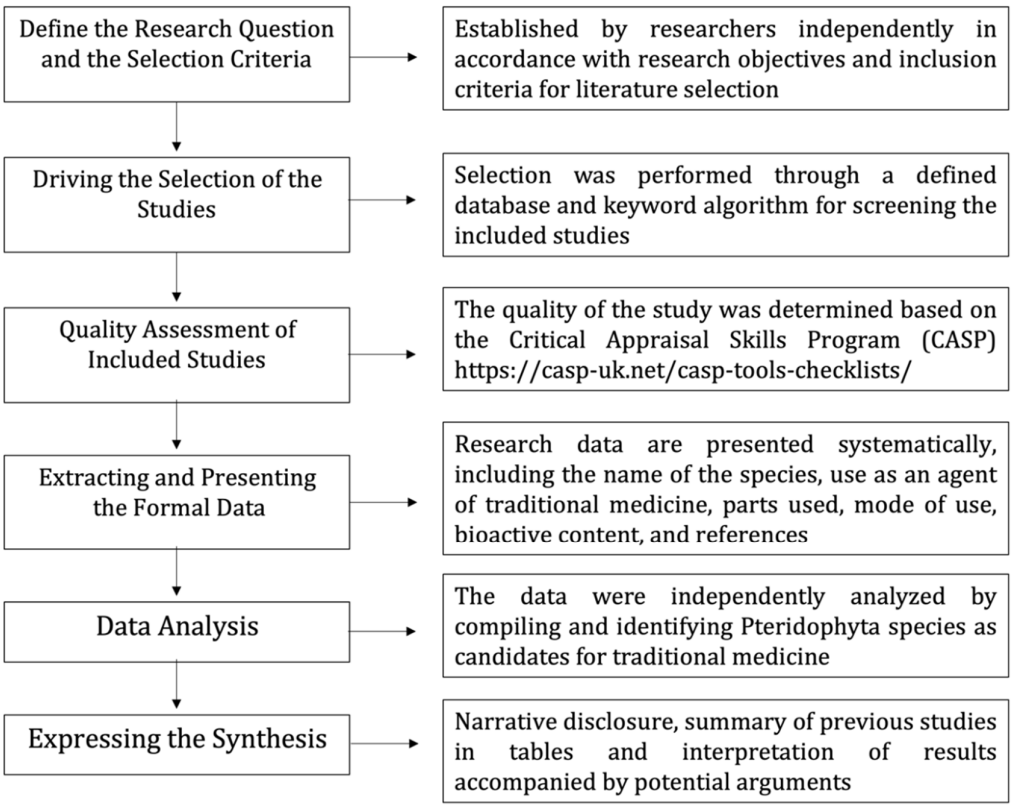

Figure 1. Meta-synthesis flow review (Lachal *et al*., 2017).

Define the research question and the selection criteria

At this stage, research questions are defined, namely, (1) What are the types and characteristics of Pteridophyta found in Taman Cyathea, Bali?; and (2) how is the potential use of *Pteridophyta* species in Taman Cyathea, Bali, as a traditional medicine agent? The selection of this study is essential to do because of several things behind it, including the common public knowledge related to the types of Pteridophyta species in Bali Cyanthea Park, lack of exploration related to utilization as a traditional medicine agent, including how to use, parts used and information related to disease treatment and the absence of *Pteridophyta* species, which is used as a standardized herbal medicine and phytopharmaceutical. However, empirical studies have been widely conducted. Through this research, he hopes to gain exploratory insights into the potential of ferns in the community as raw materials for drugs using meta-synthesis and ethnopharmacological approaches. The complex content of bioactive compounds in each *Pteridophyta* species makes the isolation of bioactive compounds in the future potentially traceable.

In this study, the determination of inclusion criteria included the following: (1) studies that discuss the morphology of *Pteridophyta* plants; (2) studies that discuss the use of *Pteridophyta* species as traditional medicine agents in disease both in vitro, and in vivo, in silico and traditional use (Ethnobotany and ethnomedicine); (3) articles reporting bioactive compounds traced while the study was conducted such as phytochemical testing, or related studies; (4) research reports on the traditional use of *Pteridophytes* in certain tribes, customs or regions; (5) articles using English (as most studies are now published in English) and Indonesian (as this is our first language); (6) articles published in the last 15 years (01 January 2008 – 31 December 2022); (7) the original article is open access; and (8) indexed in the international databases SCOPUS and Web of Science (WOS) and Science and Technology Index (SINTA) 1-3. The index is selected and determined based on the credibility of articles that have undergone rigorous peer review.

Driving the selection of the studies

The selection of studies in this study is determined using keywords to facilitate the determination of articles included in the study following predetermined criteria. Thesaurus and free-text term approaches increase the sensitivity and specificity of related study findings. There are three groups of keywords used in this study, namely, (i) those related to the topic studied; (ii) those related to the content or compound bioactivity in the relevant plant part; and (iii) local use, traditional medicinal agents, or ethnobotanical use in certain tribes or regions and ethnomedicine in certain regions.

Study selection was based on the inclusion criteria set and filtered through various databases, including PubMed Mesh term, Europe PMC, Science Direct, Elsevier, Web of Science (WOS), Goggle Scholars, and connected papers with related keywords ((['Pteridophyta', *Cyathea contaminans'*, AND 'C. Contaminants', 'Asplenium nidus L., 'OR 'Bird's nest spikes' OR 'Asplenium sp,' AND 'Asplenium (Polypodiales)' AND 'ethnomedicine applications,' *'Angiopteris evecta'* AND 'A. Evecta', 'Selaginella sp' AND 'Selaginella,' *'Dicksonia blumei*,' AND 'D. Blumei',' traditional medicine', 'fern plant', 'Pteridophytes' *'in vivo', 'in silico', 'in vitro'*])). ((([['ethnobotanical field studies,' OR 'ethnomedicine,' AND 'Traditional Medicine Agents'])), ([['Pteridophytes,' 'ethnomedicine,' AND 'herbal medicine' AND 'local knowledge' OR' medicinal knowledge,' 'health,' 'Therapeutics,' 'perspective']])), (([+ 'Antioxidants,' 'antimicrobials,' antivirals, OR 'Bioactive compounds', treatment effects'])), ((['potential uses' OR 'potential as drugs', 'diversity'])).

We also use the connected paper application for article search by entering keywords related to the search results presented in Figure 2. The data are then entered into the Mendeley reference manager for further selection in the form of duplicate articles, articles that do not meet the inclusion criteria in terms of title and abstract and are not included in any index database released at this stage. STARLITE principles for reporting literature searches are used at this stage: "**S**" sampling strategy: comprehensive; **"T"** Type of Study: original article; "**A**" Approaches": electronics; " **R"** Range of years: full reported for 15 years (01 January 2008 - 31 December 2022); "**L**" limits: language (English and Indonesian); **"I"** inclusion and exclusion: discusses related species of Pteridophyta, used as agents of traditional medicine, ethnomedicine, and ethnopharmacology following selection criteria; "**T"** term used: the search strategy is revealed along with the manuscript at publication; "**E**" Electronics sources: "PubMed, Europe PMC, Science Direct, Elsevier, Web of Science (WOS), Goggle Scholars, and connected paper. The selected articles were subjected to quality inspection with CASP (Lachal *et al*., 2017).

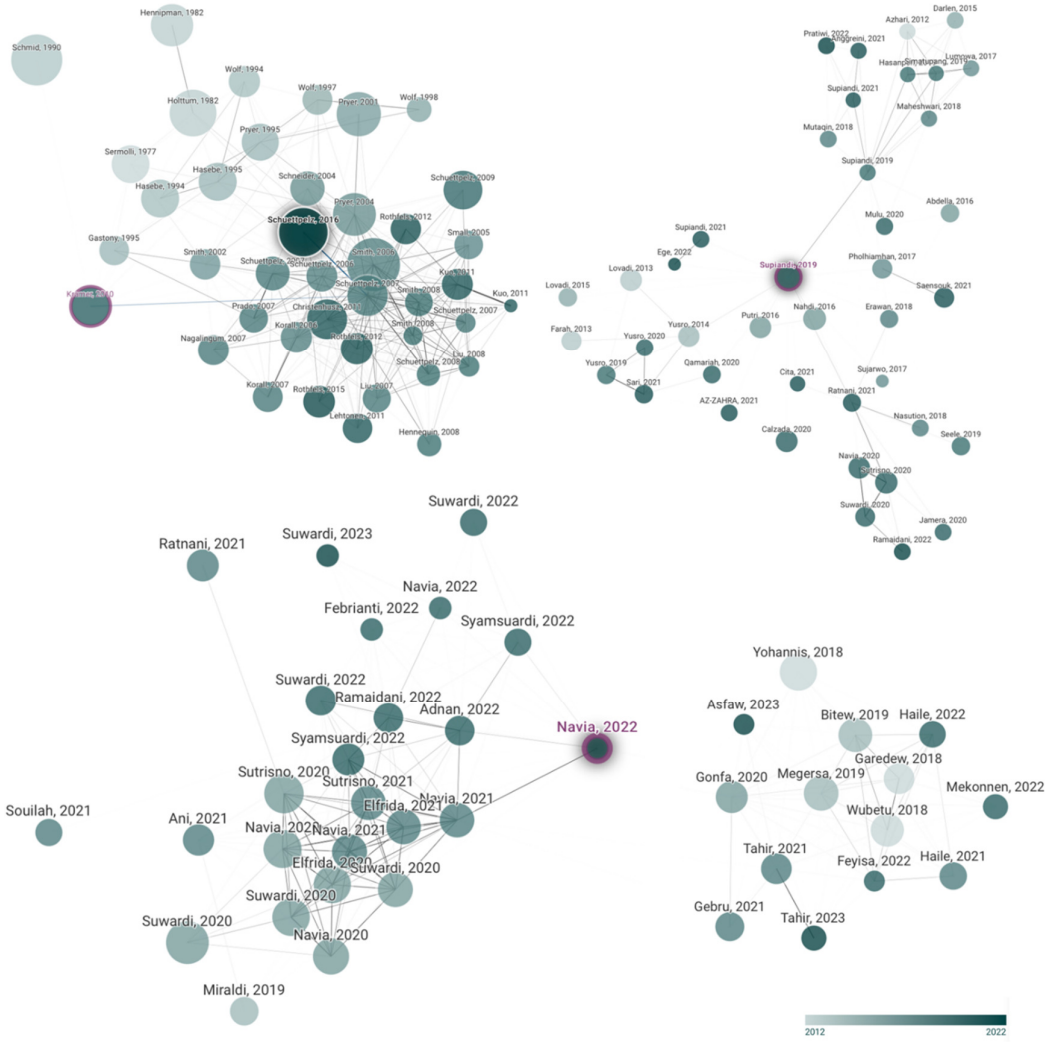

Figure 2. Search and selection of articles with connected papers

Quality assessment of included studies

Assessment of study quality in this study used the Critical Appraisal Skills Programme (CASP), which is widely used to assess study quality for qualitative research, including meta-synthesis. The choice of instrument depends on the type of study in the selected article. The CASP policy only helps assess things that underlie the quality of articles in general and is not specific to ensure uniformity in the quality of articles reviewed. Our assessment regarding selected articles is 0 = criteria not met according to CASP, 1 = criteria met < 50% of items set by CASP, and 2 = criteria met > 50% of items set by CASP. In the final result, all articles that meet the requirements with point 2 are included and further analysed (CASP 2013).

Extracting and presenting the formal data

To understand the research data in each article, researchers set criteria to be used as a reference in conducting meta-synthesis. Each article is strictly and thoroughly identified regarding the identified *Pteridophyta* species, including use as a traditional medicine agent, parts of the nail plant used, how to use it, and the content of bioactive compounds reported with potential as herbal or traditional medicine. The data are presented in a summary of the results in tabular form.

Data analysis

The compiled data are then analyzed descriptively and presented in tables and narratives to facilitate the interpretation of the research results. Evidence synthesis is based on the completeness of the material's content and the findings of research results in each article, which is then carried out in a meta-synthesis. The results lead us to discuss new insights into utilizing *Pteridophyta* species in Cyathea Park, Bali, as traditional medicine agents.

Expressing the synthesis

The synthesis of evidence of field findings in the form of *Pteridophyta* species reported in Cyanthea Park, Bali, is then studied for use by people around the world, including the content in all parts of plants that have the potential to be developed as traditional medicinal agents. Furthermore, the potential use as a drug candidate is explained narratively at a specific point while maintaining data transparency in each article with guidance on ENTREQ (Enhancing transparency in reporting the synthesis of qualitative research) (Tong *et al*., 2012).

Results

Species diversity Pteridophyta Cyathea park collection

Nail plants (*Pteridophyta*) are closely related to commodity-sporous plants and are classified as "*vascular plants*" (*Tracheophyta*) due to their true roots, stems, and leaves. They reproduce asexually by the use of spores. Nine *Pteridophyta* species were discovered during field searches in the Cyathea Park Collection at Bali's Eka Karya Botanical Garden. These plants are dominant and beneficial as traditional medicine agents. Table 1 and Figure 3 list the *Pteridophyta* species discovered in Cyathea Park.

Table 1. Data collection on *Pteridophyta* species at Cyathea Park

Species	Family	Sample code	Habitus	Fig.
Cyathea contaminans (Wall ex Hook) Copel	Cyatheaceae	XI.E.01	Terrestrial	Fig. 3A
Asplenium nidus L.	Aspleniaceae	XI.E.02	Terrestrial and epiphytic	Fig. 3B
Asplenium sp.	Polypodiaceae	XI.E.03	Terrestrial	Fig. 3C
Selaginella sp.	Selaginellales	XI.E.04	Xerophytes and epiphytes	Fig. 3D
Diplazium esculentum	Athyriaceae	XI.E.05	Terrestrial	Fig. 3E
Angiopteris evecta (G.Forst.) Hoffm.	Martiaceae	XI.E.06	Terrestrial	Fig. 3F
Cyathea sp.	Cyatheaceae	XI.E.07	Terrestrial	Fig. 3G
Nephrolepis hirsutula (Forst) C. Presl	Davalliaceae	XI.E.08	Terrestrial and Epiphytic	Fig. 3H
Dicksonia blumei (Kunze) Moore	Cyatheaceae	XI.E.09	Epiphytes and hydrophytes	Fig. 3 I

Figure 3. *Pteridophyta* species collection Cyathea Park, Eka Karya Botanical Garden. Information**:** (**a**) *Cyathea contaminans* (Wall ex Hook) Copel, (**b**) *Asplenium nidus* L., (**c**) *Asplenium* sp., (**d**) *Selaginella* sp., (**e**) *Diplazium esculentum*, (**f**) *Angiopteris evecta* (G.Forst.) Hoffm, (**g**) *Cyathea* sp., (**h**) *Nephrolepis hirsutula* (Forst) C. Presl, (**i**) *Dicksonia blumei* (Kunze) Moore

Selection studies for meta-synthesis

In this study, 564 articles discussed *Pteridophyta* based on searches using set keywords. The results of a thorough evaluation, step by step, obtained 49 articles that met the requirements for further meta-synthesis following the research objectives. Identification is carried out by reviewing the characteristics of *Pteridophyta* and their use as agents of traditional medicine. The flow of article selection for this study is presented in Figure 4.

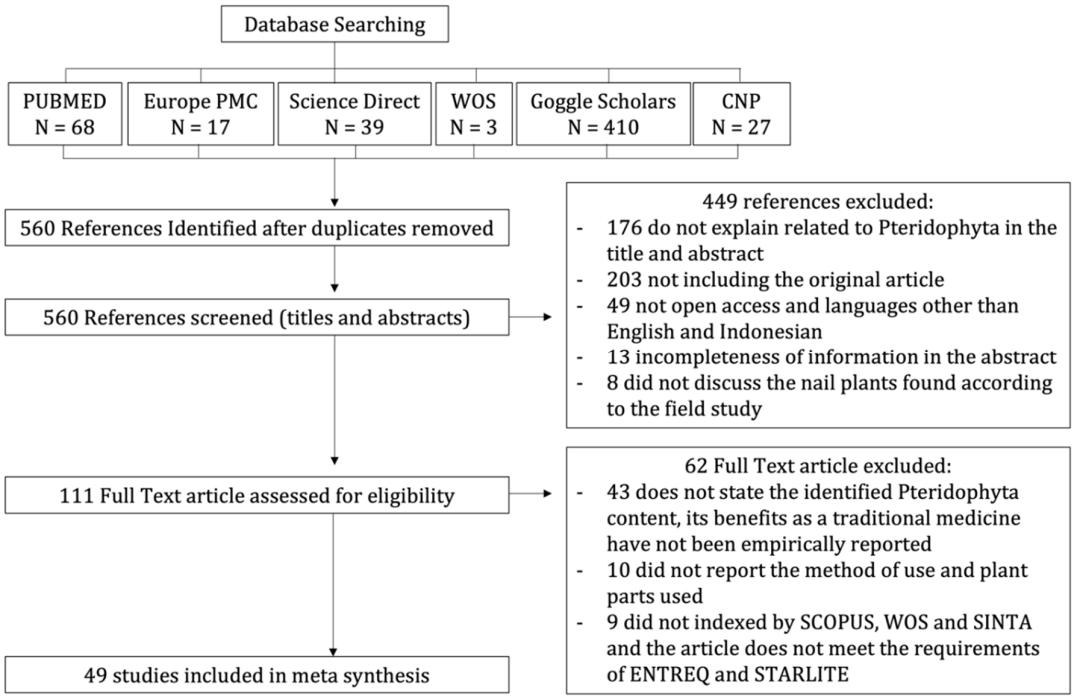

Figure 4. Article selection flow for meta-synthesis (Lachal *et al*., 2017).

Summary of the benefits of Pteridophyta species collected in Cyathea Park, Bali

The benefits of *Pteridophyta* species collected in Cyathea Park, Eka Karya Botanical Garden, Bali, are summarized in Table 2 based on the type of treatment, the sections used, the chemical content, the degree of use, and other designations by the community with the ethnopharmacology approach. Based on the summary of the study results, nine species of Pteridophyta found in Cyathea Park, Bali, have therapeutic potential and benefits, especially for treating and improving public health. The study findings showed that tree-shaped ferns and tall stature dominated Pteridophyta species and were further followed by lower fern species. The leaves, leaf shoots, roots, and stem hairs are widely used as agents of traditional medicine. Most parts of the fern plant are used directly by pounding, pasting, or taking leaf juice for medicinal purposes. Flavonoids, saponins, tannins, alkaloids, lignans, and other active compounds dominate the bioactive compound components. In addition to being used as agents and candidates for traditional medicine, ferns have benefits for ornamental plants, vegetables, growth media, carbon filters, and ceramic materials. Based on this summary, the compounds contained in ferns have the potential to be used as candidates for traditional medicine and the development of standardized herbal medicine raw material findings derived from ferns (*Pteridophyta).*

Table 2. Summary of benefits of *Pteridophyta* species collected in Cyathea Park, Bali

Species	Traditional medicine agents	Parts used	How to use	Chemical content	Other uses	References
Cyathea contaminans (Wall ex Hook) Copel	○ Antimicrobials (*B. subtilis, S. aureus, E. coli, P. aeruginosa, C. albicans*) ○ Antifungal ○ Antiinflammatory ○ Antioxidant ○ Anti-seizure ○ Cold medicine ○ Hypocholesterolemia	○ Leaf ○ Young Leaves (Shoots) ○ Trunk ○ Seed ○ Stem hair ○ Root	○ Taped to the affected area ○ Boiled by consuming boiled starch juice, ○ Pounded and affixed to the wound/swelling ○ Simple maceration	○ Saponins ○ Alkaloids ○ Flavonoid ○ Tannins ○ Anthraquinones	○ Ornamental plants ○ Media planting ○ Handcrafts ○ Vegetables, ○ Traditional game ○ Carbon filters and ceramic materials ○ Orchid support	(Amoroso et al. 2014, Gultoma et al. 2015, Suryana et al. 2018, Wardani 2018, Ahmad Faizal et al. 2020, Mustacisa-Lacaba et al. 2021, Ciawi et al. 2022)
Asplenium nidus L.	○ Fever Reliever ○ Overcoming dandruff ○ It relieves open wounds. ○ Post-Delivery Tonic ○ Analgesic ○ Treating ulcers ○ Antibiotics ○ Antimicrobial ○ Immunostimulator ○ Depurative and sedative	○ Leaf ○ Leaf shoots ○ Trunk	○ Ground, smoothed, affixed, used on the head area ○ Ground and pasted on the ulcer area ○ Taped to the area experiencing swelling ○ Boiled and consumed starch juice two times a day	○ Saponins ○ Alkaloids ○ Flavonoids ○ Tannins ○ Polyphenols ○ Kaempferol ○ Quercetin	○ Stimulate spore growth	(Mannan et al. 2008, Lai et al. 2009, Amoroso et al. 2014, Ravi et al. 2015, Faral et al. 2019, Zeng and Lai 2019b, Nikmatullah et al. 2020, Heo et al. 2021)
Asplenium sp.	○ Fever reliever ○ Burns Medicine ○ Skin disease ○ Melanoma ○ antikemotactic ○ Antioxidant ○ Monoamine oxidase inhibitor	○ Leaf ○ Root	○ Pounded and affixed to wounds, fever sufferers, and areas of the skin	○ Flavonoids ○ Tannins ○ Polyphenols ○ Luteolin glycosides ○ kaempferol ○ glucopyranosyl caffeic acid	○ Ornamental Plants ○ Planting media	(Andrade et al. 2014, Zeng and Lai 2019a, Atho et al. 2020, Ekici and Sisman 2020)

Selaginella sp.	○ Antidiabetic ○ Antiinflammatory ○ Antivirus ○ Antimutagenic, ○ Anti-nosyeptif ○ Antispasmodic, ○ Anticancer ○ Anti-Alzheimer's ○ Anti-parasite	○ Leaf ○ Trunk	○ Ground, boil, and drink water starch juice regularly	○ Flavonoids ○ Alkaloids ○ Lignans ○ Tannins ○ Saponins ○ Pigments ○ Terpenoids ○ Phenylpropanoids ○ Steroids ○ Quinoids ○ Coumarins ○ Biapigenin	○ Ornamental plants	(Setyawan 2009, Xu et al. 2015, Rindita et al. 2020, Adnan et al. 2021, Menezes and Diederich 2021, Vashistha and Tejasvi 2021)
Diplazium esculentum	○ Respiratory diseases ○ Cough ○ Urinary tract infection (UTI) ○ Gonorrhea ○ Topical dermatitis ○ Head pain ○ Body odor ○ Antibacterial ○ Antifungal ○ Immunomodulator ○ Antioxidant ○ Antiinflammatory ○ Larvicides and insecticides ○ Antidiabetic ○ Overcoming hematuria and dyspepsia	○ Leaf ○ Young Shoots ○ Root ○ Stem	○ Ground, boil and drink water starch juice regularly three times a day ○ Dried leaves and stems are burned and used as a mosquito repellent, which results from burning as a larvacide. ○ Ground and taped to the skin that has swelling	○ Flavonoids ○ Polyphenols ○ Alkaloids ○ Terpenoid ○ Saponins ○ Phytosterols ○ Leucoanthocyanins ○ Glycosides ○ Diterpenes ○ Triterpenes	○ Vegetable ○ Ornamental plants	(Roy et al. 2013, Tongco et al. 2014, Zuhri et al. 2016, Zannah et al. 2017, Balangcod and Balangcod 2018, Halimatussakdiah et al. 2018, 2020, Nikmatullah et al. 2020, Roy and Chaudhuri 2020, Semwal et al. 2021, Thomas and Bindu 2021, Sirichai et al. 2022)
Angiopteris evecta (G.Forst.) Hoffm	○ Antibacterial (*Bacillus subtilis*) ○ Anti-HIV agents	○ Leaf ○ Leaf shoots	○ Ground, boil, and drink water starch juice regularly	○ Alkaloids ○ Phenol ○ Flavonoids ○ Tannins ○ Saponins	○ Ornamental Plants	(Rindita et al. 2020, Wang et al. 2020)

				○ Triterpene ○ Steroids		
Cyathea sp.	○ Antiretroviral ○ Fever reliever ○ Stab Wound Reliever	○ Leaf ○ Leaf shoots	○ Ground, and taped to the head and legs	○ β-naphthoflavone ○ Phenol ○ kaempferol ○ Flavonoids	N/A	(Larson et al. 2014, Silalahi et al. 2015)
Nephrolepis hirsutula (Forst) C. Presl	○ Treating diarrhea ○ Smoothing Breast Milk ○ antimicrobial ○ Anti-inflammation ○ Antivirus ○ Anticancer ○ Healers of sores, coughs, and ulcers	○ Leaf ○ Leaf shoots	○ Ground, boiled, and drink water starch juice regularly ○ Ground and taped to the area of the wound/ulcer	○ Eugenol ○ β-Ionone ○ Thymol ○ Anethole ○ Cinnamaldehyde ○ Methyl palmitate	N/A	(Sajeev et al. 2015, El-Tantawy et al. 2016, Popovici et al. 2018, Rindita et al. 2020, Renjana et al. 2021)
Dicksonia blumei (Kunze) Moore	○ Fever reliever ○ Antibacterial ○ Analgesic	○ Leaf ○ Leaf shoots ○ Trunk	○ Pounded, boiled, and drink regularly	○ Flavonoids ○ Tannins ○ Saponins	○ Planting Media ○ Ornamental Plants ○ Craft	(Suryana et al. 2018, Muhyi et al. 2020, LIPI 2022)

Discussion

Meta-synthesis related to characteristics of Pteridophyta species in Cyathea Park

Cyathea contaminans (Wall. ex Hook) Copel

Cyathea contaminans (Wall. ex Hook) Copel is a tribe of Cyatheaceae and has synonyms including *Polypodium contaminans* Wall. Cat., *Alsophila contaminans* Wall. ex Hook., *Alsophila acuta* Presl, *Alsophila smithiana* Presl, and *Alsophila clementis* Copel (Warseno, 2015; Mustacisa-Lacaba *et al*., 2021). This nail is known as a "*treenail*" by some people in Indonesia. The local names of these nails in Indonesia are *pehon nails*, *board nails*, *Tihang bodas nails* (Sunda), *Pole nails* (Bali), *Bagedor* (West Java), and *Tree ferns* (North Sumatra) (Gultoma *et al*., 2015). These nail characteristics that stand out are fronds that resemble coconut trees, have a high stature, and grow in groups with other types of nails. It thrives on mountain slopes and sheltered places at 1,060-1,600 meters above sea level. Morphologically, the roots of the fibers protected by calyptra are black and slender and covered with rough roots; they are tight and thick, and there are shallow indentations of the petiole marks attached. The height of the stem reaches 6-7 m. The location of the leaves is paired. The leaf bones are purplish and equipped with sharp spines. The leaves are 150 × 30 mm in size. These spikes are equipped with a sorus near the edges of the leaves. There is no indusium. It resembles an umbrella and grows terrestrially (Wardani, 2018; Ciawi *et al*., 2022). The community widely uses this type of nail for crafts, ornamental plants, and raw materials for traditional medicine *(Ahmad Faizal et al., 2020; Mustacisa-Lacaba et al., 2021; Ciawi et al*., 2022).

Asplenium nidus L.

Asplenium nidus L. It is a tribe of Aspleniaceae and has the synonym *Asplenium nidus*, syn. with *A. ficifolium* Goldm., *Thamnopteris nidus* (L.) C. Presl., *Neottopteris rigida* Feé). This nail is known as the "bird's nest nail" by the people of Bali (Lestari and Nindira, 2021). *Asplenium nidus* L. grows in terrestrial and epiphytic areas, many of which are found in the mountains at 1,700-2,500 meters above sea level. These spikes are identical to the elongated morphology of the leaves, which are bright green and darken as they approach maturity. The length of the leaves is 150 cm long by 20 cm wide. The edges of the leaves are choppy, lanceolate, and arranged circularly, and the tips of the leaves are tapered. The petioles are sturdy, black in color and have a length of 5 cm. The texture of the leaves resembles paper. The short rhizome is covered with smooth and dense scales. Sorus is located on the lower surface of the leaves and is arranged following the venation. The sori are narrow and located above the veins of the leaves (Supiandi *et al*., 2019; Nabila *et al*., 2021). The community utilizes *Asplenium nidus* L. as an ornamental plant because of its unique shape and restorative material, especially anticonvulsant, skin disease drugs, and antichemotactics, which have been widely researched (Andrade *et al*., 2014; Faral *et al*., 2019; Zeng and Lai, 2019a; Heo *et al*., 2021).

Asplenium sp.

Asplenium sp. is a tribe of Polypodiaceae that belongs to the herbaceous nail. The terrestrial habitat has the local name of a *land nail* (Bali), which helps the bird's nest. These spikes are found in moist and terrestrial areas and are classified as terrestrial. The morphology of the leaves on these spikes is single-shaped, with fine serrations on the edges of the leaves, a pinnate shape, and a dark green to dark green coloration that suggests the presence of delicate feathers above the leaf surface. There are different types of sporophylls, anglophiles, and fertile leaves. There are also spores on the enthalpy and stiff. The stem is long and slender, measuring 1-2 cm and 60 cm - 1 m. The stem is blackish-brown and has branching. The roots are fibrous, coarse, and dark brown. The sporangium is in an annulus-shaped dun of 3-5 mm, yellow, with fine spores and sorus surrounded by insidium (Andrade *et al*., 2014; Heo *et al*., 2021; Nabila *et al*., 2021). *Asplenium* sp. leaves contain essential oils

used in traditional medicine (Hammami *et al*., 2016; Rai *et al*., 2017). It has analgesic benefits (Ekici and Sisman, 2020) and contains isolated chemical constituents for commercial purposes (Zeng and Lai, 2019b).

Selaginella sp.

Selaginella sp. is known as rane nails or moss spikes. This species grows creeping, slightly erect, and herbaceous. In addition, nails of this type can grow at an altitude of 10–1,500 meters above sea level. It grows in a partially moist environment of xerophytes and epiphytes. Morphological single, squawken leaves lined up along the stem resemble a needle with a 1-2 mm length. The dominant color of the leaves is dark green, with micropile and anisophile leaf types. On upright stems, 15-35 cm high, there are roots on branching, rounded stems, prostrate, and creeping stem types. Furthermore, the sorus in *Selaginella* sp. is heterosporous, producing microspores composed of strobilus. This species thrives under the dominance of one stem and has many branches (Baskaran *et al*., 2018b; Rindita *et al*., 2020). *Selaginella* sp. is rich in secondary metabolites in the form of flavonoids, phenols, and polyphenols that are beneficial for health (Reginaldo *et al*., 2021). Sustainable cultivation and conservation are strongly recommended to increase the number of species and cultivate plants as traditional medicinal agents (Anwar *et al*., 2021; Oon *et al*., 2021).

Diplazium esculentum

Diplazium esculentum is a tribe of Athyriaceae generally consumed by the community as vegetables. These spikes belong to homospores, which inhabit habitats in rivers or moist soils, grow at 350–1,600 meters above sea level and are classified as terrestrial spikes. Morphologically, the leaves of this nail are a type of compound leaf, pinnate, lanceolate shape, the presence of serrations, and pointed ends, with a length of 5–6 sm and a width of 1-2 cm. Young Leaves (fiddlehead) totals are generally covered with dark brown scales. Stalks and stems are green and 50–80 cm long. The roots on these spikes are fat and gathered, the rhizome is short, approximately 5 mm, and the rhizome propagates to the effect. The elongated sori resemble a crescent moon in the Indusia vein. The sorus is ring-shaped, uneven, and follows the direction of the leaf veins. This nail is utilized because it contains various therapeutic benefits, especially in traditional medicine (Halimatussakdiah *et al*., 2018; Zihad *et al*., 2019; Semwal *et al*., 2021).

Angiopteris evecta (G. Forst.) Hoffm

Angiopteris evecta (G. Forst.) Hoffm is a Marattiaceae tribe synonymous with the synonyms *Polypodium e*lected G. Forst and *Angiopteris palmiformis* (Cav.). It grows terrestrially in the tropics at 950-1,200 meters above sea level. With humid soil conditions, optimal temperatures range from 19-27 °C. This nail has the local name of elephant nail, "Bali and Java," and is widely found in the highlands of Bali (LIPI, 2022). This species has three variations at the base of the leaf frond stalk: dark green, white waxy, and brown. Leaf morphology in *Angiopteris evecta* (G.Forst.) Hoffm is a pinnate double compound, up to 6 m long, with sporophyte bone leaves and isophilic leaves with a length of 5 cm and a width of 7 cm. The leaves have a dark green color and shallow jagged edges. The stems of these spikes are erect, green, and have cavities. Part of the stem is decorated with hair thorns and rentals. The Sori is a lateral annulus and forms a long line. Sori is reddish-brown, resembles a heart, and has an indusium. Sori size ±0.5-1.5 mm from the edges is classified as homosporous (Warseno, 2015; Atho *et al*., 2020). This nail has been researched and is known to have antiretroviral benefits, especially in HIV disease, which until now has not been found to have a cure or vaccine (Rindita *et al*., 2020). Encouraging the use and cultivation of this nail is essential because tropical diseases have been a problem for many people. This will aid in searching for novel medication candidates derived from the nail *Angiopteris evecta* Hoffm (Wang *et al*., 2020).

Cyathea sp.

Cyathea sp. It is a tribe of Cyatheaceae, the most prominent family in Cyanthea Park. This nail is included in the nail of a tree with a 20 m span. These spikes grow terrestrially and include herbaceous spikes because they contain approximately 80% water in their bodies. It is characterized by a robust stem and rhizome (stick-like dominance). It can reach a height of 15 m and a 25-50 cm diameter. It has 1 m long tripinnatifid leaves with an elongated form and pointy ends. On the shoots, there are serrations. The length of the leaves reaches 7-13 cm, with a width of 4 cm. The surface is paper-like, bright green to dark, with feathers on the fronds and leaves, including acidophilus. Next, the spore type of bean seed monolet and cup monolet is the entire sorus located at the bottom of the leaves, while the roots are all-encompassing and protected by calyptra, and there are serrations at the top (Warseno, 2015). This nail is widely used as a kicker and another nail protector underneath (LIPI, 2022). In addition, these spikes have been known to be beneficial as antiretrovirals (Larson *et al*., 2014) and fever drugs.

Nephrolepis hirsutula (Forst) C. Presl

Nephrolepis hirsutula (Forst) C. Presl is a tribe of Davalliaceae that grows terrestrial and epiphytic at an altitude of 900-1,750 meters above sea level. This spike can grow in cuca and extreme temperatures, including deserts and open highland areas. The local name for this nail is *the pedang nail* (Bali, Java, and Sumatra). A particular characteristic of this nail is its elongated enthalpy resembling a sword. These nails have branching leaf bones; the leaf tips are snaking, including macrophytes (small) and macrophytes (large). The size of the leaves is 2 cm long by 1 cm wide. The shape of the leaves is pushed with the splitting tip, and the edges of the leaves are jagged. Young leaves roll, green in color, and the leaves have three types: tropophilous, sporophyll, and tropophilous. The stems of these spikes are rounded, the height of the stem reaches 0.5 cm, they are brownish, and they have fine hairs. The sporangium is neatly arranged on the leaf vein test and grows to the height of the leaves (LIPI, 2022). This nail is also helpful as an antiviral, antimicrobial, and anti-inflammatory agent and can treat diarrhea in both children and adults (Popovici *et al*., 2018; Renjana *et al*., 2021).

Dicksonia blumei (Kunze) Moore

Dicksonia blumei (Kunze) Moore is a Cyatheaceae tribe known by the local names *paku kidang, lemputu,* and *lempunah* (Bali) (LIPI, 2022). This nail belongs to the nail type of tree with a large trunk and a high stature. These spikes are found at altitudes of 1.060-1.755 masl and love moist and watery areas. These plants include epiphytes and hydrophytes but are generally affected. Morphologically, the roots of these spikes are fibers protected by calyptra, and their shape is rough, black, tight, and thick with tapered aids. Slender stem stature with a height of up to 6-7 m. It has a fresh leaf and strands of inscribed leaves and is located in pairs. The length of the petiole reaches 1 m. The bones of the primary leaves are pale, purplish, and prickly. Children have a size of 34 cm and the presence of rolled vernation on young leaves. This nail has a 1 m long, purplish brown enthalpy and a rolling enthalpy resembling a violin handle. A sporangium in the sorus is found on the lower surface of the leaves (Warseno, 2015; Zuhri *et al*., 2016). Feathers or hair-containing stems are widely used as planting media, and leaves and shoots are used in traditional medicine (Muhyi *et al*., 2020).

Meta-synthesis related to therapeutic benefits, biological activities, and potential utilization of Pteridophyta species in Cyathea Park

The therapeutic benefits and biological activity of *Pteridophyta* species in Cyathea Park, Eka Karya Botanical Garden, Bali, are summarized in Table 2 based on the type of treatment, the sections used, the chemical content, the degree of use, and other designations by the community with the ethnopharmacology approach. Several studies have shown that ferns contain enough bioactive chemicals to be used as raw materials for traditional medicine. Ahmad Faizal *et al*. (2020) describe the leaf, fruit, and stem extracts of *Cyathea contaminans* (Wall ex Hook) Copel, including 2H-tetrazole, 5-(thiophene-2-yl) methyl (14.29%), 2-thiophene

acetic acid, 2-methyl phenyl ester (14.54%), and phenol, 2,6-bis (1,1-dimethyl ethyl)-4-methyl (14.56%). The bioactive substance of *Cyathea contaminans* (Wall ex Hook) possesses moderate to vigorous antioxidant activity (IC_{50} 37.13-225.19 µg/mL). However, the hair of this plant includes moderate to weak antioxidant activity (IC_{50} 179.50-255.49 µg/mL). At a concentration of 250 g/mL, the hexane extract of fronds had the best antibacterial activity, with an inhibition percentage of 43.92% for *E. coli* and 46.8% for *S. aureu*s. 2H-Tetrazole, 5-(thiophene-2-yl)-methyl (14.29%), and 2-thiophene acetic, 2-methyl phenyl ester were shown to be the active antibacterial compounds in frond extracts (14.54%). *Cyathea contaminans* (Wall ex Hook) Copel extracts have the potential to serve as natural antioxidants and antibiotics.

Cyathea contaminans (Wall ex Hook) Copel contains several bioactive compounds with diverse biological activities. It is thought that its saponins, alkaloids, flavonoids, tannins, and anthraquinones are responsible for its therapeutic qualities. The content in this plant is responsible for its anti-inflammatory, analgesic, hypocholesterolemic, antioxidant, anti-seizure, and anti-diarrheal properties. Saponins from *Cyathea contaminans* (Wall ex Hook) Copel have anti-inflammatory effects because they stop releasing pro-inflammatory cytokines and reactive oxygen species from being made (Ahmad Faizal *et al*., 2020). Alkaloids act as analgesics, anti-inflammatory agents, and antitumor agents. The alkaloids in *Cyathea contaminans* (Wall ex. Hook) Copel has pain-relieving effects because it stops sending pain signals.

Flavonoids neutralize free radicals, diminish oxidative stress, and limit the generation of proinflammatory cytokines. By decreasing the activity of nuclear factor-kappaB (NF-κB) and reducing the production of pro-inflammatory enzymes, flavonoids in the leaves, roots, young leaves (shoots), and seeds of *Cyathea contaminans* exhibit anti-inflammatory characteristics. Furthermore, the content of tannins has antidiarrheal properties by inhibiting the secretion of water and electrolytes from the intestinal mucosa. Anthraquinones can stimulate the contraction of intestinal smooth muscle and inhibit the proliferation of cancer cells. Anthraquinones in leaf extracts have antidiarrheal properties by increasing the tone of the intestinal smooth muscle (Wardani, 2018; Mustacisa-Lacaba *et al*., 2021). Thus, the potential use as a traditional medicine tends to vary and has the potential to be developed as a candidate for traditional medicine, including the need to study active ingredients to be used as medicinal ingredients.

Asplenium nidus L., commonly known as "*Bird's Nest Fern*," is a plant that has historically been utilized as a medicine worldwide. It is thought to have sedative, antibacterial, immunostimulant, depurative, antimicrobial, analgesic, and other therapeutic effects (Faral *et al*., 2019). Kashyap *et al*. (2017) found that the leaves of *Asplenium nidus* L. have kaempferol (3-0)-gentiobioside-7,40-diglucoside. *Asplenium nidus* L. has chemicals such as flavonoids, terpenoids, and alkaloids that can relieve pain, fight infections, and kill fungi and viruses. These chemicals can reduce pain by stopping pain signals from getting through or producing cytokines that cause inflammation. They can also stop bacteria from growing and reproducing, preventing infections. Tannins and flavonoids have astringent properties. These compounds can help reduce inflammation and speed up the healing of ulcers by clumping together proteins and creating a barrier over the ulcerated areaClick or tap here to enter text.. *Asplenium nidus* L. contains polysaccharides that can stimulate the immune system. These polysaccharides can increase the production of white blood cells, which can help to fight infections and improve overall immune function (Nikmatullah *et al*., 2020; Renjana *et al*., 2021). Compounds such as flavonoids and terpenoids have detoxifying properties (Supiandi *et al*., 2019). By making liver enzymes work harder and improving kidney function, these chemicals help the body eliminate toxins. They also contain flavonoids and terpenoids that make you feel sleepy. These compounds can help to reduce anxiety, promote relaxation, and improve sleep quality (Mannan *et al*., 2008; Cao *et al*., 2017; Faral *et al*., 2019).

Plants, including vegetables, fruits, and medicinal herbs, include flavonoids such as luteolin, kaempferol, and glucopyranosyl caffeic acid (Imran *et al*., 2019; Taheri *et al*., 2021; Yu *et al*., 2021). Luteolin is an anticancer drug that works on breast, prostate, colon, glioblastoma, lung, and pancreas cancers in people. Additionally, it contains antiviral, anti-inflammatory, and immune-regulating properties (Imran *et al*., 2019). It has been

demonstrated that kaempferol possesses anti-inflammatory, anticancer, and antioxidant effects. Kaempferol, another flavonoid found in asplenium, has been shown to reduce inflammation and act as an antioxidant. Monoamine oxidase, an enzyme that degrades neurotransmitters, including dopamine and serotonin, has also been proven to be inhibited by it. This suggests that kaempferol may potentially act as a natural antidepressant. Glucopyranosyl caffeic acid has been found to have anti-inflammatory and antioxidant activities (Yu *et al*., 2021). *Asplenium nidus* L. has glucopyranosyl caffeic acid, an anti-inflammatory and antioxidant phenolic acid. It has also been shown to have anti-chemotactic properties, meaning it can prevent cells from migrating to a site of inflammation, which may be beneficial in treating conditions such as arthritis. *Asplenium* sp. is a traditional medicine for treating skin diseases such as melanoma. The mechanism of action of *Asplenium* sp. is unclear. It includes anticancer, anti-inflammatory, antioxidant luteolin glycosides, kaempferol, and glucopyranosyl caffeic acid. Luteolin has been identified as having the ability to treat prostate cancer and COVID-19. (Xie *et al*., 2022). These flavonoids may help *Asplenium* sp. treat skin diseases such as melanoma because they fight cancer, reduce inflammation, and protect cells from damage.

Selaginella sp. is a plant used as a traditional medicine by the people of Bali for centuries. It has many bioactive compounds, such as saponins, terpenoids, phenylpropanoids, steroids, quinoids, coumarins, and apigenin, which are thought to be the reason for its medicinal properties (Adnan *et al*., 2021). Research by Adnan *et al*. (2021) explains the leaf content in *Selaginella* sp. It has health benefits and is used as a medicinal agent by the public (ethnomedicine). Compounds Paucine N-(5-hydroxyselaginellic acid), N-(5-hydroxyselaginellic acid), and 3-D-glucopyranoside, Hordenine-O-[(6-O-cinnamoyl)-O-β-glucopyranosyl] -rhamnopyranoside, carboxylic acid of 17-cholestanol-21,8-O-D-glucopyranoside, N1-cis-p-coumaroylagmatine, selaginellic acid, 5-hydroxyselaginellic acid, 5-hydroxy-N8, N8-dimethylpseudophrynaminol, N-selaginellas L-phenylalanine, glycyrrhetinic acid, -sitosterol, lariciresinol On the leaves and roots, butyrolactone and selaginellin A, B, C, M, K, L, G, and H were found.

The mechanism of action of the compounds studied includes the content of saponins. It has been found to have antihyperuricemic, anti-inflammatory, and xanthine oxidase inhibition properties, which make it helpful in treating gouty arthritis. In traditional medicine, saponins are often used for their expectorant, diuretic, and anti-inflammatory effects. Additionally, it has been demonstrated that the molecule amentoflavone exhibits AKR1B10-inhibitory activities, which suppress the proliferation of A549 human lung cancer cells in vitro and in vivo (Bailly, 2021). Terpenoid molecules have biological effects, including the ability to influence the immune system and have antibacterial, anti-inflammatory, and antioxidant capabilities. Terpenoids are often used because they can relieve pain, reduce inflammation, and fight cancer (Setyawan 2009, Xu et al. 2015). Phenylpropanoids are often used for their pain-relieving and anti-inflammatory effects, and steroids and quinoids are often used for their anti-inflammatory, antioxidant, and pain-relieving effects. Coumarins have anticoagulant, antimicrobial, and anticancer activities. Biapigenin is a flavonoid found in many plants with antioxidant and anti-inflammatory properties. It also has anticancer and neuroprotective activities (Reginaldo *et al*., 2021; Vashistha and Tejasvi, 2021).

Traditional treatments for respiratory conditions, cough, urinary tract infections (UTI), gonorrhea, topical dermatitis, larvicides, and insecticides include diplazium esculentum. It has phytosterols, which have anti-inflammatory and antibacterial effects (Zannah *et al*., 2017; Semwal *et al*., 2021). Several bioactive compounds are believed to be responsible for its therapeutic effects, including phytosterols, leucoanthocyanin, glycosides, diterpenes, and triterpenes (Roy *et al*., 2013; Tongco *et al*., 2014; Halimatussakdiah *et al*., 2020; Thomas and Bindu, 2021). The plant contains compounds with antitussive and expectorant properties, which can help alleviate cough and promote the expulsion of mucus from the respiratory tract. Additionally, the antibacterial and anti-inflammatory characteristics of plant components can aid in treating the infection and lowering urinary tract irritation. The plant possesses anti-inflammatory and antioxidant chemicals that can help cure topical dermatitis and decrease inflammation and oxidative stress in the skin. It also has a poisonous

impact on insects through contact poisoning, respiratory accretion, and acetylcholinesterase inhibition (Roy and Chaudhuri, 2020; Semwal *et al*., 2021).

Angiopteris erecta (G. Forst.) In addition to Southeast Asia, Africa, and the Pacific Islands, Hoffm is a fern species found worldwide. Traditional medicine has used it to treat various diseases, including HIV. Research Bedoya *et al*. (2001) discovered that fern extracts prevented HIV from replicating in vitro. The study found that the extract inhibited HIV reverse transcriptase activity, which is essential for the virus to replicate, and inhibited the replication of the virus by up to 90%. In addition, these studies suggest that *A. erecta* may have potential as an anti-HIV agent. Furthermore, another compound reported as an antiretroviral is part of the plant extract *Cyathea* sp. It has been demonstrated that a class of substances known as -naphthoflavones has antiviral action against several viruses, including HIV (Larson *et al*., 2014). In another study, the antibacterial capabilities of *Cyathea* sp., a member of the Cyathea genus, were investigated. The plant has been used in ethnomedicine to treat cuts and wound infections (Chaparro-Hernández *et al*., 2022). gram-positive and gram-negative bacteria may both be susceptible to the antibiotic effects of *Cyathea* sp. ethyl acetate extract. Some isolated compounds, such as 2-methyl butane-1,4-diol and 3-(1-ethoxy ethoxy), may also contribute to the antibacterial property of the plant (Silalahi *et al*., 2015; Baskaran *et al*., 2018a).

Nephrolepis hirsutula (G. Forst.) C. Presl is a fern species native to the Indo-China to Pacific region (Sajeev *et al*., 2015). The *Nephrolepis hirsutula* (G.Forst.) C. Presl, numerous bioactive substances, including eugenol, β-ionone, thymol, anethole, cinnamaldehyde, and methyl palmitate, have not yet been well researched for their impact on human health. However, some traditional medicine systems have used *Nephrolepis hirsutula* for various medicinal purposes, including treating coughs and ulcers. These uses have not been thoroughly investigated, and limited scientific evidence supports these claims. Finally, *Dicksonia blumei* (Kunze) Moore is a fern species commonly found in Southeast Asia, including countries such as Indonesia and Malaysia (Muhyi *et al*., 2020). It has historically been used as a medicine, including an analgesic (pain reliever). Several compounds have been identified in *Dicksonia blumei* that may contribute to its analgesic effects, including flavonoids, alkaloids, and terpenoids (Suryana *et al*., 2018). These compounds have been shown to have anti-inflammatory and analgesic properties. The mechanism by which *Dicksonia blumei* exerts its analgesic effects is not fully understood. However, it is believed that the compounds found in the plant may inhibit the production of prostaglandins, which are molecules involved in inflammation and pain. Additionally, some of the compounds found in *Dicksonia blumei* interact with opioid receptors in the body, which could also contribute to its analgesic effects (Srithi *et al*., 2009). The use of *Dicksonia blumei* as an analgesic is supported by some data, but further studies are required to thoroughly understand its mechanism of action and possible therapeutic applications.

Policy implications

The use of herbal and traditional medicine has been practiced for centuries, and it continues to play a significant role in the healthcare systems of many countries worldwide. Pteridophytes, a group of nonflowering plants that includes ferns and their allies, have been identified as a potential source of bioactive compounds with medicinal properties. The potential of bioactive compounds in *Pteridophyta* plant parts as candidates for herbal and traditional medicine highlights the need for policies that promote biodiversity conservation, protect intellectual property rights, regulate quality control and safety, prioritize research and development funding, and preserve traditional knowledge and cultural heritage. Such policies could unlock the potential of *Pteridophyta* species as sources of new drugs and therapies and ensure equitable access to the benefits of these plants.

Research limitations

This research is still limited to exploring plants found in Cyanthea Park, Bali, and exploring the benefits through meta-synthesis. This research needs to provide a complete picture of the specific benefits and underlying mechanisms of the ability of *Pteridophyta* active compounds as traditional medicinal agents and the therapeutic effects caused. The limited data obtained make this study unable to reveal the effect and ability of fern plant compounds to cure a disease. In the future, special attention is needed, and unique tracing of compounds, biological activities, and mechanisms must be confirmed by empirical research.

Conclusions

Findings in the field showed that as many as nine species of *Pteridophyta* were identified as having benefits as traditional medicinal agents, including *Cyathea contaminans* (Wall ex Hook) Copel., *Asplenium nidus* L., *Asplenium* sp., *Selaginella* sp., *Diplazium esculentum*, *Angiopteris evecta* (G.Forst.) Hoffm, *Cyathea* sp., *Nephrolepis hirsutula* (Forst) C. Presl and *Dicksonia blumei* (Kunze) Moore. The results of the meta-synthesis showed that leaves, shoots, roots, stems, and stem hairs are used for various purposes, including restorative materials, planting media, crafts, game materials, and foodstuffs. The results of the meta-synthesis obtained 49 articles that met the study criteria. *Pteridophyta* species treat fever, cough, anticonvulsant, antibacterial, anti-inflammatory, antipyretic, antidiuretic, immunomodulatory, antioxidant, insecticide, larvicide, diabetes, and antiretroviral diseases, among others, so their potential use as traditional medicine agents and candidates for standardized herbal medicines or phytopharmaceuticals has promising prospects in the future. Apart from being easy to obtain, ferns also contribute to maintaining the archipelago's culture in the form of traditional medicine. In meta-synthesis studies, the resulting mechanism of bioactive compounds of *Pteridophyta* species has been identified as an essential part of the findings to state potential feasibility as traditional medicinal agents. Future studies on the pharmacological, phytochemical, toxicity, and efficacy of *Pteridophyta* components used as traditional medicinal compounds will be necessary.

Authors' Contributions

IMDM: Conceptualization; NKAJ, IMDM: Data curation; IMDM: Formal analysis; NKAJ: Funding acquisition; IMDM, NKAJ: Investigation; IMDM: Methodology; IMDM: Software; NKAJ: Supervision; IMDM: Validation; IMDM: Visualization; NKAJ, IMDM: Writing - original draft; NKAJ, IMDM: Writing - review and editing. All authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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