

## Medicinal Use of Ferns: An Ethnobotanical Review (Penggunaan Perubatan Paku Pakis: Suatu Ulasan Etnobotani)

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### ABSTRACT

Many fern (monilophyte) species are used in traditional medicine by indigenous communities and described in folklore in many parts of the world. Numerous plants used in folk remedies are considered efficacious by today's standards and some have been accepted as main sources of drug discovery. However, the modern use of ferns in medicine, as for other lower plants, is neglected and thought to be only of minor and local significance. In this study, we provide a comprehensive, global summary of the ethnomedicinal uses of ferns. Based on these data, the documented therapeutic potential of ferns is analysed to highlight the gaps in our knowledge that deserve further investigation and can also be used as a starting point in the development of new drugs. Literature reports of ethnomedicinal uses of ferns were collated based on published work from scientific journals, books, reports, and online databases. A total of 442 species are reported to be used, and the most prevalent therapeutic applications are for gastrointestinal disorders (45% of species). The species most frequently cited are *Adiantum capillus-veneris* L., *Equisetum arvense* L. and *Equisetum ramosissimum* ssp. *ramosissimum* Desf. Each of these important species has been reported in the primary literature more than 60 times. Further research targeting the individual ingredients responsible for the pharmacological effects and their mechanisms of action is needed. These studies will further support the therapeutic potential of medicinal fern species for their future clinical applications in modern medicine.

*Keywords:* Ethnomedicinal; ferns; medicinal plant; therapeutic

### ABSTRAK

Banyak spesies paku pakis (monilofit) digunakan dalam perubatan tradisi oleh masyarakat peribumi dan digambarkan dalam cerita rakyat di kebanyakan tempat di dunia. Sebilangan besar tanaman yang digunakan dalam ubat rakyat dianggap berkhasiat berdasarkan piawai masa kini dan beberapa telah diterima sebagai sumber utama penemuan ubat. Walau bagaimanapun, penggunaan paku pakis secara moden dalam perubatan seperti tanaman rendah lainnya, diabaikan dan dianggap hanya kepentingan kecil dan tempatan. Dalam kajian ini, kami memberikan ringkasan global komprehensif mengenai penggunaan etnobotani paku pakis. Berdasarkan data ini, potensi terapeutik paku pakis yang didokumentasikan dianalisis untuk menonjolkan jurang dalam pengetahuan kita yang layak untuk penyelidikan lebih lanjut dan juga dapat digunakan sebagai titik awal dalam pengembangan ubat baru. Laporan kepustakaan mengenai penggunaan etnobotani paku pakis disusun berdasarkan karya yang diterbitkan daripada jurnal ilmiah, buku, laporan serta pangkalan data atas talian. Sebanyak 442 spesies dilaporkan digunakan dan aplikasi terapeutik yang paling prevalen adalah untuk gangguan gastrousus (45% spesies). Spesies yang paling kerap disebut adalah *Adiantum capillus-veneris* L., *Equisetum arvense* L. dan *Equisetum ramosissimum* ssp. *ramosissimum* Desf. Setiap spesies penting ini telah dilaporkan dalam kepustakaan utama lebih daripada 60 kali. Penyelidikan lanjut menyangkan ramuan secara individu yang bertanggungjawab terhadap kesan farmakologi dan mekanisme tindakannya juga diperlukan. Kajian ini akan menyokong potensi terapi spesies paku pakis ubatan untuk aplikasi klinikal masa depan mereka dalam perubatan moden.

*Kata kunci:* Etnobotani; paku pakis; terapi; tumbuhan perubatan

### INTRODUCTION

Pesticides Ferns (monilophytes sensu Pryer et al. (2001)), also known as pteridophytes, are one of the oldest vascular plant groups and have many of the characteristics found in the earliest vascular plants (Pryer et al. 2001; Wolf et al. 1994). They represent approximately 285 to 319 genera in 47 to 48 families (Christenhusz & Schneider

2011; Christenhusz et al. 2011; Liu et al. 2013; PPGI 2016) comprising circa 9,000 to 12,000 species (Christenhusz & Chase 2014; Lehtonen 2011; PPGI 2016; Smith et al. 2006). Ferns are distributed throughout the world, with the highest diversity in the wet tropics (Chin 2005; Winter & Amoroso 2003). For more than 2000 years, ferns have been known for their medicinal values, and various European, American, Asian, and African cultures have

made use of ferns in their traditional medicines (Benniamin 2011; Chin 2005). Almost all parts of ferns, including the stems, rhizomes, leaves, young fronds and shoots can be used in some way, for example as a source of food and beverages, as fertiliser, for ornament, as materials for crafts or buildings and not least, as medicines (Chin 2005; Mannan et al. 2008; Srivastava 2007; Winter & Amoroso 2003). Ferns may be particularly important in the Chinese system of medicine (Chang et al. 2011) and other indigenous systems of medicine (Pan et al. 2014). Several fern species have been reported in traditional pharmacopoeias and are continuously used in herbal medicine in many countries (Prance & Keller 2015). A critical review may reveal more medicinal applications of ferns than expected, including documented uses dating back more than 2000 years (Benniamin 2011; Chin 2005; Van Wyk & Wink 2017). A recent study conducted in Brazil showed that low recording of ferns as medicine can be attributed to inadequate data collection, but also to the perception that these plants are inferior to flowering plants in their therapeutic value (dos Santos Reinaldo et al. 2015). However, when appropriate data collection methods are used, the proportion of ferns used medicinally is equivalent to the proportion of flowering plants used medicinally (dos Santos Reinaldo et al. 2015).

Medicinal plants comprise a rich source of compounds with a variety of pharmacological activities. Because many ferns have been used in folk medicine, some have become the focus of research concerning their bioactive constituents. Numerous compounds especially phenol and phenolic glycosides such as tannins, coumarins, and their glycosides, quinones, flavonoids and related compounds, alkaloids, terpenoids, and steroids have been isolated from fern species, suggesting that they are an extremely rich resource for the discovery of novel drugs (Winter & Amoroso 2003).

However, ferns are often overlooked as traditional medicines despite documented use of many species throughout the world. Documentation of indigenous knowledge through ethnobotanical studies is important for the conservation and utilisation of biological research. Since ethnobotanical data are scattered throughout various publications and in different languages with limited accessibility, initiatives are needed to collect data into a centralised database for easy reference (Gaikwad et al. 2011). A database of this kind will eventually facilitate further studies by other researchers. Many researchers around the world have been involved in compiling traditional knowledge of medicinal plants, and numerous studies have been published in dissertations or theses, journals, proceedings, articles, books, monographs, and technical reports (Mat-Salleh & Latiff 2002).

Information regarding the medicinal uses of ferns is scattered throughout various publications, including digital resources. The aim of this study was to compile data on the medicinal uses of fern species around the globe into a single comprehensive literature source. By

compiling a large quantity of information, the therapeutic potential of ferns can be assessed; at the same time, gaps in our current knowledge can be highlighted.

## MATERIALS AND METHODS

### ETHNOBOTANICAL INFORMATION AND DATA SOURCING

Research publications and reports on traditional uses of medicinal plants, including those specific to ferns, were reviewed (Appendix 1). Journals, books, online databases, and reports from national, regional and international organisations were scrutinised and the information related to ferns was extracted. An extensive search for literature that included information about ethnomedicinal uses of plants was performed using Google Scholar, PubMed and ISI Web of Science. The keywords 'ethnobotany', 'ethnobotanical', 'ethnomedicinal', 'ethnopharmacological', 'medicinal' and 'medicinal plant' were used independently or in combination with the term 'ferns' or 'pteridophytes'. All sources, including books, were examined for information about ferns used medicinally. For each source, it was recorded whether the findings were substantiated by cited herbarium specimens. It was also recorded whether vernacular names or specified uses (therapeutic application, plant part used, mode of application) were provided for each source.

From the sources identified, use reports were compiled that included the species scientific name and all associated data on that species originating from each publication (first row in Appendix 1). The associated information included therapeutic application, plant part used, mode of preparation and application, and vernacular name. For each report, the country/region from which the information originated was recorded; reports were assigned to botanical continents following Brummitt et al. (2001). The IUCN Red List (2015) was used to record the conservation status of all medicinal ferns recorded here.

### STANDARDISING DATA

The nomenclatural history of ferns has been unstable, thus the scientific names reported in the literature were often not those currently accepted. For this study, family and generic classification followed Christenhusz et al. (2011) with some minor changes based on more recent studies (Christenhusz & Schneider 2011; Liu et al. 2013; Rothfels et al. 2012). When a species name in a publication was considered a synonym of a currently accepted name, the current name was used to resolve synonymy and correct spelling errors. All names, including the authors' names, were checked against Tropicos (2016) and Catalogue of Life (2016).

Therapeutic applications were recorded from the source then grouped into 14 categories (Heinrich et al. 1998); cardiovascular problems/blood purity (CB), dentistry/mouth (DM), gastrointestinal (GI),

gynaecology/fertility (GF), neurological conditions (NC), ophthalmology (OP), musculoskeletal (MS), skin conditions/dermatology (SD), otorhinolaryngology (OT), respiratory/pulmonary (RP), urinary conditions (UC), poisonous animal bites (PA), general health problem (GR) and other/unclassified (OU). Appendix 2 shows the original terms from use reports assigned to each category. As the nomenclature for the parts of ferns is sometimes confused, plant parts used were recorded exactly as reported in the source, then standardised (Appendix 3). Modes of preparation and application as reported in the literature were also standardised (Appendix 4).

#### SUMMARISING DATA

The full data set, describing all use reports was explored in several ways to identify the most frequently reported families, genera, species, and uses, the spatial distribution and the conservation status of the species used.

#### RESULTS AND DISCUSSION

##### USE OF FERNS DOCUMENTED IN LITERATURE

In total, 3220 use reports were compiled. We sourced our use reports from 258 publications comprising 239 journal articles and 16 books, and from three online databases. Three books and 18 other publications (8% of published sources) reported only ferns. Most of the publications (98%) included information about therapeutic applications, but plant parts used (91%) and mode of application (76%) were less often detailed. Across all sources, 75% cited herbarium specimens and 84% provided local names. The three databases were Ngā Tipu Whakaoranga: Maori Plant Use Database (2016), Plants For a Future (2012) and Raintree-Tropical Plant Database (1996); two were global databases, and one, the Maori Plant Use Database, had a restricted geographic focus. Of the 16 books, 11 presented regional accounts and five were multi-country. Most of the 3220 use reports compiled here were sourced from journal articles (2059; 64%), followed by 856 (27%) from books and the

remaining 305 (9%) from online databases.

Reports varied in their information content, sometimes depending on whether they were primary or secondary sources. All databases and books were secondary sources, as well as 12% of the journal articles. Overall, the percentage of reports providing other associated information were as follows: 54% local names; 99% therapeutic applications; 56% mode of preparation/application; 75% plant parts used; 94% locality of use. We found that usage reports with locality information were, in general, derived from ethnobotanical field studies that recorded the site of data collection. Secondary sources rarely reported locality data, and 5% of use reports did not even record the country where use took place. For example, some data extracted from PROSEA (Winter & Amoroso 2003) recorded use as taking place in 'South East Asia' instead of providing a specific country name. Of the 3220 reports, only 46% cited herbarium specimens. The collection of voucher specimens is generally thought to be crucial for correct identification of a species. Incorrect identification devalues a database, with negative implications for analyses using those data. Some meta-analyses will only include primary data, including a methods for data collection and an explicit statement that voucher specimens were compared to herbarium material or examined by experts (de Medeiros et al. 2013). Despite the paucity of vouchered specimens, we show that our large dataset reveals patterns in the use of ferns, providing novel insights into global fern use.

##### DISTRIBUTION OF FERN USE RECORDS

Table 1 shows the continental distribution of the medicinal fern reports, species and sources. Asia-Tropical includes more than three times as many reports as the next most report-rich continent, South America. These spatial patterns are also found when considering countries from which use reports originate. Use reports originate from 84 countries, with most records from India (936 use reports and 132 species) followed by Malaysia (219 use reports and 50 species) and China (193 use reports and 77 species).

TABLE 1. Reviewed literature based on continent

Continent	Number of use- reports	Number of species	Number of sources
Asia-Tropical	1643	204	95
South America	400	118	49
Asia-Temperate	339	100	38
Europe	298	34	57
Africa	177	57	29
Pacific	93	38	9
Australasia	52	25	4
North America	40	18	12

dos Santos Reinaldo et al. (2015) suggested that ferns were poorly represented in ethnobotanical surveys because they are unrecorded by existing survey methods and are less commonly used, at least in Brazil. Without similar studies in different countries, it is impossible to explain the strong spatial patterns in fern use recovered from the present survey of the literature. We cannot account for differences in field data collection methods, bias in reporting of fern use or bias in our survey methods. Ferns comprise approximately 9600 species worldwide (Smith et al. 2006) with almost half of the known species from Southeast Asia (Winter & Amoroso 2003). Furthermore, fern communities are rich in wet tropical regions, especially in Southeast Asia and the neotropical region (Mehltreter et al. 2010). Thus, it is not surprising that ferns in this study are more apparent in these regions since fern species richness is high in these two areas.

Overall, ferns are generally well-represented in ethnomedicinal plant selections in India, China and Malaysia, as compared to other regions. A possible explanation is that some Asian countries are rich in fern species, especially China, which included 2600 fern species (Lu 2007), India, with more than 1200 species (Chandra 2000; Dixit 1984), and Malaysia, with more than 1000 species of ferns (Parris & Latiff 1997). The total number of species in these three countries represents more than 50% of global fern species, which might explain why the number of medicinal ferns is high in these areas. Furthermore, the use of herbal medicine is quite popular in India, and China where Ayurvedic medicine and Chinese herbal medicine originated, which include ferns in their therapies (Ching 2007; Nadkarni 1996). Additionally, China, India, and Malaysia are among the top five countries in which plants are used for medicinal purposes (Schippmann et al. 2002). Ethnobotanists, especially in India, are also interested in ferns; 57% of the papers specifically on ferns originated from here. These factors might be the reason behind the inflation of reported fern use in Asia-Tropical, or perhaps it is simply because of the greater importance of ferns in this region.

#### TAXONOMIC DIVERSITY

A total of 454 taxa (442 species, seven subspecies, five varieties) belonging to 121 genera in 36 families were recorded as having medicinal uses in different parts of the world. This total consists of approximately 5% of the total estimated extant fern diversity (Smith et al. 2006). Considering that there are 9000 species of ferns worldwide, there is a possibility that much of the traditional knowledge of medicinal fern species has not yet been explored. On the other hand, the 454 medicinal taxa found in this study demonstrate that we already have an abundance of promising plants that should be studied in more detail.

In terms of conservation, two species in this study were listed: *Blechnum eburneum* Christ. is listed as

vulnerable (VU) and *Culcita macrocarpa* C. Presl as near threatened (NT). It is not possible to estimate the real threat to all medicinal species, as there are still many species lacking a global assessment. Aside from overexploitation, the introduction of invasive species and urban development, the most important threat to fern communities by far is forest fragmentation (Paciencia & Prado 2005). Deforestation has a negative impact since trees provide shade for understory ferns and are hosts for epiphytic species (Mehltreter et al. 2010). According to Sodhi et al. (2004), the rapid rate of deforestation in Southeast Asia, the highest in the tropics, will result in a loss of 42% of its biodiversity by the year 2100. This current rate of habitat fragmentation and deforestation could lead to a worrisome situation for the highly diverse fern species in the tropical region (Ranker & Haufler 2008; Winter & Amoroso 2003). Various actions can be taken for the conservation and sustainable use of medicinal plants, such as protection of species by conservation of their natural habitat (*in situ*) or by the cultivation of individual species outside of their natural habitats, as in botanical gardens or horticultural institutions (Mehltreter et al. 2010). At the same time, public awareness with economic incentives are crucial for conservation efforts, especially in hot-spot regions.

The 20 most commonly medicinally used families and genera are presented in Figure 1. Of the total 36 families used, Pteridaceae has the highest number of medicinal taxa (92 taxa; 20%), followed by Polypodiaceae (91; 20%), Dryopteridaceae (47; 10%), Aspleniaceae (30; 7%), Thelypteridaceae (21; 5%) and Cyatheaceae (20; 4%). These six families together represent 66% of the medicinal taxa, while the remaining 34% of the taxa belong to 30 families that are each represented by fewer than 15 taxa. It seems that Pteridaceae and Polypodiaceae contribute the highest number of medicinal species. Pteridaceae and Polypodiaceae are among of the most diverse groups of extant ferns that include approximately 1200 spp. and 950 spp., respectively, with a nearly worldwide distribution (Smith et al. 2006). The genera with the highest number of medicinal taxa are *Adiantum* (32) followed by *Asplenium* (30), *Dryopteris* (24) and *Pteris* (19), while the other genera are represented by fewer than 15 taxa. *Adiantum* and *Asplenium* not only have cosmopolitan distributions (Bir 1963; Boonkerd & Pollawatn 2013) but have also long been used medicinally. For instance, out of 34 *Adiantum* species found in China (Flora of China: Volume 2, 1994), half have been used in traditional Chinese medicine to cure human ailments (Wu 1990). The species most frequently cited in this survey are *Adiantum capillus-veneris* L. (272 use reports in 66 publications), *Equisetum arvense* L. (113 use reports in 42 publications), *Asplenium ceterach* L. (49 use reports in 27 publications), and *Equisetum ramosissimum* ssp. *ramosissimum* Desf. (66 use reports in 22 publications). *Adiantum philippense* L., *Asplenium trichomanes* ssp. *trichomanes* L., *Lygodium flexuosum* (L.) Sw., and *Pteridium aquilinum* (L.) Kuhn, each have more than 40 use reports in 21 publications.

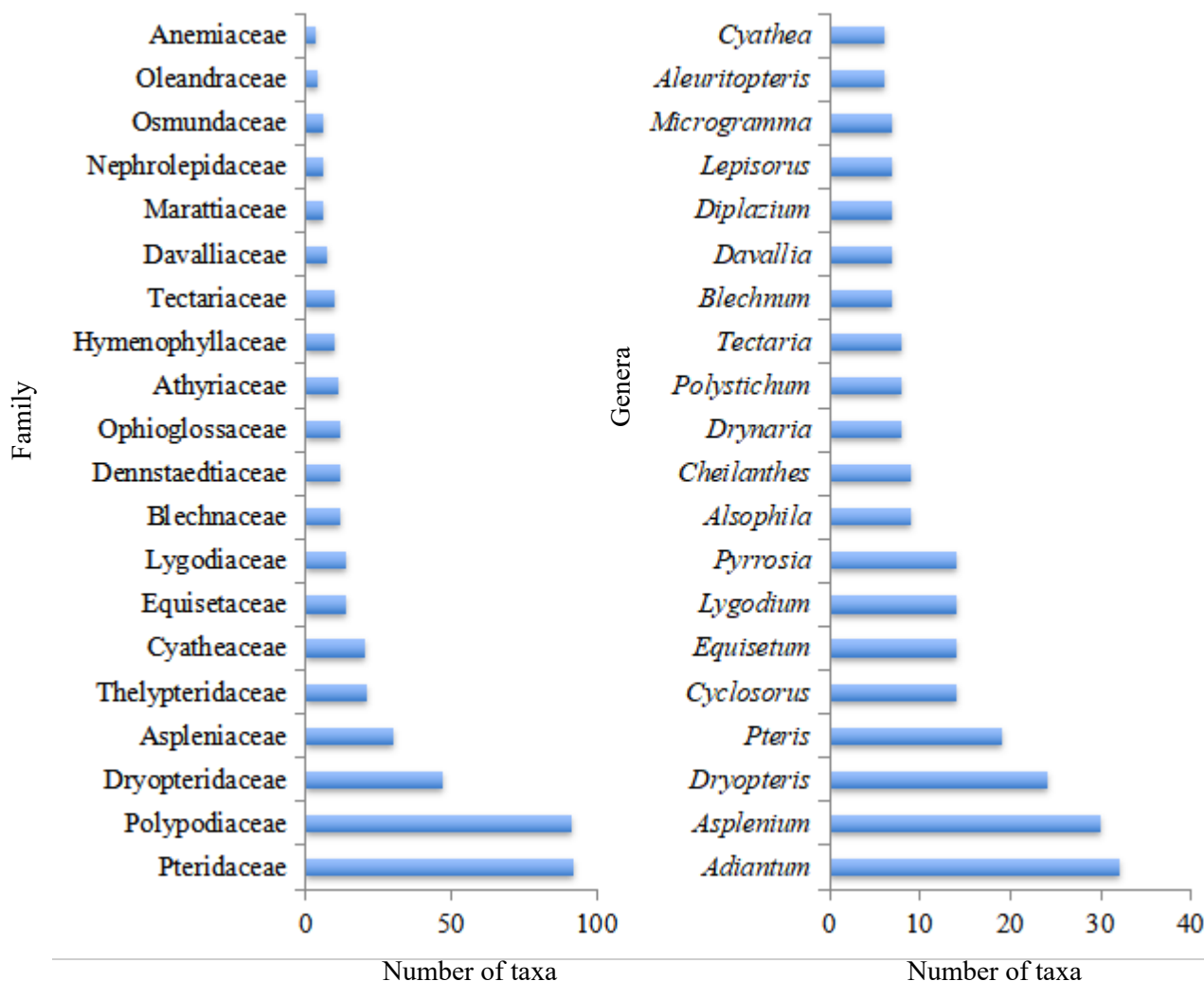


FIGURE 1. Most commonly used families (left) and genera (right) reported in the reviewed literature with the corresponding number of medicinal tax

Many medicinal plants are cultivated close to home or in home gardens, which serve as 'medicine cabinets' (Agelet et al. 2000; Ssegawa & Kasenene 2007). Several genera in the most-used families, such as *Adiantum*, *Pteris*, *Drynaria* and *Platycerium*, are widely cultivated in many home gardens (Chin 2005; Mannan et al. 2008; Winter & Amoroso 2003).

The criteria used when selecting plants for traditional medicine can include morphological characters such as shape and colour (Bennett, 2007) or organoleptic properties including taste and smell (Ankli et al. 1999; Leonti et al. 2002; Molares & Ladio 2009). Examples of morphological and organoleptic selection are apparent in ferns. For example, the hair-like, delicate stalk of *Adiantum* (maidenhair) was thought to be useful for the treatment of hair problems (Benjamin & Manickam 2007; May 1978). Indigenous women of the

Guarani of Misiones (Argentina) believe they will have a large family if they eat ferns from genus *Pechuma* and *Pleopeltis*, which are characterised by their prolific production of small fronds (Keller et al. 2011). Several species of *Polypodium* (Polypodiaceae) have a liquorice flavour and contain small amounts of ostadin, a steroid saponin which is 3000 times as sweet as sucrose (Prance & Keller 2015).

#### HOW FERNS ARE USED

Of the 3220 use reports, there were about 500 that described the therapeutic application of the species used. Figure 2 summarises the therapeutic applications recorded. Gastrointestinal ailments, primarily stomach ailments and pains, but also including other diseases related to the stomach, small or large intestine and accessory organs of digestion, were most frequently

reported (206 taxa, 45% of the total taxa). The high frequency of fern use for treating gastrointestinal ailments suggests that ferns may not be used differently from medicinal plants in general. Many studies of whole medicinal floras also report gastrointestinal applications as the most frequent therapeutic application (Aziz et al. 2017; Benítez et al. 2010; Chetry et al. 2018; Heinrich et al. 1998; Novais et al. 2004; Sher et al. 2014). Poor sanitation within some poor communities in the tropics that are reliant on medicinal plants might explain the high frequency of gastrointestinal problems reported.

Skin and dermatological problems are the second most frequently reported therapeutic application, treated with 177 taxa (39% of all taxa used), followed by gynaecology/fertility problems (141 taxa; 31%), respiratory/pulmonary illness (90 taxa; 20%), urinary conditions (82 taxa; 18%), general health (120 taxa; 26%) and musculoskeletal (111 taxa; 24%). The reporting of all other therapeutic applications is much lower, with fewer than 110 therapeutic applications and 67 species used.

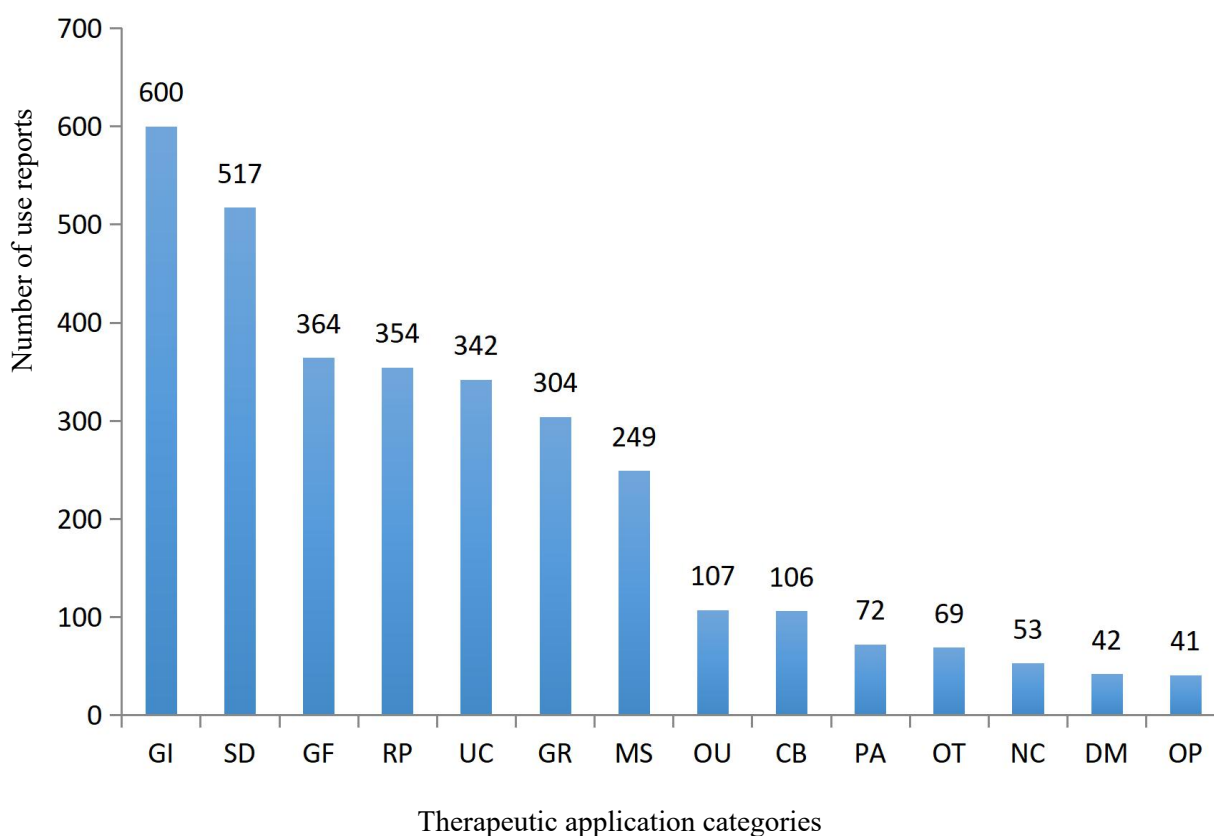


FIGURE 2. Summary of species use reports by the therapeutic application. Categories; gastrointestinal (GI), skin conditions/dermatology (SD), gynaecology/fertility (GF), respiratory/pulmonary (RP), urinary conditions (UC), general health problem (GR), musculoskeletal (MS), other/unclassified (OU), cardiovascular problems/blood purity (CB), poisonous animal bites (PA), otorhinolaryngology (OT), neurological conditions (NC), dentistry/mouth (DM) and ophthalmology (OP)

Many species are reported to have more than one medicinal use. Analysis of the data showed that half of the total medicinal species are used to treat multiple medical problems and have many therapeutic applications. A total of 261 taxa (58%) were applied to more than one category, while the other cited medicinal species (193 taxa, 42%) were used to treat only a single therapeutic application category.

The plant parts used for medicinal purposes and the method of preparation and application are shown in Figure 3(a) and 3(b). The plant part used and the method of preparation and application were infrequently specified in the literature, at 25% and 44% of use reports.

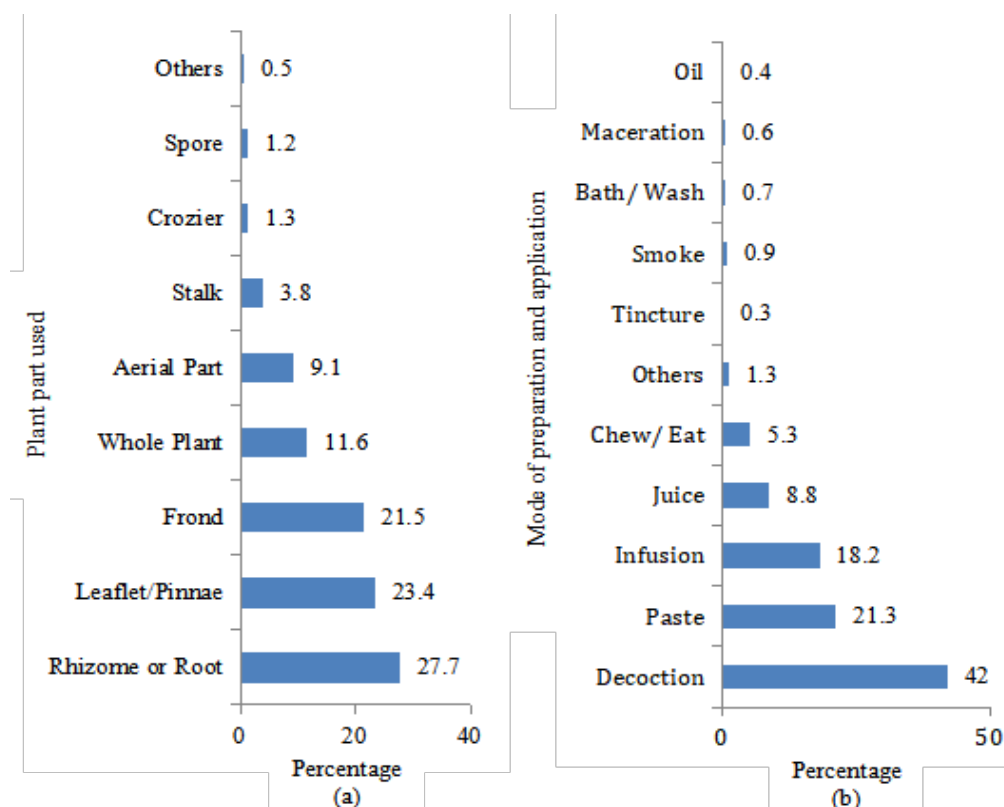


FIGURE 3. Fern plant part used and mode of preparation and application (a) Percentage of plant parts used out of the total use reports of medicinal remedies, and (b) Percentage of modes of preparation and application out of the total use reports of medicinal remedies

All parts of the fern sporophyte are used medicinally, but the rhizome or root is most frequently used (689 reports for 184 taxa). Leaflets/pinnae (581 reports for 151 taxa), fronds (533 reports for 168 taxa), the whole plant (287 reports for 95 taxa), aerial parts (226 reports for 42 taxa) and the stalk (94 reports for 43 taxa) also find significant use. The croziers and spores are less frequently mentioned (each fewer than 32 reports, 1.3% or less of the reports). Four use reports referred to sap, four to scales, two to gum, and one each for slimy tissue and pulp. Field surveys of ethnomedicinal plant use refer to the use of fruits, seeds, wood bark and flowers, structures not present in ferns. However, many general surveys report the preferential use of rhizomes, roots or leafy parts (Chetry et al. 2018; Di Stasi et al. 2002; Giday et al. 2003; Okello & Ssegawa 2007; Shrestha & Dhillion 2003; Teklehaymanot & Giday 2007). It is possible that in ferns, as in plants in general, roots are significant sources of bioactive chemicals, and this underlies their selection and use (Robinson 1974). Since ferns in tropical rainforests are mostly moderately sized with short, erect fronds (Page 1979), they are easily collected and stored.

Of the 11 categories of preparation and application, decoction is the most frequently reported (Figure 3(b)). The mode of preparation and application of medicinal plants could vary both according to the cultures using them and the plant group being used; it is beyond the scope of this study to assess whether decoction is used for preparing ferns more or less than for medicinal plants in general. The high frequency of decoction may be a result of the frequency of use of rhizome/root parts. Decoction may be popularised because of the belief that

the longer the plant is boiled, the higher the efficacy of the remedy (Speck 1941), though in some situations the cost of preparing a decoction may be limiting (Daswani et al. 2011). Pastes, infusions and juices are the next most frequent forms of use, and chewing or eating ferns for medicinal purposes are also common. The use of ashes, latex, smoke, body washes, maceration, tincture or oil is rare, each accounting for less than 1% of the reported preparations and applications. Most ailments and pains were usually treated with a single plant. In 25 cases, mixtures of two or more different plant species were used to prepare a remedy. For example, in India, fresh rhizome of *Alsophila gigantea* is mixed with *Piper nigrum* and cow's milk (Singh & Singh 2012). Since the majority of our reports are from Asia, where written systems that emphasize multi-herbal mixtures originated, we might expect more reports of mixtures including ferns in our data set. Ethnobotanical studies are rarely focused on herbal mixtures, therefore, the frequency of fern use of mixtures could be under-reported.

#### CONCLUSION

Compilation and scrutiny of the information in this study have shown the diversity of medicinal ferns throughout the globe and have revealed the many fern species used medicinally in various cultures worldwide. In conclusion, more than 400 fern species are found to treat different ailments by people throughout the world, and some may appear to have the potential for new drug discovery. Data collection is not only crucial for conserving traditional knowledge, but also contributes to

the evaluation of the likely efficacy and safety of these traditional medicines.

#### ACKNOWLEDGMENTS

The authors would like to thank the financial support from Ministry of Higher Education, Malaysia (FRGS-RACER-RACER/1/2019/STG03/UITM//2), Universiti Teknologi MARA for providing the opportunity and to those involved from University of Reading.

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Received: 20 March 2019

Accepted: 15 January 2020

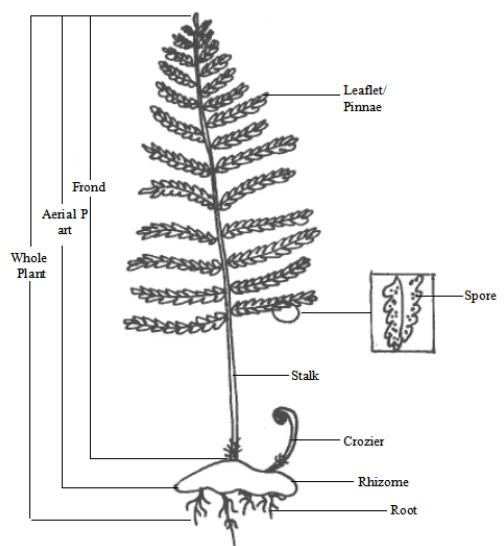
APPENDIX 1. Example of data set, describing all use reports and associated information including therapeutic application, plant part used, mode of preparation and, mode of preparation and application and vernacular name

Family	Genus	Current accepted name	Name in literatures	Continent	Common/Vernacular name	Medicinal Use reports	Medicinal Categories	Part Used	Mode of Preparation & Application	Herbarium specimen availability	Reference	IUCN Red List status
Aspleniaceae	Asplenium	Asplenium auritum Sw.	Asplenium auritum Sw.	Southern America		Fever	GR	NS	NS	No	(Winter & Amoroso, 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium auritum Sw.	Asplenium auritum Sw.	Southern America		Diuretic	UC	Leaflet/pinna	Decoction	No	(Agra et al., 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium auritum Sw.	Asplenium auritum Sw.	Southern America		Expectorant	RP	Leaflet/pinna	Decoction	No	(Agra et al., 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium balansae (Baker) Sylvester	Asplenium balansae (Baker) Sylvester	Southern America	Karaguana yyy resgaa	Menstrual analgesic	GF	Whole Plant	NS	Yes	(Keller et al., 2011)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium balansae (Baker) Sylvester	Asplenium balansae (Baker) Sylvester	Southern America	Karaguana yyy resgaa	Contraceptive	GF	Whole Plant	NS	Yes	(Keller et al., 2011)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium brasiliense Sw.	Asplenium brasiliense Sw.	Southern America	Karaguana yyy resgaa	Menstrual analgesic	GF	Whole Plant	NS	Yes	(Keller et al., 2011)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium brasiliense Sw.	Asplenium brasiliense Sw.	Southern America	Karaguana yyy resgaa	Contraceptive	GF	Whole Plant	NS	Yes	(Keller et al., 2011)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium bulbiferum G. Forst.	Asplenium bulbiferum G. Forst.	Africa	Ubeze, Okonko	Hemorrhoids	GI	Leaflet/pinna	Paste	Yes	(Nwosu, 2002)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium bulbiferum G. Forst.	Asplenium bulbiferum G. Forst.	Africa	Ubeze, Okonko	Liver problems	GI	Fond	Decoction	Yes	(Nwosu, 2002)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium bulbiferum G. Forst.	Asplenium bulbiferum G. Forst.	Australasia		Skin troubles	SD	Rhizome or r	Infusion	No	(Brooker & Cooper, 1961)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium bulbiferum G. Forst.	Asplenium bulbiferum G. Forst.	Australasia		Sore eye	OP	Rhizome or r	Infusion	No	(Brooker & Cooper, 1961)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium bulbiferum G. Forst.	Asplenium bulbiferum G. Forst.	Australasia	Mouki	Sore eye	OP	Rhizome or r	Bath-Wash	No	('Ngii Tipu Whakaoranga database, 7)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium bulbiferum G. Forst.	Asplenium bulbiferum G. Forst.	Australasia	Mouki	Cutaneous complaint	SD	Rhizome or r	Infusion	No	('Ngii Tipu Whakaoranga database, 7)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum DC.	Europe	Spaccapetri	Kidney stones	UC	Leaf and Rhi	Decoction	Yes	(Leto et al., 2013)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum DC.	Europe	Herba revellada, herba de les set sagrites	Antiameorrhoeic	GF	Fond	Infusion	Yes	(Aguilet & Vallés, 2003)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum DC.	Europe		Antialgic	GR	Fond	Infusion	Yes	(Aguilet & Vallés, 2003)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum DC.	Europe		Menses	SD	Fond	Infusion	Yes	(Aguilet & Vallés, 2003)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum Willd.	Asia Tropical		Incontinence of urine	UC	Rhizome or r	NS	No	(Mannan et al., 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum Willd.	Asia Tropical		Diuretic	UC	Rhizome or r	NS	No	(Mannan et al., 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum Willd.	Asia Tropical		Calculus	OU	Rhizome or r	NS	No	(Mannan et al., 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum Willd.	Asia Tropical		Enlargement of spleen	CB	Whole Plant	NS	No	(Mannan et al., 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Asplenium ceterach L.	Asia Tropical		Anthelmintic	GI	NS	NS	No	(Winter & Amoroso, 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Asplenium ceterach L.	Asia Tropical		Diuretic	UC	NS	NS	No	(Winter & Amoroso, 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Asplenium ceterach L.	Asia Tropical		Ophthalmia	OP	NS	NS	No	(Winter & Amoroso, 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Asplenium ceterach L.	Asia Tropical		Disease of spleen	CB	NS	NS	No	(Winter & Amoroso, 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum DC.	Europe		Respiratory problem	RP	NS	NS	Yes	(González Tejero et al., 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum Willd.	Europe		Childbirth	GF	Aerial Part	Infusion	Yes	(Guarrens et al., 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum Willd.	Europe	Spaccaprete	Abortive	GF	Aerial Part	Decoction	Yes	(De Natale & Pollio, 2013)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum Willd.	Europe	Spaccaprete	Cough	RP	Aerial Part	Decoction	Yes	(De Natale & Pollio, 2013)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum Willd.	Europe	Spaccaprete	Stomachache	GI	Aerial Part	Decoction	Yes	(De Natale & Pollio, 2013)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum DC.	Asia Temperate	Tas otu, éwatabani	Stomachache	GI	Aerial Part	Decoction	Yes	(Girdal & Küllbir, 2013)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum DC.	Asia Temperate	Tas otu, éwatabani	Gallbladder disease	GI	Aerial Part	Decoction	Yes	(Girdal & Küllbir, 2013)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum DC.	Asia Temperate	Tas otu, éwatabani	Urinary disease	UC	Aerial Part	Decoction	Yes	(Girdal & Küllbir, 2013)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum DC.	Asia Temperate	Alin out	Kidney and Gallstone	UC	Aerial Part	Infusion	Yes	(Polat & Sanli, 2012)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum DC.	Asia Temperate	Alin out	Uriner antiseptic	UC	Leaflet/pinna	Infusion	Yes	(Polat & Sanli, 2012)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum Willd.	Asia Temperate	Eshbat al-jireh, Qeshbirat al-bir, Hashibat al-dahab	Joint aches	MS	Whole Plant	Maceration	Yes	(Nelly et al., 2008)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum Willd.	Europe	Dondilla	Anti-diarrhoeal	GI	Fond	Infusion	Yes	(González et al., 2010)	Not Evaluated
Aspleniaceae	Asplenium	Asplenium ceterach L.	Ceterach officinarum Willd.	Europe	Dondilla	Hypertension	CB	Fond	Infusion	Yes	(González et al., 2010)	Not Evaluated

APPENDIX 2. Circumscription of therapeutic application categories. The 14 therapeutic application categories follow Heinrich et al. (1998). The therapeutic applications as described in the source publication are assigned to Heinrich's categories

Therapeutic application categories	Therapeutic application as described in the source
Cardiovascular problems/blood purity (CB)	Blood purification/purifier/depurative, high/low blood pressure, heart strength, cardio/ heart problem, cardiac infection, cardioac problem, circulatory disorder, hematocarthatic, hypocholesterolemia, chest pain, angina pectoris, spleen treatment, antihemorrhagic, venous problem, arteriosclerosis, depurative of blood, hyperlipidemia, hypertension.
Dentistry/mouth (DM)	Bleeding gums, toothache/odontalgia, mouth sore, mouth blister, mouth infection, dental neuralgia, Periodontitis/pyorrhea, mouth infection, tongue blemish, tongue ulcer, unhealthy tongue, dentirifice.
Gastro-intestinal (GI)	Stomach problem (stomachache/stomach pain, stomach ulcer/peptic ulcer, stomach cancer, stomach acidity, stomach cramp) gastric,anthelmintic/vermifuge/vermicide, diarrhea,dysentery,emetic/vomiting/nausea, carminative, dyspepsia, indigestion, digestion problem, diabetes, constipation, intestinal problem, jaundice, appendicitis, liver problem, nausea, hepatitis, enteritis, colitis, laxatives/purgative, hepatic disease, aperient, hemorrhoids, pancreas problem, hematemesis.
Gynecology/fertility (GF)	Gynecological problem, women problem, white discharge/leucorrhea, syphilis, gonorrhea, menstrual promoters, menstrual problem, menstrual pain/dysmenorrhea, uterine contractors, uterus problem, ovarian cyst, emmenagogue, menorrhagia, uterine hemorrhage, female haemorrhage, abortion, delivery pain, male/female fertility, venereal diseases, prostate problem, aphrodisiac, child birth problem, facilitate childbirth, mastitis, contraceptive, postpartum recovery.
Neurological conditions (NC)	Epilepsy, sedative, convulsion, sciatica pain, insomnia, sleep disorder, antidepressant, encephalitis, nervous system problem, spastic, meningitis, mental problem, amnesia, neuralgia.
Ophthalmology (OP)	Eye problem/ophthalmic, ophthalmia, sore eyes, indolent ulcer, eye infection, conjunctivitis.
Musculo-skeletal (MS)	Fracture in bone, body pain,waist pain, joint pain, muscle pain, muscle problem, rheumatism, sprain cramps, abdominal pain, knee aching, bone injuries/problem, arthritis, backache, lumbago, gout, arthralgia, rickets.
Skin conditions/dermatology (SD)	Any skin disease/problem, skin wound and cut, swelling, skin irritation, skin rashes, skin itching, skin ulcer, astringent, dandruff, scalp, hair growth, hair problem, hair loss, boils, eczema, emmolient, scabies, seborrheic dermatitis, leprosy, burn and scalds, bruise, carbuncle, leucoderma, scald, abscess, nail separation.
Poisonous animal bites (PA)	Scorpion-sting, snakebite, insect bite, honeybee sting.
Otorhinolaryngology (OT)	Catarrh, ear infection/problem, nose problem, nosebleed, sinusitis, throat infection, deafness, pharyngitis, tinnitus, laryngopharyngitis, nasopharyngeal infection.
Respiratory/pulmonary (RP)	Respiratory disorders, lung problem, cough (antitussive), cold, bronchitis problem, asthma, expectorant, tuberculosis, phthisis, haemoptysis, pneumonia.
Urinary conditions (UC)	Kidney problem/disorders, kidney inflammation, kidney swelling, kidney stones, diuretic, urinary problem/ cystitis, urethritis, urolithiasis, urinary calculus, renal problem, renal calculus, bladder complaints, hematuria, nephritis.
General health problem (GR)	Fever, anodyne, health tonic (for body strength), headache, antioxidant, antibacterial, antiviral, antifungal, febrifuge, sickness, food poisoning, general pain, fatigue.
Other/unclassified (OU)	Anti-inflammatory, illness, allergic, poisoning, ulcer (not specified), human ailments, tumor, cancer, allergic, medicinal properties.

APPENDIX 3. i) Parts of a fern. The terminology used here for plant part categories is illustrated



ii) Plant part use categories. Each plant part as reported in the source literature is assigned to one of nine categories

Plant part categories	Part used as reported in the source
Aerial part	Aerial part, frond and rhizome, frond and stem
Fronde	Fronde, leaf and stem,
Leaflet/pinnae	Leaf, pinna, pinnule, leaf and spore
Whole plant	Whole plant, all parts of the plant
Stalk	Stem, stipe, hard part, leaf stalk, nodal lump, petiole, pith, rachis
Spore	Sorus, seed, spore, inflorescence, cone, strobilus, spike
Rhizome or root	Rhizome, root, tuber
Crozier	Crozier, bud, shoot, sprout
Other	Sap, slimy tissue, gum, pulp, scale

APPENDIX 4. Categories of modes of preparation and application. Each mode as reported in the source literature is assigned to one of 11 categories

Modes of application categories	Preparation or application reports in literatures
Decoction	Decoction, extraction, boiling
Infusion	Tea, tisane, soaked with water, drink /drink with other herbs, mixed with cow milk
Tincture	Tincture, add with wine, soaked with wine
Maceration	Maceration, macerated in olive oil
Paste	Paste, applied on skin/head/hair/teeth/gum, poultice, pounded, pressed on the body, crushed (external application), powdered, powder mixed water, oil or other, cataplasm, grinding, mashed, pulverized, milling, blended, external application
Juice	Filtration, juice, squeezed
Bath/Wash	Skin wash, steam bath, scrub, bath, hand wash, body wash, gargle
Chew/Eat	Eaten as vegetables or mixed with sugar, onion, garlic, herbs, coconut, betel, porridge, fried with butter, toasted, pill, soup, chewed, cooked, grilled, oral application
Smoke	Smoke, smoke inhalation, put on fire
Oil	Oil, ointment, oleolite, lotion, burn in oil
Others	Ash, sap, latex excretion, heated