ISSN 0376-5156
Geophytology 53(1): 29–44
May 2023

Role of vascular cryptogams in treatment of human ailments

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Manuscript received: 20 March 2023
Accepted for publication: 08 April 2023

ABSTRACT

Garima, Sharma S.K. & Alam A. 2023. Role of vascular cryptogams in treatment of human ailments. Geophytology 53(1): 29–44.

Pteridophytes were the first vascular plants to appear on land. They are intermediate between bryophytes and spermatophytes. They do not produce flowers or seeds, hence they are also known as "cryptogams." Majority of studies on the biology of pteridophytes have been reported within the last three decades, and pteridophyte research has generally become more active with time. This review provides a starting point for future pteridophyte research and helps classify the medicinally significant pteridophytes. Analyses of laboratory culture, biosynthetic pathways, mechanisms of action, and genetic expression could improve a bioactive substance's efficacy. Only a small portion of the 13,000 or so species that make up the almost 48 plant families that make up the pteridophytes have had their biological activities studied. Therefore, we exhort biologists to assess the therapeutic applications of pteridophytes and their relevant elements. Early tracheophytes and pteridophytes should be used as a source for the development of combination medicines, in addition to research on their biosynthesis, pharmacokinetics, and toxicological profiles. Furthermore, secondary metabolite synthesis in pteridophytes should be used to investigate genetic links between them.

Keywords: Pteridophytes, human ailments, medicinal importance, ethnobotany.

INTRODUCTION

The oldest seedless vascular plants are known as pteridophytes (Greek: *pteron,* meaning feather, and *phyton,* meaning plant). They reproduce by means of spores and lack both fruits and seeds. These plants, also referred to as "vascular cryptogams", are represented by around 10500 species and 400 living and extinct genera (Gangulee et al. 2011). These plants allegedly ruled the earth during the Devonian Period (from 419.2 Mya to 358.9 Mya). During the Silurian Period (from 443.8 Mya to 419.2 Mya), they made their initial appearance. *Cooksonia* is the earliest known pteridophyte. Most pteridophytes, that are living today, are terrestrial and prefer cold, moist, and shady habitats, like terrestrial [*Selaginella rupestris* (L.) Spring, *Equisetum* spp.], aquatic species (*Marsilea* spp., *Azolla* spp.), xerophytic species (*Selaginella* spp.), and as epiphytic form (*Lycopodium squarrosum* (G. Forst.) A. Love & D. Love. Pteridophytes are mostly herbaceous, but some, like *Angiopteris* sp., are perennial and look like trees. The smallest Pteridophyte is *Azolla*, an aquatic fern, while the largest is *Cyathea* sp., a tree fern (Gangulee et al. 2011).

CHARACTERISTICS OF PTERIDOPHYTES

The sporophytic plant body of pteridophytes is composed of roots, stems, and leaves. The adventitious nature of roots is shown by their monopodial or

dichotomous branching. They often have a diarch internal structure. A stem typically has branches. There is monopodial or dichotomous branching. Branch growth does not begin at the leaf's axil. Several Pteridophytes use their rhizome as their stem. Depending on the species, the leaves may be small, slender, scaly, simple, and sessile (like those of *Selaginella* spp.), microphyllous (like those of *Equisetum* spp.), or enormous and complex pinnately arranged (megaphyllous, e.g., species of *Dryopteris* and *Adiantum*). The stele can be polycyclic, siphonostele (*Equisetum*), dictyostele (*Adiantum*), or protostele (*Rhynia* and *Lycopodium*). In *Angiopteris* there is no secondary growth since there is no cambium (Gangulee et al. 2011).

Both the sporophytic and gametophytic generations are nutrition independent and alternate on a regular basis in a heteromorphic way. Homosporous or heterosporous polysporangiate pteridophytes are both possible. When a sporangium breaks down, iso-, micro-, and megaspores are released, making pteridophytes free sporangiate creatures. True alternation of generation exists in pteridophytes. Multicellular sex organs antheridia and archegonia are found. Antheridia discharge the male gametes, known as antherozoids (Gangulee et al. 2011).

Antherozoids can only get to the female reproductive organ known as archegonium when there is water present. Water is important for fertilization because flagellated sperms are chemotactically driven to the archegonium when they move over a thin layer of water. Once the gametes have fused, a zygote is produced. This zygote generates the sporophyte, which divides repeatedly through mitosis in order to first develop into an embryo (Gangulee et al. 2011).

The success of plants can be determined by how well they enable individuals to exist in both physical and environmental environments (Di Michele et al. 1987, Di Michele & Aronson 1992). From a phylogenetic history perspective, success can be assessed by considering both ecological and geological time. The richness of the local flora and the percentage of that diversity that is covered are further quantitative indicators of success. To determine a species' success over geological time, look for it in strata that span a wide temporal range. Moreover, during the ecological period (Rothwell 1991, Wing et al. 1993). Incidentally, Pteridophytes were the primary vegetational components in many land ecosystems in the Cretaceous and possibly even into the Paleogene, as evidenced by greater species variety (Wing et al.1993).

EVOLUTION OF PTERIDOPHYTES

The five geological eras that makeup Earth's geological history are the Archaeozoic, Proterozoic, Palaeozoic, Mesozoic, and Cenozoic. In the Precambrian era, life first appeared on earth. Due to unfavorable environmental conditions, there are not many fossils in the rocks from this era. *Nematothallus* and *Prototaxites* have similarities to thallophytes during the Paleozoic era. In this era, Silurian and Devonian periods, the earliest fossils of land plants were discovered (225 to 350 million years ago) (Singh et al. 2018).

Taxa like, *Manograptus, Sporogonites, Zosterophyllum, Cooksonia, Pseudosporochnus, Horneophyton, Rhynia* and *Psilophyton* are a few significant representatives from the Silurian and Devonian periods. Whereas, members of *Lycopsida*, *Sphenopsida*, and *Pteropsida* created lush forests during the Carboniferous and Permian periods, the age of seed ferns refers to this time period. Lycopsids, sphenopsids, seed ferns, and gymnosperms of that time coalified to form the coal deposits of Pennsylvania and West Virginia. Some psilopsids, sphenopsids, and lycopsids fortunately managed to survive the destruction and eventually gave rise to the current forms (Singh et al. 2018).

Fossil records from the Mesozoic era (the Age of the Cycads) show that the Triassic period saw a significant presence of ferns, cycadophytes, and conifers. While flowering plants also emerged during this time, their representation was very small. During this time, the *Salicaceae*, *Araliaceae*, *Lauraceae*, and

Sapinadaceae families were founded, and about 200 of the 300 cultivated species discovered in North America were angiosperms. It demonstrates that a sizable portion of the Cretaceous vegetation was made up of angiosperms. The Cenozoic era is referred to as the age of angiosperms. During this time, high mountain ranges like the Himalayas in Asia and the Alps in Europe emerged. The impact of the hot winds was reduced, and the ice age started (Rothwell 1996, Singh et al. 2018).

These climate changes had a tremendous impact on the vegetation. The seed plants gradually moved towards the tropics for various causes, while those that couldn't migrated died off. Seasonal changes were also prevalent because the bulk of plants in the late Cenozoic were deciduous. In the temperate and polar regions, annual or biennial herbs that could endure frigid temperatures made up the majority of the plant life (Singh et al. 2018).

Pteridophytes have undergone significant adaptation to colonize various sorts of environments since they first appeared in ancient tropical habitats (Sharpe et al. 2010). There are an estimated 15,000 different species of ferns, of which 12,000 are lycophytes and ferns that have been described (Chapman 2009). Since this group of vascular plants has a longer evolutionary history than any other, many of the phylogenetically significant traits may have been lost in the process. They controlled a portion of the vegetation at that time and were abundant during the Carboniferous epoch (355–290 million years ago) (Rothwell & Stockey 2008).

DISTRIBUTION OF PTERIDOPHYTES

Pteridophytes are common in moist deciduous forests in tropical and subtropical regions, and their life cycles are moisture-dependent. However, because of habitat loss, many species have decreased, and the rare ferns are now at risk of becoming extinct (Dixit 2000). The survival of this group of plants is seriously threatened by elements such as climate change, growing urbanization, industrialization, encroachment on forest lands, haphazard development activities, and overexploitation of natural resources. Epiphytic pteridophytes have severely decreased as a result of unplanned tree-cutting in the forests (Della & Falkenberg 2019, Dixit 2000). In order to recreate postglacial colonization patterns and explain the frequent regional divide in the genetic structure of many species, Hewitt (1993) examined evidence from pollen analysis, fossil insect remnants, and the distribution of hybrid zones. He also addressed the issue of the comparatively low genetic variation in northern Europe and the larger genetic diversity in southern Europe, particularly in the Mediterranean region. The leading-edge colonization theory, according to which colonization only occurred from the northern edges of refugial areas–preventing southern populations in such refugia from participating because they are obstructed by the northern, expanding populations—explains this partitioning of genetic diversity.

Numerous pteridologists, including Punetha (1989), Bir et al. (1991), Joshi et al. (1999), Chaudhary and Dulawat (2006) and Joshi & Pande (2006), have studied the variety and pteridophyte spread across India's many biogeographical zones. Patil et al. (2012) investigated the diversity and distribution of pteridophytes in the northwestern Ghats. The Satara district in Maharashtra has a maximum height of 1500 m. Pteridophytes were divided into three zones according to the altitude range: the foothill zone (under 600 m), the middle hill zone (between 600 and 1000 m), and the higher altitude zone (above 1000 m). It is frequently observed and stated that the majority of fern species flourish under high dampness and shadow conditions, with the exception of species that prefer more xeric environments and are more heliophilous (Dudani et al. 2014, Patil et al. 2016).

The creation of detailed distribution maps and automated methods for processing distributional data (Perring & Walters 1962; Soper 1964) have made it possible to quickly identify the key characteristics of any taxon's distribution as well as to extract lists of the taxa that have been recorded in specific locations. Although it is evident that some distribution patterns

keep on repeating, it is more challenging to identify patterns and linkages between taxa and geographical regions purely by visual observation.

UTILITY OF PTERIDOPHYTES

Pteridophytes are commonly employed as decorative plants, as well as phytoremediators, bio-fertilizers, and bio-indicators for pollution. Pteridophytes offer a lot of potential in the field of medicine and have a huge variety of secondary metabolites. For all types of illnesses, the conventional medicine system is crucial to the health care of urban, rural, and tribal populations. Environmental applications can be connected to empirical findings, frameworks, and hypotheses using ecological indicators (EIs). They are widely used in the classification of habitats as well as in the assessment of stress or natural or anthropogenic alteration (Niemi & McDonald 2012, Siddig et al. 2016). EIs can be used to anticipate the distribution of other creatures, detect and track changes in the environment (natural and/or created by man), identify regions to protect and restore, and identify biotic and abiotic conditions (Sampson 1939, McGeoh 1998, Niemi & McDonald 2012).

PTERIDOPHYTES IN TRADIIONAL MEDICINAL SYSTEMS

Investigation into the value of pteridophytes as medicines in India was started by Caius (1935). Later, Chowdhury (1973), Padala (1988), Vyas and Sharma (1998) and Sureshkumar et al. (2018) revealed the understanding of pteridophyte ethnobotanical and therapeutic usage. It is recognized that various sporophyte organs, including the rhizome, stem, fronds, pinnae, and spores, can be utilized to treat a variety of ailments. It has been discovered that the plant extract of numerous pteridophytes can treat a number of illnesses. A number of pteridophytes were reported by Theophrastus (327–287 BC) and Dioscorides (50 AD) as having possible medicinal applications for treating human illnesses. Additionally, Shushruta and Charak discussed the benefits of ferns like *Marsilea minuta* L. and *Adiantum capillus-veneris* L. According to reports, *Selaginella bryopteris* L. and *Lycopodium clavatum* L. are often employed in the traditional medical system and are specifically recommended for the treatment of neurological disorders and the consequences of heat stroke. It has been discovered that *L. clavatum* is used to treat patients with dislocated bones. For herbal Ayurveda formulations to improve sexual efficacy and as a source of stimulant and aphrodisiac, *Helminthostachys zeylanica* (Kamraj) is employed. The immune system is known to be strengthened by the marsiline separated out of *Marsilea minuta* L., which even addresses gastritis, fever, sleeplessness, mental instability, diarrhea, and cough. The broad-leafed fern, *Pteris vittata* L., has also demonstrated antibacterial activity against a variety of gastrointestinal bacterial pathogens. Pteridophytes would thus prove to be a very important biological resource for the advancement of human civilization and have a wide range of medical applications.

MEDICINAL IMPORTANCE OF PTERIDOPHYTES

For even about 2000 years, mankind has known that pteridophytes had medicinal value. Today, individuals all over the globe use various pteridophyte parts to cure a variety of illnesses (Rout et al. 2009). In light of their potential application in the treatment of different infectious and chronic diseases, finding compounds with antioxidant properties, antibacterial, or reduce pain and swelling characteristics has increased in recent years (Halliwell 1996). Curative plants can be a less harmful option to synthetic antibiotics as a source of antimicrobial compounds with significant bioactivity against pathogenic and transmissible microbes (Berahou et al. 2007). In prior investigations, it was shown that the numerous therapeutic activities of *Selaginella* spp. were present, including anti-oxidative, anti-inflammatory, anti-cancer, hypoglycemic, antiviral, antibacterial, and anti-Alzheimer qualities. Some plant secondary metabolites are classified as generally considered to be harmless substances because of their antibacterial and antioxidant capabilities (Proestos et al. 2005). The demand for chemical compounds of plant origin from medicinal plants with some biomedicinal

action has increased due to the increased interest in these chemicals (Chen et al. 2008; Pesewu et al. 2008; Prachayasittikul et al. 2008). Additionally, doctors who practiced the Ancient ayurvedic set of networks of medicine utilizes pteridophytes (Uddin et al. 1998). Native physicians advise a number of ferns in the traditional Chinese medical system (Kimura & Noro 1965). Numerous researchers have recently conducted ethnobotanical and cutting-edge pharmacological studies on ferns and their associates (Dhiman 1998, Vasudeva 1999, Reddy et al. 2001, Singh et al. 2001, Gogoi 2002, Chen et al. 2005, Singh et al. 2008a, b).

PTERIDOPHYTES IN TREATING HUMAN AILMENTS

1. *Actiniopteris dichotoma* Kuhn. (*Actiniopteridaceae*)

Leptospirosis, gastroenteritis, dysentery, infection, fever, diabetes, and dermato disorders are all treated with rhizome (Warrier et al. 1996). Rhizomes are boiled and used to treat dandruff, while leaves are chewed for sore throats (Singh et al. 2005).

2. *Acrostichum aureum* L. (*Pteridaceae*)

Headaches are treated with leaf paste. Cooked young leaves are offered as a edible. The leaf like parts is used to make brooms and fish decorations. Rhizome slurry is widely utilized to treat boils as well as cuts (Shaikh et al. 2014).

3. *Acrostichum radiata* (J. Koenig ex Sw.) Link (*Actiniopteridaceae*)

Popularly known as Mayurshikhi and Morpamkhi. The paste derived from the leaves and rhizomes is used as a styptic, antiseptic, constrictor, and for gynecological problems including bronchitis. In tuberculosis, the dried fronds are employed (Singh & Upadhyay 2012; Shaikh et al. 2014). Twice a day oral administration of stem juice is used to treat diarrhea and fever (Karthik et al. 2011). To cure leucorrhoea and boost fertility, fresh paste or dried leaf powder mixed with honey is taken orally twice a day (Caius 1935). To boost a woman's potency, 5–6 leaves are eaten orally 2 times in a day with something sweet as an aphrodisiac and strength stimulant (Parihar & Parihar 2006).

4. *Acrostichum radiata* C. Presl.

Fronds, stems, and rhizomes are utilized to cure leprosy, hair loss, fever, and cough. It is also appropriate for growing in a pot (Singh & Singh 2013).

5. *Acrostichum poiretii* Wikstr.

The leaves of *A. poiretii* are used to treat cough, diabetes, fever, and dermis disease (Kumari et al. 2011).

6. *Acrostichum caudatum* L.

Mayurshika is the common name of this plant in Hindi. According to Rout et al. (2009), frond extract is used to treat wounds and to relieve coughing fits and fevers. Use of rhizomes as anthelmintic (Shaikh et al. 2014). It is also used as an expectorant for diabetes, skin conditions, coughs, and fevers (Singh et al. 2005; Srivastava et al. 2015). Burns, cuts, and wounds are treated using leaf paste.

7. *Acrostichum venustum* D. Don

Commonly known as Venus hair fern. Leaves can be utilized as a diuretic, expectorant, emetic, tonic, and more. Tea made from leaves is used to treat fevers and to ease the agony from snake and scorpion bites (Upreti et al. 2009, Singh & Upadhyay 2010).

8. *Aleuritopteris albomarginata* Clarke (*Sinopteridaceae*)

Glade fern is the vernacular name of this fern. Internal administration of a combination of the fronds, stem, and rhizome treats gastric ulcer. In order to cure female infertility, mashed ginger rhizomes (*Zingiber officinale* Roscoe) are combined with powder form dried leaves. Its mixture used orally to treat dysentery (Nwosu 2002).

9. *Alsophila gigantea* Wall. ex Hook. (*Cyatheaceae*)

In Hindi, this plant is known as Bina kantewala tree fern. Black pepper (*Piper nigrum* L.) powder and 10 grams of raw rhizome administered swallowed with cow milk two times a day for seven days on an empty stomach can prevent white discharge in females (Panda et al. 2011).

10. ***Alsophila glabra*** Bedd.

When the snake bites, its rhizomes are taken. (Kumari et al. 2011).

11. ***Adiantum capillus-veneris*** L. (*Adiantaceae*)

Popularly called Hansraj, Mayursikhi. The rhizomes and leaves are used as an aphrodisiac (Benjamin & Manickam 2007). The Bariaam, Dapka, and Gond tribe community of Badkachhar uses fresh plant juice to treat diabetes and coughs, as well as to offer youngsters as a tonic. Fever and acute bronchitis are treated with leaf extraction. To prevent chicken pox, leaves and rhizomes are kept close to the bed (Singh & Upadhyay 2012). As an eye ointment, honey and leaf extract are combined. For a quicker recovery, cuts and wounds are treated using a paste made from leaves, stems, and rhizomes with *Aloe vera* gel. For healthy hair development, a paste made from the plant's leaves, stem, and rhizome is used (Karthik et al.2011). It is also used as an astringent and diuretic (Shaikh et al. 2014). Blisters in the mouth are treated by chewing on leaves. The leaf, stem, and rhizome paste are also used as a febrifuge, expectorant, tonic, and demulcent (Upreti et al. 2009).

12. ***Asplenium indicum*** Sledge (*Aspleniaceae*)

For the treatment of gonorrhea, 5 g of fresh rhizome paste is combined with 10 ml of milk and administered three times per day for a week (Singh & Upadhyay 2012).

13. ***Asplenium nidus*** L.

Elephantiasis, fever, jaundice, and urinary issues can all be treated with an extract from the leaves and rhizome. This plant is used by tribal people to treat spleen enlargement brought on by frequent urination (Upreti et al. 2009; Singh & Upadhyay 2012).

14. ***Asplenium philippense*** L.

Ghodpavali, Bedki, Jiwali, Ghodyachiare the vernacular names of this plant. The herb is used to treat chronic nasal catarrh, bronchitis, throat swelling, and cough. Treatments for ulcers, burning feeling, and blood illnesses include frond extract. For quick relief from gastrointestinal issues, fresh fronds paste (approximately 1 g) is administered twice daily on an empty stomach for two weeks. Rhizome is used to treat glandular enlargement. For contraception, indigenous women utilize a dry rhizome powder (1 g) and water mixture taken orally once every three to five days during the menstrual cycle. Cough, Asthma, Fever, Leprosy, and Hair Falling are treated with extract of fresh leaves (Singh et al. 2003, 2005, 2007) in cases of abnormal or irregular stopping of menses (Upreti et al. 2009; Singh & Upadhyay 2010). It is among the ingredients in Hansraj, a medication used to cure coughs in India. Rhizome is regarded as a beneficial source for the treatment of both fever and elephantiasis (Kirtikar et al. 1935). Rhizome is used as an antidote for dog and snake bites (Singh et al. 2005).

15. ***Athyrium hohenackerianum*** (Kunze) Moore. (*Athyriaceae*)

The tribal people utilize the entire plant to treat the beriberi disease (Singh 1999).

16. ***Blechnum orientale*** L. (*Blechnaceae*)

Fresh fronds are applied topically to boils and bladder issues. Rhizome is used to treat typhoid fever, intestinal wounds, and as an antiseptic (Rout et al. 2009; Singh & Upadhyay 2012). This plant is often used to treat urinary and male erectile dysfunction (Singh et al. 2005).

17. ***Blechnum lanuginosum*** Wall. ex Hook et Grev.

Also known as Grape Fern. As a vegetable, young fronds are consumed. Rhizomes are boiled and used to cure flulike symptoms and pneumonia. Traditional marriage and perhaps other ceremonies employ rhizome extract and paste as a skincare routine (cosmetic) (Nwosu 2002).

18. ***Cheilanthes bicolor*** (Roxb.) Gri. ex Fras. (*Sinopteridaceae*)

Lip fern is the English name of this plant. Powdered leaves and root like structure combined with cow's ghee are used as a remedy and to help children overcome their fear. The girls decorate their ears and noses with

the stem. Rhizome is a medicinal plant (Singh & Upadhyay 2012).

19. *Cadaba farinosa* (Forsk.) Kaulf

Also known as Chandibooti, Nanha, Silver fern, and Pandhar. For a week, take a leaf infusion (10–15 ml) orally to combat inconsistent menstruation. Additionally, the decoction treats colds and fevers (one teaspoonful in a day up to 3 days). Rhizome paste is used to treat eczema and wounds. For stomach ache, rhizome decoction is used (Singh et al. 2005).

20. *Cyathea spinulosa* Wall. ex Hook. (*Cyatheaceae*)

This herb is used as a hair tonic and to prevent hair from going grey. Additionally, used as a sudorific and aphrodisiac in the form of leaf powder (Singh & Upadhyay 2010). Drinks made locally use rhizomes and soft stems. Leaves are employed as a source of food and to construct the houses' roofs (Upreti et al. 2009).

21. *Dicranopteris linearis* Burm. f. (*Gleicheniaceae*)

Rajhans, Thicket fern, and Underwood are other nomenclatures of this plant. After boiling, young rachises are consumed. Children's diarrhea can be treated using spores (Singh et al. 2005). Plant decoction is a laxative that is also used to relieve throat discomfort. The usage of fronds in asthma. The fronds' aqueous extracts have antibacterial and anti-cancerous effects. Additionally, epileptic fits employ it. In order to cure female sterility, young plant frond powder mixed with cow milk is employed (Singh 1999; Singh et al. 2005; Upreti et al. 2009; Singh & Upadhyay 2012).

22. *Diplazium esculentum* (Retz.) Sw. (*Athyriaceae*)

Also known as Vegetable fern and Kataraphala. Root and rhizome extracts are used by tribes as a natural remedy (Dixit 1989). Roots are weak points. For washing hair, the plant's decoction is utilized. To prevent insects and pests, rhizome is stored in the food stocks. Young fronds are used as a green vegetable, as well as in salads and cooked dishes (Singh & Upadhyay 2012; Srivastava et al. 2015). Scabies is treated with a leaf decoction. The leaf juice works well as a tonic for jaundice, asthma, and cough. Young frond infusion is used to treat toothaches (caries), and pregnant women might use it to prevent painful delivery (Nwosu 2002).

23. *Drynaria quercifolia* (L.) J. Smith. (*Polypodiaceae*)

Heart problems are treated internally with rhizome paste along with jaggery (Singh and Upadhyay 2012). Typhoid fever is treated using fronds, rhizomes, and stems. Fronds are also administered to inflammatory response (Singh et al. 2005; Kumari et al. 2011). An extract from the fronds is antimicrobial and is utilized to treat stomach issues, migraines, feverish fever, and tuberculosis. Additionally, it has antibacterial and expectorant properties (Warrier et al. 1996).

24. *Drynaria wallichiana* (Spreng.) Hyl.

Also known as Mountain food fern. In addition to being utilized as manure for domestic crops, leaves are fed to goats and sheep. Drinking rhizome tonic to prevent rheumatism (Nwosu 2002).

25. *Dryopteris cochleata* (D. Don) C. Chr. (*Dryopteridaceae*)

Kakolisag and Jatashankari are other names of this plant. A cooling medication for gonorrhea 50 is made from the fronds, rhizomes, and stem extract. In the event of a snake bite, it is given orally (twice per day). To prevent infection, plant paste is also applied to the bite site (Verma et al. 1995). Rhizomes have antimicrobial and antiepileptic properties (Singh 1999). Leprosy, rheumatism, and epilepsy are treated with rhizome powder taken with water twice day (Shah & Singh 1990). To cure severe diarrhea, the roots' decoction (approximately two tablespoons twice a day) is used (Manandhar 1996).

26. *Equisetum ramosissimum* Desf. (*Equisetaceae*)

Bone fractures are treated with plant paste. For gonorrhea, 10–15 ml of the rhizome's decoction were taken orally for 7–14 days (Upreti et al. 2009; Kumari et al. 2011). To aid in female fertilization, the same

amount is administered orally twice daily for a month. According to Vasudeva (1999), Singh et al. (2003), Singh et al. (2005), and Singh et al. (2007), the powder from the rhizome, stem, and branches is applied topically to treat scabies and related skin problems.

27. *Helminthostachys zeylanica* (L.) Hook. (*Helminthostachyaceae*)

The plant is used to treat sciatica and is thought to be intoxicating and anodyne. Fronds are employed as aphrodisiacs, euphoric, and analgesics (Singh & Upadhyay 2012). Whooping cough, impotence, and sciatica can all be treated with rhizome.

28. *Hypodematium crenatum* (Forssk.) Kuhn (*Woodsiaceae*)

To aid in conception in women, 5–10 g of dry fronds powder and fresh cow milk are taken orally after five days of menstruation for roughly a week (Nwosu 2002).

29. *Isoetes coromandelina* L.f. (*Isoetaceae*)

In addition to being employed by indigenous people in witchcraft (Jadu-tona), the plant is used to treat rheumatism (Singh & Upadhyay 2012). Additionally, it is applied to the treatment of liver and spleen conditions (Kumari et al. 2011).

30. *Isoetes panchananii* D.D. Pant & G.K. Srivast.

Tribal folks utilize spores in a necklace to ward off bad spirits (Singh & Upadhyay 2012).

31. *Lycopodium cernuum* (L.) Pic (*Lycopodiaceae*)

Lotion made from frond and rhizome extract is used to treat skin eruptions. It is also prescribed for cough issues and beriberi (Singh & Upadhyay 2012).

32. *Lycopodim volubile* L.

It is used to treat rheumatism, lung conditions, flatulence, and pediatric illnesses. The spores are widely used to treat skin conditions like eczema and wounds (Singh & Upadhyay 2012).

33. *Lygodium flexuosum* (L.) Sw. (*Lygodiaceae*)

Skin conditions are treated using rhizome powder. The antispasmodic properties of leaf and roots are employed in the treatment of arthritis, spasms, scabies, dermatitis, and cut wounds. Fresh roots cooked in mustard oil are used to treat rheumatism and casbundes (Singh & Upadhyay 2012). Children are given one tablespoon of leaf powder mixed with milk orally to help with memory. The use of spores to treat high fever (Srivastava et al. 2015).

34. *Marsilea minuta* L. (*Marsileaceae*)

Fronds are utilized for drowsiness, sleeplessness, fever, cough, bronchitis, diarrhea, leprosy, and spastic disorders of the leg muscles (Singh & Upadhyay 2012). Tribal people also use it as food and use it to treat pain (Srivastava et al. 2015).

35. *Nephrolepis cordifolia* (L.) Presl. (*Nephrolepidaceae*)

Tuberous sword fern is another popular name of this fern. To stop bleeding, wounds are treated with fronds paste. Pinnae are used to treat jaundice, cough, and wounds because they are antibacterial and antifungal (Kumar et al. 2003). One dose of rhizome extract (10–15 ml) given to women throughout their menstrual cycle causes them to become permanently sterile. used as a contraceptive (Dhiman 1998, Singh et al. 2003, 2007). Rhizome is utilized for cough, rheumatism, chest congestion, nose obstruction, and appetite loss since it has antimicrobial properties. (Singh 1999). Tuber extract is also used to treat coughs and gastrointestinal problems. Fresh watery tubers are boiled with salt and water and eaten as food to treat stomach ulcers and acidity (Upreti et al. 2009; Singh & Upadhyay 2012).

36. *Nephrolepis exaltata* (L.) Schott

Commonly known as Fish bone fern. For a month, Female infertility was treated with the administration of 10 to 15 ml of rhizome extract. (Singh et al. 2005). Additionally, Birth-aid and the therapy of menstruation diseases both make use of it. The tubers are chewed and then rinsed with water to treat dental, kidney, sinus, toothache, and liver issues. Rhizome extract is used to treat female infertility.

37. *Ophioglossum reticulatum* L. (*Ophioglossaceae*)

As a cooling agent, burns are treated with a paste made from leaves and rhizomes. The extract of fronds is used to make tonic, as a vulnerary, and as a wound treatment (Singh & Upadhyay 2012). In cases of menstrual difficulties, fresh fronds are combined with rice, boiled, and given orally for two to three days on an empty stomach. For two weeks with leucorrhoea and urinary haemorrhage, a decoction of the leaves and rhizome is administered orally once day. It is also given to new mothers as a tonic to increase their strength (Singh 1999).

38. *Osmunda regalis* L. (*Osmundaceae*)

Royal fern is the popular name of this fern. As an abortifacient, rhizome extract is used twice daily. Intestinal discomfort, rheumatism, and rickets are all treated using leaves and rhizomes (Nayar 1959; Singh & Upadhyay 2012).

39. *Pityrogramma calomelanos* (L.) Link (*Pteridaceae*)

To treat renal issues, rhizomes and fronds are cooked in water, and the extract is then consumed orally in the morning (Sukumaran & Kuttan 1991; Senger & Somvanshi 2000). Asthma and head-and-chest colds can be treated with leaves. It has antimicrobial properties (Banerjee & Sen 1980). For boils in the mouth and nose, an oral leaf extract is used (Kumar et al. 2003).

40. *Pteridium aquilinum* (L.) Kuhn. (*Dennstaedtiaceae*)

Roots are utilized as an antibacterial and astringent. Additionally, it can be used to treat intestinal and stomach mucous membrane inflammation. Chronic visceral and splenic illnesses are treated with extract of rhizomes and leaves (Giri et al. 2021).

41. *Pteris ensiformis* Burm. f. (*Pteridaceae*)

The juice from the fronds is used as a cooling agent as well as an astringent diuretic to treat diarrhea and malaria. Fresh leaf extract is administered for neck glandular edema (Singh et al. 2005).

42. *Pteris quadriaurita* Retz.

Rhizome paste is applied to remove pus and treat inflammation extremely quickly (Singh et al. 2005).

43. *Pteris vittata* L.

Plant extract is used as a demulcent, hypotensive, and tonic and contains antiviral and antibacterial properties. Fronds were used in devotion when people were ill. Wound healing is aided by the aqueous leaf extract of fronds and rhizomes. To make a tonic, they are cooked in four times as much water. The entire plant, whether young or mature, is utilized as feed (Singh & Upadhyay 2012).

44. *Pteris wallichiana* J. Agardh

Boiling young leaves allows for seasoning purposes. It is also well known that leaf extract has astringent qualities. In dysentery, a leaf and root extract are administered, and glandular inflammation is treated with it. To treat newborns' skin conditions, roasted leaves and sesame oil are utilized (Singh & Upadhyay 2012).

45. *Salvinia molesta* Mitchell (*Salviniaceae*)

In addition to being used for asthma, bronchitis, and bee stings, the plant also possesses antifungal properties (Singh 1999). Fresh root decoction is utilized to regulate children's uncontrollable movements. (Dixit & Vohra 1984). Stomach issues are treated by young, cooked stem (Manandhar 1996).

46. *Selaginella bryopteris* (L.) Bak. (*Selaginellaceae*)

This plant is also called Sanjeevani. As a laxative and for gonorrhea, it is used. This plant is used by tribal people for witchcraft and in rituals to create illusions. People in the area smoke tobacco and dried leaves (Singh & Upadhyay 2012). In cases of gonorrhea and other sexual disorders (such as spermatorrhoea and leucorrhoea), fresh leaf paste is administered twice daily (Singh et al. 2003, 2005, 2007).

47. *Sphaerostephanos unitus* L. (*Thelypteridaceae*)

It is applied on sprains and inflammation. Tea leaves can be replaced with dried leaves. Additionally, it is

taken internally as a diuretic and for chronic enteritis (Singh & Upadhyay2012).

48. *Tectaria cicutaria* (L.) Copal (*Tectariaceae*)

The button fern is the popular name of this plant. The herb has an antibacterial effect. It treats bronchitis, honey bee stings, and asthma (Singh 1999). Children with loose motion are treated with an infusion of the fresh root. (Dixit & Vohra 1984). Roots are used as a tonic, blood purifier, and blood dysentery combined with black pepper and cow's milk. Menstrual issues are treated with rhizome combined with *Zingiber purpureum* and *Croton roxburghii* (Singh et al. 2005). For the treatment of stomach issues, fresh, cooked stem is employed (Manandhar 1996).

49. *Tectaria coadunata* C. Chr

The plant's extract is applied to colitis. In cases of gastrointestinal problems, children are given root extract (Upreti et al. 2009). Woodcutters employ leaf paste to replace the agony produced by centipede and honey bee stings (Sharma & Vyas 1985).

50. *Tectaria wightii* (Clarke) Ching

This plant's roots are employed like an antiseptic (Dixit & Vohra 1984).

51. *Vittaria elongata* Sw. (*Vittariaceae*)

Also known as stiff shoestring fern. This fern's leaves are used to alleviate rheumatism on the Andaman and Nicobar Islands (Kumar et al. 2003).

52. *Woodwardia unigemmata* (Makino) Nakai (*Blechnaceae*)

It is utilized to treat dysentery (Gaur & Bhatt 1994).

DISCUSSION

For the advantage of individuals everywhere, the medical value should be acknowledged and spread (Tables 1–3). Every species of fern has unique micro environment preferences that depend on factors like temperature, humidity, soil type, wetness, pH, light intensity, *etc*. These preferences are exact indicators of the parameters a species needs to thrive. Except for species that favor more xeric circumstances and are more heliophilous, it is well known and documented that the majority of fern species thrive under high humidity and shade conditions (Dudani et al. 2014).

The presence of some species, such as *Nephrolepis biserrata* (Sw.) Schott, *Adiantum* spp., *Asplenium africanum* Desv., *Ctenitis lanigera* (Kuhn) Tardieu, *Cyclosorus striatus* (Schum.) Ching, *Dryopteris variabilis* (Hook.) Alston, and *Pteris marginata* Sw., with high relative frequency, indicates that those species are likely to persist there, whereas *Bolbitis acrostichoides* (Afzel. ex Sw.) Ching, *Ctenitis barteriana* (Hook.) Alston, *Cyclosorus afer* (Christ.) Ching, *Pteris atrovirens* and *Tectaria fernandensis* exist with less relative frequency and may become extinct in the near future. Similarly, the high relative frequency of *Dryopteris manniana* (Hook.) C. Chr., *Nephrolepis biserrata* (Sw.) Schott, and *Acrostichum aureum* L. in Lagos State suggests that they are likely to stay there, whereas the low relative frequency of *Lygodium microphylum* (Cav.) R. Br. and *Lygodium smithianum* C. Presl suggests that they may become rare in the future (Akinsoji et al. 2016).

All ferns of therapeutic value should be preserved, and actions are needed to stop their extinction. The following are only a few of the many tasks involved in managing these ferns:

a. It should be made simple for people to participate actively in efforts to solve fern problems at all levels.
b. We need to get a variety of perspectives and a fundamental grasp of the surroundings and the issues that these medicinally important plants's habitats face.
c. We should develop a set of environmental values, sentiments of worry, and the drive to actively contribute to environmental betterment and the preservation of these ferns.
d. To keep livestock out of the vicinity of the habitation of medicinally significant ferns, a wire fence should be built.
e. We should also have the ability to recognize and address issues with ferns that are significant from a medical standpoint.

Table 1. Pteridophytes having anti-cancerous activity

Name of Pteridophyte	*Order*	*Family*	Method	Source
Angiopteris evecta (G. Forst.) Hoffm.	*Marattiales*	*Marattiaceae*	Traditional Chinese medicine	Defilpps et al. 1998
Asplenium polyodont G. Forst.	*Polypodiales*	*Aspleniaceae*	Ancient Indian drug.	Singh 1999, Santhosh et al. 2014
Cyrtomium fortunei J. Sm.	*Polypodiales*	*Dryopteridaceae*	*In vitro* MTT experiment using the tumour cells MGC-803, PC3, and A375	Yang et al. 2013
Drynaria fortunei (Kunze ex Mett.) J. Sm.	*Polypodiales*	*Polypodiaceae*	Chinese herbal medicine	Punzon et al. 2003, Cai et al. 2004, ChPC 2005, Chang et al. 2007
Hemionitis arifolia (Burm. f.) T. Moore	*Polypodiales*	*Pteridaceae*	Indian herbal traditional medicine	Santhosh et al. 2014
Marsilea quadrifolia L.	*Salviniales*	*Marsileaceae*	Cytotoxic activity *in vitro* against MCF-7	Uma & Pravin 2013
Pityrogramma calomelanos (L.) Link	*Polypodiales*	*Pteridaceae*	Ehrlich ascites tumour cells and Dalton's lymphoma ascites tumour cells were both susceptible to *in vitro* cytotoxicity.	Sukumaran & Kuttan 1991, Shin 2010, Zakaria et al. 2011, Milan et al. 2013
Polypodium nipponicum Mett.	*Polypodiales*	*Polypodiaceae*	A two-stage carcinogenesis test was conducted in vivo on mouse papillomas.	Konoshima et al. 1996
Pteridium aquilinum (L.) Kuhn	*Polypodiales*	*Dennstaedtiaceae*	Discovered cancer-fighting substances.	Nwiloh et al. 2014
Pteris semipinnata L.	*Polypodiales*	*Pteridaceae*	Human gastric adenocarcinoma cell line (MGC-803); *in vitro* MTT assay in HL-60 cells; human nasopharyngeal carcinoma cells; human liver adenocarcinoma cell line (HePG II); *in vivo* anticancer activity.	Baskaran et al. 2018
Selaginella willdenowii (Desv. ex Poir.) Baker	*Selaginellales*	*Selaginellaceae*	Cytotoxic effect *in vitro* against human tumor cell lines.	Lee & Lin 1988, Silva et al. 1995, Sun et al. 1997

f. Considering environmental, commercial, ethical, artistic, and academic elements, we should assess the environmental protections and educational initiatives for ferns. Educated people should educate others on the technique of tissue culture for fern reproduction (Srivastava 2007).

CONCLUSION

The neglected category of plants known as pteridophytes needs a lot of applied study since they have significant medical, economic, and ecological importance. More information about the benefits of these plants will be revealed through in-depth research on the medicinal use of pteridophytes by local communities. It can be applied to promote human welfare.

In recent years, several researchers have examined the phytochemical and therapeutic benefits of lycophytes and ferns. These studies have shown the significance of ferns and its associates in the study of plants. The review may promote an understanding of pteridophytes' uses beyond decorative ones and, in particular, usage and enhancement for therapeutic purposes. This article demonstrates the variability of medicative pteridophytes with useful bioactive compounds present in the surroundings with regard to the cure of different ailments (Figure 1). There are significant gaps in our knowledge of the pharmacological activities and phytochemical traits of pteridophytes used medicinally by Indian ethnic minority.

Since the majority of the information is still held informally by the local community without any written records, its collection and documentation are urgently required. To further the nation's development and conservation, ethno-pteridological information may be efficiently collected, preserved, and applied.

High species diversity is also a result of the availability of numerous microhabitats that are conducive for the creation and sustenance of pteridophyte flora dispersed throughout multiple environments. Because

Table 2. Pteridophytes having anti-viral activity

Order	Family	Name of pteridophyte plant	Method	Source
Hymenophyllales	*Hymenophyllaceae*	*Trichomanes reniforme* G. Forst.	HIV infection-fighting capacity *in vitro*	Guha et al. 1996
Marattiales	*Marattiaceae*	*Angiopteris evecta* (G. Forst.) Hoffm.	Test for glucose tolerance *in vivo*	Miao et al. 1996, Nguyen 2005
Polypodiales	*Aspleniaceae*	*Asplenium adiantum-negrum* L.	Ancient Indian drug	Vasudeva 1999
		Asplenium polyodon G. Forst	Ancient Indian drug	Singh 1999, Chand et al. 2013, Santhosh et al. 2014
	Polypodiaceae	*Microsorum membranifolium* (R. Br.) Ching	Ancient Fijian medicine	Cambie & Ash 1994
		Pyrrosia lingua (Thunb.) Farw	Antiviral efficacy against the Herpes simplex virus *in vitro*	Zheng 1990
	Pteridaceae	*Adiantum capillus-veneris* L.	In general glucose tolerance testing, Indian traditional medicine, and traditional medicine from Amazon	Jain & Sharma 1967, Taylor 2003, Santhosh et al. 2014, Neef et al. 1995
		Hemionitis arifolia (Burm. f.) T. Moore	Traditional Indian medicine, an in-vivo glucose tolerance test, and diabetic rats that had been given the drug alloxan as well as a similar test with the drug streptozotocin.	Ajikumaran et al. 2006, Kumudhavalli & Jaykar 2012, Santhosh et al. 2014
		Pteris glycyrrhiza L.	Viral activity against the kind of bovine herpes virus *in vitro*	McCutcheon et al. 1995
	Thelypteridaceae	*Christella dentata* (Forssk.) Brownsey & Jermy	Tests for glucose tolerance *in vivo*	Paul et al. 2012, Tanzin et al. 2013, Sultana et al. 2014
Schizaeales	*Lygodiaceae*	*Lygodium flexuosum* (L.) Sw.	Ancient Indian drug	Dhiman 1998
		Lygodium japonicum (Thunb.) Sw.	Herpes simplex, Sindbis, and polio viruses have antiviral action *in vitro*	Taylor et al. 1996

Table 3. Pteridophytes having Anti-inflammatory activity.

Order	Family	Name of pteridophyte	Method
Cyatheales	*Cyatheaceae*	*Alsophila gigantean* Wall. ex Hook.	Traditional Indian medicine
		Cyathea gigantean (Wall. ex Hook.) Holttum	Anti-inflammatory properties *in vitro*
Lycopodiales	*Huperziaceae*	*Huperzia serrata* (Thunb.) Trevis.	Traditional Chinese medicine
Ophioglossales	*Ophioglossaceae*	*Ophioglossum vulgatum* L.	Ancient Indian drug
Polypodiales	*Dryopteridaceae*	*Dryopteris abbreviata* Newman	Method for *in vivo* Carrageenan-induced paw oedema
	Gleicheniaceae	*Dicranopteris linearis* (Burm. f.) Underw.	Anti-inflammatory properties in vitro
	Polypodiaceae	*Drynaria quercifolia* (L.) J. Sm.	Ancient Indian medicine
		Microsorum scolopendria (Burm. f.) Copel.	In Tonga ancient herbal medicine
		Microsorum grossum S.B. Andrews	Ancient herbal medicine
		Phlebodium decumanum (Willd.) J. Sm.	Anti-inflammatory properties *in vitro*
		Polypodium leucotomos Poir.	Ancient herbal medicine in Bolivia
	Pteridaceae	*Adiantum caudatum* L.	Traditional medicine in Malay Peninsula
		Cheilanthes farinose (Forssk.) Kaulf.	Anti-inflammatory properties *in vitro*
	Thelypteridaceae	*Christella parasitica* H.L	Traditional Indian medicine
Selaginellales	*Selaginellaceae*	*Selaginella tamarascina* (P. Beauv.) Spring	Anti-inflammatory properties *in vitro*

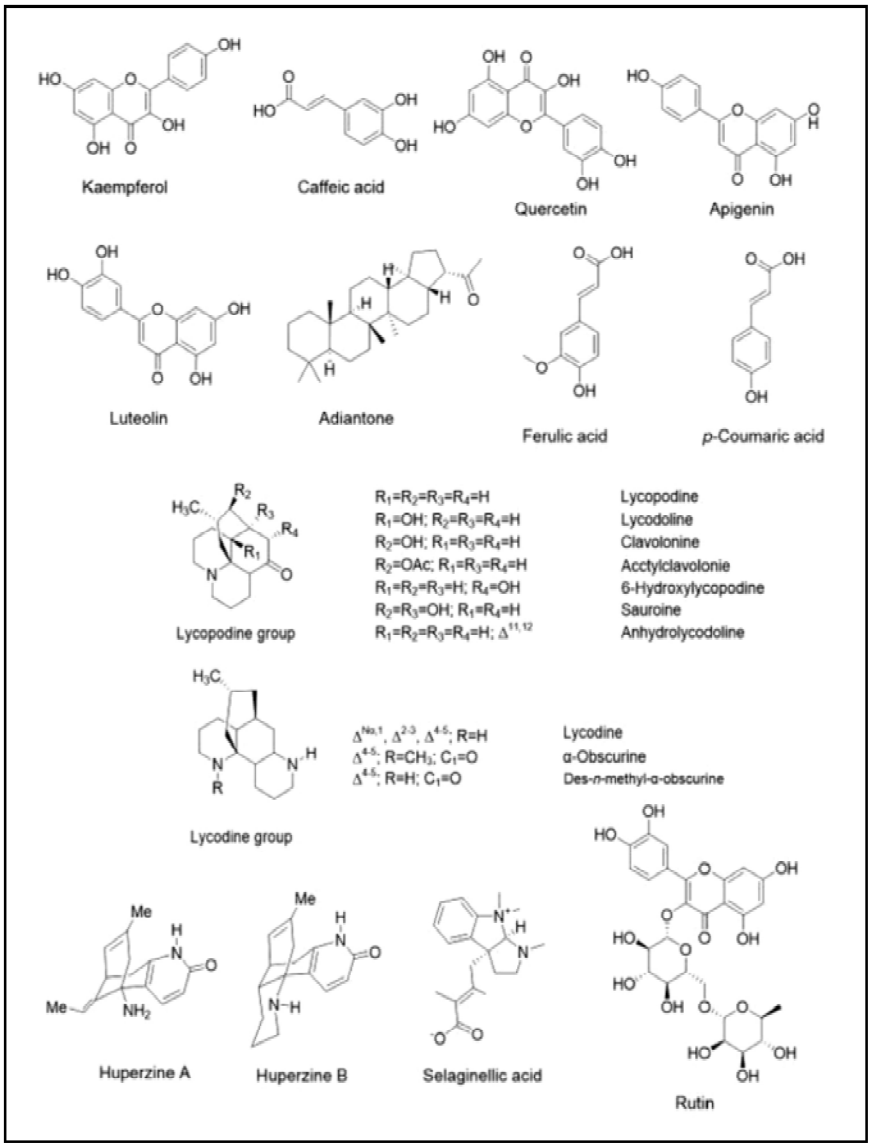

Figure 1. The various bioactive substances found in pteridophytes (Baskaran et al. 2018).

of changing climatic, vegetational, and anthropogenic conditions, fern species require both in situ and ex situ protection. It has been noted that both rural and urban populations rely heavily on medicative pteridophytes as a source of treatment for a variety of illnesses. They have in-depth understanding of ethnobotany in relation to therapeutic pteridophytes. This review reveals the importance of pteridophytes; therefore, we must protect and conserve them for future use.

ACKNOWLEDGEMENTS

The authors express gratitude to Prof. Ina Aditya Shastri, Vice-Chancellor, Banasthali Vidyapith, Rajasthan for her support and encouragement. We also thank Department of Science & Technology, Government of India for providing networking support through the FIST Program at the Department of Bioscience and Biotechnology and Bioinformatics Centre, Banasthali Vidyapith, funded by Department of Biotechnology, Government of India.

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