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REVIEW ARTICLE **OPEN ACCESS**

Himalayan Ferns: an Ethnomedicinal Species having Variable Pharmacological Activities

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ABSTRACT

The Himalayas have incredible resources of plants having ethnomedicinal importance and conventional restorative information. There are some species of ferns till now surveyed for different pharmacological activities and found to have efficacy for anticancer, antimicrobial, antioxidant, antiviral, antifungal, wound healing, anti-inflammatory, anti-bacterial, treatment in paralysis, cerebral ischemiabruises, liver toxicity etc. We have reviewed most of the ferns possesses antimicrobial, antibacterial, antifungal and antioxidant properties. Traditionally, some species like Pterisvittata, Pteris cretica, Genus –Dryopteris and many others are used in different medicines. These pteridophytes are also used widely used in Chinese medic Ines. Some ferns genus like clubmosses,spike-moss selanginella ten era, horsetails, quillwort's and Wisk ferns also have bioactive and therapeutic properties. Club mosses have many medicinal uses like urinary tract problems, diarrhea and other digestive tract problems, relieving headaches and skin ailments, and including labor in pregnancy. Selaginella is used for coughs, sore throats, and jaundice, cancer of the liver and also for the cirrhosis of the liver. The medicinal benefits of horsetails are diuretic, skin and nail care, wound healing, bone repair and in osteoporosis. Still there are several species to be explored against different pharmacological activities. Our research group is discovering more bioactive ferns which may have some more medicinal properties that can be used for different kinds of diseases.

Keywords: *Himalayan ferns, pharmacological activities, medicinal uses, ethnomedicinal.*

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INTRODUCTION

Fern are a group of plants which propagate through spores present on the dorsal side of the leaves. These are the vascular plants which doesn't have seeds, flowers, fruit or any kind of common reproductive part of plants. They are different in their habitat, form and reproductive method than any other plants. There are about 15,000 species of ferns estimated worldwide, in which 10,500 species are identified [1].Most of them have antioxidant and antimicrobial activity. Most common ferns have been proved for antibacterial activities against various gram positive and gram-negative bacteria. Ferns are categorized as the rich source of chemical constituents having a lot of medicinal activities. The common pharmacological use of medicinal Himalayan ferns is antioxidant, antimicrobial, diuretic, antibacterial, anticancer, antifungal, anti-asthmatic, anti-inflammatory, wound healing etc. The vegetative terrains of Himalayas in India, from Jammu Kashmir to West Bengal consist of boundless of species of ferns having various medicinal properties. In Kashmir valley, family Dryopteridaceae and Woodsiaceae are the most common followed by Aspleniaceae, Pteridaceae and some species of genus Polystichum [2]. The region of Uttarakhand is the rich source of various species of ferns having different pharmacological activities. The Kumaon region starts from Kathgodam (Nainital) to Pithoragarh district have a cluster of species commonly *Pteris vittata, Pteris cretica, Adiantum capillus-veneris, Pteridium aquilinum, Asplenium nidus, Blechnumm orientale, Diplezium esculentum, Polystichum vestitum* to the uncommon *species Thelypteris arida, Dryopteris Expansa, Diplazium melanochlamys, Blechnum novae-zelandiae* (kiokio fern), *Christella normalis*. It has occupied an area 21,033 sq km and made up of six districts [3]. The other region of Uttarakhand is Garhwal where mostly the species of ferns are same as in Kumaon, followed by Sikkim and Darjeeling but in diverse form. Garhwal region have much dense forests and marshy lands and their diversity of fauna and flora are also more in comparison to Kumaon region. Sikkim, Darjeeling and Arunachal Pradeshcome under a big hotspot of Indian North-eastern biodiversity[4].In Himachal Pradesh, the most common ferns and fern allies are *Adiantum capillus-veneris* L., *Adiantum incisum* Forssk., *Asplenium dalhousiae* Hook, *Athyrium attenuatum* (Wall. ex Clarke) Tagawa, *Cheilanthes bicolor* (Roxb.) *Fraser-Jenkins*, *Equisetum*

ramosissimum Desf., *Onychium contiguum* Wall. ex Hope, *Onychium plumosum* Ching, *Pteris cretica* L., *Pteris vittata* L., *Selaginella chrysocaulos* (Hook. & Grev.) Spring and *Thelypteris dentata* (Forssk.) John [5]. However, ferns have medicinal effects majorly, but nowadays it also used in biofertilizers, as an ornamental plant, treatment of contaminated soil and in some regions as a food also. Some are medicinal in properties and some are still in the stage to be explored.

MATERIAL AND METHODS

A scientific search has begun from the respectable science and herbal journals and web search engines which act as a great enhancer for our study. The utilized journals were Research gate (https://www.researchgate.net/), PubMed (https://pubmed.ncbi.nlm.nih.gov/), Web of Science (https://webofknowledge.com),Google Scholar (https://scholar.google.com/). The study was started with the deep and precise search in these databases on various family, genus and species of ferns respectively. Species of genus Adiantum, Pteris, Dryopteris were mainly found in study of various pharmacological activity possessed by pteridophytes. A review of various articles and literature were done on the basis of initiative and current study from 1980 -2020. References through numbering system in English language with full text and year of published were given on the study of various Himalayan ferns. There are references which provide the information about the descripted review on Geographical distribution of Himalayan ferns, Traditional uses, Pharmacological importance and recent advances and future scope of Himalayan ferns. The references provide knowledge of following species such as *Pteris vittata, Pteris cretica, Adiantum capillus-veneris, Pteridium aquilinum, Asplenium nidus, Blechnumm orientale, Diplezium esculentum,Cheilanthes albomarginata,Actiniopteris radiata* and *Caralluma adscendens,Yucca samilliana,Salvenia molesta.*

Geographical distribution of Himalayan ferns

In India, Pteridophytes are the second largest flora after the flowering plant. They generally grow where the water content in the localization is high. Himalayas arranged adjacent to China from Jammu and Kashmir, Himachal Pradesh to Uttarakhand. They share Himalayan ranges as a border between India and China. Much portion shared by Nepal and Bhutan. The Eastern part of Himalayas is covered by Sikkim and Arunachal Pradesh states of India. The tropical, sub-tropical and moist deciduous forest in these states connecting to Himalayas are the rich sources of various medicinal fern. The traditional ethnomedicinal uses of ferns originate from these vegetative forests. Fern species also have diversity according to their altitude, temperature, climate, type of soil etc. Though the species name's and their traits can be same at different propagating locations, but their chemical constituent and activity may differ. Jammu and Kashmir region covers different forest mainly deodar, kail, fir and broad-leaved forest. In some regions, the western disturbance due to western atmospheric depression cause much snowfall and rainfall. It causes some regions as low land and high land. Low lands are generally used as crop fields, gardens, grassland, pastures, flower and orchards etc. High lands are rich in vegetation having a diverse level of plants [2]. Himachal Pradesh is full of different ferns and clubmosses. It has been claimed that in this region a species called *Cheilanthes albomarginata* has the highest relative water content with a good revival activity. It means they have high potential to stand out even in drought. There are approximately 250 ferns have been collected in Himachal Pradesh [6].Uttarakhand state is divided into two divisions namely Kumaon region and Garhwal region. Himalayas of Kumaon are the mid-point of overall Indian Himalayas which lies between the coordinates 28°44'- 30° 49' N Lat. and 78° 45'- 81° and 1' E long. The valleys in the Kumaon are Kali valley, Gori valley, Ramganga valley, Pindari valley are most wealthy areas for tropical ferns [3]. Garhwal region comprises five districts which are Uttarkashi, Chamoli, Tehri, Pauri Garhwal and Dehradun. Garhwal Himalayas has peaks namely Nilkantha, Chaukhamba, Trisul and Nandadevi have connecting forest with maximum biodiversity. Due to the analysis, it has been confirmed that soil in these areas is varied from sandy to gravel form with immense stone at some places from brownish black to grey with alkaline in nature. In the region where less vegetation is present, *Pinus roxburghii* is the major species followed by *Cedrus deodara* [7]. In Sikkim, the estimated no. of ferns is around 9000 to 15000 species. According to the coordinates of the world map, Sikkim lies between88° 00'58'' - 88° 55'25''E and 27° 4'00" - 28°7'48" N and spread over 7096 square km [4]. Sikkim is the country which surrounds with three international boundaries that is Tibet (province of China), Bhutan and Nepal. Sikkim biodiversity is much similar to Darjeeling of West Bengal as they are connected with one of the state boundaries. They are called as the hotspot of the Himalayan biodiversity because this region has varied climate, temperature, diverse altitudes in support with the Himalayas which makes so rich in diverse species. It comes in the count of 17 mega biodiversity of the country [4]. Nearby this, the north-eastern state of Arunachal Pradesh also comes in the hotspot of Himalayan biodiversity which have 83,743 square kilometers of are with much biological richness. It is surrounded with China, Myanmar and

Bhutan. This state is also identified as the place where 50% of the total flowering plant species can be found [8].

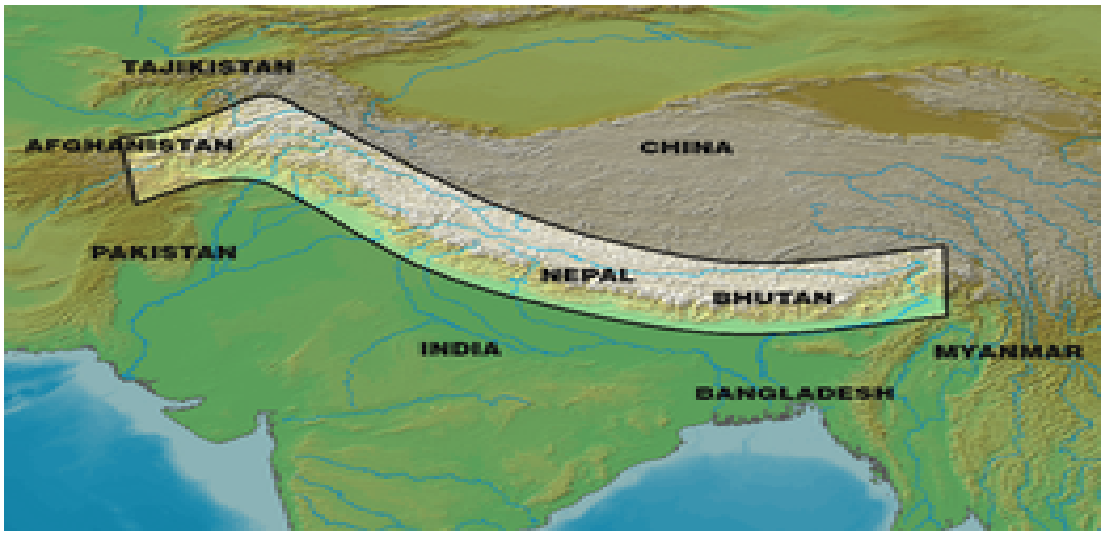


Figure 1. Countries surrounded by Himalayas adjacent to India

Source: Physiographic Divisions of India: (https://www.iasmania.com/physiographic-divisions-of-india/ accessed on -5/02/2021)

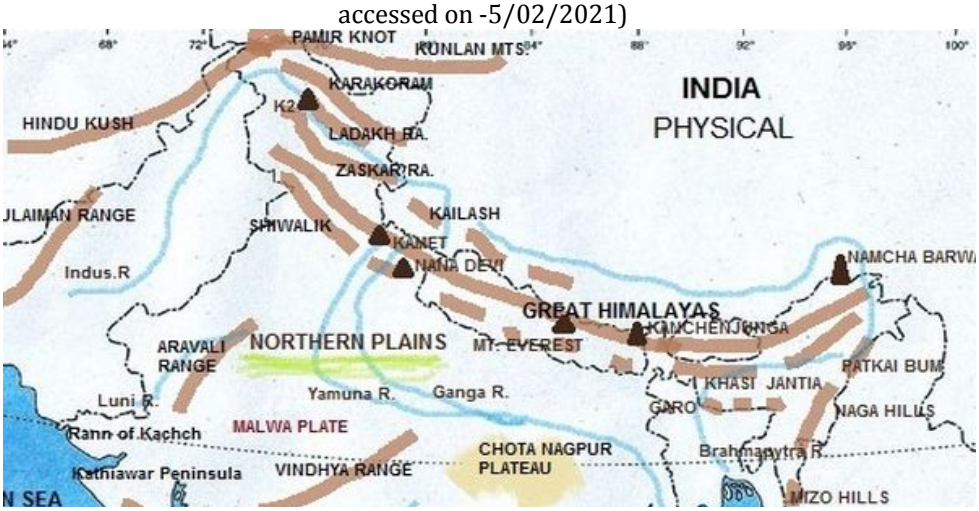


Figure 2.Himalayan ranges

Source:(https://en.wikipedia.org/wiki/Himalayas accessed on - 05/02/2021)

Traditional use of Himalayan ferns

Traditional use of pteridophytes has been known from about 2000 years ago. In the old collection of manuscripts like Sashruta and Charaka have mentioned different ferns with their therapeutic use. Theophrastus and Dioscoroides referred many times fern as a medicinal herb. These ferns had been used as a traditional medicine from one generation to another as recorded in the classical literature like Ayurveda, Unani, Siddha etc. In the medieval and ancient literatures all over the world mentioned ferns, bryophytes and various other herbs as medicinal plants with different pharmacological activities. In developing countries, ferns are still used to treat various sickness and maladies as they have specific use in different fields with less side effects. They have been used as herbal products in primary healthcare for cultural and economic reasons. Traditionally they were used as a purgative and antibacterial to treat renal and gastric infections [9]. They were also used as diuretics, pain killers (to treat headache, stomachaches, gastrointestinal aches) and anti-inflammatory agents. Related literature described that different parts of the ferns (rhizomes, stems, fronds, pinnae, and spores) were utilized in various ways using recipes specific to each region. Related literature described that different parts of the plants (rhizomes, stems, fronds, pinnae, and spores) were utilized in various ways using recipes specific to each region. Plant based remedies are delivered either by external application (topical applications such as lotions, frictions, poultices, eye drops, fumigations, baths, and gargles) or by internal intake formulated in different ways (potions) [9]. Some of the traditionally known species are so magnificent that treatment of

various ailments are comprises only in a single species. Table-1 has been depicted to know some of the traditionally used ferns having treating ability to various disorders.

Table 1: Some traditional fern with their ethnomedicinal uses:

S. N.	FAMILY	GENUS	SPECIES	TRADIONAL USES	REFERENCE
1.	Pteridaceae	Pteridium	aquilinium	astringent, anthelmintic gastric acid and intestinal inflammation treatment	[10]
2.	Pteridaceae	Pteris	biureta	chronic disorders	[3]
3.	Selaginellalceae	Selaginella	bryopteris	diuretic and gonorrhea treatment	[3]
4.	Tectariaceae	Tecttaria	coadunate	Colitis and stomachache treatment	[3]
5.	Thelypteridaceae	Thelypteris	arida	wound healing	[3]
6.	Polypodiaceae	Phyllitis	flexuosum	expectorant, in rheumatism, sprains, scabies, eczema and for treating cuts, liver disorder treatments	[3]
7.	Polypodiaceae	Phyllitis	japonicum	Diuretic, Antispasmodic, In Rheumatism and In Treatment of Pulmonary And Renal Disease	[3]
8.	Nephrolepidaceae	Nephrolepis	cordifolia	Wound Healing, Antitussive, Intestinal Disorders, Stomach Ulcers, And Treatment of Acidity	[3]
9.	Ophioglossaceae	Ophioglossum	reticulatum	To Treat Burns, As A Tonic, In Wound Healing	[3]
10.	Gleicheniaceae	Dicranopteris	linearis	Laxative, Anthelmintic,Antibacterial,In Asthma and Women Sterility Treatment	[3]
12.	Heliminthostachyaceae	Helminthostachys	zeylanica	Intoxicant, In Sciatica, Aphrodisiac Antidiabetic, Pain Killer in Burns, Spleen Treatment and Liver Diseases	[3]
13.	Blechnaceae	Blechinum	orientale	Anthelminthic, In Typhoid Treatment, Hepatitis Treatment	[3]
14	Aspleniaceae		venustum	Tonic, Expectorant, Astringent, Emetic, Diuretic, Febrifuge, In Scorpion Bite Treatment	[3]
15	Adiantaceae	Adiantum	incisium	Controlof Internal Burning of The Body	[3]
16	Adiantaceae	Adiantum	philippense	Antitussive,Febrifuge,Leprosy, Asthma	[3]
17	Adiantaceae	Adiantum	philippense	Antitussive,Febrifuge,Leprosy,Asthma and As A Treatment of Hair Fall	[3]
18	Salviniaceae	Salvinia	minima	Anti-Cancerous,Anti-Diabetic,Anti-Inflammatory, Anti-Pyretic	[11]
19	Dryopteridaceae	Dryopteris	cochleata	Epilepsy, Leprosy, Antifungal Gonorrhea, Muscular Pain, Treatment ofCuts,	[12]

				Wound Healing,Throat Problem	
20	Marsileaceae	Marsilea	minuta	Astringent,Diuretic,Hypnotic, Expectorant,Digestive,Fever Skin Deasease,Fungal Infection	[13]
21	Cyatheaceae	Cyathea	nilgirensis	Anti-Inflammatory Antifungal	[14]
22	Blechnaceae	Stenochlaena	palustris	Aliphatic Hyosidesdrocarbons Fatty Acids Phytosterols Kaempferol Glycroids	[15]
23	Apocynaceae	Carralluma	adscendens	Anti-Inflammatory,Antioxidant Anti-Ulcers,Hypoglycemic,Antifungal	[16]
24	Pteridaceae	Actinopteris	radiate	Analgesic,Anti-Fertility,Styptic Anthelmintic,Anti Tubercular Antifungal	[16]
25	Lygodiaceae	Lygodium	venustum	Antibacterial,Antifungal, Antimicrobial	[17]
26	Pteridaceae	Hemionitis	aerifolia	Arthritis,Intestinal Worms,Migrane, Antifungal	[18]
27	Thelypteridaceae	Christella	parasitica	Bactericidal, Antibiotic	[18]
28	Blechnaceae	Stenochlaena	palustris	Fever,Skin Deasease,Ulcers Stomachache,Antifungal	[15]
29	Athyriaceae	Diplazium	esculentum	Antitumor, Anti-asthmatic, Treatment Of Acne, Antifungal Activity, Insecticides,Antibiotics	[15]
30	Equisetaceae	Equiestetum	arvense	To Stop Bleeding Antituberculosis, Kidney Problems bladder stone	[19]

Pharmacological Importance of Himalayan ferns

Pteridophytes are traditionally known class for having variable pharmacological activity. Earlier their consumption was started as a purgative and antibacterial. Now ferns have so much explored that different species have variousactive constituents for diverse treatment. Much of the species show various activity in different solvents extract such as:

Antibacterial activity:

Antibacterial activity against *S. typhi* and *E. coli* like *Actiniopteris radiata* and *Caralluma adscendens*. The aqueous extract and extract through ethanol helps in determination of minimum inhibitory concentration through cup plate method. Disc function method is used to evaluate antibacterial activity of maiden hair fern fighting towards multidrug resistance (MDR) bacterial strain. The pathogens such as *Providencia, Klebsiella pneumoniae, Shigella, Vibrio cholera, Staphylococcus aureus, Proteus vulgaris* and *Salmonella typhi* can be maximally inhibited through methanolic extract of leaves of *Adiantum capillus-veneris*. Their stem extract is very much strong against *Escherichia coli, K. pneumonia* and *S. typhi* [16]. Ethanolic extract of *C. nilgirensis* showed the antibacterial activity against two pathogens viz., *P. aureus* and *K. pneumoniae* [20].

Antifungal activity:

The methanolic extract of flowers and roots of the *Yucca samillianaferns* howed the antifungal activity of 64.0% and 34.0% against *F. oxysporum* and 66.0% and 62.0% P.capsici 7.0% and 41.0% agaist *B.cinerea* respectively [21].It was notice that ethanolic extract of the *Salvenia molesta*recorded the maximum zone of inhibition againest *P.aeruginosa* with 28mm/ml concentration [22]. Ethanolic extract of*C. crinita* against *P. aureus* and *K. pneumonia* L. *lanceolatus* and *A. niger* revealed antifungal properties. Different concentrations (25, 50 and 100 µg/ml) of ethanolic extracts of selected ferns show the inhibitory effect on four susceptible pathogens [14].*E. arvense* act straightly against *Candida* fungal strain [19].

Wound healing:

Pteridophytes are also very much interactive towards wound healing. Extraction through water of *A.capillus-veneris*enhances angiogenesis byusing both capillary-like tubular formations and proliferation of endothelial cells. Aqueous and butanol extract provide security to fibro-blasts by oxygen free radicals so that they can't be damaged. (b) In an animal testing, it has been proofed that a mixture of maidenhair fern, Aloe vera, Henna and Myrrhacan treat wounds in diabetic lab animal [23].

Antioxidant activity:

An ultrasonic-assisted flavonoid extract of fern (*A.capillus-veneris)* has been found which can uphold a good antioxidant activity. DPPH, scavenging capacity of superoxide anion, chelating capability of ferrous ion and reducing power tests were performed in assays (in-vitro). Acute mice liver injury experiment is utilized for In-vivo inspection [23]. These tests and assays evaluated that the species have much potent antioxidant activity. Dryopteris filix-mas has the most spotted antimicrobial activity over gram negative and gram-positive bacteria [24]. *Dryopteris chocleatav* with different extract (hexane, chloroform, ethylacetate, acetone, methanol and water)were determined by agar well diffusion method show anti-oxidant activity [25].

Neuro-pharmacological activity:

The same species above can be used to evaluate neuro-pharmacological activity which states its existence in the Himalayan ferns through ethanolic extraction. It can be beneficial to treat convulsions and seizures. Experimentally it has been observed that it stretches the onset of action and subtract the duration of seizure in animal model having triggered PTZ [23].

Renal pharmacological activity:

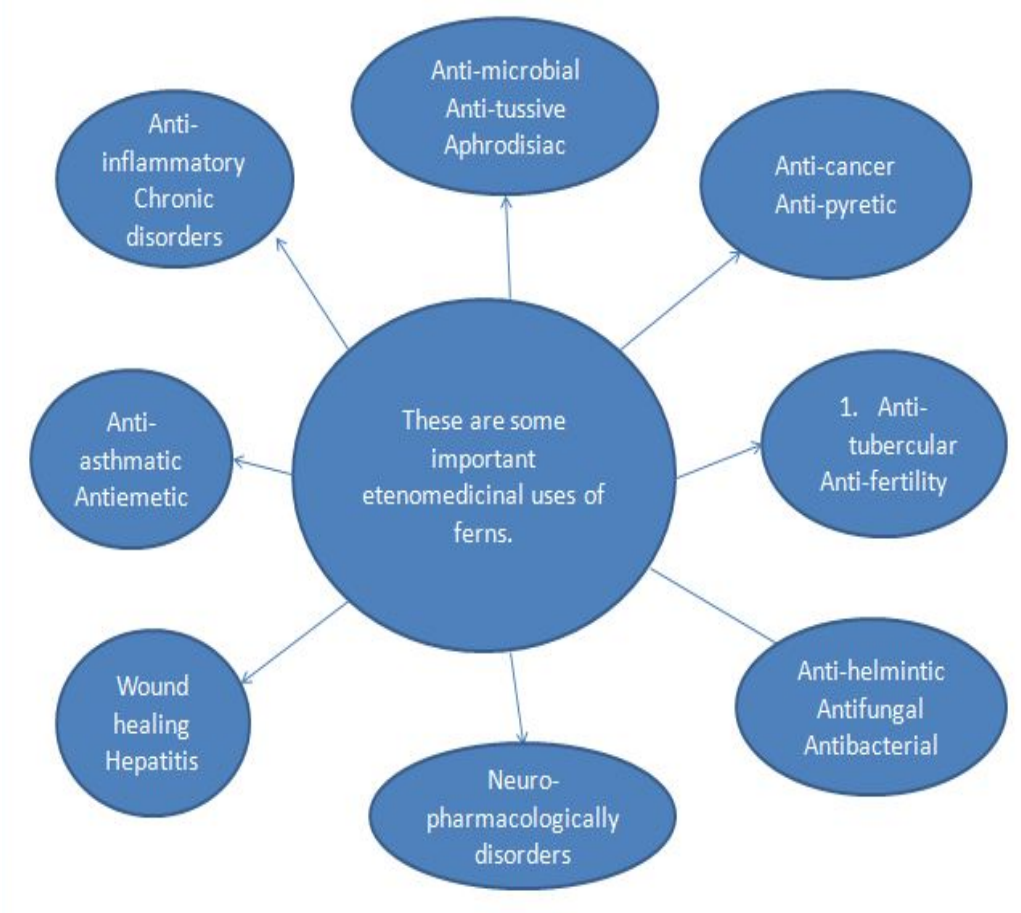
The same water extract above can be assessed for urinary disorders. It is observed that it can inhibit all tested bacterial species and *Candida albicans* strain is inserted in the model in order to evaluate the protective activity. It states that Adiantum can be used to make therapeutics which can treat urinary tract infections [23]. Ethnomedicinally, Blechnumorientale Linn. (Blechnaceae) is used for stomach pain, urinary bladder complaints and sterilization of women [26].

Anti-asthmatic activity:

The ethanolic extract of same species also confirmed that it acts against asthma also. The histamine aerosol-induced asthma in guinea pig were tested as traditionally also the species is spoked as anti-asthmatic [23].

Anti-cancer activity

Blechnum orientale Linn methanolic extract along with five other solvent extract show an extensive cytotoxic property. Methanolic extraction is performed after successive extraction through with petroleum ether, chloroform, ethyl acetate, butanol and water. MTT assay is employed in which four cancer cell lines are checked for observing cytotoxic properties [26].The tribes of the Valparai hills, Western Ghats, and Tamil Nadu (India) use *H. arifolia* (Burm.) Moore and whole plants of *Adiantum capillus-veneris* L for anti-cancer activity [18].



Flow chart 1: Common pharmacological activities of some Himalayan ferns

OTHER PHARMACOLOGICAL ACTIVITIES OF HIMALAYAN FERNS

Hemionities aerifolia also have anti-diabetic activity. The species contains ingredient of polyherbal phytomedicines for diabetes [18]. 95% ethanolic extract of *Blechnum orientale* Linn gives anti-inflammatory activity [26].*Athyrium filix-femina* (lady fern) acts as anthelmintic plant which have the property to protect stomach from various worms. Their stem and roots are mainly used to maintain digestive and overall health [18]. *Pteridium aquilinum* is used in the treatment of tuberculosis through decoction method [18].In an animal model, it has been observed that *A. capillus-veneris* can have hypocholesterolemic effect after giving a high cholesterol diet to the animal [23].

Recent advances and future scope

The resistance of pathogenic fungi and failure of drug therapy increased dramatically**.** New researches have shown a potentiated antifungal activity, if the fern extract were given with fluconazole then it inhibits morphological changes in *Candida* species [17].Some new Pterosins have been found in genus Pteris which can be distinguish for various antimicrobial activity [27].Nowadays, they are also widely usable for chemical and fertilizers industry as to defend the crops from rust through various fungal and bacterial diseases. Due to this, they can be valuable for economic and commercial purposes.

CONCLUSIONS

Most of the people thought ferns as an unwanted weed growth in the forest grown mainly at marshy lands where water content is much. Their rapid growth and deleterious effects are much seen by the people but their essential and beneficial use are much ignored. They are unknown for most of the common sectors of science. Due to this, they left the corner that to be explored. Their ethnomedical knowledge gave a way to enhance the study for further development, so this review regards a complete brief knowledge about the ferns and gave an idea to go on further milestone. Due to their past and present study, we can evaluate future aspects which is an important and crucial area in research and development in resource management.

AUTHOR'S CONTRIBUTIONS

Pratibha and Suraj contributed equally for the literature and manuscript writing. Abhishek coined the idea and concluded the work. Priya done the evaluation and designing of manuscript.

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