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SHORT REVIEW

# *Nephrolepis cordifolia*: An Interdisciplinary Review of Its Ecological, Ethnobotanical and Pharmacological Significance

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## Abstract

*Nephrolepis cordifolia*, commonly called the sword fern, is a terrestrial plant valued for its ecological, medicinal, and cultural relevance. It is native to tropical and subtropical regions but has successfully adapted to a variety of environments, including forests, rocky areas, and urban ecosystems. This review synthesises available research on the species, emphasising its roles in ecological restoration, traditional medicine, and pharmacological development. From an ecological standpoint, *N. cordifolia* plays an important role in maintaining soil integrity and preventing erosion. It contributes to ecosystem stability by supporting biodiversity and participating in natural processes such as phytoremediation. Chemically, the plant is a rich source of secondary metabolites, including flavonoids, alkaloids, saponins, terpenoids, and phenolic compounds. These constituents are linked to various biological activities such as antioxidant, anti-inflammatory, antimicrobial, hepatoprotective, and cytotoxic effects. Traditional healing systems across Asia and other regions have long used this fern to treat ailments such as indigestion, fever, respiratory problems, and skin disorders. In some areas, it has also been utilised for its diuretic and contraceptive properties. Although traditional knowledge provides a strong foundation for its use, comprehensive scientific validation, particularly through clinical studies and molecular research, remains limited. This review aims to consolidate current findings and highlight the plant's therapeutic and environmental relevance. It underscores the necessity of a multidisciplinary research approach to fully explore the potential of *Nephrolepis cordifolia*. With more concentrated scientific inquiry, this resilient and underexplored species could emerge as a significant contributor to both natural healthcare and sustainable ecological practices.

**Major Findings:** *Nephrolepis cordifolia* contributes significantly to ecological restoration through soil stabilisation and phytoremediation. Its rich phytochemical profile supports traditional medicinal uses and reveals potential for pharmacological development.

**Keywords:** *Nephrolepis cordifolia*, Ecological Restoration, Phytoremediation, Phytochemicals, Traditional Medicine, Pharmacological Potential

## 1. Introduction

Ferns and fern allies are Pteridophytes; these are vascular, non-flowering, feathery plants included under "Cryptogams," meaning hidden reproduction. Pteridophyte consists of more than 300 genera and 12'000 species. Some ferns are edible with numerous pharmacological actions, whereas some have fatal effects[1].

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Ferns are fiercely rooted in the tropical rainforest amid muggy conditions and in temperate and mild conditions. It can be seen growing into the putrescent of logs in between fractures of stones, marshes, and alpine and subalpine zones[2]. Ferns are little known for their medicinal uses, even though they are used in treating gastrointestinal diseases and as an anti-inflammatory agent in isolated areas of the Amazon. Ferns such as Maxon are used to treat respiratory diseases such as cough and bronchitis[3]. Some different types of ferns are given in Table 1.

*Nephrolepis* is a terrestrial fern with tiny scales over its body parts. It consists of long brown roots with tubers in it. The fronds are attached to the rachises in a pinnate arrangement. The plant contains a collection of sporangia called sori[6]. Among the genus *Nephrolepis*. *N. cordifolia* is native to *Nephrolepidiaceae* (Nothern Australia and Asia)[7]. Traditionally, *Nephrolepis cordifolia* was used to cure diseases like respiratory problems, renal disorders, jaundice, and stomach ulcers[8]. Many studies have suggested the presence of potent phytoconstituents such as phenolics, steroids, flavonoids, terpenoids, tannins, alkaloids, and anthraquinones[9].

## 2. Botanical Description[10,11]

- Classification: *Pteridophyte*
- Family: *Nephrolipidiaceae*
- Genus: *Nephrolepis*
- Species: *Nephrolepis cordifolia*
- Common Name: Tuberous sword fern
- Habit: Herb
- Habitat: Grows on rocks and trees
- Synonym: *Neprolepis tuberosa*
- Fertile: December-March

**Table 1.** Different types of ferns concerning its origin[1,4,5]

| Sl. No. | Name of the fern | Family | Origin |
|---|---|---|---|
| 1 | *Adiantum poiretii* N. | *Adiantaceae* | Republic of India |
| 2 | *Cyathea nilgirensis* | *Cyatheaceae* | Republic of India |
| 3 | *Deparia petersen* | *Athyriaceae* | Republic of India |
| 4 | *Drynaria quercifolia* | *Polypodiaceae* | Republic of India |
| 5 | *Nephrolepis oxalate* | *Nepheolipidiaceae* | Republic of India |
| 6 | *Nephrolepis cordifolia* | *nepheolipidiaceae* | Republic of India |
| 7 | *Lygodium palmatum* | *Lygodiaceae* | North America |
| 8 | *Culcita marcocarpa* | *Culcitaceae* | New Zealand |
| 9 | *Onoclea sensibilis* | *Onocleaceae* | New Zealand |
| 10 | *Cystopteris bulbifera* | *Cystopteridaceae* | Eastern North America |



**Figure 1.** Leaf and whole of *Nephrolepis cordifolia*.

## 3. Morphological Description

The plant can grow 50cm long. *Nephrolepis cordifolia* can grow up to 3 feet and 3 inches wide. The pinnae are lanceolate in shape-holding numerous spores on the margin of the leaflets called sori. These leaflets grow onto the sides of light brown ranches up to 1.5-4 inches; the lower part of the leaflets is overlapped[7] shown in Figure 1. The runners of the plant grow horizontally and spread into the ground, holding onto the soil with their tiny, densely packed scales. The plant contains fleshy tubers, round and kidney-shaped, that creep out of the rhizome and are covered with a brown, hair-like structure.

## 4. Phytochemical Constituents

The plant is covered with an extensive amount of epidermal glands that possess numerous phytochemical constituents like flavonoids, glycosides, alkaloids, phenols, saponins, tannins, steroids, terpenoids, etc[13].

### 4.1 Flavanoids

Flavonoids are secondary metabolites with phenolic structures that can be subdivided into flavones, flavonols, flavanones, isoflavonoids, neoflavanoids, anthocyanins, and chalcones commonly found in herbs, vegetables, cereals, nuts, seeds, and flowers. These compounds exhibit significant pharmacological actions, including anticancer, neuroprotective, anti-proliferative, and antimalarial properties. They also play a major role in cosmetics and skin care[14,15].

Flavonols are one of the most important subtypes of flavonoids, mostly found in green vegetables like broccoli, tomatoes, onion, and olives, some fruits like apples and citrus fruits, and also in red wine and tea. Four main flavonoids are mainly studied: kaempferol, fisetin, quercetin, and myricetin. These flavonoids show anticancer activity. Flavonols are known to interfere with biochemicals that can trigger cardiovascular diseases; flavanols are also used as a substitute for the treatment of viral diseases and acquire properties for the treatment of neurodegenerative diseases, kidney disease, and malaria[16].

Flavones are found in dietary sources like fruit skin, tomato skins, buckwheat, red wine, and red pepper. In plants, they are found in Aloe vera, *Mentha longifolica,* and *Momordica charantia.* Leutein, rutin, luteolin glycosides, chrysin, and apigenin are some of the main groups of compounds in Flavors[17].

Iso-flavonoids are mostly found in the soya beans, microbes, and legumins; they have a narrow occurrence in plants. These compounds are used to treat menstrual health, cancer, and the cardiovascular system. Due to the estrogenic activity of the plant, it can also serve as phytoestrogens[17].

### 4.2 Glycosides

Glycosides are characterised by a glycone and an aglycone moiety in their structure. This chemical ingredient is commonly embedded in plants and animals. Based on the glycone unit, glycosides are grouped as rhamnose, arabinose, fructose, and glucuronic acid. The presence of these glycone units increases bioavailability due to their high-water solubility characteristics. Glycosides can be classified based on the nature of the sugar moiety present in them; they are categorised as O-glycosides, S-glycosides, and N-glucosides, among which O-glycosides are obtained as secondary metabolites. N -N-glycosides can be obtained from quinine and morphine, whereas S-glucosides play a major part in thioglycosides, which use sulfur atoms for the glycosidic connection. Glycosides ought to show pharmacological actions like antimicrobial activity due to the presence of saponin, anticancer activity by acting on $Na^{+}$+/K+-ATPase pump, anti-inflammatory activity can be seen as they alter the signalling pathway involved to cause inflammation, and some other pharmacological activities like immunomodulatory activity, antioxidant activity, and neuroprotective activity are likely seen[18].

### 4.3 Alkaloids

Alkaloids are one of the important phytochemicals in human medicine. Alkaloids act as a natural defence moiety in living organisms[19,20]. In modern medicine, alkaloids are widely used as cardioprotective and anaesthetics. Morphine, ephedrine, and nicotine are some of the known alkaloids used as modern clinical ingredients for treating analgesia[21]. Alkaloids are the active elements in the field of ethnomedicine and potentially contribute to drug discovery. Over a decade, more than 27,683 alkaloids were discovered as per the Dictionary of Natural Products (DNP)[22].

### 4.4 Phenols

Phenolic compounds are secondary metabolites that are bioactive in nature and contain phenol moiety. Its structure contains a benzene ring with a hydroxyl group as a substitute in it. The phenolic group has immense health benefits it exhibits anti-inflammatory properties, antioxidants, and antimicrobial properties. These phytoconstituents are omnipresent, and commonly found in fruits like bananas, apples, oranges, mangoes, papaya, strawberries, peaches, and pomegranates with other phytoconstituents and acids like myricetin, gallic acid, quercetin, cyanidin, naringenin, vanillic acid, found in it[23].

### 4.5 Saponins

Saponins are glycosidic compounds that are naturally occurring and non-volatile with a foaming nature. Due to their foaming nature, they are commonly used in soaps for cleaning procedures. A hydrophilic sugar moiety is present, which is covalently affixed to the backbone of the triterpene, making it surface active. As saponins exist as terpenoids, over 60 kinds of dissimilar triterpenoid saponins are extracted from different plants and distinguished. Saponins have multiple biological activities such as hypoglycemic, anti-tumour, anti-inflammatory, and hypocholesterolemic. It is also suitable for the treatment of cerebrovascular and cardio diseases; other than these properties, the plant has a self-defensive mechanism for microorganisms[24].

### 4.6 Tannins

Tannins are large biomolecules with a polyphenolic nature, grouped as hydrolyzable and condensed tannins. Tannins can be obtained from plants by the metabolism of the plants through biogenetic pathways. Grapes, walnuts, nuts, blackberries, mangoes, tea, and strawberries are some common fruits where tannins can be found. Tannins protect plants and trees from microorganisms like fungi, and pathogens and also act as insecticides. Tannins can be classified into two main groups, i.e, hydrolyzable tannin and condensed tannin. The condensed tannins encompass flavonoids unaccompanied by a sugar core, whereas hydrolysed tannins encompass gallic acid and ellagic acids with a sugar core[25].

### 4.7 Steroids

Steroids are lipophilic molecules that regulate the body's organ, cellular, and tissue functions. Some hormones, such as aldosterone, estradiol, and testosterone, are produced from cholesterol in the adrenal gland, ovaries, and testes, and are then released into circulation from specialised endocrine cells. Steroid hormones also play a vital role in fetal development, including the respiratory system, cardiovascular system, and brain. Steroids are complex organic molecules that have four rings and serve many roles in living organisms[26].

### 4.8 Terpenoids

Terpenoids are naturally occurring compounds primarily found in plants. They are the volatile compounds that give fragrance to plants and their flowers. The term' terpene' refers to a compound isolated from terpenoids; it is a volatile liquid derived from pine trees. Essential oils consist of simpler mono- and sesquiterpenes as chief components. Diterpenoids, on the other hand, are not steam volatile; they are obtained from tree resins and gums. Terpenoids from different groups of compounds are called carotinoids[27].

## 5. Traditional Uses

In Indian traditional medicine, *N. cordifolia* was used as a contraceptive, diuretic, and for certain liver diseases, including liver cirrhosis. In other countries, such as Malaysia, the plant is utilised for treating skin disorders[28]. *N. cordifolia* was cultivated in Shillong and consumed to quench thirst, while the root tubers were taken to alleviate indigestion, headaches, coughs, colds, hematuria, and the entire plant was used to address skin and renal disorders[29,30].

*Nephrolipis cordifolia* has a rich history of traditional use across various cultures. Table 2 below expands on its ethnomedical uses in different regions[31-35].

## 6. Pharmacological Activities of *Nephrolepis cordifolia*

*Nephrolepis cordifolia* is a fern traditionally used in various medicinal systems. Modern research is increasingly validating its therapeutic potential through several pharmacological activities.

**Table 2.** Traditional use of *N. cordifolia* in different parts of the world

| Region | Traditional Use | References |
|---|---|---|
| Nepal | Juice of root tubers is consumed for fever, indigestion, headache, cough, cold, and hematuria. Whole plant used for kidney, liver, and skin disorders. | 31 |
| India | Young leaves are cooked as a vegetable. Decoction of fresh fronds is used for cough and skin diseases. Rhizome extract is used once during the menstrual period to induce permanent sterility in women. | 32 |
| Philippines | Decoction of fresh fronds is used for fever due to cold, chronic coughing, and enteritis-diarrhoea. | 33 |
| Nigeria | Rhizomes cleaned, boiled with salt and water, and eaten as food. | 34 |
| Papua New Guinea | Leaves are placed among bones in death ceremonies. | 34 |
| Tamil Nadu, India | Tuber extract taken for stomach upsets and urinary problems. | 35 |
| Madhya Pradesh, India | Plant used on wounds to stop bleeding. Also used for cough, intestinal disorders, stomach ulcers, and acidity. | 35 |
| Sikkim, India | Tuber juice used for gastric troubles. | 35 |

## 6.1 Antioxidant Activity

The fern is rich in phenolic compounds and flavonoids, which help neutralise free radicals and reduce oxidative stress. Studies employing assays such as DPPH and FRAP have demonstrated that ethanolic extracts of *N. cordifolia* exhibit considerable antioxidant capacity, suggesting a role in preventing cellular damage linked to chronic diseases[36] (Figure 2).

## 6.2 Anti-inflammatory Properties

Historically, *N. cordifolia* has been used to relieve inflammatory symptoms. Animal model studies have shown that its extracts can significantly reduce inflammation, likely by inhibiting pro-inflammatory mediators like prostaglandins, supporting its traditional application for conditions characterised by inflammatio[37] (Figure 2).

## 6.3 Wound Healing Effects

Traditional use of *N. cordifolia* includes topical treatment for wounds. Scientific investigations reveal that aqueous extracts from the rhizome accelerate wound closure, enhance collagen synthesis, and stimulate fibroblast proliferation, which collectively facilitate improved wound healing outcomes[38] (Figure 2).

## 6.4 Antidiabetic Potential

Experimental studies in diabetic animal models have indicated that both methanolic and aqueous extracts of *N. cordifolia* lower elevated blood glucose levels. This hypoglycaemic effect may be associated with improved insulin sensitivity, enhanced regeneration of pancreatic cells, or inhibition of carbohydrate-digesting enzymes, aligning with its historical use in blood sugar management[39] (Figure 2).

## 6.5 Hepatoprotective Activity

Research has demonstrated that *N. cordifolia* extracts can protect the liver from toxin-induced damage. In models of paracetamol-induced hepatotoxicity, treatment with the plant extract resulted in improved liver enzyme profiles and reduced histopathological damage, which suggests a hepatoprotective effect likely related to its antioxidant and membrane-stabilising properties[40] (Figure 2).

## 6.6 Diuretic Effect

The rhizome of *N. cordifolia* is traditionally consumed as a diuretic. Experimental studies in animal models have confirmed that administration of the rhizome juice leads to a significant increase in urine output along with enhanced excretion of electrolytes such as sodium and potassium, supporting its use in managing fluid retention[41] (Figure 2).

## 6.7 Antifertility/Contraceptive Use

Ethnobotanical surveys from regions in India have documented the use of *N. cordifolia* rhizomes as a natural contraceptive. Women in certain tribal communities reportedly consume a single dose of a rhizome preparation to induce sterility. Although the exact mechanism remains unclear, this traditional

practice underlines the need for further investigation into its active components and hormonal effects[42].

## 6.8 Cytotoxic and Anticancer Activity

Preliminary studies on essential oils extracted from the aerial parts of *N. cordifolia* have shown cytotoxic effects against various human cancer cell lines, including those derived from breast, lung, and colon cancers. The anticancer potential may be attributable to specific monoterpenes and sesquiterpenes that disrupt cancer cell proliferation, although additional research is required to elucidate the underlying mechanisms fully[43-45].

Its extract, rich in flavonoids, phenolics, and terpenes, initiates primary actions like antioxidant, anti-inflammatory, and wound healing effects. These lead to overall therapeutic benefits, such as improved tissue repair and metabolic balance. Secondary outcomes include antidiabetic, hepatoprotective, diuretic, and antifertility effects. Ultimately, it also exhibits cytotoxic/anticancer activity through the induction of cancer cell death. *Nephrolepis cordifolia*, a member of the *Nephrolepidaceae* family, stands out as a resilient and multifaceted fern with considerable ecological and therapeutic value. This species exhibits a unique ability to grow across a range of environmental conditions, including disturbed landscapes, rocky surfaces, forest floors, and urban areas. Its adaptability makes it not only ecologically significant but also highly applicable for biodiversity conservation, soil stabilisation, and environmental restoration projects.

From an environmental perspective, the plant plays a vital role in improving soil quality, reducing erosion, and supporting local ecosystems by acting as a shelter and microhabitat for various organisms. Moreover, it

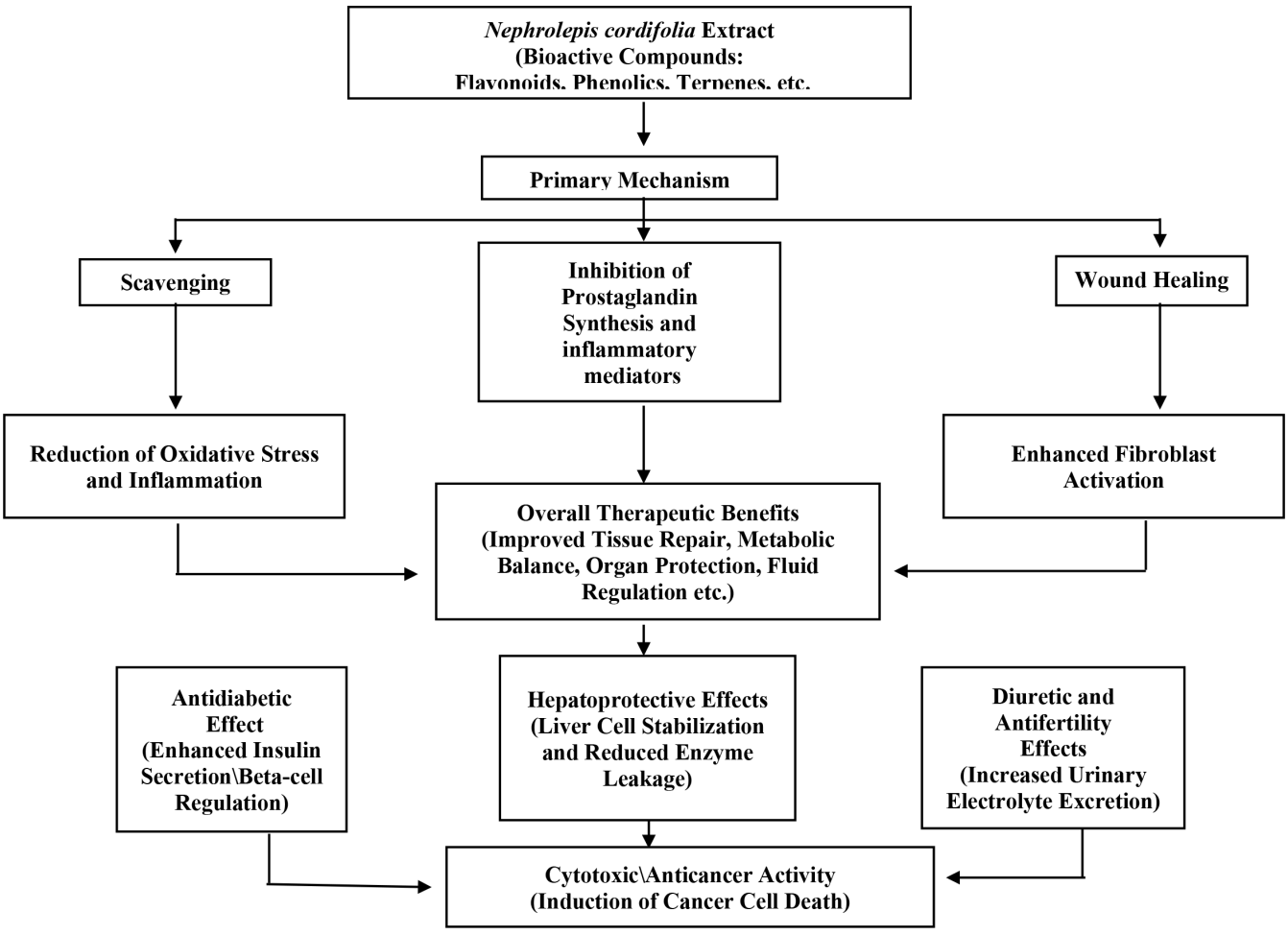



**Figure 2.** The diagram outlines the pharmacological mechanism of *Nephrolepis cordifolia*.

has shown potential in phytoremediation—absorbing and breaking down harmful pollutants and heavy metals from the soil—positioning it as a promising candidate for sustainable environmental management.

In traditional medicine, *N. cordifolia* has long been valued for its healing properties. Communities across India, Nepal, the Philippines, and several other regions have incorporated this fern into their local health practices for generations. It has been traditionally used to manage fevers, digestive issues, liver problems, skin ailments, and respiratory conditions. Some indigenous groups have even employed it as a natural contraceptive or diuretic. These applications highlight its deep-rooted cultural significance and the rich ethnobotanical knowledge surrounding the species.

Phytochemical investigations confirm that *N. cordifolia* is a reservoir of biologically active compounds. Its tubers, fronds, and rhizomes contain valuable secondary metabolites such as flavonoids, saponins, alkaloids, phenolics, tannins, steroids, and terpenoids. These compounds have demonstrated a variety of pharmacological activities, including antioxidant, anti-inflammatory, antimicrobial, hepatoprotective, antidiabetic, and even anticancer effects in experimental settings. Notably, the antioxidant properties help in reducing oxidative stress, while the presence of oleanolic acid contributes to liver protection.

Despite its extensive use in traditional medicine and the promising outcomes of preliminary pharmacological research, *N. cordifolia* remains under-researched in several crucial areas. Molecular-level studies, clinical trials, toxicological assessments, and bioavailability investigations are necessary to fully understand its mechanisms of action and validate its medicinal potential. Additionally, sustainable harvesting and conservation strategies must be developed to prevent overexploitation as demand grows. The nutritional value of the plant, particularly the tubers, which are rich in moisture, carbohydrates, fats, and minerals, further supports its potential in functional foods and dietary supplements. Its insecticidal activity against certain pests also points toward eco-friendly agricultural applications.

Overall, *N. cordifolia* offers a wide spectrum of uses that bridge ecological health, traditional wisdom, and modern science. The plant's multifunctional nature positions it as a valuable resource not only for pharmacological development but also for sustainable agriculture and environmental conservation. Encouraging further interdisciplinary research into this fern could unlock new therapeutic agents and support broader ecological goals. In a time when biodiversity is under threat and natural resources are increasingly exploited, species like *N. cordifolia* remind us of the untapped potential that lies in overlooked plants. A deeper understanding of its properties may lead to innovative solutions in medicine, nutrition, and environmental restoration.

## 6. Author Contribution

Conceptualization: N.G.; Literature review: A.S., B.A.; Data curation: T.S.; Writing – original draft preparation: A.S., B.A.; Writing – review and editing: J.M., N.G.; Supervision: N.G. All authors have read and agreed to the published version of the manuscript.

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