INTERNATIONAL JOURNAL OF
PHARMACEUTICAL AND HEALTHCARE INNOVATION
journal homepage: www.ijphi.com

OPEN ACCESS

Review Article

A Review: Anti-Alzheimer Potential of *Rungia pectinata*

Shubham Kumar* Gupta, Ms. Saumya Tripathi, Mr. Shekhar Singh
Suyash Institute of Pharmacy, Hakkabad, Gorakhpur, U.P., India-273016

Article Info

Article history:

Manuscript ID:

IJPHI0204160403052026
Received: 02-Apr -2026
Revised : 16-Apr -2026
Accepted: 03-May-2026
Available online: May 2026
DOI:
doi:10.62752/ ijphi.v3i2.248

Keywords:
Rungia pectinata , Alzheimer's disease, Neuroprotection, Acetylcholinesterase inhibition

Corresponding Author:
shubham.r.gupta7259@gmail.com

Abstract

This review summarizes modern studies on the phytochemical profile, pharmacological actions, and mechanisms underlying the neuroprotective effects of the plant. The most important bioactivities identified are antioxidant, anti-inflammatory, and acetylcholinesterase inhibitory activities, which are crucial in countering the pathological mechanisms of Alzheimer's disease progression. Neuroinflammation and oxidative stress damage neurons in Alzheimer's disease, and the anti-oxidant and anti-inflammatory compounds in Rungia pectinata have the potential to reduce these effects. In addition, blocking acetylcholinesterase, an enzyme that breaks down acetylcholine, can augment cholinergic neurotransmission, which is usually damaged in patients with Alzheimer's disease. The pharmacological research is an experimental support of these activities with a promise of the plant as a source of neuroprotective agents. Although these results are encouraging, there are still concerns regarding standardization of extracts, understanding of specific molecular targets, and clinical trials to prove efficacy. The direction of future research is that pharmacodynamic and toxicological analyses require thorough evaluation to enable the application of Rungia pectinata to the neurodegenerative conditions. Therefore, this review is a starting point for investigating the therapeutic value of Rungia pectinata in the management of Alzheimer's disease.

Introduction

The introduction of the review article on the antit-Alzheimer potential of *Rungia pectinata* can be considered background summary that puts into perspective the importance of this medicinal plant in the general context of neurodegenerative disease studies, especially Alzheimer 'sdisease (AD). It lays the groundwork to study *Rungia pectinata* by connecting its traditional therapeutic applications to modern scientific interest in its neuroprotective properties. The introduction emphasizes the timeliness and topicality of the study of plant-based interventions because of the growing worldwide rates of AD and the shortcomings of existing therapies(1). Alzheimer's disease is a progressive neurocognitive disorder in which patients develop impairments in memory, progressive deterioration in cognition, and neuronal loss, which are accompanied by complex pathophysiological processes, including oxidative stress, neuroinflammation, and cholinergic impairment. These pathological hallmarks have been highlighted as essential areas that can be addressed through therapeutic intervention. The introduction highlights that oxidative injury and inflammation are also major factors in neuronal degeneration, and lower levels of acetylcholine hamper neurotransmission, which exacerbates cognitive symptoms(2). *Rungia pectinata* is introduced as a potential solution to these pathological processes. The plant is traditionally used in different medicinal systems and has a wide range of phytochemicals that possess antioxidant, anti-inflammatory, and acetylcholinesterase inhibitory properties. These bioactivities are especially pertinent because antioxidants can counteract free radicals that result in oxidative stress; anti-inflammatory agents can inhibit the progression of harmful neuroinflammation; and acetylcholine degradation inhibitors can prevent the degradation of acetylcholine, thus enhancing cholinergic signaling(3). The introduction preconditions a thorough investigation of the phytochemical constituents and pharmacological effects of *Rungia pectinata* by summarizing existing research. This means that the review will review experimental evidence supporting the neuroprotective effects of the plant, focusing on its multifaceted mechanisms of action. The approach has an integrative realization that the most effective AD therapies may have to be aimed at several pathways simultaneously. In addition, the introduction recognizes the existing limitations in translating the potential of *Rungia pectinata* into clinical practice. These obstacles include variability in extract standardization, incomplete knowledge of molecular targets, and strict clinical validation requirements. This pessimistic outlook highlights the need to conduct additional studies to overcome these obstacles and optimize the therapeutic value of *Rungia pectinata* . Overall, the introduction contextualizes *Rungia pectinata* as a promising medicinal plant with significant potential in the treatment of AD, based on both traditional and new scientific findings. It describes the pathology of AD, the rationale for targeting oxidative stress and inflammation and acetylcholinesterase levels, and the bioactivities of the plant. It also emphasizes the need for further studies to utilize the potential of R. pectinata as a neuroprotective compound to the fullest, thus aiding a holistic and focused point of entry to the detailed review that follows(4).

Botanical Description and Traditional Uses

The paragraph on the Botanical Description and Traditional Uses of *Rungia pectinata* provides a comprehensive picture of the taxonomy, morphology, habitat, and ethnomedicinal uses of the plant, which constitutes the basis of knowledge regarding its therapeutic potential, especially for neurodegenerative disorders such as Alzheimer's disease(5).

Botanical Description

Rungia pectinata is a species of the family Acanthaceae with various medicinal properties. It is a fast-growing, erect, herbaceous plant that typically grows to a height of approximately 30–60 cm. The plant has simple and opposite leaves that are ovate-lanceolate in shape with serrated margins. Its flowers are small and tubular, frequently purplish or pinkish, and spike-shaped or racemous. The plant grows in moist shaded conditions, such as undergrowth in a forest or along a riverbank, and is common in tropical and subtropical climates, especially in India and Southeast Asia. Its ability to adapt to various environmental factors and the convenience of growing it also make it highly accessible, which is important in both conventional and modern medicine. The botanical features not only help in the proper identification of the species but also help to differentiate it from other related species that may not possess similar pharmacological effects(6).

Traditional Uses

Rungia pectinata has been used in traditional medicine systems, such as Ayurveda and folk medicine, because of its wide range of therapeutic uses. It has been used as an anti-inflammatory, diuretic, and treatment for respiratory diseases, such as cough and asthma. Leaf extracts and the entire plant are commonly administered to the skin to treat wounds and skin infections, and internally to treat fever, digestive, and urinary tract infections. In some Indian traditional medicines, fresh leaves are crushed and used as a

poultice in swollen and painful inflamed joints, which is indicative of the anti-inflammatory properties of the leaves. Similarly, the plant is used as a decoction to treat bronchitis and other respiratory diseases, demonstrating that the plant has expectorant and calming effects(7). The ethnomedicinal applicability of *Rungia pectinata* is also emphasized by the fact that it is used to treat diseases of the nervous system. Traditional healers use it to soothe agitation and enhance cognitive functions, which is consistent with recent scientific research on its neuroprotective properties. This ancient application has served as an ethnopharmacological starting point for exploring the use of the plant to treat neurodegenerative diseases, such as Alzheimer 's disease, in which inflammation and oxidative stress are key pathophysiological pathways(8).

Example of Traditional Application

A realistic case study of the traditional application of *Rungia pectinata* is in village communities in India, where the plant is usually referred to as Pecinta. The infusion is prepared from the leaves by local practitioners and is administered to older patients showing signs of memory loss and cognitive decline. Although this is anecdotal, this practice represents the empirical knowledge that has been passed down across generations, and that is only now being substantiated by modern research in the fields of phytochemical and pharmacological research(9).

Linking Botanical and Traditional Knowledge to Pharmacological Research

Knowledge of the botanical characteristics and traditional applications of *Rungia pectinata* is important to inform scientific research on bioactive compounds and their mechanisms of action. The medicinal features of the plant are in accordance with its rich phytochemical profile, including flavonoids, alkaloids, and phenolic compounds. These ingredients are known to have antioxidant and anti-inflammatory properties, especially in the case of Alzheimer 's disease. For example, flavonoids of *Rungia pectinata* leaves have been found to exhibit free radical scavenging in vitro, which substantiates the traditional application of the plant in the treatment of inflammation and oxidative injury(10). Likewise, the alkaloids in the plant could be involved in acetylcholinesterase inhibition, which is the action of current therapies for Alzheimer 's to increase cholinergic neurotransmission(11).

Significance in Drug Development

A detailed botanical description and traditional medicinal uses of *Rungia pectinata* have led to scientific research on its potential as a source of novel neuroprotective agents. Its ease of production and previous applications make it a promising candidate for further pharmacological validation and standardization. Additionally, ethnobotanical understanding can be used as a reference to select the plant parts, mode of preparation, and dosage forms that may be maximized to achieve the desired therapeutic effects(12).

Phytochemical Constituents of *Rungia pectinata*

The phytochemical composition of *Rungia pectinata* is the biochemical basis of the reported pharmacological properties of the plant, such as potential anti-Alzheimer effects. Knowledge of these constituents is critical to explaining the processes by which the plant exerts neuroprotective effects, including antioxidant, anti-inflammatory, and acetylcholinesterase effects. In this section, we discuss in detail the key categories of bioactive compounds found in *Rungia pectinata* , their chemical properties, and their roles in modulating neurodegenerative diseases. Significant phytochemical families in *Rungia pectinata* (13).

Flavonoids

Flavonoids are polyphenols which are well known due to their strong antioxidant capacity. *Rungia pectinata* possesses various flavonoids that are responsible for its free radical scavenging property. These compounds neutralize reactive oxygen species (ROS), thereby lowering oxidative stress, a major pathological determinant of Alzheimer 's disease. Flavonoids can also alter signaling pathways that control inflammation and neuronal survival, thereby exerting neuroprotective effects. Certain flavonoids present in R. pectinata, such as quercetin, kaempferol, and luteolin derivatives, have been proven to be effective in curbing oxidative injury in neuronal cell models(14).

Phenolic Compounds

Other antioxidants found in *Rungia pectinata* include phenolics. These compounds possess good radical-scavenging and metal-chelating properties and alleviate neuronal damage caused by oxidative stress. The plant yields phenolic acids, including gallic and caffeic acids, which have been shown to prevent lipid peroxidation and neuronal membrane damage. They also have anti-inflammatory effects that make them useful in minimizing neuroinflammation, which is a key aspect of Alzheimer's pathology(15).

Alkaloids

Alkaloids are nitrogenous products with high pharmacological functions, such as acetylcholinesterase inhibition. *Rungia pectinata*

produces alkaloids that can improve cholinergic neurotransmission by preventing the activity of acetylcholinesterase, which degrades acetylcholine at the synaptic cleft. This inhibition is useful in sustaining higher acetylcholine levels and enhancing memory and cognitive capabilities in patients with Alzheimer's disease. Although the alkaloids in *Rungia pectinata* still need further characterization, initial investigations indicate their role in the regulation of neurotransmitters(16).

Terpenoids and Steroids

Another type of phytochemical present in *Rungia pectinata* is terpenoids and steroids. These compounds have been reported to exert anti-inflammatory and neuroprotective effects. Triterpenes (terpenoids) can block the production of proinflammatory cytokines and inhibit the activation of microglial cells, thus reducing neuroinflammation. Steroidal compounds also contribute to membrane stabilization and neuroprotection. Their lipophilicity facilitates their crossing of the blood-brain barrier, making them applicable in central nervous system (CNS) therapeutics(17).

Saponins

Saponins are surfactants (glycosides) with anti-inflammatory and antioxidant effects. Saponins can improve neuroprotection by regulating the inflammatory response and antioxidant capabilities in *Rungia pectinata* . They also affect the fluidity of membranes and receptors, which may enhance neuronal communication(18).

Tannins

Tannins are a subclass of polyphenols with antioxidant and anti-inflammatory properties. They have the potential to chelate metal ions and prevent enzymes that participate in oxidative stress pathways, contributing to the neuroprotective profile of *Rungia pectinata* . Tannins can also prevent the activity of acetylcholinesterase, which contributes to improved cognition(19).

Relevance of Phytochemicals to Anti-Alzheimer Mechanisms

Phytochemicals in *Rungia pectinata* target multiple pathological mechanisms implicated in Alzheimer's disease(20).

Antioxidant Activity: Flavonoids, phenolics, tannins, and saponins reduce oxidative stress by scavenging reactive oxygen species and inhibiting lipid peroxidation. This helps protect neurons from oxidative damage, which is a leading cause of neurodegeneration(21).

Anti-inflammatory Effects: Terpenoids, flavonoids, and phenolics prevent the production of proinflammatory mediators, such as tumor necrosis factor-alpha (TNF-α), interleukins, and cyclooxygenase enzymes. These compounds preserve neuronal function and integrity by reducing neuroinflammation(22).

Acetylcholinesterase Inhibition: The tannins and alkaloids inhibit acetylcholinesterase and raise the level of acetylcholine in the brain. This measure enhances cholinergic neurotransmission that is important in memory and learning which in most cases is affected in patients with Alzheimer disease(23).

Phytochemical Extraction and Characterization

The extraction of these compounds using ethanol, methanol, or aqueous mixtures from *Rungia pectinata* has been investigated. The bioactive constituents have been identified and quantified using phytochemical screening and chromatographic methods, such as high-performance liquid chromatography (HPLC), gas chromatography–mass spectrometry (GC–MS), and thin-layer chromatography (TLC).In particular, a study on the use of *Rungia pectinata* leaf extract indicated a high level of flavonoid and phenolic compounds, which is associated with high antioxidant activity in in vitro tests. Fractions containing alkaloids have shown acetylcholinesterase inhibitory properties in enzyme assays, which are considered therapeutically relevant(24).

Background: Quercetin, a flavonoid, and neuroprotection.

An example of a phytochemical that contributes to neuroprotection is quercetin, a flavonoid present in *Rungia pectinata* . Quercetin removes reactive oxygen species and proinflammatory cytokines and alters NF-κB and Nrf2 signaling pathways, which control oxidative stress and inflammation. The anti-acetylcholinesterase effect of quercetin also increases cholinergic activity. These complex activities render it an important constituent of the anti-Alzheimer potential of *Rungia pectinata* (25).

Synergistic Effects and Phytochemical Interactions

The therapeutic activity of R. pectinata is likely a result of the synergy between the phytochemicals of the plant and not the individual compounds. The synergistic action of antioxidant, anti-inflammatory, and enzyme-inhibitory functions forms a holistic neuroprotective effect, which may be more effective than individual-target drugs. This synergy highlights the relevance of whole-plant extracts in traditional medicine and justifies their exploration in modern pharmacology(26).

Challenges and Future Directions in Phytochemical Research

Although *Rungia pectinata* has promising phytochemical profiles, the full characterization of all bioactive compounds in *Rungia pectinata* remains challenging. Diversity in phytochemical content because of geographical, seasonal, and extraction method differences hinders standardization efforts. The isolation and structural elucidation of certain alkaloids and terpenoids are required to understand their exact mechanisms. High-tech methods, such as nuclear magnetic resonance (NMR) spectroscopy and mass spectrometry, can be used to detect new compounds(27). Moreover, fractionation using bioassays can provide a correlation between certain phytochemicals and their pharmacological activities. The pharmacokinetics, bioavailability, and blood–brain barrier permeability of such compounds should also be investigated in the future to confirm their therapeutic usefulness in organisms. Combining phytochemical information with molecular docking and in silico analysis can be used to predict interactions with the disease targets of Alzheimer's, thereby simplifying drug development(28).

Pathophysiology of Alzheimer's Disease

Alzheimer 's disease (AD) pathophysiology involves a complex interaction of molecular and cellular processes that lead to progressive neurodegeneration and cognitive and memory impairments. Understanding the underlying mechanisms is important for the development of therapeutic targets and the quality of interventions based on *Rungia pectinata* . The main features of AD are the presence of extracellular amyloid-beta (Aβ) plaques and intracellular neurofibrillar tangles filled with hyperphosphorylated tau protein(29). The aggregation of A2 peptides is a consequence of misplaced cleavage of amyloid precursor protein (APP) to form toxic oligomers that interfere with the functioning of synapses and facilitate neuronal death. Concurrently, tau protein is abnormally phosphorylated, destabilizing microtubules and disrupting axonal transport, which also leads to additional neuronal dysfunction. Oxidative stress is a pathological hallmark of AD. Overgeneration of reactive oxygen species (ROS) overwhelms the antioxidant defenses of the brain, damaging lipids, proteins, and nucleic acids. This oxidative damage disrupts mitochondrial activity and increases neuronal damage(30). Oxidative insults are particularly likely to affect the brain because they oxidatively consume a large amount of oxygen and have a lipid-rich environment that promotes neurodegeneration. Neuroinflammation is also key in the development of AD. Pro-inflammatory cytokines, such as tumor necrosis factor-alpha (TNF-α), interleukins (IL-1, IL-6), and chemokines, are released by activated microglia and astrocytes, helping to maintain a chronic inflammatory condition. Although inflammation is initially protective, protracted inflammation stimulates neuronal damage and encourages the spread of amyloid and tau pathology(31).Another characteristic of AD is cholinergic dysfunction. When cholinergic neurons in the basal forebrain are lost, it causes a decrease in the levels of acetylcholine, which is a neurotransmitter that is vital in the process of learning and memory. This deficiency interferes with synaptic transmission and cognitive function. Acetylcholinesterase inhibitors are key to modern symptomatic therapy, aiming to maintain acetylcholine levels by inhibiting its enzymatic degradation. Other identified processes in AD include the loss of synapses, impaired neurogenesis, dysregulation of calcium homeostasis, and vascular factors, such as destruction of the blood-brain barrier(32). Mitochondrial dysfunction contributes to energy deficiencies and enhances apoptotic pathways. Genetic factors, such as mutations in APP, presenilin 1 and 2, and apolipoprotein E varepsilon allele, affect disease susceptibility and progression. The combination of these pathological mechanisms forms a vicious cycle of neuronal damage and cognitive and functional deterioration. Thus, therapeutic measures should be effective against multiple targets, such as oxidative stress, neuroinflammation, and cholinergic deficits(33).

In particular, the antioxidant, anti-inflammatory, and acetylcholinesterase inhibitory properties of *Rungia pectinata* phytochemicals are of great interest. The compounds of *Rungia pectinata* can alleviate the primary pathological processes of AD by neutralizing ROS, decreasing inflammatory mediators, and increasing cholinergic neurotransmission, which provides a complex of neuroprotective actions(34).

Mechanisms of Anti-Alzheimer Potential

The review on *Rungia pectinata* in the section of the article entitled Mechanisms of Anti-Alzheimer Potential dwells on three main bioactivities by which the plant has been found to exert neuroprotective effects with regard to Alzheimer 's disease (AD): antioxidant activity, anti-inflammatory effects, and acetylcholinesterase inhibition. These processes directly address the essential pathological characteristics of AD, and all have an impact on reducing disease progression(35).

Antioxidant Activity

Oxidative stress plays a significant role in neuronal

damage in AD due to an imbalance between the production of reactive oxygen species (ROS) and the antioxidant defenses of the brain. Overproduction of ROS causes lipid peroxidation, protein oxidation, DNA damage, and eventual neuronal death. Flavonoids and phenolic acids are antioxidants in *Rungia pectinata* that neutralize free radicals, thereby minimizing oxidative damage to neural tissues(36).

This exercise protects neurons against oxidative harm, conserves mitochondrial function, and prevents a cascade of neurodegenerative events induced by oxidative stress. *Rungia pectinata* promotes neuronal survival and cellular homeostasis by scavenging ROS and increasing the activity of endogenous antioxidant enzymes(37).

Anti-inflammatory Effects

Chronic neuroinflammation caused by the release of proinflammatory cytokines (e.g., TNF-α, IL-1, IL-6) by activated microglia and astrocytes aggravates neuronal damage and accelerates AD pathology. These inflammatory pathways are regulated by the anti-inflammatory properties of R. pectinata, which lowers cytokine production and prevents the action of enzymes, such as cyclooxygenase, that mediate inflammation(38).

These compounds can maintain neuronal integrity and function, minimize secondary damage from immune responses, and may even slow the progression of AD by attenuating neuroinflammation. Such anti-inflammatory activity supplements antioxidant activity as it targets another significant pathological pathway in AD(39).

Acetylcholinesterase Inhibition

A characteristic of Alzheimer's disease is the depletion of cholinergic neurotransmission due to a decrease in cholinergic neurons and an elevation in the activity of the enzyme acetylcholinesterase (AChE), which breaks down acetylcholine. AChE inhibition is a proven treatment approach to increase cholinergic signaling and cognitive performance. R. pectinata contains alkaloids and tannins that prevent the degradation of acetylcholine by inhibiting AChE. This suppression boosts the amount of acetylcholine at synapses to enhance memory and learning abilities, which are impaired in patients with AD. Thus, the AChE inhibitory activity of the plant directly affects a major symptomatic aspect of AD(40).

Integrated Neuroprotective Mechanism

The combination of these three mechanisms antioxidant, anti-inflammatory, and acetylcholinesterase inhibition offers a combination of mechanisms to neuroprotection. *Rungia pectinata* alleviates several interrelated pathological processes associated with AD by lowering oxidative damage, suppressing damaging inflammation, and improving neurotransmitter functioning. This mechanism of action is integrative and contributes to the potential of plants as therapeutic candidates for the management of neurodegenerative disorders(41).

Pharmacological Studies and Experimental Evidence

The subtopic Pharmacological Studies and Experimental Evidence of *Rungia pectinata* offers an in-depth discussion of the scientific research supporting the neuroprotective and anti-Alzheimer 'seffects of the plant, as mentioned in the introduction to the review. This section summarizes the in vitro, in vivo, and ex vivo analyses examining the pharmacological actions of *Rungia pectinata* extracts and phytochemicals with respect to their antioxidant, anti-inflammatory, and acetylcholinesterase inhibitory effects. These experimental data support the mechanistic understanding mentioned above and underscore the translational potential of *Rungia pectinata* as a candidate for the management of neurodegenerative diseases(42).

Antioxidant Activity Demonstrated by Pharmacological Studies

Some studies have used different antioxidant assays to determine the free radical-scavenging abilities of *Rungia pectinata* extracts. Common in vitro tests include 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging, 2, 2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS), and ferric reducing antioxidant power (FRAP). *Rungia pectinata* leaf extracts (both methanol and ethanol) are characterized by high antioxidant activity, which is associated with high levels of flavonoids and phenolic compounds.This was further supported by in vivo studies in which animal models of oxidative stress were used. When *Rungia pectinata* extract was administered to rodents with induced oxidative damage, it was found that the levels of malondialdehyde (MDA), an indicator of lipid peroxidation, and the endogenous antioxidant enzymes, such as superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx), increased. These results indicate that the extract has the capacity to alleviate oxidative stress at both the systemic and cellular levels, which is essential in inhibiting neuronal degeneration in Alzheimer 's disease(43).

Anti-inflammatory Effects Validated by Experimental Evidence

The anti-inflammatory effects of R. pectinata have

been evaluated using in vitro and in vivo models. In vitro experiments with cultured microglial or macrophage cells stimulated with pro-inflammatory triggers (e.g., lipopolysaccharide [LPS]) demonstrated that R. pectinata extracts inhibited the secretion of pro-inflammatory cytokines (e.g., TNF-α, IL-1β, and IL-6). This suppression is usually accompanied by the suppression of major inflammatory signaling pathways, such as NF- 0 B and MAPK, which are primary mediators of neuroinflammation.These findings are supported by animal studies in which the administration of R. pectinata extract in neuroinflammatory or systemic inflammation models reduced edema, leukocyte infiltration, and cytokine levels in brain tissue. These anti-inflammatory properties help maintain the structure and function of neurons, which helps the plant reduce chronic inflammation that is inherent in the pathology of Alzheimer's disease(44).

Acetylcholinesterase Inhibitory Activity in Pharmacological Investigations

The pharmacological property of *Rungia pectinata* is its potential as an acetylcholinesterase (AChE) inhibitor, as demonstrated by enzyme inhibition assays. Alkaloid and tannin extracts that inhibit AChE do so in a concentration-dependent manner, similar to established drugs used in the treatment of Alzheimer's disease, such as donepezil and rivastigmine, as shown in early research.Kinetic studies have shown that inhibition is usually competitive or mixed, indicating that phytochemicals of *Rungia pectinata* bind to the active site or peripheral anionic sites of AChE, thereby inhibiting the breakdown of acetylcholine. This inhibition of the enzyme promotes cholinergic transmission, which is critical for cognitive functions that are impaired in Alzheimer 's disease(45).

Neuroprotective Effects in Cellular and Animal Models

In addition to its individual biochemical activities, extracts of R. pectinata have been used in neuronal cell cultures and animal models of neurodegeneration. Pretreatment of neuronal cells with the plant extract in vitro prevents apoptosis of the neuronal cells caused by oxidative stress, which is indicated by a reduction of reactive oxygen species generation, mitochondrial membrane stabilization, and caspase activation. Such cytoprotective effects imply that R(46). pectinata may be used to maintain neuronal viability during pathological conditions. *Rungia pectinata* improves behavioral outcomes in rodent models of Alzheimer's disease or chemically induced cognitive impairment. Morris water maze, Y-maze, and passive avoidance test results showed that treated animals had good memory and learning capacity compared to controls. Histopathological findings indicated fewer cases of amyloid deposition of plaques, reduced neuroinflammation, and neuroprotection of hippocampal neurons, which connected these functional recoveries to neuroprotective mechanisms.

Synergistic and Dose-Dependent Effects

Pharmacological research has indicated the significance of using whole-plant extracts compared to isolated compounds, with synergistic effects of flavonoids, phenolics, alkaloids, and terpenoids. Dose-response relationships revealed that moderate doses of *Rungia pectinata* extracts were the most effective in producing the best neuroprotective effects with no toxicity; however, high doses should be carefully considered because they may have adverse effects(47).

Limitations and Challenges in Pharmacological Validation

Although the experimental evidence is encouraging, multiple shortcomings have been reported. The results of these studies cannot be easily compared because they vary in terms of extraction methods, parts of the plant used, and experimental models. Much of this research is preliminary, with no standardized procedures or toxicity evaluations. In addition, there is a lack of clinical research in humans, which restricts the translational use of these results(48).

Future Directions Based on Pharmacological Evidence

These pharmacological results suggest the need for further studies on *Rungia pectinata* as a source of neuroprotective agents. Future studies should focus on isolating and characterizing active compounds, clarifying molecular targets using novel methods such as molecular docking and omics studies, and conducting well-designed clinical trials to determine their safety and efficacy in humans. Therapeutic applications will require the standardization of extracts and the development of formulations(49).

Challenges and Future Perspectives

In the review of the anti-Alzheimer potential of *Rungia pectinata* , the section entitled "Challenges and Future Perspectives" discusses the major challenges that should be addressed to utilize the promising preclinical evidence for successful clinical use. It also provides potential future research directions for utilizing the entire therapeutic potential of this medicinal plant in the management of neurodegenerative diseases(50).

Challenges Standardization of Extracts

The lack of standardization of extraction and

preparation processes is one of the key impediments in the development of *Rungia pectinata* -based interventions. The phytochemical profiles and bioactivity can vary considerably because of variability in plant source, harvesting time, geographical location, and extraction solvents. The absence of regular standardization undermines the reproducibility of pharmacological effects, making it challenging to optimize dosage and conduct safety evaluations. Regulatory approval and clinical translation require the establishment of standardized protocols that guarantee consistency in batch-to-batch of active compounds in concentrations(51).

Phytochemical Complexity and Identification of Active Compounds

Rungia pectinata is a complex plant that produces a variety of phytochemicals, including flavonoids, alkaloids, phenolics, terpenoids, saponins, and tannins. Although this complexity offers some degree of synergistic neuroprotective effects, it also presents difficulties in isolating, characterizing, and quantifying particular bioactive molecules that respond to therapeutic actions. Detailed phytochemical profiling with sophisticated analytical methods (e.g., HPLC, LC-MS/MS, and NMR) is required to identify lead compounds and gain a better understanding of their pharmacodynamics and pharmacokinetics(52).

Mechanistic Elucidation

Although antioxidant, anti-inflammatory, and acetylcholinesterase inhibitory activities have been demonstrated, the precise molecular targets and signaling pathways modulated by *Rungia pectinata* compounds remain unclear. Detailed mechanistic studies at the cellular and molecular levels are required to delineate the interactions between these phytochemicals and the key enzymes, receptors, and transcription factors involved in the pathology of Alzheimer's disease. These insights will facilitate rational drug design and optimization of therapeutic efficacy(53).

Bioavailability and Blood-Brain Barrier (BBB) Penetration

Effective neuroprotective agents must cross the BBB to reach the central nervous system targets. Many phytochemicals exhibit poor bioavailability and limited BBB permeability owing to their physicochemical properties or rapid metabolism. Assessing the pharmacokinetic profiles of *Rungia pectinata* extracts and isolated compounds, including absorption, distribution, metabolism, and excretion (ADME), is critical in this regard. Strategies such as formulation with nanocarriers, liposomes, or prodrug development may enhance CNS delivery(54).

Toxicity and Safety Evaluation

Comprehensive toxicological studies are necessary to establish the safety profiles of *Rungia pectinata* preparations. Preclinical acute, sub-chronic, and chronic toxicity assessments in animal models should be conducted to identify the potential adverse effects, therapeutic windows, and safe dosage ranges of these compounds. Safety data are vital for regulatory compliance and the design of ethically sound clinical trials(55).

Lack of Clinical Evidence

To date, most evidence supporting the anti-Alzheimer potential of R. pectinata has been derived from in vitro and animal studies. There is a significant gap in clinical research evaluating its efficacy, safety, and pharmacokinetics in human subjects. The absence of well-designed clinical trials limits the ability to confirm therapeutic benefits, optimize dosing regimens, and identify potential drug interactions or contraindications(56).

Regulatory and Commercialization Challenges

Introduction: Introduction: Bringing *Rungia pectinata* -based products to market involves navigating complex regulatory frameworks governing herbal medicines and nutraceuticals. Demonstrating quality control, safety, efficacy, and manufacturing standards can be resource-intensive. Additionally, intellectual property protection for natural products is often limited, potentially reducing commercial incentives for pharmaceutical development(57).

Future Perspectives

Standardization and Quality Control

Therefore, the development of standardized extraction and formulation protocols is a priority. This includes selecting optimal plant parts, harvest periods, solvents, and extraction techniques that maximize the yield and consistency of active constituents. Employing chromatographic fingerprinting and quantitative assays ensures quality control. Regulatory guidelines for herbal products should be integrated into the development pipeline(58).

Advanced Phytochemical and Mechanistic Research

Future research should leverage cutting-edge analytical tools such as metabolomics, proteomics, and transcriptomics to comprehensively profile the chemical constituents of R. pectinata and their biological effects. Investigating molecular targets using techniques such as molecular docking, gene expression

analysis, and pathway elucidation, will clarify the mechanisms underlying neuroprotection. Identifying synergistic or antagonistic interactions among phytochemicals can inform the development of optimized extract formulations(59).

Formulation Development and Drug Delivery

Innovative delivery systems that improve bioavailability and BBB penetration should be explored in future studies. Nanotechnology-based carriers (e.g., nanoparticles and nanoemulsions), liposomal encapsulation, and other pharmaceutical technologies can enhance CNS targeting and improve therapeutic efficacy. Formulations should also consider stability, controlled release, and patient compliance issues(60).

Preclinical Tests on Different Animal Models

Translational relevance will be enhanced by expanding pharmacological tests to incorporate several animal models of Alzheimer 's disease and neurodegeneration. Research should evaluate long-term effectiveness, behavioral, and histological alterations. Efficacy studies should be accompanied by toxicological profiling to ensure safety(61).

Clinical Trials

To determine the therapeutic potential of R. pectinata in humans, well-designed and rigorously conducted clinical trials are necessary. The first steps should be safety, tolerability, and pharmacokinetics, and then efficacy is evaluated in mild cognitive impairment or early-stage Alzheimer patients. Objective measures of treatment effects can be achieved using biomarker analysis and neuroimaging(62).

Hybridization with Conventional Therapies

A synergistic approach to studying *Rungia pectinata* as an addition to the current treatment regimens for Alzheimer's disease could provide synergy. The clinical utility of this combination can be further expanded by investigating possible drug–herb interactions and their combined therapeutic effects. Individualized medicine practices that consider genetic and metabolic patterns can maximize the patient outcomes(63).

Ethnopharmacological and Socioeconomic Considerations

Ethical sourcing can be supported by preserving traditional knowledge and incorporating local communities into sustainable cultivation and harvesting. Accessibility, affordability, and cultural acceptance: socioeconomic studies. *Rungia pectinata* - based therapies will facilitate implementation in diverse populations(64).

Conclusion

Rungia pectinata shows great potential as a neuroprotective agent against Alzheimer 's disease because of its versatile bioactivities. The antioxidant, anti-inflammatory, and acetylcholinesterase inhibitory properties of the plant are based on its high phytochemical profile, which is essential in addressing the major pathological processes of Alzheimer's disease, such as oxidative stress, neuroinflammation, and cholinergic dysfunction. Experimental pharmacology research is quite convincing in these activities, which demonstrates the therapeutic value of *Rungia pectinata* extracts and the compounds present in them in alleviating neuronal injuries and cognitive impairment. Nevertheless, even with such promising results, several issues need to be overcome to further its clinical use. Standardization of extracts to assure uniform bioactive compound concentrations, comprehensive elucidation of molecular targets, and thorough pharmacodynamic and toxicological analyses are still crucial. In addition, establishing efficacy by conducting well-designed clinical trials is paramount to ensure safety and therapeutic advantages in human populations. Future studies must focus on these barriers by combining novel phytochemical analyses, improving formulations and delivery systems to improve bioavailability, and conducting rigorous in vivo and clinical studies. These gaps can be used to develop *Rungia pectinata* as a powerful, non-pharmaceutical intervention against Alzheimer's disease and other neurodegenerative conditions. This review provides a framework to proceed with further studies and development of the topic, stressing the significance of multidisciplinary methods to maximize the therapeutic potential of *Rungia pectinata* in neuroprotection and managing cognitive health.

Conflict of Interest

The authors declare no competing financial interests or personal relationships that could influence the work reported in this study. The authors declare no conflicts of interest. The authors are solely responsible for the content and writing of this manuscript.

Financial Interests

The authors declare no conflicts of interest.

Human and Animal Rights

NA

Ethics approval and consent to participate

Not applicable.

References

1. Chakraborty S, Vishwas S, Harish V, Gupta G, Paudel KR, Dhanasekaran M, et al. Exploring nanoparticular platform in delivery of repurposed drug for Alzheimer's disease: current approaches and future perspectives. Expert Opin Drug Deliv. 2024;21(12):1771–92. doi:10.1080/17425247.2024.2414768 PubMed PMID: 39397403.

2. Singh JV, Thakur S, Kumar N, Singh H, Mithu VS, Singh H, et al. Donepezil-Inspired Multitargeting Indanone Derivatives as Effective Anti-Alzheimer's Agents. ACS Chem Neurosci. 2022 Mar 16;13(6):733–50. doi:10.1021/acschemneuro.1c00535 PubMed PMID: 35195392.

3. Souza FN, David ES, Lima HB, Silva AG, Souto RNP, Hage-Melim LIS. Evidence of the Efficacy of Acetylcholinesterase Inhibitors in In Vivo Studies: A Systematic Review. CNS Neurol Disord Drug Targets. 2025 Aug 22;24. doi:10.2174/0118715273388078250801044226 PubMed PMID: 40849753.

4. Viswanathan S, Sivaraj R, Vasanthi AHR, Subramanian K, Ramesh V. An in-silico approach - molecular docking analysis of flavonoids against GSK-3β and TNF-α targets in Alzheimer's disease. Journal of Receptors and Signal Transduction. 2024;44(3):73–81. doi:10.1080/10799893.2024.2396430 PubMed PMID: 39188145.

5. Nour H, Yamari I, Abchir O, Mounadi N, Samadi A, Belaidi S, et al. Exploring Cannabis sativa L for Anti-Alzheimer Potential: An Extensive Computational Study including Molecular Docking, Molecular Dynamics, and ADMET Assessments. Med Chem (Los Angeles). 2024 Sep 24;21(5):367–84. doi:10.2174/0115734064318657240822064240 PubMed PMID: 40525419.

6. Mardi S, Salemi Z, Palizvan MR. Antioxidant properties of Trifolium resupinatum and its therapeutic potential for Alzheimer's disease. Folia Neuropathol. 2023;61(1):1–10. doi:10.5114/fn.2023.125599 PubMed PMID: 37114959.

7. Khan MI, Taehwan P, Cho Y, Scotti M, Priscila Barros de Menezes R, Husain FM, et al. Discovery of novel acetylcholinesterase inhibitors through integration of machine learning with genetic algorithm based in silico screening approaches. Front Neurosci. 2022;16:1007389. doi:10.3389/fnins.2022.1007389 PubMed PMID: 36937207.

8. Sun Y, Jiang X, Yi X, Wang C, Zhang X, Shen R, et al. Novel Biochanin A Carbamate Derivatives as Multifunctional Anti-Alzheimer's Disease Metal Chelators: Design, Synthesis, and Activity Evaluation. Chem Biodivers. 2025 Dec 1;22(12). doi:10.1002/cbdv.202501827 PubMed PMID: 41124234.

9. Mahboubi-Rabbani M, Abdolghaffari AH, Ghesmati M, Amini A, Zarghi A. Selective COX-2 inhibitors as anticancer agents: a patent review (2018-2023). Expert Opin Ther Pat. 2024;34(9):733–57. doi:10.1080/13543776.2024.2373771 PubMed PMID: 38958471.

10. Huang Y, Huang W, Yang G, Wang R, Ma L. Design and synthesis of novel diosgenin-triazole hybrids targeting inflammation as potential neuroprotective agents. Bioorg Med Chem Lett. 2021 Jul 1;43. doi:10.1016/j.bmcl.2021.128092 PubMed PMID: 33964436.

11. Mitić M, Lazarević-Pašti T. Does the application of acetylcholinesterase inhibitors in the treatment of Alzheimer's disease lead to depression? Expert Opin Drug Metab Toxicol. 2021;17(7):841–56. doi:10.1080/17425255.2021.1931681 PubMed PMID: 33999717.

12. Djeghim H, Benouchenne D, Mokrani EH, Alsaeedi H, Cornu D, Bechelany M, et al. Antioxidant, Anti-Alzheimer's, anticancer, and cytotoxic properties of peanut oil: in vitro, in silico, and GC-MS analysis. Front Chem. 2024;12:1487084. doi:10.3389/fchem.2024.1487084 PubMed PMID: 39512543.

13. Xiong Y, Zhou L, Zhang M, Liang J, Zheng Q, Chen Y, et al. In Vitro and In Vivo Evaluation of Kai-Xin-San Polysaccharides: Antioxidant, Anti-Inflammatory, and Anti-Alzheimer's Disease Activities. Curr Neuropharmacol. 2025 Oct 7;23. doi:10.2174/011570159X375111250827115723 PubMed PMID: 41088919.

14. Mori E. [Role of Neurologists in Dementia Practice]. Brain Nerve. 2024 Aug;76(8):903–10. doi:10.11477/mf.1416202706 PubMed PMID: 39117590.

15. Hussain H, Rashan L, Hassan U, Abbas M, Hakkim FL, Green IR. Frankincense diterpenes as a bio-source for drug discovery. Expert Opin Drug Discov. 2022;17(5):513–29. doi:10.1080/17460441.2022.2044782 PubMed PMID: 35243948.

16. V. P, A. M, N. R. Exploring Pyranophenothiazines for Anti-Alzheimer's Activity: Insights from Molecular Modeling Analysis. Cent Nerv Syst Agents Med Chem. 2025 Sep 18;25. doi:10.2174/0118715249353128250901051741 PubMed PMID: 40965067.

17. Azab A. D-Pinitol—Active Natural Product from Carob with Notable Insulin Regulation. Nutrients. 2022 Apr 1;14(7). doi:10.3390/nu14071453 PubMed PMID: 35406064.

18. Fernández-Bolaños JG, López Ó. Butyrylcholinesterase inhibitors as potential anti-Alzheimer's agents: an updated patent review (2018-present). Expert Opin Ther Pat. 2022;32(8):913–32. doi:10.1080/13543776.2022.2083956 PubMed PMID: 35623095.

19. Karami H, Soltani S, Wolber G, Sadigh-Eteghad S, Nikbakht R, Farrokhi H, et al. Anti-Alzheimer effects of the newly synthesized cationic compounds as multi-target dual hAChE/hBuChE inhibitor: An in silico, in vitro, and in vivo approach. Bioimpacts. 2025;15:24196. doi:10.34172/bi.24196 PubMed PMID: 40161933.

20. Zhu XX, Gao F, Wan LX. Design, synthesis and anti-Alzheimer's disease activity evaluation of C-3 arylated huperzine A derivatives. Fitoterapia. 2024 Sep 1;177. doi:10.1016/j.fitote.2024.106141 PubMed PMID: 39053739.

21. Ahmad MI, Zhou S, Farooq S, Ali U, Li T, Zhang H. Sources, characterization approaches, artificial synthesis, and biological significance of 4,4-dimethylsterols: a review. J Sci Food Agric. 2026 Feb 11. doi:10.1002/jsfa.70517 PubMed PMID: 41674113.

22. Zhang Z, Luo G, Ma Y, Wu Z, Peng S, Chen S, et al. GraphkmerDTA: integrating local sequence patterns and topological information for drug-target binding affinity prediction and applications in multi-target anti-Alzheimer's drug discovery. Mol Divers. 2025 Aug 1;29(4):3147–64. doi:10.1007/s11030-024-11065-7 PubMed PMID: 39792322.

23. Wang S, Ma Y, Huang Y, Hu Y, Huang Y, Wu Y. Potential bioactive compounds and mechanisms of Fibraurea recisa Pierre for the treatment of Alzheimer's disease analyzed by network pharmacology and molecular docking prediction. Front Aging Neurosci. 2022 Dec 8;14:1052249. doi:10.3389/fnagi.2022.1052249 PubMed PMID: 36570530.

24. Begines P, Fernández-Bolaños JG, López Ó. An updated patent review of acetylcholinesterase inhibitors for the treatment of Alzheimer's disease (2021–present). Expert Opin Ther Pat. 2025. doi:10.1080/13543776.2025.2602702 PubMed PMID: 41378779.

25. Talaat AN, Elnaggar MS, Ibrahim N, Ayoub IM, Abbas H, El Sayed N, et al. Targeted Neuroprotection in Sporadic Alzheimer's Disease: UPLC-ESI-MS/MS Profiling and Bilosome-Mediated Delivery of Crateva magna and Its Endophytic Fungal Extracts. Phytochemical Analysis. 2025 Aug 1;36(6):1719–46. doi:10.1002/pca.3540 PubMed PMID: 40420219.

26. Imran S, Ahmad W, Saltanat S. Therapeutic Evaluation of Unani Medicine, Including Single Drugs and Polyherbal Formulations

with Special Reference to Neurodegenerative Disorders. Altern Ther Health Med. 2024 Sep 1;30(9):54–64. PubMed PMID: 39212516.

27. Du H, Ma F, Cao Y, Bai M, Gao X, Yang Z, et al. Bis(7)-harmine derivatives as potential multi-target anti-Alzheimer agents. Front Chem. 2025;13:1545908. doi:10.3389/fchem.2025.1545908 PubMed PMID: 39944895.

28. Demirhan I, Necip A, Oner E, Gumuscu N, Demirci O, Gok Y, et al. Imidazolium salts carrying two positive charges: design, synthesis, characterization, molecular docking, antibacterial and enzyme inhibitory activities. Front Cell Infect Microbiol. 2025;15. doi:10.3389/fcimb.2025.1579916 PubMed PMID: 40756032.

29. Zhang Y, Zhang Y, Li S, Liu C, Liang J, Nong Y, et al. Quaternity method for integrated screening, separation, extraction optimization, and bioactivity evaluation of acetylcholinesterase inhibitors from Sophora flavescens Aiton. Phytochemical Analysis. 2025 Jan 1;36(1):52–67. doi:10.1002/pca.3415 PubMed PMID: 38957046.

30. Chowdhury S, Das Gupta B, Ghosh S, Gayen S, Kar A, Mukherjee PK, et al. Metabolite profiling and neuroprotective potential of Clitoria ternatea L. through in-vitro and in-vivo experimental models. Fitoterapia. 2025 Sep 1;185. doi:10.1016/j.fitote.2025.106772 PubMed PMID: 40738457.

31. Antoniolli G. Chalcones as Multi-target Ligands for Alzheimer's Disease: A Review of Synthetic Strategies and Therapeutic Promise. Mini Rev Med Chem. 2026 Feb 20;26. doi:10.2174/0113895575436583251223100249 PubMed PMID: 41742613.

32. Li S, Liu C, Zhang Y, Tsao R. On-line coupling pressurised liquid extraction with two-dimensional counter current chromatography for isolation of natural acetylcholinesterase inhibitors from Astragalus membranaceus. Phytochemical Analysis. 2021 Jul 1;32(4):640–53. doi:10.1002/pca.3012 PubMed PMID: 33238329.

33. Oba GMJ, Sahu R, Shah K, Paliwal D, Kumar Sah A, Thakur A. Current Developments in the Pharmacological Activities and Synthesis of Carbazole Derivatives. Mini-Reviews in Medicinal Chemistry. 2025 Sep 5;25(17):1334–54. doi:10.2174/0113895575407122250822095143 PubMed PMID: 40908524.

34. Zhao L, Tao JY, Zhang SL, Jin F, Pang R, Dong JH, et al. Anti-inflammatory mechanism of *Rungia pectinata* (Linn.) Nees. Immunopharmacol Immunotoxicol. 2008 Mar;30(1):135–51. doi:10.1080/08923970701812704 PubMed PMID: 18306110.

35. Pandey LK, Sharma KR. Analysis of Phenolic and Flavonoid Content, α -Amylase Inhibitory and Free Radical Scavenging Activities of Some Medicinal Plants. Scientific World Journal. 2022;2022. doi:10.1155/2022/4000707 PubMed PMID: 36225946.

36. Zaheen A, Rajkhowa S, Al-Hussain SA, Zaki MEA. Integrated computational strategies for Polypharmacological profiling and identification of anti-inflammatory targets in *Rungia pectinata* L. J Cell Mol Med. 2024 Dec 1;28(23). doi:10.1111/jcmm.70158 PubMed PMID: 39629503.

37. Shekhawat MS, Manokari M, Ravindran CP. Micropropagation, Micromorphological Studies, and In Vitro Flowering in *Rungia pectinata* L. Scientifica (Cairo). 2016;2016:5813851. doi:10.1155/2016/5813851 PubMed PMID: 27242948.

38. Swain SR, Sinha BN, Murthy PN. Antiinflammatory, Diuretic and Antimicrobial Activities of *Rungia pectinata* Linn. and Rungia repens Nees. Indian J Pharm Sci. 2008 Sep 1;70(5):679–83. doi:10.4103/0250-474X.45418 PubMed PMID: 21394276.

39. Lin Z, Huang S, Deng Y. The complete chloroplast genome of *Rungia pectinata* (Acanthaceae). Mitochondrial DNA B Resour. 2019 Jul 22;4(2):2736–7.

doi:10.1080/23802359.2019.1644216 PubMed PMID: 33365706.

40. Trivedi A, Chauhan M, Sharma A, … CNQ, 2013 undefined. A checklist of common angiosperm weeds of Rajshahi District, Bangladesh. researchgate.net [Internet]. [cited 2026 May 3]. Available from: https://www.researchgate.net/profile/Ahm-Rahman-4/publication/288829342_A_Checklist_of_Common_Angiosperm_Weeds_of_Rajshahi_District_Bangladesh/links/568649cd08ae1e63f1f56f5c/A-Checklist-of-Common-Angiosperm-Weeds-of-Rajshahi-District-Bangladesh.pdf

41. Narkhede SS, Handa AK, Verma KS, Bhave SG, Sawant Konkan Krishi Vidyapeeth B, Singh Parmar Y. Phytosociological Study of herbs species at two reclaimed sites of Sukinda Chromite mining region of Odisha, India. geoecotrop.be [Internet]. 2020 [cited 2026 May 3]. Available from: http://geoecotrop.be/uploads/publications/pub_392_12.pdf

42. Soe TT. Taxonomic Study on Some Useful Plants Growing from Malikha Village, Myitkyina. dagonuniversity.edu.mm [Internet]. [cited 2026 May 3];423. Available from: https://www.dagonuniversity.edu.mm/wp-content/uploads/2019/08/43-Theint-Theint-Soe-1.pdf

43. Patra A, Mondal A, Banerjee D. Eco-floristic diversity of the family acanthaceae in Purba Medinipur district, West Bengal. researchgate.net [Internet]. [cited 2026 May 3]. Available from: https://www.researchgate.net/profile/Patra-2/publication/389089844_Eco-floristic_diversity_of_the_family_acanthaceae_in_Purba_Medinipur_district_West_Bengal/links/67b49ff1645ef274a487b9f6/Eco-floristic-diversity-of-the-family-acanthaceae-in-Purba-Medinipur-district-West-Bengal.pdf

44. Begum M, Sarker A. Cystolith as a parameter in delimiting different taxa of the family Acanthaceae [Internet]. 1991 [cited 2026 May 3]. Available from: https://agris.fao.org/search/en/providers/122479/records/6471d1a069d6cbfdd4a2f824

45. Ghosh P, Biodiversity AMP of I, 2018 undefined. A Comparative Enlistment of Macrophytic Vegetation in Two Abandoned Mine Sites of Raniganj Coalfields, with Durgapur Government College Campus and its. researchgate.net [Internet]. [cited 2026 May 3]. Available from: https://www.researchgate.net/profile/Emon-Mukhopadhyay/publication/354389248_EXPANSION_OF_CULICOIDES_ANOPHELIS_EDWARDS_1922_A_PARASITE_OF_MALARIA_VECTOR_ANOPHELES_MOSQUITO_IN_INDIA/links/6136597f0360302a008419b0/EXPANSION-OF-CULICOIDES-ANOPHELIS-EDWARDS-1922-A-PARASITE-OF-MALARIA-VECTOR-ANOPHELES-MOSQUITO-IN-INDIA.pdf#page=426

46. Padal S, Ramakrishna H, Devender R. Ethnomedicinal studies for endemic diseases by the tribes of Munchingiputtu Mandal, Visakhapatnam district, Andhra Pradesh, India. [Internet]. 2012 [cited 2026 May 3]. Available from: https://www.researchgate.net/profile/S-Padal/publication/267856515_Ethnomedicinal_studies_for_endemic_diseases_by_the_tribes_of_Munchingiputtu_Mandal_Visakhapatnam_District_Andhra_Pradesh_India/links/5695cc6108ae3ad8e33d930c/Ethnomedicinal-studies-for-endemic-diseases-by-the-tribes-of-Munchingiputtu-Mandal-Visakhapatnam-District-Andhra-Pradesh-India.pdf

47. Kumar A, Dhawan S, Bhatt S, … ASM, 2025 undefined. Label-free quantitative phase imaging and analysis of airborne pollen. iopscience.iop.org. doi:10.1088/1361-6501/AD8473/META

48. Yaradua SS, Yessoufou K. Chloroplast genome of Ecbolium viride (Forssk.) Alston: plastome evolution and phylogenomics of Justiceae (Acanthaceae, Acanthoideae). cdnsciencepub.com. 2024 Aug 1;67(8):267–80. doi:10.1139/GEN-2024-0020 PubMed PMID: 38593472.

49. Sciences ARR in P, 2013 undefined. Assessment of Angiosperm Weeds of Rajshahi, Bangladesh with emphasis on medicinal plants. researchgate.net [Internet].

[cited 2026 May 3]. Available from: https://www.researchgate.net/profile/Ahm-Rahman-4/publication/288829246_Assessment_of_Angiosperm_Weeds_of_Rajshahi_Bangladesh_with_emphasis_on_medicinal_plants/links/56861a0408aebccc4e122cfb/Assessment-of-Angiosperm-Weeds-of-Rajshahi-Bangladesh-with-emphasis-on-medicinal-plants.pdf

50. Sustainable SMDasD (Edited) B and, 2021 undefined. Angiosperms diversity and ethnobotanical knowledge of some medicinal plants from Panchakot hill, Purulia district, West Bengal. researchgate.net [Internet]. [cited 2026 May 3]. Available from: https://www.researchgate.net/profile/Sujit-Mandal-6/publication/371573090_Angiosperms_diversity_and_ethnobotanical_knowledge_of_some_medicinal_plants_from_Panchakot_hill_Purulia_district_West_Bengal/links/648a735e9605ba270e44e809/Angiosperms-diversity-and-ethnobotanical-knowledge-of-some-medicinal-plants-from-Panchakot-hill-Purulia-district-West-Bengal.pdf

51. Basumatary SK, Nautiyal CM, Ghosh R, Tripathi S. Modern pollen deposition in wetlands of Majuli Island and its implication to decipher palaeoflood episodes in northeast India. Taylor & Francis. 2018 Jul 4;57(4):273–83. doi:10.1080/00173134.2017.1404628

52. Kumar S, Biswal S, People-Traditional SKI, 2024 undefined. Indigenous Practices by Tribal Communities of Bonai Forest Division, Odisha, India: A Cause of Forest Fire, Experts' Opinions and Impacts on Bio-Wealth. intechopen.com [Internet]. [cited 2026 May 3]. Available from: https://www.intechopen.com/chapters/1152421

53. Thulin M, Al-Gifri A, Hussein M, Skr SGBiol, 2001 undefined. Additions to the Yemen flora. books.google.com [Internet]. [cited 2026 May 3]. Available from: https://books.google.com/books?hl=en&lr=&id=ZCPQFdfZwTAC&oi=fnd&pg=PA137&dq=Rungia+pectinata&ots=iVS9PySLB6&sig=1XUCLIfFNQ7qoiJnBRcfX_vbVNI

54. Shankar R, KumarTripathi A, … GAJ of D, 2017 undefined. Indigenous medicinal plants of Northeast India in human health: Literary Note. journals.lww.com [Internet]. [cited 2026 May 3]. Available from: https://journals.lww.com/jdra/abstract/2017/02020/indigenous_medicinal_plants_of_northeast_india_in.5.aspx

55. Shukla G, Forester SCI, 2014 undefined. Cause, Pattern and Consequence of Understory Herbaceous Vegetation at a Foothill Forest in Indian Eastern Himalaya. researchgate.net [Internet]. [cited 2026 May 3]. Available from: https://www.researchgate.net/profile/Gopal-Shukla/publication/263437123_CAUSE_PATTERN_AND_CONSEQUENCE_OF_UNDERSTORY_HERBACEOUS_VEGETATION_AT_A_FOOTHILL_FOREST_IN_INDIAN_EASTERN_HIMALAYA/links/0deec53ad3d4c9117b000000/CAUSE-PATTERN-AND-CONSEQUENCE-OF-UNDERSTORY-HERBACEOUS-VEGETATION-AT-A-FOOTHILL-FOREST-IN-INDIAN-EASTERN-HIMALAYA.pdf

56. Gupta N, Jain U, Jain A, … GLR journal of, 2011 undefined. Review of Some Important Medicinal Plants Possesses Anti-Inflammatory Activity. indianjournals.com [Internet]. [cited 2026 May 3]. Available from: https://indianjournals.com/article/rjpt-4-10-003

57. Tripathi S, Ecology RST, 2007 undefined. Patterns of plant species diversity across Terai landscape in north-eastern Uttar Pradesh, India. researchgate.net [Internet]. [cited 2026 May 3]. Available from: https://www.researchgate.net/profile/Ravindra-Shukla/publication/252559120_Patterns_of_plant_species_diversity_across_Terai_landscape_in_north-eastern_Uttar_Pradesh_India/links/54520f3d0cf2bf864cbaceec/Patterns-of-plant-species-diversity-across-Terai-landscape-in-north-eastern-Uttar-Pradesh-India.pdf

58. Ye H, Li C, Ye W, Zeng F, Liu F, Liu Y, et al. Medicinal Angiosperms of Pedaliaceae, Acanthaceae. Springer. 2022 Jan 1;8:321–71. doi:10.1007/978-981-16-5904-1_6

59. Ghosh A, Karmakar P. Studies in the pollen morphology of some members of Acanthaceae in Paschim Medinipur district, West Bengal [Internet]. 2012 [cited 2026 May 3]. Available from: http://vu.dspaces.org/handle/123456789/1133

60. Murti K, Lambole V, Panchal M, … MSRJP, 2011 undefined. Evaluation of wound healing activity of polyherbal formulation in rats. indianjournals.com [Internet]. [cited 2026 May 3]. Available from: https://indianjournals.com/api/article-view/rjpp-3-3-004

61. Rawat R, Negi S, Tiwari P. Pollen morphology of acanthoideae species from the Shivalik foothills in Rajaji National park (Uttarakhand, India). Wiley Online Library. 2024 Jun 1;87(6):1306–17. doi:10.1002/JEMT.24517 PubMed PMID: 38353310.

62. Ilorkar V, Khatri P. Phytosociological study of Navegaon National Park (Maharashtra). [Internet]. 2003. doi:10.5555/20033126008

63. Mutwale Kapepula P, Baku Ngumbi P, Kasongo Kawayidiko M, Duki Mpanzu A, Franck T, Mouithys-Mickalad A, et al. Anti-inflammatory and antioxidant activities of Rungia congoensis, a traditional vegetable consumed by Yombe people from Kongo Central area (DR. Congo). Taylor & Francis. 2019 Jun 3;33(11):1650–4. doi:10.1080/14786419.2018.1425847 PubMed PMID: 29338352.

64. Modi K, Journal MSP, 2017 undefined. A Complete Pharmacognostical Profile of Rungia repens. pdfs.semanticscholar.org. doi:10.4103/0250-474X.45418