



HEALING — WITH — NATURE



Edited by

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PREFACE

Healing with Nature brings together ten comprehensive reviews of lesser-studied medicinal plants, herbs such as *Caesulia axillaris*, *Desmodium triflorum*, *Drosera burmanni* and *Utricularia stellaris* that have long sustained traditional and tribal healing systems across the Indian subcontinent, yet remain largely overlooked in mainstream scientific literature. Each chapter traces a single species from its ethnomedicinal roots through its phytochemistry to its documented pharmacological effects, weaving generations of folk knowledge together with contemporary laboratory findings. The guiding purpose of the book is to close the gap between indigenous plant-based practice and evidence-based pharmacology. From systematically compiling what is known about each plant's bioactive compounds and their associated antioxidant, antimicrobial, anti-inflammatory and other therapeutic properties, the contributing authors not only validated age-old remedies but also identified where current knowledge falls short, pointing toward the mechanistic and clinical studies still needed before these plants can be more fully realized as sources of new drugs and nutraceuticals. Compiled through the collaborative work of botanists, pharmacologists and researchers from institutions across India, this book is intended as a resource for students, researchers and practitioners in ethnobotany, pharmacognosy and natural product drug discovery. We hope that by bringing these scattered studies into a single book, *Healing with Nature* will inspire renewed scientific attention to the plants that traditional medicine has trusted for generations.

(Editors)



BACKGROUND

India and its neighbouring regions harbour one of the richest reservoirs of medicinal plant diversity in the world, much of it embedded in centuries-old tribal and folk healing traditions. Species such as *Caesulia axillaris*, *Mecardonia procumbens*, *Glinus oppositifolius* and *Polygala*, *Marsilea* and *Begonia* varieties have been used by indigenous and rural communities to treat ailments ranging from infections and inflammation to fever and metabolic disorders. Yet much of this knowledge exists only in oral tradition or scattered regional ethnobotanical surveys and a large share of these plants have never been subjected to systematic pharmacological scrutiny. This imbalance between traditional use and scientific validation is the starting point for the present work. The need for structured documentation of such knowledge is urgent. Traditional plant-use practices are transmitted informally across generations, making them vulnerable to loss as rural populations urbanize, elder knowledge-holders pass away and habitats that sustain these species come under pressure from land-use change and climate stress. Once this knowledge disappears, it is exceedingly difficult to reconstruct. Compiling what is currently known ethnomedicinal uses, phytochemical profiles and pharmacological findings into a single accessible reference protects this heritage from being permanently lost and creates a durable record that future researchers can build upon rather than starting from scratch.

Beyond preservation, systematic documentation serves a scientific and practical purpose; it identifies where traditional claims align with measurable pharmacological activity and, just as importantly, where the evidence is still thin. Many of the plants covered in this book have yielded bioactive compounds flavonoids, phenolics, essential oils and other secondary metabolites that show antioxidant, antimicrobial, anti-inflammatory, analgesic and other effects in preliminary studies. Bringing these fragmented findings together allows researchers to see the fuller picture for each species; what is well-supported, what is merely anecdotal and what specific mechanistic or clinical studies are needed next. Without this kind of consolidation, promising leads risk remaining buried across disparate, hard-to-find publications.

The significance of this work, then, lies in bridging traditional ecological knowledge and modern pharmacological research at a moment when both are needed to address contemporary health challenges, including antimicrobial resistance and the search for new therapeutic and nutraceutical compounds. Offering a consolidated, evidence-based account of underexplored medicinal plants, this book aims to serve as a foundation for future drug discovery efforts, while also affirming the value of the traditional knowledge systems from which this scientific inquiry originally drew.

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Chapter 1

***Caesulia axillaris* Roxb.: a comprehensive review of its ethnomedicinal heritage, bioactive profile and pharmacological potential**

Rita Shivilal Chudasama¹, Kadambini Das², J Jeline Rani³, Manoj Kumar Pradhan⁴, Poonam Dilip Sable⁵, Anju Kumari Thakur⁶, Nibedita Jena⁷ and Smitaa Basole^{8*}

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Abstract: *Caesulia axillaris* Roxb. from Asteraceae family is a fascinating wetland herb that has not received much attention yet. It is native to the Indian subcontinent and can be found thriving as a weed in paddy fields and marshy areas throughout India, Bangladesh and Nepal. For generations, traditional and tribal medicine systems have utilized its leaves, stems and seeds to tackle several health issues. Phytochemical research has uncovered a variety of bioactive compounds in this plant, including essential oils packed with dl-limonene and eusarone, as well as flavonoids and phenolic compounds. These components contribute to a wide array of proven pharmacological effects, such as antioxidant, antimicrobial, anti-inflammatory, antipyretic, analgesic and gastroprotective properties. The present chapter takes a deep look into the ethnomedicinal history, phytochemistry and pharmacological potential of *C. axillaris*, blending traditional wisdom with modern scientific findings. Thus, bringing together scattered research showcases the therapeutic potential of this plant, points out important gaps in current knowledge and highlights its promise for future drug discovery

and nutraceutical uses, all while stressing the importance of further mechanistic and clinical studies.

Keywords: Anti-inflammatory, bioactive compounds, marshy, microbial infection, wetland herb

Introduction

Climate change and anthropogenic activities are two major global problems (Maslin et al., 2025). Climate change has been observed in recent decades, marked by biodiversity loss, forest degradation and the disruption of delicate relationships among flora, fauna and communities (Shivanna, 2022). These changes have significant impacts on our health and the environment. Anthropogenic activities are increasingly dangerous and pervasive worldwide (Tazerji et al., 2022). As a result, numerous health problems, environmental issues, and new diseases are being observed (Apetrei-Pandrea and Dascalu, 2026). This indicates a need for floral exploration, including studies of different plant groups and their potential as food, medicine and ecological agents. In this context, wetlands and their plant species play a vital role by retaining water, sequestering carbon and helping maintain global temperature (Zhang et al., 2025). Keeping these problems and potential solutions in mind, an attempt has been made to study the ethnomedicinal values, bioactive compounds and pharmacological potential of the wetland plant, *Caesulia axillaris*. It typically grows in wetlands and belongs to the Asteraceae family (Arya et al., 2022). Sometimes, due to overgrowth in paddy fields, it is considered a common weed in India, Bangladesh and Nepal (Sharma et al., 2024). It has some ethnobotanical uses and its plant parts are used to treat several health problems. Researchers have reported its pharmacological activities and the available bioactive compounds (Sharma et al., 2026). The study aims to compile information on its medicinal uses from published literature and present it to bring attention to the biowealth of wetlands and their medicinal uses in day-to-day life.

Methodology

The present study pulls together a thorough review of the existing literature on *C. axillaris*, gathered from peer-reviewed journals, books and traditional ethnobotanical sources. The authors have collected and analysed key

information on its morphology, ethnobotanical uses, phytochemical composition, pharmacological properties and ecological and economic importance. The data comes from a variety of scientific databases and regional ethnobotanical surveys, aiming to provide a comprehensive overview that showcases the plant's therapeutic potential and highlights its status as an underexplored wetland bioresource that deserves more scientific attention (Jena et al., 2025).

Morphology

C. axillaris is a charming little herb that stands tall or slightly upright, usually reaching heights of 15 to 40 cm. Its leaves are long and slender, ranging from 7 to 13 cm in length and 0.5 to 1.5 cm in width, featuring gently toothed edges and pointed tips. These smooth leaves taper down into a short petiole, which has a broad, semi-amplexicaul base that wraps around the cluster of flower heads.

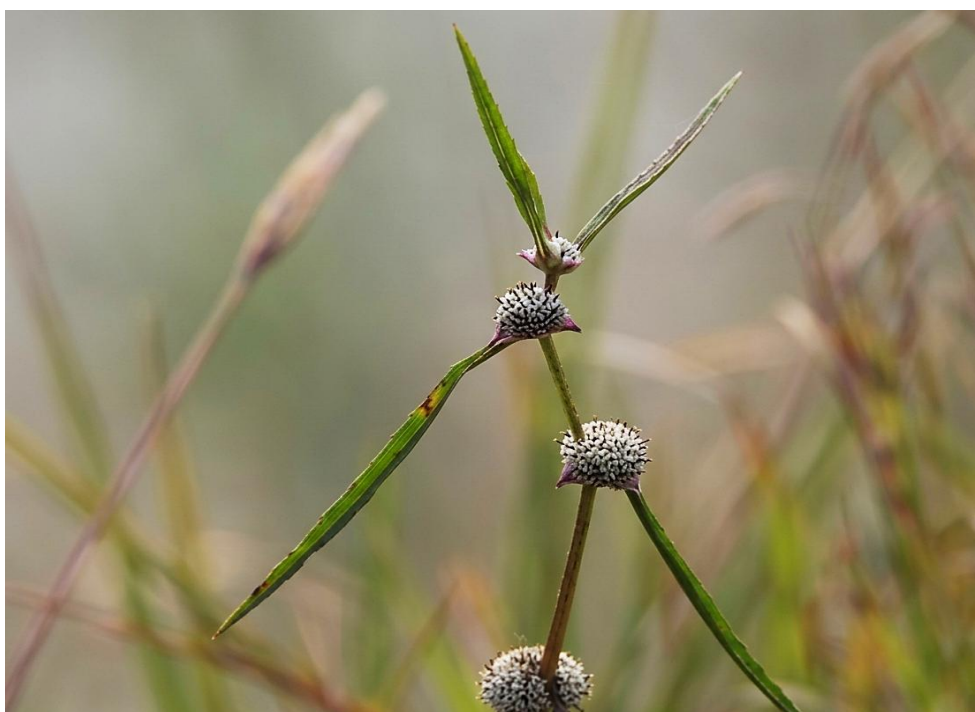


Figure 1: Leaves and flowers of *C. axillaris*

The flower heads themselves are small and white, each one snugly encased by two fleshy, compressed involucre bracts that have a delicate, translucent

appendage. This unique setup gives the flower head a whimsical look, almost like a winged achene with two oval pappus scales. The anthers stick out proudly, while the pappus is notably absent. The pollen grains are spiky and the style branches are short and quite blunt. The achenes are a lovely brown, obovoid in shape, smooth and hairless. This species blooms and bears fruit from August to January and is often found in marshy areas, showcasing its knack for thriving in wetland and semi-aquatic environments (Saxena and Brahmam, 1995; Figure 1).

Ethnobotany

Ethnobotanical knowledge, passed down through generations of indigenous experiences and traditional healing practices, remains a crucial resource for discovering plants with medicinal properties (Ralte and Singh, 2024; Lulesa et al., 2025). This is especially true for those that are often overlooked as common weeds but hold significant therapeutic value in local communities (Maiyo et al., 2024; Wang et al., 2025). For instance, *C. axillaris* from the Asteraceae family is typically seen as a common aquatic or semi-aquatic weed (Sharma et al., 2024). Despite its weedy reputation, it plays a vital role in traditional and folk medicine, with local and tribal communities using various parts of the plant like the leaves, stem and seeds for generations to address a wide range of health issues (Sharma et al., 2026). Traditional practitioners prepare decoctions or infusions from leaves and stems to help bring down high body temperatures (Panda and Luyten, 2018). Poultices made from the leaves are applied to inflamed areas, helping to reduce swelling and pain (Shrivastava and Jain, 2014). Infusions made from the leaves are taken orally to help relieve symptoms and support respiratory health. Some traditional uses include employing the plant's extracts as an expectorant to help clear mucus from the respiratory tract (Sharma et al., 2024). The leaves are applied to wounds and cuts to promote healing (Naidu et al., 2005; Suntar, 2014; Arya et al., 2022). In the Indian System of Medicine, it is traditionally used to tackle baldness and goitre, highlighting its importance in treating hair and endocrine-related conditions (Nandkumar et al., 2021). It is also noted for its role in managing boils, alongside other folk plants like *Leucas aspera* and *Melia azedarach*. Whole plant extracts of *C. axillaris* are frequently used by the coastal tribes of Odisha to cure malaria

(Panda and Luyten, 2018). Arya et al., (2022) reported that the whole plant is useful for the treatment of cold, cough, dysentery, malaria and nasal congestion. Ancient ethnomedicinal texts reveal that local communities have long recognized its potential in treating ailments caused by bacterial and fungal infections, showcasing its antimicrobial properties even before modern science caught up. Moreover, tribal and rural groups, including the Tharu community, have shared their experiences of using *C. axillaris* for various skin disorders (Sharma et al., 2014). Its frequent mention in ethnobotanical surveys of weeds and wetland flora, including records from protected areas like Dudhwa National Park, emphasizes its value as an ethnomedicinal resource that, while not extensively studied pharmacologically, deserves more scientific exploration and conservation efforts (Kumar and Bharati, 2014).

Bioactive compounds

The impressive pharmacological potential of *C. axillaris* can be largely credited to its rich and varied phytochemical makeup. This plant boasts a remarkable range of bioactive compounds, including phenolic compounds, flavonoids, alkaloids, terpenoids, saponins and essential oils, each playing a unique role in its therapeutic benefits. Together, these components contribute to the antioxidant, anti-inflammatory, antimicrobial, analgesic and gastro-protective properties of *C. axillaris*. As research into its phytochemicals advances, researchers are discovering new aspects of the plant's bioactive potential, highlighting its promise as a significant player in future pharmacological and drug-discovery efforts (Natarajan and Paulsen, 2000; Farooqui et al., 2016; Nandkumar et al., 2021).

Pharmacological activities

Because of its rich history in traditional medicine, *C. axillaris* has piqued the interest of scientists who are eager to explore and confirm its medicinal properties. Various studies on *C. axillaris* have uncovered a range of bioactive compounds, which are thought to be responsible for its wide array of therapeutic benefits and pharmacological properties (Kumar et al., 2012; Pradhan et al., 2017).

Analgesic activity

Flavonoids and various other compounds found in the plant play a key role in its ability to relieve pain. These compounds probably work by blocking pain pathways and lessening how we perceive pain (Rao et al., 2021).

Anti-inflammatory activity

Researchers have observed the presence of anti-inflammatory compounds like flavonoids and saponins. These compounds work by blocking the production of pro-inflammatory cytokines and enzymes, including cyclooxygenase (COX), which are key players in the inflammatory process (Sharma et al., 2026).

Antimicrobial activity

C. axillaris shows impressive antimicrobial properties. Research indicates that different parts of the plant extract have varying levels of effectiveness, with leaf extracts at a 2% concentration standing out for their strong antifungal capabilities. This suggests that the type of solvent used and its concentration play a crucial role in how well the extraction works and how effective the antimicrobial action is. The activity is primarily fueled by bioactive compounds like alkaloids, terpenoids and flavonoids, which operate through several mechanisms such as breaking down microbial cell walls and membranes, blocking protein synthesis and disrupting DNA replication. These findings highlight the need to fine-tune extraction methods and highlight the phytochemical foundations that contribute to the wide-ranging antimicrobial potential of *C. axillaris* (Liu et al., 2017; Pradhan et al., 2017).

Antioxidant activity

The plant is packed with a variety of phenolic compounds, flavonoids and other antioxidants. These powerful compounds help neutralise free radicals, which can reduce oxidative stress and may lower the risk of chronic diseases such as cancer and heart disease (Sharma et al., 2026).

Antipyretic activity

The antipyretic effect is attributed to compounds such as flavonoids and saponins. These substances are thought to disrupt the body's production of

prostaglandins, which play a key role in triggering fever (Panda and Luyten, 2018; Sharma et al., 2024).

Gastroprotective activity

C. axillaris has been noted for containing compounds that may help protect the gastrointestinal tract. These components are believed to play a role in defending the gastric mucosa through various mechanisms, such as enhancing the mucosal barrier, lowering gastric acid secretion and providing antioxidant protection to the stomach lining against oxidative harm. Together, these effects hint at the potential of *C. axillaris* in preserving gastrointestinal health and addressing gastric issues (Sharma et al., 2026).

Ecological and economic values

C. axillaris plays a fascinating dual role in the wetland and rice-based agro-ecosystems of the Indian subcontinent. This annual plant, known for its prolific seeding, thrives in marshy lowlands, along pond edges and in paddy fields up to 1000 meters in elevation (Swapna et al., 2011). It is a key player in the rice-field weed community, enhancing the biodiversity of wetlands and contributing to the intricate food web of agro-ecosystems (Singh et al., 2005). Like many other wetland weeds, it provides valuable ecological benefits, such as stabilizing soil, offering alternative forage and serving as a haven for beneficial insects and their natural predators. This support is crucial for the ecosystem services found in traditionally managed paddy landscapes. However, its robust growth and competitive nature with rice crops make it a significant economic weed, often requiring specific cultural and chemical control strategies to reduce yield losses, something which is well-documented in agronomic weed management literature (Panda et al., 2019). Interestingly, this same species also shows promise as a non-timber bioresource, with its essential oil exhibiting strong antifungal and anti-aflatoxigenic properties against fungi that can spoil stored herbal materials. This suggests potential uses in post-harvest preservation and the herbal product industry. All in all, these insights highlight *C. axillaris* as a plant that is deeply rooted in ecology, presents agronomic challenges, yet holds exciting economic potential that deserves more attention and valorization efforts (Bastiaans et al., 2000).

Conclusion

The present study concluded that wetlands possess medicinally important species like *C. axillaris*, which have sound ethnobotanical practices and are used to treat environmental health problems. It also has ecological and economic values; therefore, the present study suggests that there is an urgent need to conduct exploration works on the biowealth of wetlands of India. It is necessary to screen the medicinal plants from wetlands for the development of new therapeutic agents.

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Chapter 2

Ethnomedicinal uses and pharmacological activities of *Mecardonia procumbens* (Mill.) Small

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Abstract: *Mecardonia procumbens*, commonly known as "Baby jump-up," is a charming mat-forming herb from the Plantaginaceae family that plays a significant role in Mesoamerican traditional medicine. It's been used to tackle a variety of health issues, including fatigue, anaemia, malaria, fever, eye problems, skin blemishes and wounds. This resilient plant can be found thriving in disturbed habitats across the Americas, Africa and Asia. Despite its widespread presence, it remains relatively underexplored in terms of its phytochemical properties. However, existing research shows the presence of phenolics, flavonoids and tannins as its primary bioactive compounds, with the acetone extract from its flowering stage boasting the highest concentration and strongest antioxidant activity. This extract also shows impressive potential for scavenging free radicals, hinting at its possible applications as a natural preservative in both food and pharmaceuticals. On an ecological note, *M. procumbens* contributes to soil stabilization and provides support for pollinators. This review brings together the current understanding of the plant's morphology, ethnobotany, phytochemistry and pharmacology, while emphasizing the urgent need for more research to unlock its hidden therapeutic potential.

Keywords: Antioxidant, Baby jump-up, phytochemistry, traditional medicine, underexplored

Introduction

Forest fringe, forest road, grasslands and marshy areas give us different types of flora (Dangol and Maharjan, 2012; Hsiao et al., 2024). These floras are usually unexplored and ignored in ethnomedicinal and pharmacological aspects (Asigbaase et al., 2023). They are mostly herbs and provide shelter to different types of minor faunal species. They also provide local food for local communities and different landscapes (Raj et al., 2018). Currently, we are facing different types of ecological, social and health problems (Eriksson et al., 2025). In this scenario, these species should be explored and evaluated for their potential in different aspects of life. Among such plant species, *Mecardonia procumbens* is a small herb that has ethnomedicinal uses (Salazar-Gómez and Alonso-Castro, 2022). It can be observed easily due to its yellow, attractive small flowers near forest roads, forest fringes, wasteland near forests and rural areas, grassland and marshy places (Junior et al., 2024). Several communities use it for different purposes and it has pharmacological potential (Shende et al., 2023). Keeping the importance of this small herb in mind, an attempt has been made to gather its morphology, habitat, ethnobotanical uses, pharmacological potential and available bioactive compounds from the published literature during 2024-2025 and presented in this chapter. The gaps in its pharmacological research and ecological significance are also discussed. The chapter provides baseline data on this herb for future research work.

Methodology

The present study is based on a narrative literature review methodology, compiling published information on the ethnomedicinal uses, phytochemistry and pharmacological properties of *M. procumbens* from scientific databases including PubMed, Scopus, Web of Science and Google Scholar, using keywords such as "*Mecardonia procumbens*", "ethnomedicine", "phytoconstituents" and "pharmacological activity." Supplementary information was gathered from classical ethnobotanical texts, regional floras and traditional medicine compendia to capture indigenous knowledge not extensively indexed in scientific journals. The collected

literature, comprising predominantly recent studies alongside key historical references, was screened and thematically organized to correlate traditional uses with pharmacological evidence and identify existing gaps for future research (Jena et al. 2025).

Morphology

M. procumbens is a charming little herb from the Plantaginaceae family. It has a low-growing, mat-forming habit, with a slender taproot and fibrous roots sprouting from its rooting nodes. The stem is thin, sharply four-angled and often branches out from the base (Nguyen et al., 2024). The leaves are simple, opposite arranged in a decussate pattern and light green with a fleshy texture. The blades are elliptic to ovate-elliptic with serrated edges mainly towards the tip (Junior et al., 2024).



Figure 1: Whole plant of *M. procumbens*

The flowers are a delightful sight, appearing solitary in the axils, bright yellow with reddish veins in the throat and zygomorphic in shape (Figure 1).

The fruit is a tiny capsule, about 4-5 mm long, filled with numerous tiny, brown seeds that have a reticulate coating (Saxena and Brahmam, 1995).

Ethnobotany

M. procumbens, a charming little creeping herb, is often called "Baby jump-up" (Kumar, 2025). This plant holds a cherished spot in the realm of Mexican traditional medicine (Yakandawala and Yakandawala, 2007). Traditional healers have turned to this herb for ages, using it to tackle issues like fatigue, anaemia, manage malaria, gallbladder problems, reduce fevers, treat eye conditions and even help clear up facial blemishes. Among its various folk remedies, its use for treating wounds is particularly noteworthy. Traditional herbalists prepare a decoction by boiling the entire plant. This concoction serves a dual purpose; the liquid is sipped as an infusion while the wound is still open and the boiled plant material is used to clean the wound site before being applied as a compress. This holistic approach continues until the wound is fully healed (Salazar-Gómez and Alonso-Castro, 2022). Further ethnobotanical records showed that this species thrives in a variety of habitats, often in disturbed areas. It can be found in oak-pine forests, tropical scrublands, arid grasslands and even waterlogged pastures. It also grows in riparian zones, along moist woodland edges, stream banks, springs and seeps (Lichvar et al., 2016). Its ability to adapt to poor, degraded and sometimes flooded soils is believed to be linked to its traditional use as a resilient folk remedy, easily accessible in marginal rural landscapes (Philley, 2020). Moreover, the plant has caught the eye of botanical foragers and naturalists in the southeastern United States, where it is recognized as a common yet often overlooked native creeping herb (Schoch et al., 2020). All the provided information highlights *M. procumbens* as a plant with significant ethnomedicinal importance, particularly in Mesoamerican folk practices, while its distribution has expanded globally, leaving its therapeutic potential in regions like South Asia and Africa largely uncharted and ready for ethnobotanical exploration.

Bioactive compounds

The documentation on the phytochemicals found in *M. procumbens* is still quite sparse, but it does suggest that this plant is a significant source of phenolic and flavonoid compounds (Shende et al., 2023). A comparative

study revealed that its vegetative and flowering stages have the highest phenolic content in the acetone extract from the flowering stage (Nguyen et al., 2024). A similar trend was observed for flavonoid content. On the other hand, tannin levels peaked in the methanol extract of the flowering stage. This indicates that both the choice of solvent and the growth stage play a crucial role in determining the yield of extractable phytochemicals. Notably, the acetone extract from the flowering stage also exhibited the strongest free-radical scavenging activity and inclusive antioxidant capacity, suggesting that the plant builds up its richest store of antioxidant phytochemicals during this time (Nguyen et al., 2024). These findings highlight phenolics, flavonoids and tannins as the main bioactive groups identified in *M. procumbens* so far. However, the complete phytochemical profile-including specific isolated compounds, alkaloids, terpenoids or essential oil constituents has yet to be thoroughly explored in the literature, presenting a clear opportunity for future research in this area.

Pharmacological potential

1. Antioxidant activity

When it comes to the antioxidant activity of *M. procumbens*, the standout feature is its impressive potential. Researchers have looked into this across different growth stages, both vegetative and flowering, using organic solvents that vary in polarity. They found that the acetone extract from the flowering stage exhibited the most robust free-radical scavenging activity. This extract also showed the highest overall antioxidant capacity, which aligns perfectly with the increased levels of phenolic and flavonoid compounds present during this stage. This variation highlights how the plant's ability to combat oxidative stress is closely linked to the accumulation of these beneficial compounds, peaking during the flowering phase rather than the vegetative one (Shende et al., 2023).

2. Anti-inflammatory activity

While research on *M. procumbens* is still in its early stages, the evidence has suggested that its anti-inflammatory properties might stem from flavonoids, phenolic compounds and iridoid glycosides, which help reduce oxidative stress and inflammatory mediators. This information backs up its traditional

use in medicine, but there is definitely a need for more detailed studies and clinical trials to really confirm its potential as a treatment (Salazar-Gómez and Alonso-Castro, 2022).

3. Antimicrobial and preservative potential

The extracts of *M. procumbens*, particularly those obtained using acetone and methanol, have been reported as more effective bioactive fractions, with researchers suggesting their potential suitability as natural preservatives in food and pharmaceutical formulations, owing to their favourable phenolic, flavonoid and antioxidant profiles (Shende et al., 2023).

Ecological values

M. procumbens may be small and weedy, but it plays a significant role in the ecosystems where it grows. This tough, fast-spreading mat-forming herb thrives in disturbed soils, along moist woodland edges and in open cultivated areas, where it helps to stabilize the soil and curb erosion in damaged habitats. Its tiny yellow flowers are a delightful nectar source for pollinators, including various butterflies, which helps bolster local pollinator communities (Kumar, 2025). With its wide ecological range across the Americas, Africa and Asia, this plant showcases remarkable adaptability and resilience, making it a fascinating subject for research on plant colonization, naturalization and ecosystem resilience in areas that have been disturbed.

Conclusion

The findings of the study highlight the significance of *M. procumbens* as an underexplored plant species occurring in forest fringes, roadside habitats, grasslands and marshy ecosystems. The documented ethnobotanical uses, coupled with its reported pharmacological properties, indicate considerable potential for its utilization in traditional healthcare and future drug discovery programs. Despite its recognized value, *M. procumbens* remains inadequately investigated, warranting comprehensive phytochemical, pharmacological, toxicological and clinical studies to validate its therapeutic efficacy and safety. Furthermore, the present chapter draws attention towards the importance of conserving such overlooked plant resources and encourages field-based ecological and experimental investigations to better understand their ecological roles, distribution patterns and sustainable

utilization. Future research on *M. procumbens* may contribute not only to the development of novel therapeutic agents but also to the conservation and sustainable management of biodiversity-rich habitats.

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Chapter 3

Unveiling the therapeutic potential of *Desmodium triflorum* (L.) DC.: ethnopharmacology, bioactive compounds and future clinical prospects

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Abstract: *Desmodium triflorum* (L.) DC. is a legume that holds a special place in traditional medicine, especially in South and Southeast Asia, where it has been used for ages to tackle issues like inflammation, respiratory problems, wounds and digestive disorders. In the present study, the authors took a closer look at its ethnopharmacological uses and phytochemical makeup, which includes flavonoids, alkaloids and phenolics, to explore its various pharmacological benefits, such as antioxidant, anti-inflammatory, antimicrobial and hepatoprotective properties. The present study aims to bridge the gap between traditional wisdom and contemporary pharmacology, pinpointing the gaps in both mechanistic and clinical research, while also shining a light on the exciting possibilities for drug discovery, standardization and therapeutic advancements that this often-overlooked medicinal plant has to offer.

Keywords: Digestive disorder, drug discovery, ethnopharmacological, therapeutic advancement

Introduction

In different groups of plants, creepers play an important role. They provide food, medicine and have also ecological values (Jach et al., 2022). They also reduce soil erosion and cover the forest floor, grassland, wasteland and open areas in and around human habitats (Mahmood, 2019). Some herbivores graze them to get food and nutraceuticals. They are usually ignored and very few species are utilized by the local people (Cao et al., 2023). Among such species, a very common plant is *Desmodium triflorum* (L.) DC. It belongs to the Leguminaceae group of plants and performs nitrogen fixation (Protachevicz et al., 2023; Adan et al., 2024). The leaves are used as a medicine in Indian Ayurveda and among different folk practices of the world. Some bioactive compounds are also identified from its plant parts, having therapeutic properties (Nguyen-Ngoc et al., 2022). Researchers have also documented their pharmaceutical activities (Dar et al., 2025). Despite their multipurpose uses, very less documentations are available in published literature. Keeping this in view, an attempt has been made to gather information from authenticated publications up to 2026. Standard methods were used to collect the information from the literature (Kumar et al., 2021; Jena et al., 2025). The collected data are presented to bring attention towards the ignored medicinal plant species that are abundantly available in our nearby areas.

Methodology

The present documentation is based on a narrative review of the existing literature on *D. triflorum*. The information collected from various databases, including PubMed, Google Scholar, Scopus, ScienceDirect and Web of Science, was obtained using keywords like "*Desmodium triflorum*", "ethnopharmacology", "phytochemistry", "bioactive compounds" and "pharmacological activity." Authors carefully screened peer-reviewed articles, reviews and book chapters published up to 2026, focusing on their relevance to traditional uses, phytochemistry, pharmacology and clinical evidence, while steering clear of non-validated sources. The extracted data

was thematically organized and cross-verified with resources like PubChem and World Flora Online. The extracted information was synthesized qualitatively to shed light on what we know, what gaps exist and the future therapeutic potential of this fascinating species (Kumar, 2025; Sahu et al., 2026).

Morphology

D. triflorum of the Fabaceae family tends to creep around like a weed (Ilandara et al., 2015). The stems are slender and wiry, branching out and rooting at the nodes, often adorned with fine hairs that can either lie flat or spread out. The leaves are typically trifoliate, arranged alternately on short petioles and come with persistent stipules. The leaflets are small and shaped like an obovate or obcordate, with the terminal leaflet being a tad larger than the side ones, all featuring smooth edges and a rounded or slightly notched tip. The flowers can be found in axillary or terminal clusters, usually showcasing two to three small, pretty papilionaceous blooms that range from pink to purple, all supported by bracts that stick around.

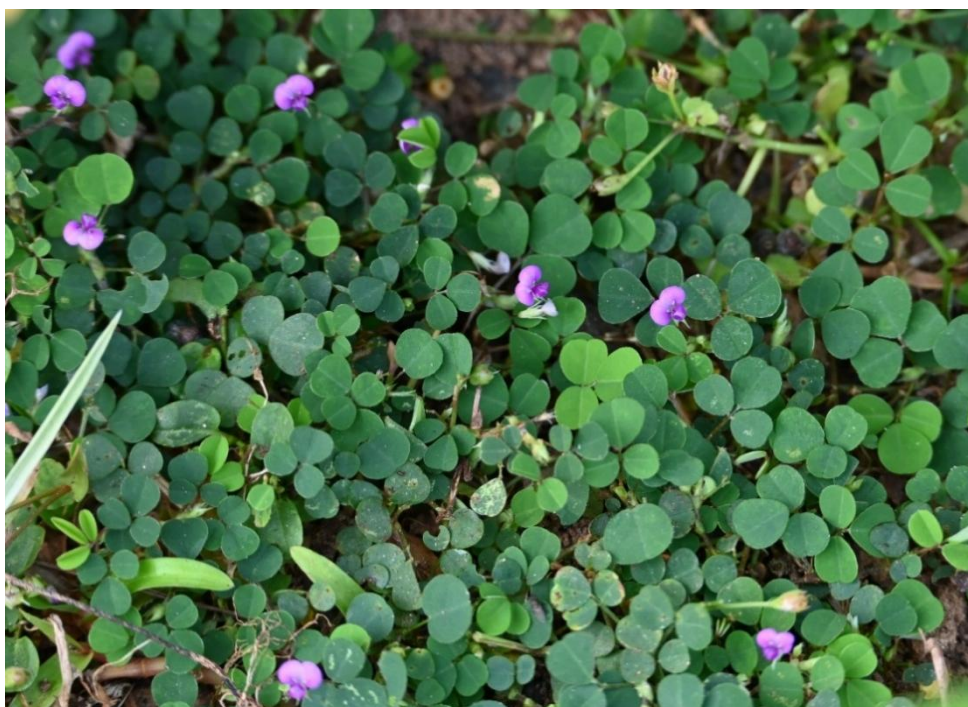


Figure 1: Leaves and flowers of *D. triflorum*

The fruit is a tiny, flattened loment made up of two to four segments, each containing a single seed, often covered in hooked hairs that help with seed dispersal by hitching a ride on animals. The seeds themselves are tiny, brownish and shaped like little beans. Its root system is fibrous and nodulated, typical of legumes, which allows it to fix nitrogen and thrive as a popular ground cover (Saxena and Brahmam, 1994; Dar et al., 2025; Figure 1).

Ethnobotany

D. triflorum is a plant that plays a vital role in traditional and folk medicine throughout tropical Asia, Africa and parts of the Pacific (Vedpal et al., 2016). The entire plant, especially its leaves, roots and aerial parts, has been used for ages to tackle a variety of health issues, such as diarrhoea, dysentery, fever, cough and respiratory problems, as well as wounds, skin infections and boils, often applied as a poultice or brewed into a decoction (Sharma et al., 2013). In Ayurvedic and folk medicine in India and Sri Lanka, this plant is cherished for its anti-inflammatory, vermifuge and febrifuge properties, making it a go-to for treating urinary disorders, jaundice and general weakness, particularly in children (Cueva-Chamba et al., 2023). In African traditional medicine, decoctions of *D. triflorum* are used to address gastrointestinal issues, act as an anthelmintic and aid in wound healing (Singh et al., 2024). Meanwhile, in parts of Southeast Asia, it serves as a galactagogue to support lactation in nursing mothers and as a tonic for overall weakness (Ahmad et al., 2011). Beyond its medicinal uses, this plant is also fed to livestock and utilized as green manure and cover crop due to its ability to fix nitrogen, showcasing its importance in both health and agriculture. These varied traditional uses, passed down through generations, lay the groundwork for scientific exploration into the plant's bioactive properties (Ilandara et al., 2015).

Bioactive compounds

D. triflorum is known for its impressive variety of phytoconstituents, which play a significant role in its numerous pharmacological effects. Research into its phytochemistry has uncovered a range of alkaloids, including indole alkaloids like N, N-dimethyltryptamine (DMT) and other related tryptamine

derivatives (Joshi et al., 2023). These compounds are typical of several *Desmodium* species and are linked to neuromodulatory and antimicrobial properties (Kumar and Saravanan, 2025). The plant also boasts flavonoids such as vitexin, orientin, quercetin and kaempferol derivatives, which enhance its remarkable antioxidant and anti-inflammatory capabilities. Moreover, *D. triflorum* contains phenolic acids (like gallic acid and chlorogenic acid), tannins and saponins, all of which contribute to its antimicrobial, wound-healing and liver-protective effects (Nguyen-Ngoc et al., 2022). Additionally, triterpenoids and phytosterols, particularly lupeol and β -sitosterol, have been identified for their anti-inflammatory and immunomodulatory benefits (Ahmad et al., 2011; Ilandara et al., 2015). There are also trace amounts of essential oils, fatty acids and polysaccharides, which further enrich the plant's therapeutic potential (Joshi et al., 2023). All in all, this diverse phytochemical makeup provides a solid scientific basis for the traditional medicinal applications of *D. triflorum* and highlights its promise as a source of lead compounds for future drug development.

Pharmacological activities

D. triflorum has been recognized for its wide range of pharmacological benefits, due to the presence of its impressive array of phytochemicals. The extract from this plant showcases remarkable antioxidant properties, as demonstrated by its ability to scavenge free radicals in tests like DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2'-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid) and FRAP (Fluorescence Recovery After Photobleaching), primarily due to its flavonoid and phenolic compounds. It also shows significant anti-inflammatory effects, helping to lower pro-inflammatory mediators and inhibit enzymes such as COX (Cyclooxygenase) and LOX (Lipoxygenase), which aligns with its traditional use for treating inflammation (Chowdhury et al., 2005; Lai et al., 2010; Dar et al., 2025). Research into its antimicrobial properties reveals that the extract is effective against various Gram-positive and Gram-negative bacteria, as well as some fungal strains, supporting its historical use in healing wounds and fighting infections. Additionally, studies have shown that it has hepatoprotective effects, where the extract helps to alleviate chemically induced liver damage by restoring antioxidant enzyme levels and lowering serum marker enzymes (Ahmad et al., 2011; Sharma et al., 2013; Ilandara et al., 2015). Moreover, the plant has been found to possess antidiarrheal and antidysenteric

properties, reinforcing its traditional applications for gastrointestinal issues, along with analgesic and antipyretic effects noted in animal studies. Early research also hints at its potential for anthelmintic, wound-healing, immunomodulatory and mild central nervous system (CNS) activity, likely due to its alkaloid contents (Gowda et al., 2012; Chang et al., 2024). In addition, some pharmacological assessments have suggested anticonvulsant, nephroprotective and antidiabetic effects, although these findings need more thorough investigation and clinical validation (Gowda et al., 2012). Altogether, this pharmacological information lends strong support to the traditional medicinal claims surrounding *D. triflorum* and highlights its potential as a promising candidate for future drug discovery and development.

Ecological and economic values

D. triflorum is quite the ecological powerhouse. This low-growing, mat-forming legume plays a significant role in enhancing soil health and stabilizing ecosystems (Joshi et al., 2023). Its partnership with nitrogen-fixing rhizobium bacteria in its root nodules helps boost soil fertility by transforming atmospheric nitrogen into a form that plants can actually use (Ilandara et al., 2015). This not only benefits the plant itself but also supports neighbouring vegetation, leading to improved soil productivity. With its sprawling growth habit and stems that root at the nodes, it makes for an excellent ground cover, effectively preventing soil erosion, retaining moisture and keeping pesky weeds at bay. Additionally, it thrives in disturbed areas like lawns, pastures and roadsides, showcasing its resilience and ability to pioneer in degraded or nutrient-poor soils. On top of that, its flowers attract small pollinators, while its leaves provide food for various herbivorous insects and grazing animals, enriching local biodiversity and the food web in grassland and agroecosystem settings (Protachevicz et al., 2023). Beyond its role in supporting ecosystems, *D. triflorum* is also a significant player in the economy, especially in farming and livestock sectors. This plant is a popular choice as a nutritious fodder crop for cattle, goats and other grazing animals, thanks to its great taste and high protein content (Dar et al., 2025). This makes it a key asset in managing pastures and rangelands. Its ability to fix nitrogen means it can serve as a natural green manure and cover crop, helping to cut down on the need for synthetic fertilizers and encouraging sustainable, low-input farming practices (Protachevicz et al., 2023). Moreover, its traditional

uses in medicine have opened doors to herbal markets, particularly in rural and indigenous communities where it is harvested to treat common health issues (Singh et al., 2024). With increasing scientific interest in its bioactive compounds, this plant could also have significant economic potential in the pharmaceutical and nutraceutical fields, especially if its health benefits are further confirmed and standardized. This positions *D. triflorum* as a cost-effective, sustainable resource with diverse applications in agriculture, medicine and commerce.

Conclusion

The present study on *D. triflorum* gives baseline data on its ethnobotanical uses, bioactive compounds, pharmacological activities, ecological significance, along with economic values, morphology and its habitat are also discussed in the chapter. The present study indicates that there is a need for advanced experimental work in different aspects of science and the plant parts should be investigated for the development of future therapeutic agents.

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Chapter 4

Bioactive compounds and pharmacological attributes of *Drosera burmanni* Vahl: From traditional knowledge to modern therapeutics

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Abstract: *Drosera burmannii* Vahl, a fascinating carnivorous herb, has a rich history in Ayurvedic, tribal, Chinese and European folk medicine. Traditionally, it has been cherished for its ability to soothe coughs and act as a rubefacient and this review explores its bioactive potential. The therapeutic benefits of this plant come from its unique compounds, including naphthoquinones like plumbagin and 7-methyljuglone, flavonols such as hyperoside and quercetin and derivatives of ellagic acid. Recent studies have confirmed its impressive range of activities, including antitumor, antioxidant, hepatoprotective, anti-inflammatory, antimicrobial, antifertility and anticonvulsant effects, which not only validate its traditional uses but also point to its pharmaceutical potential. Additionally, *D. burmannii* plays an important ecological role as a wetland indicator species. However, it is currently facing population declines due to over-collection driven by the demand for its medicinal and ornamental uses. This situation highlights the urgent need for sustainable cultivation

practices that can connect traditional knowledge with future therapeutics and drug development.

Keywords: Antifertility, antitumor, carnivorous, naphthoquinones, wetland indicator species

Introduction

Flowering plants play an important role in nature and provide habitat to the living and non-living organisms (Fernando, 2012). There are several plant groups categorized as per habit, habitat, behaviour and ecological functions (Chondol et al., 2025). The most fascinating group of angiosperms is the parasitic and carnivorous plant groups. They have unique morphological characters and functions (Teixeira-Costa and Davis, 2021). Among the carnivorous plant species, the genus *Drosera* represents the most sophisticated characters with natural enzymes (Lichtscheidl et al., 2021). They grow in poor soil and due to stress and self-defence mechanisms, they produce several types of bioactive compounds (Gerschler et al., 2022). The therapeutic potential of these plants is due to this mechanism and their bioactive compounds. Very early, human beings had identified their therapeutic potential and used them in different folk medicinal practices (Satapathy, 2020). Despite being the most fascinating group of plants, very limited data are available on their pharmacological potential. In Ayurveda, they are used to prepare “swarnabhasma” and are useful to treat different health problems, including respiratory ailments (Patil-Bhole et al., 2021). Some compounds are also identified and characterized from *Drosera* species. Keeping the unique morphological character, self-defence mechanism and availability of natural enzymes, an attempt has been made to collect the data on bioactive compounds and pharmacological potential of *Drosera burmannii* and presented in this chapter. Indigenous traditional therapeutic practices and unique morphological characters are also discussed with taken photographs from field survey. The present chapter highlights the ethnomedicinal significance of carnivorous species.

Methodology

The authors gathered literature for this review by searching across several platforms, including PubMed, Google Scholar, Scopus, Web of Science and ScienceDirect. The systematic search strategy incorporated keywords like

"*Drosera burmannii*", "bioactive compounds", "ethnobotanical uses", "traditional medicine" and "pharmacological potential". Information regarding traditional and folk medicine was compiled through a rigorous review of regional pharmacopoeias, theses, books and ethnobotanical literature. The collected information was carefully analyzed, cross-checked across different sources and organized thematically to blend traditional knowledge with modern pharmacological findings, ultimately giving us a comprehensive look at the morphology, therapeutic uses and pharmacological properties of *D. burmannii* (Kumar, 2025; Sahu et al., 2026).

Morphology

D. burmannii is a charming little herb that loves to feast on insects, belonging to the Droseraceae family (Figure 1). This petite plant usually forms a neat, stemless rosette that measures about 1-3 cm across, though it can stretch up to 5 cm if the conditions are just right. It is an annual plant that either has no roots or just a very short, fibrous root system. The leaves are arranged in a dense rosette that either lies flat against the ground or stands slightly upright. These leaves are broadly obovate to spatulate, tapering into a short, wide petiole and they are adorned with numerous glandular, reddish tentacles on their upper surface and edges. These tentacles secrete a sticky, dew-like fluid that attracts, traps and digests tiny insects. The leaves can range in color from green to a striking red or purplish-red, especially when basking in bright sunlight, due to an increased accumulation of anthocyanins. The plant produces a slender, upright flower stalk that rises from the centre of the rosette, showcasing small, actinomorphic flowers that are white to pale pink, featuring five sepals, five petals, five stamens and a superior ovary with three to five styles that are often deeply split. Its fruit is a tiny loculicidal capsule filled with numerous tiny black or dark brown seeds. The overall look of the plant, with its glistening, dew-covered leaves, gives it a distinctive shine in its natural habitat, which typically includes moist, sunny and nutrient-poor soils like laterite outcrops, marshy grasslands and rock crevices (Saxena and Brahmam, 1995).



Figure 1: Habitat of *D. burmannii*

Ethnobotany

In Ayurveda, *D. burmannii* has been celebrated for ages as a potent rubefacient. This means it is applied to the skin to create localized redness and warmth by expanding the tiny blood vessels just beneath the surface (Madhavan et al., 2009; Ghate et al., 2015). This effect is closely tied to the plant's mucilaginous secretions and its naphthoquinone content, especially plumbagin, which can irritate the skin upon contact (Yanthan et al., 2017). In traditional practices across the Indian subcontinent, people often use crushed leaves from *D. burmannii* and its relatives, like *Drosera indica* and *Drosera peltata*, as a rubefacient and vesicant. They apply these to create blisters over sore joints or skin lesions as a form of counter-irritant therapy. Interestingly, this approach is also mirrored in classical Chinese medicine, where the entire plant is utilized (Kumar et al., 2018). Indigenous and tribal communities in eastern and northeastern India particularly the forest-dwelling groups in Odisha, Jharkhand and West Bengal have shared fascinating information into the ethnomedicinal uses of *D. burmannii* (Satapathy, 2020). This species

thrives in lateritic and moist sandy soils and its applications have been highlighted in broader studies of carnivorous plant pharmacognosy in the area (Mishra and Kumar, 2021; Rani et al., 2023). Many of these field surveys, carried out by botanists from the Botanical Survey of India, revealed that locals refer to this plant as mukhjali (Bakshi et al., 2017). They use it for healing wounds, treating skin issues and as a folk remedy for inflammation and infections, aligning with its historical role as a topical counter-irritant (Mishra and Kumar, 2021). Moreover, *D. burmannii* play a role in Ayurvedic medicine, featuring in formulations like “swarnabhasma”, which is a calcined "gold ash" preparation. Here, the components of sundew have been traditionally recognized as key ingredients or enhancers in the preparation of these medicinal drugs (Patil-Bhole et al., 2021).

Bioactive compounds

D. burmannii, much like its relatives in the Droseraceae family, boasts a unique array of secondary metabolites that are primarily found in its glandular leaves and roots. Among these, naphthoquinones stand out as the key group that defines its chemo-taxonomy (Schlauer et al., 2024). This genus is rich in naphthoquinones, which play a crucial role in its biological activities, with plumbagin and 7-methyljuglone being the two most prominent naphthoquinones found across various *Drosera* species (Sanhueza et al., 2019). Plumbagin, in particular, is recognized as the primary active compound in these plants. However, when comparing phytochemical studies, it was noted that *D. burmannii* has significantly lower levels of plumbagin compared to species like *D. indica*, which can have much more of this compound, with the aerial parts typically showing higher concentrations than the roots (Boonsongcheep et al., 2019). In addition to naphthoquinones, *D. burmannii* is also abundant in flavonoids and ellagic acid derivatives. All members of the *Drosera* section, including *D. burmannii*, exclusively feature quercetin-type flavonols, highlighting its close genetic ties within this group (Braunberger et al., 2015). Previous phytochemical research has specifically identified hyperoside alongside quercetin in *D. burmannii*. More generally, *Drosera* species are known for their physiologically active compounds, including flavonoids, ellagic acid and naphthoquinones, with the flavonoids and naphthoquinones exhibiting antimicrobial and anti-inflammatory properties that are beneficial for treating infectious and inflammatory conditions (Gerschler et al., 2022). Together, this mix of naphthoquinones

(like plumbagin and ramentaceone/7-methyljuglone), flavonol glycosides (such as quercetin and hyperoside) and phenolic acids forms the essential phytochemical foundation that supports the traditional and medicinal uses associated with *D. burmannii*.

Pharmacological activities

D. burmannii has been a staple in both traditional and homeopathic medicine for quite some time (Ghate et al., 2016; Rani et al., 2023). It made its way into the French Pharmacopoeia back in 1965, primarily for treating inflammatory, respiratory issues like chronic bronchitis, asthma and whooping cough, which aligns perfectly with its known rubefacient properties (Madhavan et al., 2009; Donno et al., 2016). Building on this rich ethnopharmacological history, modern research has uncovered a wide range of pharmacological effects. Both alcohol and aqueous extracts of the whole plant have shown significant antifertility effects in female Wistar rats, leading to notable anti-implantation and abortifacient outcomes, along with reported anticonvulsant and antitumor activities in mice (Ghate et al., 2015; Rani et al., 2023). The anticancer potential has been further confirmed *in vitro*, where a methanolic extract was found to inhibit the growth of breast cancer cells without harming non-cancerous cells (Ghate et al., 2016; Shrihastini et al., 2021). These findings also back up the plant's traditional use for anti-inflammatory purposes. Additionally, the 70% methanolic extract has shown impressive broad-spectrum antioxidant activity, effectively scavenging various radicals like DPPH, hydroxyl, hypochlorite, superoxide, singlet oxygen, nitric oxide, peroxynitrite and hydrogen peroxide (Wójciak et al., 2023). It also demonstrated significant iron-chelating ability and protected supercoiled DNA from oxidative damage. This antioxidant profile translated into notable *in vivo* hepatoprotective effects in iron-overloaded mice, where the extract helped normalize serum liver enzymes, restore hepatic antioxidant enzyme levels, reduce liver iron deposits and improve liver histology, showing results comparable to the standard iron-chelating drug desirox (Grevenstuck et al., 2009). Research has shown that *D. burmannii* has some impressive antimicrobial properties, not just from its direct plant extracts but also from an antimicrobial metabolite created by an endophytic *Bacillus amyloliquefaciens* strain found in its leaves (Chaudhuri et al., 2021). This suggests that there is an additional layer of bioactivity linked to its microbiome. All in all, these discoveries revealed that *D. burmannii* is packed with a range of beneficial effects, including antifertility, anticonvulsant,

antitumor/anticancer, anti-inflammatory, antioxidant, hepatoprotective and antimicrobial activities. This not only supports its traditional uses in medicine but also points to its potential as a valuable resource for modern drug development.

Ecological and economic values

D. burmannii, commonly known as the tropical sundew, is a charming little carnivorous herb that forms rosettes and thrives in nutrient-poor, moist and acidic environments (Pavlovič et al., 2014). Its unique glandular leaves are like tiny traps, catching and digesting insects to compensate for the lack of nitrogen and minerals in the soil, giving it an edge over non-carnivorous plants in these challenging conditions. Field studies revealed that its populations tend to be small and scattered, influenced by factors like soil moisture, the variability of monsoons, temperature and disturbances in its habitat. Ecologically, this species plays a vital role in keeping local insect populations in check and serves as an indicator of healthy, undisturbed and nutrient-poor wetland microhabitats (Yanthan et al., 2017; Mithofer, 2022).

D. burmannii is highly regarded for its bioactive compounds like naphthoquinones, flavonoids and phenolics, which are commonly used in herbal remedies (known as *Drosera herba*) for their expectorant, diuretic and antispasmodic effects (Madhavan et al., 2009). Its impressive antitumor, antioxidant and hepatoprotective properties have caught the attention of both the pharmaceutical and nutraceutical industries. Additionally, this plant is sought after in the carnivorous-plant horticulture market for its ornamental value. However, the combination of its medicinal and aesthetic appeal has led to significant over-collection in the wild, causing declines in regional populations and even prompting red-listing in certain areas of India. Despite being classified as Least Concern globally by the IUCN, this situation highlights the urgent need for sustainable cultivation practices to meet the growing demand (Król et al., 2011; Ghate et al., 2016; Rani et al., 2023; Wójciak et al., 2023).

Conclusion

Carnivorous plants are unexplored in pharmacological aspects. The present chapter highlights their habitat, ethnomedicinal values, pharmacological potential and identified bioactive compounds. The present study concludes that *D. burmannii* is a fascinating herb, growing in poor nutrient soil, having

ethnobotanical uses with sound pharmacological properties. Further, there is a need for advanced pharmacological research to characterize the active biocomponents and their bioassay to develop therapeutic agents and address emerging lethal global health problems.

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Chapter 5

Ethnopharmacology, phytoconstituents and pharmacological properties of *Glinus oppositifolius* (L.) Aug. DC.

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Abstract: *Glinus oppositifolius* (L.) Aug. DC., a medicinal herb from the Molluginaceae family, has been a staple in traditional medicine for ages. It is commonly used in folk remedies to tackle issues like jaundice, liver problems, malarial fever, skin infections and even intestinal worms. Phytochemical research has pinpointed several key bioactive compounds. Pharmacological studies have backed up many of its traditional uses, showing that it has hepatoprotective, antioxidant, anti-inflammatory, antimicrobial and antidiabetic properties. However, there is still a lack of detailed mechanistic and clinical studies. The present study focuses on the ethnopharmacology, phytochemical makeup and pharmacological evidence surrounding *G. oppositifolius*, emphasizing its therapeutic potential and the pressing need for more scientific research to support drug development.

Keywords: Antidiabetic, hepatoprotective, jaundice, skin infection, triterpenoid, saponin

Introduction

Plants are essential to the natural ecosystem, supporting countless organisms and maintaining ecological balance (Fernando, 2012). Angiosperms, in particular, are categorized into several distinct groups based on their growth habits, habitat preferences and ecological roles (Chondol et al., 2025). Among these, the herbaceous plants that thrive in marshy, waterlogged and nutrient-poor environments have developed some impressive survival strategies that really set them apart (Teixeira-Costa and Davis, 2021). One fascinating group includes the stress-tolerant medicinal herbs from the Molluginaceae family, especially the genus *Glinus*. These plants are remarkable for their ability to endure tough soil and moisture conditions thanks to their unique physiological adaptations (Sheu et al., 2014). These are found in poor, often waterlogged soils, thought to trigger natural defence and stress-response mechanisms, leading to the production of a variety of bioactive secondary metabolites (Sukhorukov et al., 2021). This adaptive biochemistry is a big reason why plants like *Glinus oppositifolius* have been valued for their therapeutic properties. They were recognized early on by rural and tribal communities and have been woven into indigenous medicinal practices for treating issues like jaundice, liver problems, malarial fever, intestinal worms and various skin ailments (Satapathy, 2020). Even though this plant is a common ingredient in traditional and Ayurvedic remedies for liver protection and digestive issues, it has not received as much scientific scrutiny, leaving its pharmacological data somewhat scattered and less developed compared to other well-known herbs (Patil-Bhole et al., 2021). Given its fascinating stress-adaptive chemistry and its long history of medicinal use that has not been thoroughly explored scientifically, the present study aims to gather the existing literature on the bioactive compounds and pharmacological potential of *G. oppositifolius*. Authors also discuss traditional healing practices linked to the plant and its physical characteristics, complete with photographs taken during field surveys. Ultimately, this chapter aims to highlight the ethnomedicinal significance and pharmacological potential of this often-overlooked yet readily available medicinal herb.

Methodology

This chapter presents a thorough literature review that gathers information on the ethnopharmacology, phytochemical components and pharmacological

validation of *G. oppositifolius*. The information was collected from a variety of databases, including PubMed, Google Scholar, Scopus, ScienceDirect and SpringerLink, as well as trusted resources like Kew's Plants of the World Online for taxonomic confirmation. Our search utilized keywords such as "*Glinus oppositifolius*", "ethnobotany", "phytochemistry" and "pharmacological activity." The study focused on peer-reviewed articles, reviews, book chapters and classic ethnomedicinal texts, while steering clear of unverified sources (Kumar, 2025). The gathered data was carefully examined and categorized into sections on taxonomy, traditional uses, phytochemical constituents and pharmacological activities, highlighting studies that support traditional therapeutic claims with experimental evidence. All sources are properly cited to maintain accuracy and uphold scientific integrity (Sahu et al., 2026).

Morphology

G. oppositifolius is a charming little herb that can either sprawl out or stand up tall. It usually reaches heights of 10-40 cm and is found all over the tropical and subtropical areas of Asia, Africa and Australia (Sheu et al., 2014). It is often spotted thriving in moist, disturbed places like roadsides, paddy fields and riverbanks. This plant has a slender taproot with fibrous lateral roots and its stem is herbaceous, much-branched and can be prostrate or decumbent. It is cylindrical and a bit succulent, sporting a green to reddish-green hue and it often roots at the nodes when it touches damp soil. The leaves are simple and arranged in whorls of 3-5 at the nodes, which is where the name *oppositifolius* comes from. They vary in size and shape, with smooth edges and they taper into a short petiole. The flowers are small and not very showy, featuring bisexual, actinomorphic blooms that grow in clusters of 2-8 in the axils on slender pedicels. Each flower has 5 free, greenish-white sepals, no petals and 3-5 (sometimes up to 10) free stamens. The fruit produces a small, ovoid to globose capsule that's membranous and has three valves. This capsule, which is enclosed by the persistent sepals, holds a bunch of tiny, reniform seeds that are reddish-brown to blackish, with a finely textured surface and a small appendage at the hilum (Saxena and Brahmam, 1995; Figure 1).



Figure 1: Habitat of *G. oppositifolius*

Ethnobotany

G. oppositifolius has a rich history in traditional and folk medicine throughout Asia and Africa (Zorem et al., 2026). This plant, especially its leaves and tender shoots, is cherished not only as a nutritious leafy vegetable but also as a medicinal herb (Ragasa et al., 2015). In Ayurveda and various indigenous practices across the Indian subcontinent, it's known as "gima saag", "gima" or "chikkani" (Choudhary and Khaled, 2022). Traditionally, it's used to tackle liver issues, jaundice and digestive problems, earning a reputation as a remedy that protects the liver and boosts appetite. In Southeast Asian nations like Thailand, Vietnam and Malaysia, people often prepare decoctions or infusions of the plant to help with fever, malaria, hypertension and urinary issues (Moniruzzaman et al., 2016). Meanwhile, in African traditional medicine-especially in Nigeria, Senegal and other West African regions it is utilized for treating skin infections, wounds, dysentery, intestinal worms and gonorrhea (Gulumian et al., 2018). It also serves as a laxative, diuretic and anti-inflammatory agent. Additionally, several ethnic communities use it in traditional postpartum care as a galactagogue and for managing diabetes and rheumatic pain (Chen et al., 2023). Thanks to its easy

availability, pleasant taste and perceived health benefits, *G. oppositifolius* remains a vital part of ethnomedicinal practices and local pharmacopoeias, paving the way for further research into its bioactive properties.

Bioactive compounds

G. oppositifolius boasts a rich and varied bioactive profile that supports its wide range of ethnopharmacological uses (Sheu et al., 2014). Phytochemical studies have uncovered a treasure trove of compounds, including triterpenoid saponins (especially glycosides based on spergulagenin A), flavonoids (like vitexin, isovitexin and various quercetin derivatives), alkaloids, tannins, steroids, phenolic acids and essential oils, along with minerals and ascorbic acid found in its leaves and whole plant extracts (Zhang et al., 2019). Together, these components provide a remarkable array of pharmacological activities, such as hepatoprotective, antioxidant, anti-inflammatory, antipyretic, analgesic, antimicrobial, antidiabetic, anthelmintic and even cytotoxic/anticancer effects (Ragasa et al., 2015). Many of these benefits have been confirmed through both *in vitro* and *in vivo* studies, aligning with the plant's traditional applications for treating liver issues, fevers, skin problems, intestinal worms and inflammatory conditions (Das et al., 2024). Notably, the combined action of saponins and flavonoids is often highlighted as a key factor behind the plant's hepatoprotective and antioxidant properties, making *G. oppositifolius* a promising candidate for further research in pharmacognosy and drug development.

Pharmacological activities

G. oppositifolius has been thoroughly explored in the realm of pharmacology, with a wealth of studies backing up its traditional medicinal claims. This plant is particularly noted for its strong hepatoprotective properties, as shown in animal studies where it effectively countered liver damage caused by chemicals like carbon tetrachloride and paracetamol (Gupta et al., 2007). The extracts significantly lowered elevated liver enzyme levels and helped restore the liver's histopathological structure, largely thanks to its rich content of saponins and flavonoids (Ragasa et al., 2015). Its impressive antioxidant capabilities have been validated through various assays like DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS and FRAP, which correlate with its phenolic and flavonoid content, highlighting its role in combating oxidative

stress-related diseases (Zorem et al., 2026). Moreover, *G. oppositifolius* exhibits significant anti-inflammatory and analgesic properties, as demonstrated in models of carrageenan-induced paw edema and acetic acid-induced writhing, along with antipyretic effects in yeast-induced fever models (Hoque et al., 2011). This lends scientific support to its use in treating fever and inflammation. Antimicrobial and antifungal tests have shown it to be effective against a variety of Gram-positive and Gram-negative bacteria, as well as different fungal strains (Ragasa et al., 2015). Additionally, anthelmintic studies have confirmed its effectiveness against several helminths, reinforcing its traditional use for intestinal parasitic infections (Moniruzzaman et al., 2016). Its potential as an antidiabetic agent has been highlighted by improved glucose tolerance and enzyme inhibition (α -amylase and α -glucosidase) in experimental settings. Preliminary studies on cytotoxicity and anticancer effects using cell line assays have also suggested it may have antiproliferative properties, indicating promising possibilities in cancer treatment (Phi et al., 2024). Collectively, these diverse pharmacological benefits, primarily driven by the synergistic action of its phytoconstituents, position *G. oppositifolius* as a versatile therapeutic plant that deserves more in-depth mechanistic and clinical research.

Ecological and economic values

G. oppositifolius is quite an interesting plant with significant ecological importance. As a pioneer species, it plays a vital role in stabilizing soil and controlling erosion in wetland and semi-aquatic ecosystems. Its sprawling, mat-like growth not only helps keep the soil moist but also keeps pesky weeds at bay in certain agricultural settings. In addition, it adds to local biodiversity by providing ground cover and a habitat for small invertebrates. In some areas, it even acts as a bioindicator, signalling soil moisture and nutrient levels thanks to its close ties with hydromorphic soils. Its knack for thriving in nutrient-poor, disturbed or seasonally flooded environments highlights its adaptability and resilience, making it a key player in understanding wetland plant communities and a potential candidate for phytoremediation or soil reclamation efforts in degraded agricultural lands (Sheu et al., 2014; Ragasa et al., 2015; Moniruzzaman et al., 2016; Zorem et al., 2026). It plays a significant role in the economies of rural areas in Asia and Africa. This humble leafy vegetable is not only affordable but also contributes to food security and a diverse diet. Additionally, its traditional

medicinal uses keep local herbal markets buzzing, giving gatherers and traditional healers a chance to earn some extra income. Since it's a low-maintenance plant that often grows wild, there is also exciting potential for developing nutraceutical and phytopharmaceutical products (Sheu et al., 2014; Cruz-Garcia et al., 2016; Chakraborty and Paul, 2017). With some focused cultivation and standardization, *G. oppositifolius* could really boost its commercial appeal.

Conclusion

G. oppositifolius is truly a remarkable herb, celebrated for its nutritional and medicinal benefits, with a rich history in traditional practices throughout Asia and Africa. Packed with a variety of phytochemicals, it boasts impressive properties such as hepatoprotection, antioxidant effects, anti-inflammatory action, antimicrobial capabilities and antidiabetic benefits, which really support its use in traditional medicine. But it is not just about health; this plant plays an important role in the ecosystem by stabilizing soil and serves as a valuable food and herbal resource for rural communities. Given its widespread availability and promising health benefits, it is crucial to conduct more in-depth studies of its mechanisms, toxicity and clinical applications to fully unlock the potential of *G. oppositifolius* as a reliable phytopharmaceutical and nutraceutical option.

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Chapter 6

***Polygala* species in traditional medicine, ethnomedicinal uses and modern pharmacological validation**

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Abstract: The genus *Polygala* belongs to the Polygalaceae family, which includes over 500 species found in tropical, subtropical and temperate areas and plays a significant role in traditional medicine systems like Ayurveda, Traditional Chinese Medicine and various indigenous practices. Plants such as *Polygala abyssinica*, *Polygala arvensis*, *Polygala furcata*, *Polygala persicariifolia*, *Polygala senega* and *Polygala tenuifolia* have been used for ages to treat respiratory issues, cognitive decline, anxiety and inflammation. This is largely due to their rich content of bioactive compounds like triterpenoids, saponins, xanthenes, flavonoids and alkaloids. Recent pharmacological research has backed up many of these traditional uses, showing that these species possess neuroprotective, anti-inflammatory, antidepressant, expectorant, antimicrobial and even anticancer properties. In the present chapter, the authors explore the ethnobotanical importance and the connections between phytochemicals and pharmacological effects of key *Polygala* species, shining a

light on their therapeutic potential while also pointing out areas that need more research for future therapeutic agents and drug discoveries.

Keywords: Antidepressant, expectorant, indigenous practice, temperate, therapeutic potential

Introduction

Global health problems and the development of new therapeutic agents are major challenges throughout the world (Kirwan, 2009; Sharma et al., 2025). For both aspects, researchers should know about the source agent. Source agents should be easily available, which reflects the character of plant diversity (Hakim et al., 2025). Several plant species remain unexplored and unknown to pharmacologists and scientists searching for therapeutic agents. Hence, to fill this gap, researchers have to work with plant taxonomists and ethnobotanists to find the unexplored plant groups (Kakkar et al., 2023). Among those plants, the genus *Polygala* is unknown to modern pharmacologists, even though they have ethnomedicinal and pharmacological values (Lacaille-Dubois et al., 2020). Keeping this in view, an attempt has been made to draw attention to *Polygala* species through this chapter and their ethnomedicinal uses, available bioactive compounds and pharmacological activities are discussed. For identification purposes, morphology, ecological and economic values are presented. The chapter provides baseline data on *Polygala* species for designing advanced experimental research work in the drug discovery sector of science.

Methodology

The present study is based on a narrative literature review methodology that brings together published research on the ethnomedicinal applications, phytochemistry and pharmacology of various *Polygala* species. Authors tapped into databases like PubMed, Scopus, Web of Science and Google Scholar, using keywords such as "*Polygala*", "ethnomedicine", "phytoconstituents" and "pharmacological activity." To enrich our findings, we also referenced classical ethnobotanical texts and regional floras, ensuring we captured the essence of traditional knowledge. The literature we reviewed, mainly from the past two to three decades along with some pivotal historical sources, was carefully screened and thematically analyzed. This process helped us connect traditional uses with pharmacological evidence

and pinpoint areas where further research is needed (Kumar, 2025; Sahu et al., 2026).

Morphology

Polygala species show a fascinating range of shapes and sizes, from tiny annual or perennial herbs to subshrubs and shrubs. They usually have simple, alternate leaves, sometimes opposite or whorled, that are typically smooth-edged and lack stipules. The flowers, which are a standout feature of this genus, have a unique pea-like or papilionaceous look, even though they belong to the Polygalaceae family instead of Fabaceae. Each flower has five sepals, with the two side ones often resembling petals and being larger, while three petals are fused into a tube and the lower keel-shaped petal often sports a fringed or crested appendage. There is an occurrence of eight stamens joined together in a sheath that splits on one side. The inflorescences can be seen as terminal or axillary racemes or spikes and the colours of the flowers can vary widely among species, showcasing shades of purple, pink, white, yellow and even greenish tones.



Figure 1: Whole plant of *Polygala arvensis*



Figure 2: Habitat of *Polygala furcata*

The fruit is typically a small, flattened capsule that splits open to release its seeds, which are often hairy or have a caruncle to help with dispersal. The root systems can range from fibrous to robust taproots, with the latter being especially important in medicinal species like *P. senega* and *P. tenuifolia*. In these cases, the root is the main source of bioactive saponins and plays a crucial role in their traditional and medicinal uses (Saxena and Brahmam, 1994; Figures 1 & 2).

Ethnobotany

Polygala species have found their way into a variety of ethnobotanical traditions around the globe. Different parts of the plant, like roots, leaves, the whole herb and sometimes even flowers, are used in indigenous and folk medicine to tackle a wide range of health issues (Wang et al., 2008; Lacaille-Dubois et al., 2020). For instance, in Traditional Chinese Medicine, the dried root of *P. tenuifolia*, known as Yuan Zhi, has been cherished for centuries as a calming tonic that boosts memory and helps with insomnia, anxiety and cognitive challenges (Li et al., 2024). Meanwhile, in North America, Native American tribes have traditionally turned to *P. senega* or Seneca snakeroot as an expectorant for respiratory problems and even as a remedy for snakebites, a practice that later made its way into Western herbal medicine (Kako et al., 1996). In Africa, species like *P. arvensis* and *P. persicariifolia* are utilized to treat fever, inflammation, wounds and digestive issues, often prepared as decoctions or infusions from the whole plant or roots (Lacaille-Dubois et al., 2020). Similarly, in South and Southeast Asian folk medicine,

various *Polygala* species are valued for their anti-inflammatory, pain-relieving and antimicrobial effects, being used to address skin infections, diarrhoea and general weakness (Hao et al., 2015). Across these diverse cultural landscapes, the consistent focus on respiratory, neurological and anti-inflammatory uses highlights a shared ethnobotanical wisdom that has often been supported by later phytochemical and pharmacological studies on this fascinating genus.

Bioactive compounds

Polygala species exhibit a remarkably diverse bioactive profile, with triterpenoid saponins being the most prominent, particularly presenegenin-based glycosides like senegin and tenuifolin (Vinh et al., 2020; Li et al., 2024). These compounds are widely recognized as the key players behind the genus's expectorant, neuroprotective and anti-inflammatory properties. But that's not all; the genus also boasts a wealth of xanthones (including polygalaxanthones), oligosaccharide esters (like tenuifoliside and sibiricose derivatives), flavonoids, coumarins, alkaloids and phenolic acids. Many of these compounds work together to enhance the reported antidepressant, cognitive-boosting, antioxidant, antimicrobial and anticancer effects seen in various *Polygala* species (Deng et al., 2020). In particular, *P. tenuifolia* and *P. senega* have shown that the combination of saponins and oligosaccharide esters is closely tied to central nervous system benefits, such as improved memory and mood (Zhang et al., 2023). Additionally, xanthone-rich extracts have displayed impressive antioxidant and liver-protective properties (Yang et al., 2022; Oriola and Kar, 2024). This intricate and chemically diverse mix of phytoconstituents highlights the genus's significant ethnopharmacological importance and fuels ongoing research aimed at isolating, understanding and evaluating the mechanisms of individual bioactive compounds for their potential therapeutic and pharmaceutical uses.

Pharmacological activities

Polygala species have shown a remarkable range of pharmacologically validated activities, backing up their long-standing traditional uses (Ünlü et al., 2022). One of the standout features is their neuroprotective and cognitive-enhancing effects, especially linked to *P. tenuifolia*. The saponins and oligosaccharide esters found in this plant, like tenuifolin and BT-11, have proven effective in boosting memory and learning in animal models of

Alzheimer's disease and age-related cognitive decline. They also exhibit notable antidepressant and anxiolytic effects by influencing neurotransmitter systems and promoting neurogenesis in the hippocampus (Park et al., 2002; Wang et al., 2020). On the respiratory front, *P. senega* is well-known for its expectorant and protective properties, with its saponin-rich root extracts stimulating bronchial secretions, making it a historical go-to for cough and bronchitis treatments (Paul et al., 2010). The genus also boasts significant anti-inflammatory and analgesic effects, validated through models of carrageenan-induced oedema and nociception, along with impressive antioxidant activity shown in DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2'-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid) and superoxide radical scavenging assays, largely due to its xanthone and flavonoid content (Sammaiah et al., 2018; Alagammai et al., 2012). Antimicrobial and antifungal tests have demonstrated its ability to inhibit various bacterial and fungal pathogens, supporting its traditional use in wound healing and infection management (Johann et al., 2011). Moreover, hepatoprotective studies indicate that certain *Polygala* extracts can reduce chemically-induced liver damage and oxidative stress (Dhanabal et al., 2006; Xin et al., 2023). Preliminary anticancer research using different cell lines has suggested that some compounds derived from *Polygala* may have antiproliferative and pro-apoptotic effects (Paul et al., 2010; Bian et al., 2020). These findings underscore *Polygala* as a pharmacologically diverse genus with significant potential in neuropharmacology, respiratory medicine and more.

Ecological and economic values

Polygala species play a vital role in maintaining the ecological balance of the various habitats they thrive in, from grasslands and open woodlands to rocky slopes and marshy meadows, even in those disturbed roadside areas across tropical, subtropical and temperate regions. Many of these species are low-growing herbs or subshrubs with fibrous or taproot systems, which help stabilize the soil and control erosion, especially in sloped or degraded landscapes. Their flowers are often rich in nectar and designed to attract pollinators, making them essential resources for bees, butterflies and other pollinating insects. This, in turn, supports local pollination networks and the reproduction of a wider range of plant communities. Moreover, several *Polygala* species act as indicators of specific soil and moisture conditions, providing insights into the ecological health and nutrient levels of grassland

and meadow ecosystems. Their ability to thrive in disturbed or marginal lands highlights their ecological resilience and suggests their potential use in habitat restoration and efforts to conserve biodiversity (Rath et al., 2013; Tokumoto et al., 2020; Zhang et al., 2024; Wang, 2025).

Polygala species are quite valuable economically, mainly due to their role in the pharmaceutical and herbal trade rather than through large-scale farming. For instance, the root of *P. senega* has been a well-known botanical product on the international market, harvested and exported from North America for use in cough syrups and expectorants that are recognized in Western pharmacopoeias. On the other hand, *P. tenuifolia* root plays a crucial role in Traditional Chinese Medicine, being widely cultivated and traded throughout China for its applications in memory enhancement and as a sedative in herbal remedies. This ongoing demand helps support rural communities through wild harvesting, small-scale farming and local herbal markets, especially in China, India and parts of Africa, where various species are gathered for traditional medicine practices. Additionally, the growing pharmacological research validating the benefits of this genus, particularly in neuroprotection and cognitive enhancement, has piqued the interest of the nutraceutical and pharmaceutical sectors. This positions certain *Polygala* species as exciting prospects for developing standardized extracts, commercial cultivation and creating value-added products in the global herbal and pharmaceutical markets (da Rocha et al., 2019; Kuang et al., 2024; Çalış et al., 2025; Fu et al., 2026).

Conclusion

Ethnobotanical uses, bioactive compounds, pharmacological potential, ecological significance and economic values indicate that *Polygala* species are potential unexplored plants that can be used in plant diversity studies and development of new therapeutic agents. They have economic value; therefore, value addition strategies can be made to provide livelihood for local communities. They play an important role in ecological balance; hence, their therapeutic potential can be documented through systematic field surveys in future for sustainable development and conservation of local biodiversity.

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Chapter 7

Phytochemical diversity and pharmacological mechanisms of *Curculigo orchioides* Gaertn.

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Abstract: The genus *Curculigo*, which belongs to the Hypoxidaceae family, especially *Curculigo orchioides*, commonly known as "Kali Musli," is highly regarded in Ayurveda for its rejuvenating properties. It is traditionally used to address issues like sexual dysfunction, infertility, rheumatism, asthma and weakness. Phytochemical investigations have uncovered a rich array of compounds, including phenolic glycosides (with curculigoside being a standout), triterpenoid saponins, flavonoids, lignans and cycloartane-type substances, all contributing to its therapeutic benefits. Recent studies have backed up many of these traditional uses, showing that it possesses aphrodisiac, immunomodulatory, antioxidant, hepatoprotective, anti-inflammatory and anticancer effects through various molecular pathways. The present chapter focuses on the phytochemical variety and pharmacological actions of *C. orchioides*, assessing the potential for drug development while pinpointing important areas that need further research.

Keywords: Aphrodisiac, anticancer, hepatoprotective, immunomodulatory, rheumatism

Introduction

The forest floor is an integral part of the forest ecosystem (Deilmann et al., 2025). It gives life to almost all living and non-living organisms related to this system. It provides food for wildlife and medicine for local communities (Jacob et al., 2020). It is also a part of petty cash for local inhabitants as they collect the roots, dry them and sell them in local markets as a medicinal agent (Masoodi and Sundriyal, 2020). In some places, over-extraction of some medicinal plants growing on the forest floor has been observed and their population is decreasing at an alarming rate (Kala et al., 2006). Addressing such species is an important task. The most common medicinal plants on the forest floor in India are *Asparagus racemosus*, *Curculigo orchoides*, *Eulophia nuda*, *Eulophia explanata*, *Geodorum densiflorum*, *Elephantopus scaber*, *Premna herbacea*, *Ceropegia candelabrum*, *Curcuma longa*, *Curcuma amada*, *Curcuma caesia*, etc. (Chauhan et al., 2010; Alok et al., 2013; Dinh et al., 2026). They are extracted for their medicinal roots. Among them, *C. orchoides* is a common Sal-associated medicinal herb (Gao et al., 2025). It is also common in pine forests of the Western Himalaya. The over-extraction of this species is going on; therefore, to address the medicinal uses and create awareness of its conservation and sustainable use, this chapter is designed. Morphology, ethnomedicinal uses, bioactive compounds, pharmacological activities, ecological and economic values are discussed here. The chapter highlights the importance of tuberous plants on the forest floor.

Methodology

The present study is based on a narrative literature review methodology and systematically gathers and analyzes published scientific literature focused on the phytochemistry and pharmacological properties of *C. orchoides*. Relevant data were searched for in peer-reviewed articles, reviews and book chapters from various scientific databases like PubMed, Scopus, Web of Science, Google Scholar and ScienceDirect. This was accomplished by using keyword combinations such as "*Curculigo orchoides*", "Kali Musli", "phytoconstituents", "curculigoside" and "pharmacological activity." Classical Ayurvedic texts, ethnobotanical surveys and regional pharmacopeial monographs were studied to gather traditional and indigenous knowledge related to this genus. Preference was given to studies published

largely in the last two to three decades to reflect current phytochemical isolation studies and mechanistic pharmacological findings, while certain older foundational references were preserved for their historical and traditional significance. The compiled literature was systematically screened, categorized and critically analyzed under thematic headings like phytochemical composition, pharmacological mechanisms and traditional applications. This approach allowed us to connect ethnomedicinal claims with scientific validation and pinpoint existing research gaps, paving the way for future exploration into the therapeutic potential of *C. orchioides* (Kumar, 2025; Sahu et al., 2026).

Morphology

Curculigo species are fascinating perennial herbs that stand out with their short, tuberous or cylindrical rootstocks and fleshy, fibrous adventitious roots. These roots are crucial as they store the bioactive compounds found in *C. orchioides*. The leaves typically emerge in a rosette from the rootstock, showcasing a simple, sessile or sub-sessile structure that ranges from lanceolate to linear-lanceolate. They feature prominent parallel veins and a unique pleated folding, which is a hallmark of the Hypoxidaceae family. When it comes to their flowers, they usually form a short, axillary raceme or spike, often hidden among the leaf bases and radical leaves. These blooms are small, bright yellow and star-shaped, with six tepals arranged in two whorls. Most flowers are bisexual, sporting six stamens and an inferior, trilocular ovary that ends in a long, slender, hair-like beak, a distinctive trait of the genus. The fruit is a capsule, often clavate or oblong, filled with several black, wrinkled seeds that help in propagation. Together, the tuberous roots, pleated radical leaves and beaked capsular fruits create a distinctive profile for *Curculigo*, making it easily identifiable within its family and highlighting its medicinal significance (Saxena and Brahman, 1995; Figure 1).

Ethnobotany

Curculigo species, especially *C. orchioides*, hold a significant spot in traditional medicine throughout South and Southeast Asia. The tuberous rhizome, often referred to as "Kali Musli" or "Talmuli" in Ayurveda, is part

of the "Dashamula" group and is highly regarded as a powerful Rasayana (rejuvenative) and aphrodisiac (Chauhan et al., 2010; Nie et al., 2013).



Figure 1: Habitat of *C. orchioides*

It is commonly used to address issues like sexual dysfunction, infertility, spermatorrhoea and weakness, typically prepared as powders, decoctions or medicated oils mixed with milk or ghee (Bhukta et al., 2023). In Siddha and Unani medicine, the rhizome serves a similar purpose as a tonic and aphrodisiac and it is also utilized to treat conditions like jaundice, asthma, diarrhoea and rheumatic issues (Jena et al., 2021). Various tribal and indigenous communities in India, Nepal, Bangladesh and parts of China and Southeast Asia traditionally applied the root paste on the skin for ailments and wounds as well as taken orally for piles, urinary problems and to boost milk production in nursing mothers (Bui-Le et al., 2023; Mahmud et al., 2025). In Traditional Chinese Medicine, *C. orchioides*, known as Xian Mao, is used to strengthen the kidneys, enhance bones and muscles and tackle impotence and lower back weakness, often combined with other herbs in classic recipes (Chen et al., 2021; Liu et al., 2022). This broad and culturally

diverse use of *C. orchoides*, particularly for reproductive health, vitality and musculoskeletal strength, highlights a shared ethnobotanical wisdom that has significantly influenced ongoing phytochemical and pharmacological studies of this species.

Bioactive compounds

Curculigo species are home to a fascinating mix of bioactive compounds, with a strong emphasis on phenolic glycosides. Among these, curculigoside and its various forms (curculigoside A, B, C, D) stand out as the key players driving much of the pharmacological benefits associated with this genus (Wu et al., 2018; Wang et al., 2021). They work alongside other phenolics like orcinol glucosides and curculigine. *C. orchoides* also boasts a wealth of triterpenoid saponins and cycloartane-type triterpenes, which play a significant role in its immunomodulatory and anti-osteoporotic effects (Xu et al., 1992). Additionally, findings of flavonoids, lignans, phenolic acids and mucilaginous polysaccharides that enhance its antioxidant and adaptogenic qualities (Huong et al., 2025). There are also some lesser-known components, such as curculigenin-type saponins, phytosterols and volatile compounds, particularly found in the tuberous roots of *C. orchoides*, which are the main source of these bioactive substances (Pandit et al., 2008). The dynamic interaction between curculigoside-based phenolics and cycloartane triterpenoid saponins is considered crucial for the aphrodisiac, hepatoprotective, immunomodulatory and neuroprotective effects of the genus (Kim et al., 2022). This makes these compounds prime candidates for further phytochemical studies, structural analysis and exploration of their pharmacological mechanisms.

Pharmacological activities

C. orchoides has shown a wide range of pharmacological activities that back up its traditional uses. This species is particularly noted for its aphrodisiac and reproduction-boosting effects, with studies on rhizome extracts revealing improvements in libido, sperm count and motility in animal models (Chauhan et al., 2007; Bui-Le et al., 2023). Additionally, it boasts significant immunomodulatory properties due to its polysaccharide and saponin components, which enhance both humoral and cell-mediated immune responses (Bafna and Mishra, 2006; Murali and Kuttan, 2015). The strong antioxidant capabilities of *C. orchoides* have been confirmed through

various assays like DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2'-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid) and superoxide radical scavenging, which correlate with its phenolic glycoside content (Wu et al., 2005; Wang et al., 2021). This antioxidant strength is key to its impressive hepatoprotective effects, as shown by reduced liver enzyme levels and oxidative damage in models of chemically induced liver toxicity (Du et al., 2022). This species also exhibits notable anti-osteoporotic and bone-protective benefits, with curculigoside promoting osteoblast activity and inhibiting bone resorption in ovariectomized animal studies, reinforcing its traditional role in supporting musculoskeletal health (Zhao et al., 2015). Other validated effects include anti-inflammatory and analgesic properties observed in carrageenan-induced edema and pain models, neuroprotective and cognitive-enhancing benefits in memory impairment and neurodegeneration studies, antidiabetic effects through improved glucose tolerance and enzyme inhibition and antimicrobial activity against various bacterial and fungal pathogens (Mahmud et al., 2025). Moreover, early anticancer research has indicated that curculigoside and related compounds can induce antiproliferative and apoptosis effects in several cancer cell lines, along with documented adaptogenic and antistress properties (Guo et al., 2022; Ma et al., 2025). These findings highlight *C. orchoides* as a pharmacologically important species with significant potential for applications in reproductive health, bone metabolism, liver protection and neuropharmacology.

Ecological and economic values

Curculigo species are usually found as understory herbs thriving in the moist deciduous forests, grasslands and semi-shaded areas of South and Southeast Asia. Their tuberous rootstocks help them endure dry spells and disturbances like fire. These plants play a vital role in retaining soil moisture and stabilizing the forest floor, while their flowers provide essential support for local pollinators. Acting as indicators of forest health and canopy cover, their presence signifies relatively untouched ecosystems. However, with increasing habitat degradation, *C. orchoides* has become vulnerable in several areas, highlighting its importance in the conservation of forest biodiversity (Nie et al., 2013; Wang et al., 2021; Bhukta et al., 2023).

C. orchoides is quite significant in the economic landscape as a popular medicinal resource in Ayurvedic, Siddha and Unani practices

throughout South Asia. Its trade not only brings in revenue through wild harvesting but also through pharmaceutical companies. However, the soaring demand has led to overharvesting and a decline in its population, sparking a growing interest in cultivating this plant sustainably. With increasing pharmacological research backing its benefits, kali musli has caught the attention of both nutraceutical and pharmaceutical sectors, boosting its commercial appeal and providing additional income opportunities for rural and tribal communities engaged in its trade (Mathew et al., 2004; Zhu et al., 2015; Kushalan et al., 2022).

Conclusion

Curculigo orchioides is commonly known as ‘Kali Musli’. It is a Sal-associated medicinal herb and is used to treat several health problems. Many bioactive compounds are identified from the plant parts of *C. orchioides* and their pharmacological activities are documented. It has ecological and economic values; therefore, over-extraction is observed. There is a need for a conservation plan and sustainable harvesting of this important herb region-wise in India.

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Chapter 8

***Marsilea* species: bioactive secondary metabolites, mechanisms of action and pharmacological significance**

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Abstract: *Marsilea*, a fascinating genus of aquatic ferns from the family Marsileaceae, is packed with bioactive secondary metabolites like flavonoids, alkaloids, terpenoids, phenolic acids and saponins. These compounds have been the backbone of its traditional medicinal uses for ages. The present study gives a closer look at these phytoconstituents and the various pharmacological activities they exhibit, such as antioxidant, anti-inflammatory, antimicrobial, anticancer, neuroprotective, hepatoprotective and antidiabetic effects, while also delving into the molecular mechanisms and cellular targets at play. The authors tried to fill the gap between traditional ethnopharmacological practices and modern scientific validations, shedding light on the key challenges faced, like the scarcity of clinical data and the need for standardization, which can impede the translation of these findings into therapeutic applications. Integrating current knowledge, this chapter aims to highlight the

Marsilea species as a promising and largely untapped source of bioactive compounds that holds great potential for future drug discovery.

Keywords: Drug discovery, phytoconstituents, scientific validation, therapeutic application

Introduction

In the current scenario, where we are facing climate change and biodiversity loss, work on wetland species is a more important global task for researchers (Xing et al., 2023; Liu et al., 2026). For the conservation of wetlands, we need to draw attention towards their biowealth and how they are useful for human beings (Díaz et al., 2006; Xu et al., 2019). Throughout the world, the degradation of wetlands is observed. There are several unexplored plant species belonging to wetland, needs to be documented (Fluet-Chouinard et al., 2023; Huang et al., 2026). Keeping the importance of wetlands and their biowealth in mind, an attempt has been made to document the ethnobotany, bioactive compounds, pharmacological potential, ecological significance and economic values of *Marsilea* species. *Marsilea* species grow as aquatic plants and sometimes in a semi-aquatic environment. The genus belongs to the Marsileaceae family (Soni and Shrivastava, 2025). The creeping rhizome is a prominent character of this genus. Their plant parts are used as a medicinal food in different parts of the world (Chakraborty et al., 2013). The chapter highlights the importance of wetland plants and provides baseline data on *Marsilea* species.

Methodology

The present study follows a narrative review methodology, synthesizing findings from peer-reviewed articles, review papers and book chapters sourced from databases including PubMed, Scopus, Web of Science and Google Scholar. Relevant searches were guided by keywords such as "*Marsilea*", "secondary metabolites", "phytochemistry" and "pharmacological activity". Relevant studies published in English were carefully examined and organized thematically according to metabolite class, biological activity and mechanism of action. Additionally, the traditional use information was cross-referenced with modern findings to create a comprehensive, evidence-based overview (Kumar, 2025; Sahu et al., 2026).

Morphology

The genus *Marsilea*, often referred to as water clover, is a fascinating fern that thrives in aquatic to semi-aquatic environments. Belonging to the Marsileaceae family, it features a slender, creeping rhizome that either creeps along or burrows beneath the mud, sprouting nodes and internodes from which its roots and leaves emerge. One of its most striking characteristics is its clover-like leaves, which have four obovate leaflets arranged in a cross pattern, all stemming from a long petiole. These leaves display a unique growth pattern when young, known as circinate vernation and they exhibit nyctinasty movements, folding up at night and unfurling during the day. Depending on the water level, the leaves can either float or stand upright. *Marsilea* reproduces through hard, bean-shaped sporocarps that form at the base of the petiole near the rhizome. Inside these sporocarps are sori that produce both microspores and megaspores. As a whole, *Marsilea* has a low-growing, sprawling habit, with solitary leaves sprouting from the rhizome nodes, making it perfectly adapted to life in ponds, marshes and rice paddies (Saxena and Brahmam, 1996; Figure 1).

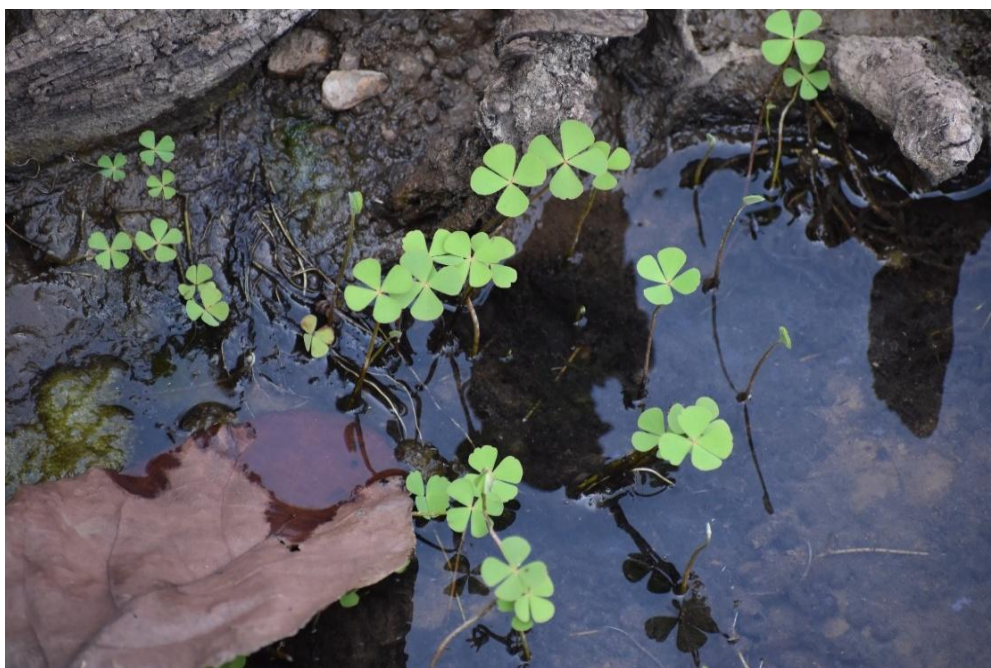


Figure 1: Habitat of *Marsilea minuta*

Ethnobotany

Marsilea species are quite important in the world of ethnobotany, especially within traditional medicine systems like Ayurveda, Siddha and various folk practices in Asia and Africa (Bhattamisra et al., 2008; Subramanian et al., 2023). Different parts of the plant, particularly the leaves, have been used to tackle a variety of health issues (Chakraborty et al., 2013; Roy et al., 2024). Traditionally, it has been recognized as a sedative and nerve tonic, helping to manage insomnia, anxiety and other mental health concerns. It is often dubbed a "brain tonic" for its potential to enhance memory and cognitive abilities (Bhattamisra et al., 2012; Subramanian et al., 2023). The leaves also play a role in treating diarrhoea, dysentery, urinary problems and skin problems. In some indigenous communities, decoctions or pastes made from the leaves are applied to soothe inflammation, heal wounds and even treat snake bites (Alerico et al., 2015; Mondal et al., 2025). Beyond its medicinal uses, *Marsilea* is enjoyed as a leafy vegetable in certain rural and tribal areas, appreciated for its nutritional benefits. Additionally, it finds a place in ethnoveterinary practices, helping to address health issues in livestock (Marndi and Kumar, 2017). This rich traditional knowledge, handed down through generations, remains a vital source for modern research into the therapeutic possibilities of *Marsilea* species.

Bioactive compounds

Marsilea species are a treasure trove of various bioactive secondary metabolites (Mondal et al., 2025). They boast an impressive array of flavonoids, including marsiline, quercetin, kaempferol and their glycosides, as well as triterpenoids and sterols like marsiline-related triterpenes, β -sitosterol and stigmasterol (Bhattamisra et al., 2008). Studies also find alkaloids, phenolic acids such as gallic acid, caffeic acid and ferulic acid, along with tannins, saponins and essential oil components, not to mention polysaccharides and fatty acids that vary in concentration across different parts of the plant (Jan et al., 2022). Flavonoids and phenolic compounds are particularly plentiful in the leaves, playing a key role in the plant's impressive antioxidant and free radical scavenging abilities (Zhang et al., 2016). Meanwhile, the triterpenoid and sterol components are known for their anti-inflammatory, hepatoprotective and anticancer properties. Alkaloids and saponins have been linked to effects on the central nervous system, which aligns with the traditional use of *Marsilea* as a sedative and memory booster.

(Subramanian et al., 2023). Moreover, tannins and other phenolics show promise for their antimicrobial and wound-healing capabilities. The exact makeup and concentration of these metabolites can differ among *Marsilea* species and are influenced by factors like habitat, seasonal changes and extraction methods (Arokiyaraj et al., 2018). This makes thorough phytochemical profiling crucial for linking specific compounds to their pharmacological effects.

Pharmacological activities

Marsilea species are packed with a wide range of pharmacological benefits that have been backed by numerous studies, both in the lab and in living organisms, reinforcing their traditional medicinal uses (Rithanyaa and Radhakrishnan, 2024). One of the standout features of *Marsilea* extracts is their impressive antioxidant activity, thanks to their rich flavonoid and phenolic content (Rahayu et al., 2021). This helps them combat free radicals and lessen damage caused by oxidative stress. Moreover, these plants show significant effects on the central nervous system, including anxiolytic, sedative, anticonvulsant and nootropic (memory-boosting) properties, which aligns perfectly with their traditional role as brain tonics (Zhang et al., 2016). In addition, *Marsilea* species are known for their anti-inflammatory and pain-relieving qualities, as well as their ability to protect the liver from damage caused by toxins. They also exhibit anti-diabetic and anti-hyperlipidemic effects, with extracts that can lower blood sugar and lipid levels in experimental settings. Additionally, research points to their promising antimicrobial, antifungal and wound-healing properties, along with anticancer potential shown through cytotoxic effects on various cancer cell lines. They even have antidiarrheal and diuretic effects, further supporting their traditional use in treating gastrointestinal and urinary issues (Sajini et al., 2019; Bano et al., 2025). These varied pharmacological properties highlight the therapeutic potential of *Marsilea* species and suggest they could be a valuable resource for future drug development.

Ecological and economic values

Marsilea species are vital players in wetland and aquatic ecosystems. They help stabilize muddy substrates, prevent soil erosion and create thick mats that offer shelter and breeding grounds for various aquatic life. Through absorbing excess nitrogen and phosphorus, they contribute to nutrient

cycling, which aids in water purification and helps reduce eutrophication. Moreover, their sensitivity to environmental changes makes them excellent bioindicators for assessing the health of wetlands (Rai, 2009; Urakawa and Bernhard, 2017; Sudhama et al., 2025; Khalaf et al., 2026).

Marsilea is quite valuable economically, especially in rural areas. Its leaves are enjoyed as a nutritious vegetable and play a role in traditional and Ayurvedic medicine, helping to treat various neurological, liver and metabolic issues. Additionally, it is grown as a beautiful aquarium plant thanks to its lovely leaves. In farming regions, it also serves as fodder for livestock, which adds to its worth, even though it can sometimes be seen as a weed in rice paddies (Sajini et al., 2019; Rathore and Solanki, 2024).

Conclusion

The present study highlights the uses of *Marsilea* species as wetland plants. The study also highlights the importance of wetlands and their usefulness to living organisms. *Marsilea* species have medicinal, ecological and economic significance; hence, species of this genus can be evaluated for pharmacological activities, with value addition for local livelihoods.

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Chapter 9

***Begonia* species in traditional and modern medicine: an ethnopharmacological overview**

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Abstract: *Begonia*, a diverse genus of flowering plants belonging to the family Begoniaceae, boasts over 2,000 species and plays a significant role in traditional medicine, where it has been used to address issues such as inflammation, respiratory problems, fevers, wounds and digestive disorders. This chapter examines the ethnomedicinal importance of various *Begonia* species and presents new pharmacological evidence supporting their healing potential. Phytochemical research has uncovered a range of bioactive compounds such as flavonoids, phenolics, terpenoids and alkaloids that contribute to their noted antioxidant, anti-inflammatory, antimicrobial, antidiabetic, liver-protective and anticancer effects. Through linking the traditional uses with contemporary pharmacological insights, this chapter highlights the promise of *Begonia* in drug discovery, while also pointing out the need for more research into its toxicity and clinical applications. It advocates for scientific validation, standardization and the sustainable use of this valuable ethnobotanical genus.

Keywords: Antidiabetic, Begoniaceae, bioactive compounds, liver-protective, scientific validation, toxicity

Introduction

In plant categories of forests, wild ornamental plants are always a fascinating group. In wild ornamental plants, trees, climbers, shrubs, herbs and large lianas are present (Orlóci and Fekete, 2023). Among them, wild ornamental herbs are usually seasonal and regionally based. During monsoon and post-monsoon, most wild ornamental herbs emerge and beautify the forest with their brightly coloured and aromatic flowers (Layek et al., 2025). *Begonia picta* is a well-known wild ornamental plant of this group having ecological, medicinal and food values (Tian et al., 2018). There are about 2000 species of *Begonia* reported from different parts of the world. Still, many *Begonia* species are undiscovered and unexplored (Xiao et al., 2023). Some common *Begonia* species are *Begonia grandis*, *Begonia roxburghii*, *Begonia picta* and *Begonia fimbristipula*. The local communities of different parts of the world consumed its leaves as a medicinal food and used them as a wild ornamental plant, particularly in hilly areas (Ayunanda et al., 2025). Very limited literature is available on *Begonia* species and their significance. Therefore, the present chapter aims to gather information about morphology, ethnobotanical uses, bioactive compounds reported, pharmacological potential, ecological significance and economic values of *Begonia* species. The chapter also recommends using local plants for ornamental purposes to reduce the pressure of invasive and weed species.

Methodology

A systematic narrative review strategy was followed in this chapter to gather literature from various databases, including PubMed, Scopus, Web of Science, Google Scholar and ScienceDirect. Books, theses and regional ethnobotanical surveys were also consulted to enrich the review findings. The search strategy combined '*Begonia*' with relevant keywords such as "ethnomedicine", "phytochemistry", "pharmacological activity" and "toxicity." Studies contributing ethnobotanical, phytochemical or pharmacological insights were prioritized, whereas non-English publications, duplicate records and studies of insufficient rigour were excluded from consideration. Relevant data on traditional uses, bioactive components and pharmacological mechanisms were gathered and species

names were cross-referenced with recognized taxonomic databases to maintain accuracy (Kumar, 2025; Sahu et al., 2026).

Morphology

The genus *Begonia* is a fascinating group of plants that showcases a wide range of forms, including succulent herbaceous perennials, subshrubs and sometimes even climbing or epiphytic varieties.



Figure 1: Habitat of *Begonia picta*

These plants can be categorized based on their growth habits into fibrous-rooted, rhizomatous, tuberous and cane-like types, each with root systems that help them thrive whether they are fibrous, tuberous or rhizomatous. Their

stems are often succulent and jointed, with a translucent or reddish hue and swollen nodes, varying from short creeping types to tall, climbing canes. One of the standout features of *Begonia* is their unique leaf structure, which has an asymmetric base. The leaves are simple, alternate and stipulate, displaying a range of margins from entire to serrate or lobed, along with incredible diversity in color, texture and variegation. *Begonia* species are monoecious, meaning they produce unisexual flowers arranged in cymose inflorescences. The male flowers typically have 2-4 tepals and a cluster of yellow stamens, while the female flowers are easily recognized by their winged inferior ovary, topped with 2-5 tepals and twisted, often bifid stigmas, showcasing colors from white and pink to red and yellow. The fruit usually takes the form of a winged capsule filled with tiny seeds that are dispersed by the wind. This remarkable variety in leaf shape, growth patterns and floral structures not only makes *Begonia* appealing to gardeners but also allows them to adapt successfully to a wide range of ecological environments (Saxena and Brahmam, 1995; Figure 1).

Ethnobotany

Begonia species have a fascinating role in traditional and folk medicine throughout Asia, Africa and the Americas. Communities have been using their juicy leaves, stems and rhizomes for both nutrition and healing for ages (Lalawmpuii and Tlau, 2021). In China, varieties like *Begonia fimbristipula* and *Begonia grandis* are staples in traditional Chinese medicine, known for their ability to clear heat, detoxify and help with coughs and menstrual issues (Huang and Wang, 2020, Xiao et al., 2025). Meanwhile, in India and Nepal, tribal and Himalayan groups turn to *Begonia roxburghii* and *Begonia picta* to tackle dysentery, diarrhoea and indigestion, often enjoying the sour leaves and petioles as food or flavouring agents (Khakurel et al., 2021). Over in Southeast Asia, Malaysia, Indonesia and the Philippines, people crush the leaves to make poultices for boils, skin infections, inflammation and they also enjoy them as a vegetable (Rajbhandary, 2013). In Africa, particularly in Cameroon and other tropical areas, local species are brewed into decoctions to relieve respiratory problems, fevers and stomach issues. Latin America also values native *Begonia* species for their astringent and anti-inflammatory properties, especially in treating wounds and respiratory infections. Across these diverse regions, common uses include managing gastrointestinal troubles, respiratory issues, wound healing, fevers and inflammation, along

with culinary applications as a souring agent due to the oxalic acid found in the leaves and stems (Ramesh et al., 2002; Borah et al., 2025). This consistent pattern of ethnopharmacological use, emerging independently in far-flung cultures, has piqued scientific interest, leading to research aimed at validating these traditional practices through phytochemical and pharmacological studies.

Bioactive compounds

Research into various *Begonia* species has uncovered a fascinating and diverse range of bioactive secondary metabolites. These include flavonoids like quercetin and kaempferol, along with their glycosides, as well as phenolic acids such as gallic, caffeic and ferulic acids (Karima et al., 2017). Studies also found tannins, terpenoids, steroids, alkaloids and saponins, not to mention organic acids like oxalic acid, which give many species their distinctive sour flavour (Coyago-Cruz et al., 2024). Some species even boast essential oils, coumarins, anthraquinones and lignans, along with powerful antioxidant compounds like ascorbic acid and carotenoids (Periferakis et al., 2022). The concentrations of these compounds can vary significantly across different parts of the plant leaves, stems, rhizomes and flowers and are influenced by geographical and seasonal changes. Together, these components contribute to the impressive range of pharmacological activities associated with *Begonia* species, including antioxidant, anti-inflammatory, antimicrobial, antidiabetic, hepatoprotective, antinociceptive and anticancer effects (Pandikumar et al., 2009; Borah et al., 2025). This rich chemical profile not only supports traditional ethnomedicinal uses but also highlights their scientifically backed therapeutic potential.

Pharmacological activities

Extensive pharmacological investigations on *Begonia* species have confirmed many of their traditional medicinal uses, uncovering a wide range of biological activities linked to their diverse phytochemical makeup (Lalawmpuii and Tlau, 2021). Extracts from different species, such as *Begonia picta*, *Begonia fimbristipula*, *Begonia malabarica*, *Begonia palmata* and *Begonia roxburghii*, have shown impressive antioxidant properties by scavenging free radicals and reducing markers of oxidative stress (Xiao et al., 2025). They also exhibit strong anti-inflammatory effects by inhibiting pro-inflammatory cytokines and pathways like COX-2 and NF- κ B (Bairagi

et al., 2025). Studies on their antimicrobial and antifungal properties reveal effectiveness against various bacterial and fungal pathogens, supporting their traditional roles in wound healing and managing infections (Frei et al., 1998). Additionally, their antidiabetic effects have been demonstrated through the inhibition of α -amylase and α -glucosidase, along with improved glucose tolerance in experimental models (Pandikumar et al., 2009; Chilanti et al., 2025). Reports of hepatoprotective activity against chemically induced liver damage are promising and several species have shown significant anticancer and cytotoxic effects on different cancer cell lines, likely due to mechanisms like apoptosis induction and cell cycle arrest (Chediyankandy et al., 2026). Other notable activities include antinociceptive and analgesic effects, antidiarrheal and antiulcer properties, anthelmintic activity and wound-healing potential (Maulana et al., 2023). Together, these findings highlight the pharmacological versatility of *Begonia* species and their potential as candidates for future drug discovery, although most evidence is still limited to preclinical studies, emphasizing the need for further clinical validation.

Ecological and economic values

Begonia species, boasting over 2,000 recognized varieties, play a vital role in tropical and subtropical understorey ecosystems. These are typically found thriving in the shaded, humid floors of forests, along riverbanks and on limestone outcrops. Many of these species exhibit strong microendemism, which makes them excellent bioindicators for assessing habitat quality and microclimate stability. Their beautiful flowers attract pollinators like bees and flies, while their lush ground cover is great for retaining soil moisture and preventing erosion. However, their specific habitat needs make them particularly susceptible to threats like deforestation and climate change, highlighting their importance as sentinel species in the conservation of tropical forests (Harrison et al., 2016; Li et al., 2022; Thomas et al., 2024).

Begonias play a vital role in the global ornamental plant market, where a variety of hybrid cultivars are planted in gardens, pots and hanging baskets, bolstering significant horticultural industries around the world. Some species are also gaining attention in the fields of pharmaceuticals and nutraceuticals, due to their bioactive compounds like flavonoids and phenolics, which have been used in traditional medicine. Moreover, certain species are enjoyed locally as nutritious, vitamin C-rich greens, supporting rural economies. All these factors highlight the commercial and biomedical

importance of the *Begonia* genus, emphasizing the need for sustainable cultivation practices to safeguard wild populations (Chen et al., 2024; Ginori et al., 2025).

Conclusion

The present chapter highlights the bioactivities, ecological services and ethnobotanical uses of *Begonia* species. About 2000 *Begonia* species are blooming throughout the globe, which need attention towards their conservation and advanced research work on their bioactivity to formulate new therapeutic drugs. The chapter also brings attention to its ecological and economic significance. Hence, the genus should be taken for value addition and exploration works.

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Chapter 10

Medicinal and pharmacological values of *Utricularia stellaris* L.f. (Lentibulariaceae): a carnivorous plant of India

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Abstract: *Utricularia stellaris* L.f. (Lentibulariaceae) is a free-floating aquatic carnivorous plant that has received limited scientific attention despite its reported ethnomedicinal importance. The present study provides a comprehensive review of the taxonomy, morphology, ethnobotanical uses, phytochemical composition, pharmacological potential and ecological significance of *U. stellaris*, supplemented with a preliminary qualitative phytochemical evaluation of the hydroethanolic extract of the whole plant. The phytochemical screening revealed the strong presence of carbohydrates, proteins, tannins, saponins, reducing sugars and steroids, while terpenoids and phenolic compounds were detected in moderate amounts. Amino acids, lipids, starch, sucrose, flavonoids and alkaloids were absent in the extract. The occurrence of these bioactive constituents suggests the plant possesses promising antioxidant, antimicrobial and anti-inflammatory potential, supporting its traditional medicinal applications. In addition to its therapeutic prospects, *U. stellaris* contributes significantly to freshwater ecosystem functioning and serves as an indicator of healthy wetland habitats. The findings highlight the need for further phytochemical characterization, pharmacological validation, toxicity assessment and conservation initiatives to fully understand the medicinal potential of this underexplored carnivorous species while ensuring its sustainable utilization.

Keywords: Bioactive compounds, carnivorous plant, conservation, ethnobotany, pharmacological potential

Introduction

Carnivorous plant species are a very fascinating group of angiosperms. The most common species of carnivorous plants are *Drosera burmanni*, *Utricularia aurea* and *Nepenthes khasiana* (Adamec et al., 2021). In some ancient therapeutic literature, they are reported as a medicinal agent (Mishra and Kumar, 2021). A lot of ethnopharmacological work has been carried out on other angiosperms, but very less work has been done with carnivorous plants (Egan and van der Kooy, 2013). *D. burmanii* is used to prepare a popular formulation, “Swarnabhasma”, in Ayurveda; still, modern researchers have not taken it for advanced research in India (Asirvatham et al., 2013). Its carnivorous character is due to some natural enzymes that can be a therapeutic agent for human beings (Ravee et al., 2018). So, keeping the unique character of carnivorous plants, less documentation and emerging global health problems, an attempt has been made to gather information about the morphology, ethnobotanical significance, pharmacological potential as well as ecological and economic values from literature. In addition, field surveys were also carried out, followed by qualitative phytochemical screening to assess the presence of major bioactive constituents. The chapter highlights the medicinal and biotechnological potential of carnivorous plants and their importance as promising candidates for future drug discovery and development, while emphasizing the need for further phytochemical, pharmacological and conservation-oriented research.

Methodology

The present study combined a comprehensive literature review with preliminary phytochemical investigations of the whole plant of *U. stellaris*. Published information on its taxonomy, botanical description, distribution, traditional medicinal uses, phytochemical constituents and pharmacological properties was compiled from peer-reviewed journals and scientific databases, including Scopus, Web of Science, PubMed, ScienceDirect and Google Scholar (Kumar, 2025; Sahu et al., 2026). For the experimental investigation, whole-plant specimens were collected, taxonomically authenticated, shade-dried at room temperature and ground into a fine powder. The powdered material was extracted using hydro-ethanolic solvent, following standard extraction procedure. The concentrated extracts were subjected to qualitative phytochemical screening using established protocols

to detect the presence of primary metabolites (carbohydrates, proteins, amino acids, starch, sucrose and lipids) and secondary metabolites, including alkaloids, flavonoids, tannins, saponins, glycosides, steroids, terpenoids and phenolic compounds, based on characteristic colour reactions and precipitation tests. The phytochemical observations were systematically recorded to evaluate the phytochemical composition of *U. stellaris* and to correlate the detected bioactive constituents with its reported ethnomedicinal uses and potential therapeutic applications (Jena et al., 2025).

Results

Morphology

U. stellaris is a fascinating, rootless aquatic plant that floats freely in the water. Belonging to the Lentibulariaceae family, it can often be found in ponds, lakes and slow-moving freshwater areas. Its slender, branched stems float just beneath the surface, adorned with finely dissected leaves that are arranged in a whorled, star-like pattern, hence the name "stellaris." This unique plant features numerous small, bladder-like structures known as utricles, which are modified leaf segments that act as specialized traps for catching tiny aquatic creatures like protozoans, small crustaceans and rotifers (Miranda et al., 2021). These traps work through a quick suction mechanism activated by sensitive trigger hairs. Interestingly, *U. stellaris* does not have true roots; instead, its submerged shoot system takes on the roles of anchoring and absorbing nutrients (Saxena and Brahmam, 1995; Figures 1 & 2).

Ethnobotany

While *U. stellaris* might not be as well-known in ethnobotanical circles as some other medicinal aquatic plants, it has found its place in the traditional practices of certain rural and tribal communities living near wetlands and freshwater sources. These groups have used the plant for a variety of healing purposes, such as treating skin issues, wounds and inflammation (Sharma et al., 2024). Typically, they apply the whole plant or its extract as a poultice or paste to aid in healing and reduce swelling. In folk medicine, people also prepare decoctions or infusions from *U. stellaris* to help with digestive troubles, fevers and urinary problems, showcasing the community's understanding of its gentle diuretic and anti-inflammatory effects (Haron and Chew, 2012). Moreover, this plant occasionally plays a role in traditional veterinary care, helping to address minor health issues in livestock. In some

areas, it even serves as a sign of clean, unpolluted freshwater habitats, reflecting its minor yet significant role in local ethno-ecological knowledge (Koller-Peroutka et al., 2015). Despite the limited documentation surrounding it, the ethnomedicinal applications of *U. stellaris* highlight the deep-rooted reliance on aquatic and wetland plants among indigenous communities, emphasizing the need for more ethnobotanical research to validate and preserve this valuable traditional knowledge (Mishra and Kumar, 2021).



Figure 1: Habitat of *Utricularia stellaris*

Bioactive compounds

U. stellaris, much like its relatives in the Lentibulariaceae family, boasts a fascinating mix of bioactive compounds that play a role in its traditional medicinal uses and potential pharmacological benefits (Sharma et al., 2024). However, when it comes to specific phytochemical data, still a lot needs to be learnt compared to better-studied species like *U. gibba* and *U. vulgaris*. Initial phytochemical screenings of various *Utricularia* species have uncovered a range of compounds, including flavonoids (like quercetin and luteolin, along with their glycosides), phenolic acids, tannins, alkaloids, terpenoids, steroids and naphthoquinones, especially plumbagin and similar quinonoid compounds (He et al., 2012). These compounds are known for their impressive antioxidant, antimicrobial and anti-inflammatory properties.



Figure 2: Whole plant of *Utricularia stellaris*

The flavonoids and phenolic compounds are particularly credited with the plant's ability to scavenge free radicals and provide antioxidant benefits,

which help protect against cellular damage caused by oxidative stress (Chaudhuri et al., 2019). Additionally, the presence of tannins and saponins aligns with its traditional applications in wound healing and as an astringent. Alkaloids and terpenoids found in related *Utricularia* species have also shown promise for antimicrobial, antifungal and liver-protective effects, hinting that *U. stellaris* may share similar pharmacological potential. Moreover, the naphthoquinone derivatives, especially plumbagin-type compounds that are frequently noted in this genus, are particularly intriguing due to their anticancer, antimicrobial and anti-inflammatory effects observed in various studies (Thikare et al., 2025). The bioactive profile of *U. stellaris* makes it a compelling candidate for further research into phytochemical isolation, characterization and pharmacological evaluation, especially to back up its traditional uses and explore new possibilities for drug discovery from this unique aquatic carnivorous plant.

Phytochemical screening of *U. stellaris* whole plant

The shade-dried, powdered whole plant of *U. stellaris* was subjected to continuous hot extraction using a Soxhlet apparatus with hydroethanolic solvent for 6-8 hours until complete extraction. The resulting extract was filtered, concentrated under reduced pressure and subjected to preliminary phytochemical screening for various bioactive constituents. The preliminary phytochemical screening of the hydroethanolic extract of the whole plant of *U. stellaris* revealed the presence of several important primary and secondary metabolites (Table 1). Among the primary metabolites, carbohydrates and proteins showed strong positive reactions, whereas amino acids, lipids, starch and sucrose were absent. In the case of secondary metabolites, tannins, saponins, reducing sugars and steroids were strongly present, while terpenoids and phenolic compounds showed moderate presence. In contrast, flavonoids and alkaloids were not detected in the extract. The presence of these bioactive compounds, especially tannins, saponins and steroids, hints at potential pharmacological properties like antioxidant, antimicrobial and anti-inflammatory activities, which could be worth exploring further, supporting its traditional medicinal importance.

Table 1: Detection of Primary and secondary metabolites of *U. stellaris* whole plant using hydroethanolic extract

Primary metabolites	Hydroethanolic extract	Secondary metabolites	Hydroethanolic extract
Amino acid	-	Tannin	++
Carbohydrate	++	Saponin	++
Lipid	-	Flavonoid	-
Protein	++	Terpenoid	+
Starch	-	Phenolic group	+
Sucrose	-	Reducing sugar	++
		Steroid	++
		Alkaloid	-

(“+”: Positive; “++”: Strongly positive; “-”: Negative)

Pharmacological activities

While there have not been many direct pharmacological studies on *U. stellaris*, some interesting conclusions based on its similarities to other well-researched *Utricularia* species can be drawn. This plant is packed with flavonoids and phenolic compounds, which are known for their impressive antioxidant properties (Pradhan et al., 2025). Tests like DPPH and reducing power assays have shown that it can effectively scavenge free radicals, hinting at its potential to protect cells from damage caused by oxidative stress. Moreover, extracts from *U. stellaris* have shown promise in fighting off various Gram-positive and Gram-negative bacteria. This antimicrobial activity is largely due to the presence of compounds like tannins, alkaloids and naphthoquinone derivatives such as plumbagin, which can disrupt microbial cell membranes and hinder their growth (Thikare et al., 2025). In addition, related species have demonstrated anti-inflammatory effects, likely by inhibiting pro-inflammatory mediators and enzymes, which supports the traditional use of this plant to treat swelling and skin issues (Haron and Chew, 2012). There is also evidence suggesting that extracts from similar *Utricularia* plants may help protect the liver from toxicity caused by chemical agents due to their antioxidant properties. Furthermore, plumbagin and other quinonoid compounds found in this genus have shown promising anticancer effects in various lab studies, promoting apoptosis and slowing down the growth of several cancer cell lines (Wójciak et al., 2023). They also exhibit antifungal and wound-healing properties, aligning with traditional

uses. While the diuretic and antipyretic effects of *U. stellaris* are not well-documented, it has been noted in folk medicine for managing urinary issues and fevers. These pharmacological insights highlight the therapeutic potential of this fascinating plant.

Ecological and economic values

U. stellaris, a fascinating free-floating carnivorous plant, plays a vital role in freshwater ecosystems like ponds and lakes (Popponga et al., 2015). It helps keep populations of protozoans, tiny crustaceans and rotifers in check with its unique bladder-like utricles, which in turn support nutrient cycling and maintain a healthy microfaunal balance (Singh et al., 2011). Its lush floating growth not only provides a cozy habitat for aquatic invertebrates and small fish but also helps control light levels in shallow waters. Additionally, this species acts as a bioindicator, signalling the health of clean, unpolluted freshwater environments. However, it is sensitive to issues like eutrophication and habitat loss, highlighting the importance of conserving wetlands (Haron and Chew, 2012). The economic importance of *U. stellaris* may be modest right now, but it is definitely on the rise, especially due to its charm in aquatic gardening and its growing fan base among carnivorous plant lovers. From an ecological standpoint, its knack for munching on mosquito larvae and other tiny organisms hints at its potential as a natural pest control solution (Vincent and Marmottant, 2011). Plus, the presence of bioactive compounds like flavonoids, tannins and naphthoquinones opens the door to exciting possibilities in pharmaceuticals and nutraceuticals, though there is still a need for more scientific research to back that up.

Conclusion

Utricularia stellaris represents a valuable yet underexplored aquatic carnivorous plant with significant ethnobotanical, phytochemical and pharmacological potential. The present study revealed the presence of important bioactive constituents in its hydroethanolic extract, supporting its traditional medicinal relevance and therapeutic prospects. However, comprehensive investigations on bioactive compound isolation, pharmacological validation and safety assessment are essential to establish its medicinal applications. Concurrent conservation efforts are also necessary to protect this ecologically important species and ensure its sustainable utilization.

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EDITORS' PROFILE



Dr. Emdad Hossain

He is currently serving as an Associate Professor in the Department of Pharmaceutical Technology at Jadavpur University, Kolkata. He earned both his M. Pharm and Ph. D. degrees from Jadavpur University, Kolkata and has devoted the past twenty-five years to teaching and research in the field of Natural Products Studies. Over the course of his academic career, Dr. Hossain has authored twenty-seven research and review papers published in reputed, high-impact, peer-reviewed international journals, along with one conference proceeding, one editorial, twenty-eight book chapters, two authored books and ten edited books. He has presented more than 83 research papers at various national and international conferences, demonstrating his active engagement with the scientific community. Dr. Hossain is a life member of several distinguished professional associations. He serves as the Editor-in-Chief of the Global Academic Journal of Pharmacy and Drug Research. Additionally, he is the Associate Editor of the Indian Journal of Research in Pharmacy & Biotechnology and Biochemica. He contributes as an editorial board member to twelve other national and international journals. He is also an active reviewer for several journals published by Elsevier, Springer-Nature, Wiley and Taylor & Francis. A sought-after academic speaker, he has delivered numerous lectures at refresher courses, as well as at national and international conferences in India and abroad. His contributions to academia and research have earned him numerous honors, including the Best Teacher Award (2002), Jewel of India Award (2014), Young Performer Award (2015), Best Faculty Award (2018), Shikshak Shri Award (2018), Bharat Ratna Dr. Abdul Kalam Gold Medal Award (2018), Nirali's Pharma Recognition Award (2019), Best Researcher Award (2019), Best Educationist Award (2019), Rastriya Vidya Gaurav Gold Medal Award (2019), SAS Best Principal Award (2020) and the Prof. M. L. Schroff Pharma Recognition Award (2025), among several other accolades.



Dr. Kumari Sunita

She is a distinguished academican and researcher in the Department of Botany, Plant Physiology, Biochemistry and PGPR Lab. at Deen Dayal Upadhyaya Gorakhpur University, India. Before her current role, she served at A.N.D.N.N.M.M. Harsh Nagar, Kanpur, Uttar Pradesh, India. She completed her schooling in Kolkata and Rajasthan. She earned her B.Sc. and M.Sc. from Gorakhpur, followed by a Ph.D. from the same university, where she secured the top position in her pre-Ph.D. exam. She has a uniformly brilliant academic record & Received Five Medals during her Academic training. She is GATE & NET Qualified. Her research focuses on plant physiology, PGPR ethnobotany, environmental remediation and Agricultural Science. She has published 59 research articles/ review articles, 5 books and 15 book chapters, 3 patents and has a cumulative impact factor of 55.5. With 12 years of teaching and 11 years of research experience, she has participated in 55 conferences and received numerous awards, including the Best Poster Award at BHU and the Best Oral Presentation Award at an IPS conference. She has been recognized as an outstanding researcher in PGPR in Malaysia 2022 & Best Teacher by DDU Gorakhpur University in Teaching and Excellence in Research 2021, receiving multiple accolades such as the Young Scientist Award 2022, Fellow Award at SKAUST Kashmir 2023 and the Eminent Scientist Award at Ranchi GUR BMR 2024. She is actively involved in various committees, curriculum development and conference organization. She also serves as an NSS Programme Officer and is a life member of several professional societies. She guides three research students and has been involved in numerous university administrative roles. She is currently executing three projects sponsored by NABARD and UP CST.





Ms. Nibedita Jena

She is currently working at Ambika Prasad Research Foundation, Cuttack, Odisha, India, as a Senior Research Fellow. She has completed her M.Sc. in Biotechnology from Sambalpur University, Odisha, India. Her research work focuses on the study of medicinal plants, primary and secondary metabolites with their biological activities, phytochemistry, pharmacological potentials, antimicrobial properties, ethnomedicinal uses, indigenous traditional knowledge and healing practices of tribal communities. She has published 26 research articles, 133 book chapters, along with 6 edited books and authored two.





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