Unveiling the Aerial Mysteries of Hygrophila Auriculata: Ethnomedicinal Insights, Phytochemical Profiles, and Pharmacological Potentials

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ABSTRACT

The article extensively examines *Hygrophila auriculata*, covering its historical medicinal usage, chemical composition, and potential health benefits. It delves into its traditional applications for ailments like jaundice, digestive issues, urinary disorders, and skin problems. Additionally, it highlights the diverse range of bioactive compounds found in the plant, including flavonoids, alkaloids, triterpenes, sterols, minerals, and essential oils. Furthermore, it outlines the broad spectrum of therapeutic effects exhibited by extracts and substances derived from *Hygrophila auriculata*, such as antimicrobial activity, liver protection, antioxidant properties, and anti-inflammatory effects. In essence, the review provides a thorough overview of the medicinal potential of this plant species.

Keywords: Hygrophila auriculata, medicinal plant, phytochemical composition, ethnomedicinal, pharmacological uses.

INTRODUCTION

For thousands of years, herbal medicines have been an essential component of medical care, prized for their accessibility and effectiveness. The interest in herbal medicine has been growing exponentially due to the increasing recognition of natural products as sources of new pharmaceuticals. [1,2] As synthetic drugs sometimes exhibit adverse effects and develop resistance, there has been a turn towards natural remedies which have fewer side effects and have been used safely for centuries. Among the numerous medicinal plants explored, *Hygrophila auriculata* (synonym *Asteracantha longifolia*), belonging to the Acanthaceae family, holds great promise due to its wide range of therapeutic applications. It is known in Ayurvedic texts by different names like Ikshura, Ikshu Gandha, and Kailashi, often compared to the Kokila or Indian Cuckoo. Found extensively across India, Sri Lanka, Burma, Malaysia, and Nepal, this annual herb has spiny, upright stems, oblong leaves adorned with yellowish-brown spines, and clusters of pale to purple-blue flowers. Its oblong fruits contain 4 to 8 seeds encased in round capsules. When submerged in water, the plant secretes mucilage, giving it a slightly bitter taste with no specific Odor. [3,4]

Traditionally, H. auriculata has been used in various medicinal systems such as Ayurveda, Unani, Siddha, and folk medicine for its anti-inflammatory, hepatoprotective, diuretic, and aphrodisiac properties [5]. Its phytochemical constituents include alkaloids, flavonoids, tannins, steroids, and triterpenoids, which are responsible for the diverse pharmacological activities [6]. Despite its extensive use in traditional medicine, scientific validation and further pharmacological studies are necessary to fully realize its potential in modern medicine.

This paper explores the various ethnomedicinal, pharmacological, and therapeutic uses of H. auriculata, alongside an analysis of its phytochemical profile, with reference to modern scientific studies supporting its traditional applications.

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Composition of Asterracantha longifolia [7]

Hygrophila auriculata, or "Kokilaksha" in Ayurveda, is another name for the medicinal plant Asteracantha longifolia, which is well renowned for its therapeutic qualities. Alkaloids, flavonoids, tannins, saponins, and steroids are among the many bioactive substances found in the plant. Its roots are abundant in alkaloids, including betulin and lupeol, which support its hepatoprotective and anti-inflammatory properties. The leaves include flavonoids, such as luteolin and apigenin, which are recognised for their antioxidant qualities. The fatty oils, proteins, and mucilage that make up the seeds provide them aphrodisiac and diuretic qualities. It is also known that the plant's aerial portions contain phenolic chemicals with antibacterial properties. All things considered, the intricate phytochemical makeup of Asteracantha longifolia lends credence to its historic use in the treatment of reproductive, urinary, and liver ailments.

Table 1:

Part of the plant	Chemical components
Leaves	The aliphatic esters 25-oxo-hentriacontanyl acetate and methyl 8-n-hexyltetracosanoate, Botulin, Lupeol, Stigmasterol, and β-sitosterol
Stems	Lupeol, β-sitosterol
Aerial parts	Linoleic acid, palmitic acid, stearic acid, Asterol I-IV, Asteracanthine, and asteracanthinine (alkaloids), Lupeol, β-sitosterol
Roots	Lupeol, β-sitosterol

Ethnomedicinal Uses of Hygrophila Auriculata

Medicinal Applications of H. auriculata in Traditional and Alternative Medicine Systems:

In Ayurvedic medicine, Hygrophila auriculata has long been prescribed for treating ailments such as jaundice, rheumatism, gastrointestinal disorders, and as a diuretic. This traditional use aligns with findings in modern research, which have demonstrated the plant's potent anti-inflammatory and diuretic properties. [8,9] The seeds, in particular, are valued for their effects on reproductive health and have been used as an aphrodisiac, while the roots are employed for their hepatoprotective properties.

In Unani medicine, H. auriculata is recommended for treating impotence, sexual dysfunction, and urinary disorders. The plant is often prepared in combination with other herbs and natural ingredients to enhance its efficacy. The powdered seeds are sometimes combined with honey or milk to increase vitality and strength. [10] Siddha practitioners primarily use the leaves for managing high blood pressure and liver-related issues, while in homeopathy, it has been utilized for treating conditions like jaundice, arthritis, and urinary tract infections. [11]

Traditional and folklore uses:

The indigenous and folklore uses of H. auriculata extend beyond its application in formal medicinal systems. In rural areas of India, Nepal, and Sri Lanka, the plant is used in remedies for venereal diseases, digestive problems, and inflammatory conditions [12]. In these communities, the seeds are often ground into a fine paste and consumed with buttermilk or applied topically for treating skin diseases and ulcers. The root is also highly valued for its use in managing tuberculosis, cancer, and reproductive disorders [13].

Therapeutic Applications of Tal Makhana (H. auriculata) in Traditional Medicine Systems:

Leaf: Traditionally used to manage symptoms of cough, the leaves of H. auriculata are believed to possess expectorant properties, which help in clearing mucus from the respiratory tract. Folk medicine prescribes the use of the plant's leaf extract for alleviating symptoms related to anal fistula [14].

Seed: The seeds are employed in traditional practices to treat blood-related issues, possibly due to their purifying properties [14].

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Root Decoction: A well-known remedy for jaundice, the decoction of the root is believed to possess hepatoprotective qualities [14].

Vegetable: The aerial parts of the plant are often consumed as a vegetable in rural areas to treat anaemia, owing to their rich iron content [14].

Leaf Paste (Applied externally): Used in treating Prameha (a diabetes-related condition), the leaf paste is applied topically to affected areas. Topically applied leaf paste is also believed to reduce lumbago and joint pain, acting as an anti-inflammatory agent. [14]

Root: Effective for treating urinary stones, the root of H. auriculata is used in Ayurvedic formulations. [14]

Root Decoction (Whole Plant): Known for its ability to treat rheumatoid arthritis, the entire plant is used in decoction form. Commonly prescribed in traditional medicine for managing edema, the decoction of the root is believed to act as a diuretic. [14]

Tal Makhana Ash (Mixed with cow urine or water): This preparation is widely used in traditional medicine for its anti-inflammatory properties. [15]

Decoction (Tal Makhana combined with other herbs): This formulation is often used to treat insomnia and other sleep disorders. [16]

Entire Plant: Used in treating dropsy, the entire plant, including leaves, seeds, and roots, is employed for its diuretic and anti-inflammatory effects [17,18,19].

Powder (Tal Makhana combined with sugar and milk): This traditional preparation is used as an aphrodisiac, believed to enhance sexual vitality and performance [20].

Fig. 1. Utilization Proportions of different Parts of Hygrophila auriculata in traditional medicine system

Table 2: Indigenous and cultural medicinal uses of different parts of Hygrophila auriculata.[21]

Plant parts	Preparation methods for Indigenous and cultural medicinal use
Leaves	The treatment involves blending powdered leaves with castor oil, utilizing either the powdered form or extract, and ingesting juices. Additionally, decoctions made from young leaves or fresh leaves boiled down, along with incorporating fresh leaves into dishes, are employed. These remedies target a variety of conditions, including skin diseases, tuberculosis, respiratory issues like cough, urinary problems, inflammation, anaemia, allergies, body swelling, rheumatism, stomach aches, constipation, and jaundice.

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Seed	Seeds are crushed into a paste and mixed with buttermilk for treating venereal diseases and diarrhoea in traditional medicinal practices.
Root	The powdered root or extract, when prepared as a decoction, paste, or dissolved in water, is used for various purposes, such as addressing conditions related to libido, cancer, edema, bodily discomfort, yellowing of the skin, malaria, TB, fistula, erectile dysfunction, urinary and reproductive issues, liver problems, acting as a diuretic, relieving edema, easing bodily discomfort.
Stem	The stem juice is known to possess aphrodisiac properties.

Indigenous and cultural medicinal uses of the whole part of H. auriculata: [21]

1. The plant's powder or extract serves various medicinal purposes.
2. Traditional remedies utilize the plant's powder and ashes.
3. The plant's powdered form, often ingested with milk in tablet form, is used to treat conditions such as jaundice, rheumatoid arthritis, itching, swelling, and pain.
4. It is efficient in managing gastrointestinal ailments such as dysentery, diarrhea, digestive discomfort, colic, acid reflux, constipation, bloating, appetite loss, and abdominal pain. [21]
5. The plant extracts exhibit diuretic characteristics and can be advantageous for conditions such as icterus, fluid retention, rheumatism, hepatic blockages, breaking down of gallstones, nephrolithiasis, hepatic disorders, and urogenital tract diseases.[21]
6. Moreover, it aids in relieving constipation and abnormal vaginal discharge.
7. The plant's properties include being effective against dysentery, tuberculosis, and diarrhoea.

Total metabolites and phytoconstituents:

The bioactive compounds present in H. auriculata include alkaloids, glycosides, flavonoids, steroids, and essential oils [22]. These compounds contribute to the plant's therapeutic effects, including its anti-inflammatory, diuretic, hepatoprotective, and aphrodisiac activities. Studies have confirmed the presence of these metabolites through phytochemical screening and analytical techniques, suggesting a robust pharmacological potential. In particular, the mucilage found in the seeds of H. auriculata has been linked to its use in treating respiratory disorders, while the potassium salts are believed to contribute to its diuretic effects [21]. The presence of bioactive sterols such as stigmasterol, β-sitosterol, and lupeol further underscores its medicinal properties, particularly in relation to its anti-inflammatory and hepatoprotective activities.

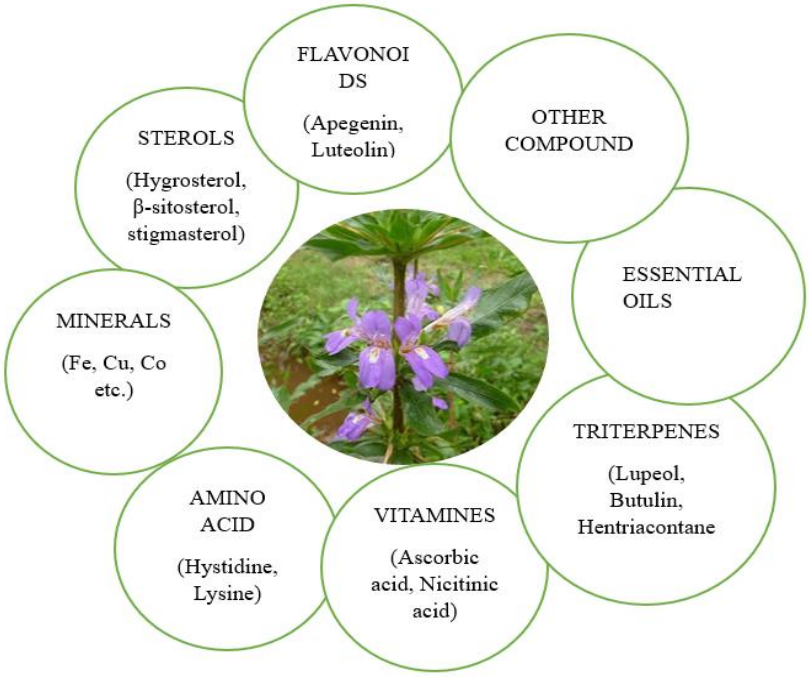

Fig. 2. Phytochemicals present in H. auriculata [23,35]

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Phytochemical Composition

The pharmacological effects of H. auriculata are largely attributed to its rich phytochemical profile, which includes various bioactive constituents like alkaloids, flavonoids, tannins, steroids, and triterpenoids. Recent research into the plant's phytochemistry has provided detailed insights into the specific compounds responsible for its medicinal properties.

Alkaloids: H. auriculata contains alkaloids like asteracanthine and asteracanthinine, which are primarily responsible for the plant's aphrodisiac and neuroprotective effects [24]. These alkaloids have been shown to modulate neurotransmitter levels and enhance sexual behaviour in experimental models.

Flavonoids: Flavonoids like quercetin, kaempferol, and luteolin are abundant in H. auriculata. These compounds are well-known for their antioxidant, anti-inflammatory, and anti-cancer properties. Quercetin, in particular, has been linked to the plant's anti-inflammatory and hepatoprotective activities [25]. The antioxidant potential of flavonoids helps in scavenging free radicals, thereby preventing oxidative damage to cells and tissues [26].

Steroids and Triterpenoids: The presence of steroids such as stigmasterol and β-sitosterol, along with triterpenoids like lupeol, contributes to the plant's anti-inflammatory, hepatoprotective, and diuretic effects. These compounds modulate the immune response, reduce inflammation, and protect the liver from toxin-induced damage [15].

Phenolic Compounds: The phenolic content of H. auriculata includes compounds like caffeic acid and ferulic acid, which exhibit strong antioxidant activity. Phenolic compounds play a vital role in reducing oxidative stress and inflammation, thereby supporting the plant's therapeutic applications in liver protection, cardiovascular health, and cancer prevention [7].

Pharmacological Effect

Research into the pharmacological properties of H. auriculata has revealed a diverse range of activities, supporting its traditional use in treating various ailments.

Aphrodisiac activity: The ethanolic extract of H. auriculata has shown a significant improvement in sexual behaviour in animal models. Studies indicate that the plant's aphrodisiac properties may be attributed to its effect on the testosterone levels in male rats, enhancing libido and sexual performance. This aligns with its traditional use in Unani and Ayurvedic medicine for treating male sexual dysfunction and impotence [27].

Neurological Effects: The neuroprotective potential of H. auriculata has been investigated, particularly in models of cerebral ischemia. Studies suggest that terpenoid fractions of the plant provide protective effects against brain damage caused by ischemia-reperfusion injury, making it a potential candidate for managing neurodegenerative diseases. Additionally, its sedative and sleep-inducing effects have been supported by traditional use for treating insomnia and related disorders [28].

Antioxidant activity: Several studies have highlighted the antioxidant potential of H. auriculata, particularly its leaf extracts. Both methanolic and aqueous extracts have demonstrated significant free radical scavenging activity, which may contribute to the plant's overall anti-inflammatory and hepatoprotective effects [28].

Cardiovascular health: H. auriculata has shown promise in treating conditions related to the cardiovascular system. In particular, its role in restoring blood levels during anaemic conditions has been studied. Its rich iron content and ability to enhance erythropoiesis may contribute to its traditional use in treating anaemia [29].

Hypoglycaemic activity: The plant has been traditionally used for managing diabetes, and recent research supports its hypoglycaemic effects. Studies in animal models have demonstrated that extracts of H. auriculata significantly reduce blood glucose levels, possibly through the modulation of insulin secretion or glucose uptake [24].

Antitumor/anticancer activity: Certain plant extracts of H. auriculata have been found to possess selective

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anticancer activity. Studies have demonstrated that the ethanolic extracts of H. auriculata exhibit cytotoxic effects against various cancer cell lines, such as breast cancer (MCF-7) and colon cancer (HT-29) cells. The presence of flavonoids, alkaloids, and phenolic compounds is believed to be responsible for these effects, potentially through the inhibition of cell proliferation and induction of apoptosis. The plant's potential in cancer therapy highlights the need for further research to explore its efficacy and safety in clinical settings. [30]

Anti-inflammatory activity: The anti-inflammatory properties of H. auriculata have been validated in various studies. The plant's extract has demonstrated significant inhibition of inflammation in models of induced edema in rats. The presence of bioactive compounds like lupeol and stigmasterol plays a crucial role in modulating inflammatory pathways, possibly through inhibition of pro-inflammatory cytokines and enzymes like COX-2 and iNOS [29,31]. This anti-inflammatory activity supports its traditional use in treating conditions like arthritis, rheumatism, and other inflammatory disorders [22].

Antibacterial and Antifungal Properties: The antimicrobial potential of H. auriculata has been well-documented. Studies have shown that the methanolic and ethanolic extracts exhibit significant activity against various bacterial strains, including *Escherichia coli, Staphylococcus aureus, and Pseudomonas aeruginosa*. Additionally, the plant extracts have demonstrated antifungal activity against species like Candida albicans and Aspergillus Niger [32]. The antimicrobial properties of H. auriculata may be attributed to its phytochemicals, particularly flavonoids, tannins, and saponins, which disrupt microbial cell membranes [28].

Hepatoprotective activity: Hepatoprotection is one of the most prominent traditional uses of H. auriculata, especially in the management of jaundice and liver disorders. Experimental studies have shown that the ethanolic extracts of the plant provide protection against chemically induced liver damage in rats, reducing serum liver enzyme levels such as ALT, AST, and ALP [33]. This hepatoprotective effect is likely due to the plant's antioxidant properties, which reduce oxidative stress in liver cells, and the presence of hepatoprotective compounds such as lupeol and β-sitosterol [27].

Analytical Techniques for Evaluting Phytochemicals in Hygrophila Auriculata

GC- MS

GC-MS analysis of the entire H. auriculata plant extracted with diethyl ether revealed the presence of several compounds, including tetradecanoic acid, Diundecyl phthalate, 2-furancarboxaldehyde, hydroxymethyl, ellipticine,2hydroxycyclopentadecane, 1-octadecene, quercetin, and 2,3-dihydrobenzofuran. [32]

HPTLC

In another study, HPTLC was employed to quantify lupeol and sitosterol in extracts from various plant parts using toluene: ethyl acetate: methanol (15:3:1.5, v/v/v) [25]. Additionally, a different method utilized toluene: methanol: formic acid (7.0:2.7:0.3, v/v/v) as a mobile phase with a scanning wavelength of 530 nm for simultaneous quantification of stigmasterol and luteol [34].

HPLC

For simultaneous determination of betulin, lupeol, and stigmasterol, HPLC with a Luna C18 column was employed, using an isocratic elution of acetonitrile and 0.1% acetic acid in water (94:6, v/v) at a flow rate of 1.0 mL/min and detection at 215 nm [26].

FUTURE PROSPECTS AND CONCLUSION

The pharmacological and therapeutic potential of Hygrophila auriculata is vast, as evidenced by its traditional use in various medical systems and the growing body of scientific literature supporting its bioactive compounds. However, more extensive studies are necessary to explore the mechanisms of action, efficacy, and safety of H. auriculata in treating specific diseases, particularly in the areas of neuroprotection, hepatoprotection, and anticancer therapy.

While several preclinical studies have demonstrated promising results, clinical trials are required to validate the efficacy of H. auriculata in humans. Additionally, efforts to standardize the plant's extracts and isolate its active compounds are needed to ensure consistent therapeutic outcomes and safety profiles.

In conclusion, the widespread use of H. auriculata by numerous ethnic tribes over generations as a medicinal plant underscores its significance in traditional medicine. Despite its long-standing reputation for efficacy, the need for more comprehensive clinical trials to substantiate its therapeutic claims is evident. While initial studies have shed light on its potential benefits, further exploration is necessary to ascertain its true medicinal value. Phytochemical analyses have revealed a rich array of compounds within the plant, suggesting a complexity that warrants deeper investigation. Moreover, its inclusion in formulations aimed at addressing ailments such as kidney stones and enhancing sexual behaviour highlights its versatility and potential utility in modern healthcare. However, the mechanisms underlying its pharmacological effects remain largely unexplored, emphasizing the importance of continued research to elucidate its mode of action. Moving forward, prioritizing efforts towards standardization and thorough characterization of its constituents is crucial in unlocking the full therapeutic potential of H. auriculata and harnessing its benefits for human health.

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