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Boerhavia diffusa L. (RBr): Morphology, Phytochemistry, Pharmacology, and Traditional Uses

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Abstract

Boerhavia diffusa, commonly known as Punarnava, is a perennial herbaceous plant with significant medicinal value, widely recognized in traditional medicine systems such as Ayurveda, Unani, and Siddha. This article provides a comprehensive review of the morphology, phytochemistry, and pharmacology of *B. diffusa* alongside its traditional uses. Morphologically, the plant is characterized by its prostrate stems, fleshy roots, and small, pinkish flowers. Phytochemical analysis reveals that *B. diffusa* is rich in bioactive compounds, including alkaloids (punarnavine, boerhavine), flavonoids (quercetin, kaempferol), glycosides, steroids, and saponins, which contribute to its wide-ranging therapeutic effects. Pharmacologically *B. diffusa* exhibits a broad spectrum of activities, including anti-inflammatory, diuretic, hepatoprotective, nephroprotective, antidiabetic, antimicrobial, and antioxidant effects. These properties make it a valuable resource in treating various ailments, such as kidney and liver disorders, edema, arthritis, diabetes, and respiratory conditions. The traditional uses of *B. diffusa* further emphasize its role in promoting overall health and longevity, with applications in managing digestive disorders, menstrual irregularities, and skin conditions. The article highlights the importance of *B. diffusa* as a multifunctional medicinal plant, bridging the gap between traditional practices and modern pharmacological research. By integrating traditional knowledge with contemporary scientific findings, this review underscores the potential of *B. diffusa* in contributing to holistic healthcare and its promising role in developing new therapeutic agents.

Keywords: *Boerhavia diffusa,* Antimicrobial activity, Anti-inflammatory activity, Antidiabetic activity, Hepatoprotective activity

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Introduction

Boerhavia diffusa Linn (RBr), commonly known as Punarnava or Spreading Hogweed, is a perennial herbaceous plant belonging to the Nyctaginaceae family. Widely distributed across tropical and subtropical regions, this plant has gained significant attention for its extensive use in traditional medicine systems such as

Ayurveda, where it is revered for its rejuvenating and healing properties. The name "Punarnava," meaning "that which renews," reflects its traditional use in revitalizing and restoring health. The study of *B. diffusa* encompasses various aspects, including its morphology, phytochemical composition, and pharmacological properties.

Morphologically, the plant is characterized by its fleshy roots, prostrate stems, and small, pinkish flowers, with each part contributing to its medicinal utility. Phytochemically *B. diffusa* is rich in bioactive compounds such as flavonoids, alkaloids, and steroids, which are believed to be responsible for its therapeutic effects. Pharmacologically, *B. diffusa* has demonstrated a wide range of biological activities, including anti-inflammatory, diuretic, hepatoprotective, and antimicrobial effects. These properties have made it a subject of interest in modern pharmacological research, with studies exploring its potential applications in treating various ailments, including liver disorders, kidney problems, and inflammatory conditions. This article aims to provide a comprehensive overview of the morphology, phytochemistry, and pharmacology of *B. diffusa* highlighting its significance as a medicinal plant and its potential role in contemporary healthcare.

Taxonomic classification

Kingdom: Plantae
Division: Magnoliophyta (Angiosperms)
Class: Magnoliopsida (Dicots)
Order: Caryophyllales
Family: Nyctaginaceae
Genus: *Boerhavia*
Species: *diffusa*

Synonym: *Boerhavia procumbens* Linn, *Boerhavia repens* Linn

Vernacular names

Bengali: Punarnnava
English: Spriding Hogweed, Hogweed
Gujarati: Vasedo satodi
Hindi: Santh, Gadhaparna, Pathar chetaka
Kannada: Adakaputtana gida
Malayalam: Thazhuthama, Punarnnava, Thavizhama
Marathi: Punarnava
Sanskrit: Punarnnava, Punarnnavam.
Tamil: Chattarani, Thamizhamai
Telugu: Gelijeru, Atakamamidi
Urdu: Tukhm-i-ispast

Plant description

B. diffusa, commonly known as *Punarnava* or *Spreading Hogweed*, is a perennial herb belonging to the Nyctaginaceae family. It is widely distributed in tropical and subtropical regions. They thrive in various environments, including grasslands, roadsides, and wastelands. The plant has an extensive, fleshy, tuberous root system that often appears white or brownish externally and internally white – the main medicinal part used in traditional medicine. The stems are prostrate or decumbent, which means they spread horizontally and may root at the nodes. They are slender, cylindrical, and may be slightly ribbed, somewhat pubescent (hairy) or glabrous (smooth). They are often reddish or purple and can grow up to 1 m long. Leaves are simple, opposite, and somewhat variable in shape, generally ovate or elliptic. They measure around 1-5 cm in length and 0.5-3 cm in width. The upper surface of the leaves is green, while the underside is pale green or whitish. They are smooth and fleshy with prominent veins. Flowers are small, inconspicuous, pinkish, or reddish and are

clustered in small axillary or terminal inflorescences, forming an umbel-like structure. Each flower is about 2-3 mm in diameter. They are bisexual and have a perianth that is tubular, five-lobed, and persistent. The fruit is a small, one-seeded, sticky, and ribbed achene which is about 3-4 mm long and brown or blackish coloured when mature. The surface of the fruit is often covered with sticky glandular hairs, which help in dispersal by adhering to animals and humans. The seeds are tiny, black, and contained within the persistent perianth of the fruit—the sticky nature of the fruit aids in seed dispersal.

Chemical constituents

B. diffusa is a rich source of various bioactive compounds that contribute to its wide range of therapeutic properties (Narayan Prajapati et al., 2004). The phytochemical constituents of this plant include alkaloids, flavonoids, glycosides, steroids, and other secondary metabolites, each playing a significant role in its pharmacological effects (Apu et al., 2012; Agrawal et al., 2011; Pereira et al., 2009; Mili, 2007; Seth et al., 1986; Mishra & Tiwari, 1971). Here's an overview of the major phytochemicals found in *B. diffusa*:

Alkaloids

Punarnavine: One of the primary alkaloids isolated from *B. diffusa* which is known for its diuretic and anti-inflammatory properties. It is a key compound in treating kidney and liver disorders.

Boerhavine: An alkaloid that has been identified, with potential anti-cancer and immune-modulatory effects (Agarwal & Dutt, 1936).

Flavonoids

Kaempferol and Quercetin: These potent antioxidants contribute to the plant's anti-inflammatory and anti-diabetic activities by neutralizing free radicals and reducing oxidative stress.

Luteolin: A flavonoid with potent anti-inflammatory, antimicrobial, and hepatoprotective effects. It is crucial in protecting the liver and other organs from damage.

Glycosides

Boerhavioside: A glycoside with anti-inflammatory and immunosuppressive activities. It has been evaluated for its role in modulating immune responses and reducing inflammation.

Hypoxoside: Another glycoside known for its anti-tumor properties, making it of interest in cancer research.

Steroids

α-*Sitosterol*: A phytosterol with cholesterol-lowering properties. It is also known for its anti-inflammatory and immune-boosting effects.

Ecdysteroids: These are plant-derived steroids that have been studied for their role in enhancing physical performance, improving muscle mass, and their protective effects against oxidative stress.

Phenolic compounds

Syringic acid and Vanillic acid: These phenolic acids exhibit strong antioxidant properties, contributing to the plant's ability to scavenge free radicals and protect cells from oxidative damage.

Caffeic acid: Another significant phenolic compound known for its anti-inflammatory and antimicrobial properties.

Saponins

Oleanolic acid: A saponin with hepatoprotective and anti-cancer

properties. It is also recognized for its role in protecting the liver from toxins and promoting overall liver health.
Punarnavoside: A saponin glycoside unique to *B. diffusa* known for its diuretic and nephroprotective effects, is beneficial in treating kidney ailments.

Lipids and Fatty acids

Palmitic acid and Linoleic acid: These fatty acids are present in the plant and are associated with anti-inflammatory and skin-protective properties.

Other compounds

Tannins: Known for their astringent properties, tannins contribute to the plant's antimicrobial and antioxidant activities.
Lignans: These are a group of compounds with antioxidant and estrogenic activities, contributing to the overall medicinal profile of the plant.

Pharmacological activities and traditional uses

B. diffusa, widely known for its medicinal properties, has been extensively studied for its pharmacological activities (Das et al., 2022; Agrawal et al., 2011; Wahi et al., 1997; Surange & Pendse, 1972). The plant exhibits a broad spectrum of biological effects, making it valuable in treating various ailments. *B. diffusa* commonly known as Punarnava has been used for centuries in various traditional medicine systems, particularly Ayurveda, Unani, and Siddha, for its wide-ranging therapeutic properties. The name "Punarnava" in Sanskrit translates to "one that rejuvenates or renews the body," reflecting its prominent role in promoting health and longevity (Gaur et al., 2022; Bhowmik et al., 2012). The key pharmacological activities and the traditional uses associated with *B. diffusa* are:

Anti-inflammatory activity and pain relief

Anti-inflammatory: B. diffusa, has demonstrated significant anti-inflammatory properties, primarily attributed to its bioactive compounds like punarnavine, flavonoids (quercetin, kaempferol), and steroids (α-sitosterol). These compounds inhibit the release of pro-inflammatory cytokines and reduce the activity of enzymes like cyclooxygenase (COX), which play a role in inflammation. The anti-inflammatory effects are particularly beneficial in conditions such as arthritis, gout, and other inflammatory diseases (Bairwa & Jachak, 2015; Gharate & Kasture, 2013; Shubha & Govindaraju, 2013). It is traditionally used to alleviate pain and inflammation associated with arthritis, gout, and other rheumatic conditions. Its anti-inflammatory properties help reduce swelling and pain in joints and muscles.
Wound healing: The plant is applied topically to treat wounds, ulcers, and skin inflammation due to its soothing and anti-inflammatory effects (Shameela et al., 2015; Hiruma-Lima et al., 2000).

Diuretic and kidney health

Treatment of edema: *B. diffusa* is traditionally used as a diuretic to treat water retention (edema), particularly in conditions like ascites (fluid accumulation in the abdomen) and anasarca (generalized edema). It helps in the excretion of excess fluid from the body through urine.
Management of kidney disorders: The plant is extensively used in treating various kidney-related ailments, including

nephritis (inflammation of the kidneys) and kidney stones. Its diuretic and nephroprotective properties help in cleansing and protecting the kidneys. The diuretic effect is primarily due to saponins like punarnavoside and alkaloids like punarnavine (Gaitonde et al., 1974). It promotes the excretion of excess water and salts from the body, making it helpful in managing hypertension and congestive heart failure.

Hepatoprotective activity and liver health

Hepatoprotective activity: The plant has shown strong hepatoprotective (liver-protecting) effects. Compounds like oleanolic acid and flavonoids such as luteolin contribute to its ability to protect the liver from toxins, drugs, and alcohol-induced damage. The plant enhances liver function by improving antioxidant defences, reducing lipid peroxidation, and preventing the accumulation of toxic substances (Rawat et al., 1997; Chandan et al., 1991). In Ayurvedic medicine, *B. diffusa* is often prescribed to protect and detoxify the liver. It is used to treat jaundice, liver enlargement, and other hepatic disorders. The plant is believed to enhance bile secretion and improve liver function.
Detoxification: The plant is also used as a general detoxifying agent, helping to cleanse the liver and remove toxins from the body (Muthulingam, 2014).

Nephroprotective activity

The plant has nephroprotective (kidney-protecting) properties, making it beneficial in treating chronic kidney disease and nephritis. The saponins, particularly punarnavoside, help reduce inflammation and oxidative stress in the kidneys. It also helps in the excretion of urea and creatinine, which are markers of kidney function, thus aiding in managing kidney ailments (Gaurav et al., 2022, Kalaivani et al., 2015).

Antidiabetic activity

B. diffusa, exhibits antidiabetic properties, attributed to its ability to modulate glucose levels and improve insulin sensitivity. The flavonoids (quercetin and kaempferol) and phenolic compounds present in the plant help in reducing blood sugar levels. It is used traditionally to manage diabetes and related metabolic disorders (Akhter et al., 2019; Alam et al., 2018; Nalamolu et al., 2004; Pari & Satheesh, 2004; Satheesh & Pari, 2004).

Antimicrobial and antiparasitic uses

Antimicrobial activity: The plant has demonstrated broad-spectrum antimicrobial activity against various bacteria, fungi, and viruses. Compounds like caffeic acid, luteolin, and tannins contribute to its ability to inhibit the growth of pathogens. This activity makes *B. diffusa* helpful in treating infections, particularly in traditional medicine for wound healing and skin infections. It treats various infections, including urinary tract infections, skin infections, and parasitic infestations. Its antimicrobial properties help in combating bacterial, viral, and fungal infections.
Anthelmintic activity: The plant is also used to expel intestinal worms and parasites, especially in children, due to its anthelmintic properties (Umamaheshware et al., 2010; Verma & Awasthi, 1979).

Antioxidant activity

B. diffusa, a rich source of antioxidants, help neutralize free radicals and reduce oxidative stress. Flavonoids, phenolic acids, and lignins contribute significantly to its antioxidant potential. The antioxidant properties are crucial in preventing cellular damage and are linked to the plant's anti-aging and disease-prevention effects (Alam et al., 2018; Singh et al., 2014).

Immunomodulation and general health

The plant has been shown to modulate the immune system, enhancing immune responses in some cases while suppressing excessive immune activity in others. Alkaloids like punarnavine and glycosides like boerhavioside are involved in this activity. This immunomodulatory effect is beneficial in managing autoimmune disorders and in enhancing overall immune function.

Rejuvenation and Longevity: *B. diffusa* is regarded as a Rasayana in Ayurveda, meaning it is used to rejuvenate the body, enhance vitality, and promote longevity. It is commonly used as a general tonic to boost overall health and strengthen the immune system.

Adaptogen: The plant is also used as an adaptogen, helping the body adapt to stress and reduce fatigue, making it valuable in maintaining mental and physical well-being (Manu & Kuttan, 2007; Pandey et al., 2005; Mehrotra et al., 2002a; Mungantiwar et al., 1999).

Anticancer activity

B. diffusa has shown potential anticancer effects, particularly in inhibiting the growth of cancer cells. The alkaloids, flavonoids, and saponins present in the plant induce apoptosis (programmed cell death) and inhibit proliferation in cancer cells. It is being studied for its potential use in cancer therapy, especially in combination with other treatments (Gunaseelan et al., 2022; Bharali et al., 2003, Mehrotra et al., 2002b).

Antistress and adaptogenic activity

The plant is known for its adaptogenic properties, which help the body to resist stress and adapt to changing conditions. This is partly due to its ability to regulate the hypothalamic-pituitary-adrenal (HPA) axis, which plays a central role in stress response. *B. diffusa* is used in traditional medicine to alleviate stress, anxiety, and fatigue (Sumanth & Mustafa, 2007).

Cardioprotective activity

The plant exhibits cardioprotective effects by improving heart function and protecting against myocardial damage. The flavonoids and steroids present in the plant help in reducing cholesterol levels, improving blood circulation, and protecting the heart from oxidative stress. This activity makes it useful in managing cardiovascular diseases such as hypertension and atherosclerosis (Nimbal & Koti, 2016).

Gastroprotective activity

B. diffusa has been shown to have protective effects on the gastrointestinal tract. It helps in reducing gastric ulcers and improving digestive function. The plant's anti-inflammatory and antioxidant properties contribute to its gastroprotective effects (Gharate & Kasture, 2013).

Conclusion

Boerhavia diffusa, or Punarnava, is a remarkable medicinal plant with a rich history in traditional medicine and a growing body of scientific validation. Its diverse morphological features and complex phytochemical profile provide the foundation for its extensive range of pharmacological activities. The plant's bioactive compounds, including alkaloids, flavonoids, glycosides, and steroids, contribute to its potent anti-inflammatory, diuretic, hepatoprotective, nephroprotective, and antimicrobial effects. The traditional uses of *B. diffusa* across various cultures highlight its importance in treating a broad spectrum of ailments, from kidney and liver disorders to respiratory and digestive issues. Integrating traditional knowledge with modern pharmacological research underscores the plant's potential in preventive and therapeutic healthcare. As research continues to explore the full potential of *B. diffusa*, it is likely to play an increasingly important role in developing new natural therapies and drugs. Its broad-spectrum efficacy and its safety profile make it a valuable asset in the pursuit of holistic health and wellness. In conclusion, *B. diffusa* bridges the gap between ancient wisdom and modern science and offers promising avenues for future therapeutic innovations.

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