

Review

Morphological, phytochemical and pharmacological, studies on *Boerhaavia diffusa* L.

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Medicinal plants constitute an important group of non-wood forest products. Approximately 80% of the world population uses plants as a source of medicine for healthcare. India has been one of the pioneers in the development and practice of well-documented indigenous systems of medicine, particularly Ayurveda, Siddha and Unani. For millennia, the Indian population has depended mainly upon plant based crude drugs for a variety of ailments. This alternative system of medicine is gaining increasing popularity worldwide. This review on *Boerhaavia diffusa* focuses over the plant morphology, chemical compositions, its ethnomedicinal uses, linked from ancient times to the present with a scope of development in future.

Key words: Ayurveda, *Boerhaavia diffusa*, ethnobotany, pharmacology.

INTRODUCTION

Boerhaavia diffusa L. occurs abundantly as a weed throughout India. It is a creeping and spreading perennial herb, with a stout root-stock and many erect or spreading branches. It is also cultivated to some extent in West Bengal. The plant is found throughout the Philippines, U.S.A., Brazil and the African continent in open places in the settled areas at low and medium altitudes. It is a common weed in and about towns, and is pantropic in distribution. Out of the 40 species of this genus, five are found in India – *B. diffusa*, *B. chinensis*, *B. erecta*, *B. rependa*, and *B. rubicunda* (Chopra, 1969; Anonymus, 1988; Dev, 2006).

Boerhaavia diffusa (Nyctaginaceae) is an important medicinal plant much used in Ayurveda and Unani medicines and other traditional medicines in many parts of the world. The importance of this plant can be gauged from the fact that there are almost forty regional names for it the world over (<http://www.rain-tree.com/ervatostao.htm>). The plant commonly known as Punarnava (and also, Shothagni, Rakta punarnava) in Ayurveda because the top of the plant dies during hot summers and puts forth fresh shoots after rains and is believed to be a rejuvenator. In Brazil *B. diffusa* is known

as Erva tostao and is extensively used in traditional medicine (Hiruma-Lima et al., 2000). *B. diffusa* is an exclusive or important constituent of several Ayurvedic preparations such as Abana (HeartCare), Bonnisan, Diabecon (GlucCare), Evicare (MenstriCare), Geriforte (GeriCare / StressCare), Lukol, V-Gel (FemCare Gel), Digyton, Geriforte Aqua, Geriforte Vet, Immunol, Nefrotec Vet, Punarnava, Chyavanaprasha (http://www.himalayahealthcare.com/herbfinder/h_boerha.htm).

PLANT MORPHOLOGY

B. oerhaavia diffusa is a diffusely branched, pubescent and prostrate herb. The plant has an orthotropic and superimposed axis. Each axis becomes pendulous and the renewable shoots arise on the upper surface of this axis. The part distal to this shoot becomes main axis. Despite orthotropic shoot construction, *Boerhaavia* is almost prostrate because of the rapid proliferation of relay axis over a length of the main axis. The stem is cylindrical, creeping sometimes purplish or greenish in colour, swollen at the nodes. The branches attain a length of about 90 to 158 cm. All the branches are sylleptic and emerge at every node in alternate fashion. The subtending leaves of these branches are smaller

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than the opposite leaf. The primary opposite decussate orientation of leaves and branches is limited only to the most terminal shoots. The rootstock is stout, fusiform, woody, tapering, light yellow, brown or brownish grey in colour. The root is about 30 to 50 cm deep in soil. The distal part of shoot which bears the composite inflorescence stalk usually dies out after fruiting and thus triggers the emergence of new branches during the subsequent growing season.

The cluster of monochasial cymes borne on peduncles is terminal in position and limits the growth of axial shoots. The inflorescence buds are arranged in an umbel. The flowers are small (2.5 to 3 mm) shortly stalked and light to dark pinkish in colour and hermaphrodite. The stamens are 3, pinkish, slightly exerted with two unequal lobes of anther. Ovarial part is about 0.5 to 1 mm long, with glandular secreting trichomes. The pistils may be equal, larger or shorter than the stamens. The pistils are light pink with a large flattened disc shaped stigma. The fruit is an achene, 3 to 4 mm long, detachable, ovate, oblong, pubescent, five-ribbed and viscid on the ribs (Fig. 1 A- F). The seed coat is so thin that the position of embryo can be seen easily (Anonymous, 1999; Chaudhary, 2010).

Different parts of punarnava have almost similar taste, however red and white land races of *B. diffusa* are bitter in taste. Edible parts of *B. diffusa* are leaves, seeds and roots. Leaves and seeds are cooked but sometimes it can be ground into a powder and added to cereals when making bread, cakes etc. while roots are rich in carbohydrate and protein used in baked form (Anonymous, 1999).

ETHNOMEDICAL USES

In India, *B. diffusa* has a long history of medicinal use in the Ayurveda and Unani forms of medicine. Different plant parts used as an appetizer, alexiteric, eye tonic, flushing out the renal system, to treat seminal weakness and blood pressure and so on. Seeds are used as tonic, expectorant, carminative lumbago, scabies, scorpion-sting, blood purifier, and useful in muscular pain. Its roots are used in treating jaundice, ascites, anasarca, sentry urine, internal inflammations, asthma, piles, the plain juice used as an antidote for rat-poisoning (Gupta et al., 1962; Gaitonde et al., 1974; Nadkarni, 1976; Anand, 1995; Mitra and Gupta, 1997; Mudgal, 1975; Shah et al., 1983; Jain and Khanna, 1989; Khare, 2004; Singh and Dey, 2005).

In Brazil the plant as a whole or its extracts is used for albuminuria, beri-beri, bile insufficiency, cystitis, edema, gallstones, gonorrhoea, guinea worms, hepatitis, hypertension, jaundice, kidney disorders, kidney stones, liver disorders, liver support, nephritis, renal disorders, sclerosis (liver), snakebite, spleen (enlarged), urinary disorders, urinary retention and gallbladder problems

(Cruz, 1995). In Guatemala it is used for erysipelas, guinea worms (Taylor, 2005) while in Iran it is used for abdominal pain, anemia, ascites, asthma, blood purification, cancer, cataracts, childbirth, cholera, constipation, cough, debility, digestive sluggishness, dropsy, dyspepsia, edema, eye problems, fever, gonorrhoea, guinea worms, heart ailments, heart disease, hemorrhages (childbirth), hemorrhages (thoracic), hemorrhoids, inflammation (internal), internal parasites, jaundice, kidney disorders, kidney stones, lactation aid, liver disorders, liver support, menstrual disorders, renal insufficiency, rheumatism, snakebite, spleen (enlarged), urinary disorders, weakness, and as a diuretic and expectorant. In Iraq it is used for oedema, gonorrhoea, hives, intestinal gas, jaundice, joint pain, lumbago, nephritis, and as an appetite stimulant, diuretic and expectorant. In Nigeria, it is used for abscesses, asthma, boils, convulsions, epilepsy, fever, guinea worms, and as an expectorant and laxative. In West Africa it is used for abortion, guinea worms, menstrual irregularities, and as an aphrodisiac. In tropical Africa the boiled roots are applied to ulcers, abscesses and to assist in the extraction of Guinea worm. The boiled roots and leaves are considered expectorant and febrifuge, and in large doses emetic. A decoction of the aerial parts is also taken to treat gastro-intestinal pains, convulsions, intestinal worms and to regulate menstruation. In Mauritania the seeds are ground and made into cakes which are cooked and eaten as a remedy for dysentery. (Whitehouse, 1996; Burkill, 1997; Neuwinger, 2000; Database entry for Erva Tostao - Boerhaavia diffusa - htm; www.rain-tree.com; www.allayurveda.com/herb; www.ProtabaseRecord.htm)

CHEMICAL COMPOSITION OF *B. DIFFUSA*

B. diffusa contains a large number of compounds such as flavonoids, alkaloids, steroids, triterpenoids, lipids, lignins, carbohydrates, proteins, and glycoproteins. potassium nitrate (Chopra et al., 1923), hypoxanthine 9-L-arabinofuranoside (Ahmad and Hossain, 1968), ursolic acid (Mishra and Tiwari, 1971), Punarnavine (Surange and Pendse, 1972), a glycoprotein (Verma and Awasthi, 1979), punarnavoside (Jain and Khanna, 1989), boeravinone A-F (Lami et al., 1990,1992), liiodendrin (Aftab et al., 1996), caffeoyltartaric acid (Ferrerres et al., 2005), boeravinone G and H (Borrelli et al., 2005), quercetin and kaempferol (Pereira et al., 2009). The herb contains 15 amino acids such as argenine (total amino acid in herb 0.47% and in root 0.75%), alanine (total amino acid in herb 0.88% and in root 1.18%), aspartic acid (total amino acid in herb 0.69% and in root 0.95%), methioine (total amino acid in herb 0.41% and in root 0.45%), leucine (total amino acid in herb 0.67% and in root 0.88%), phenylalanine (total amino acid in herb 0.52% and in root 0.71%), proline (total amino acid in

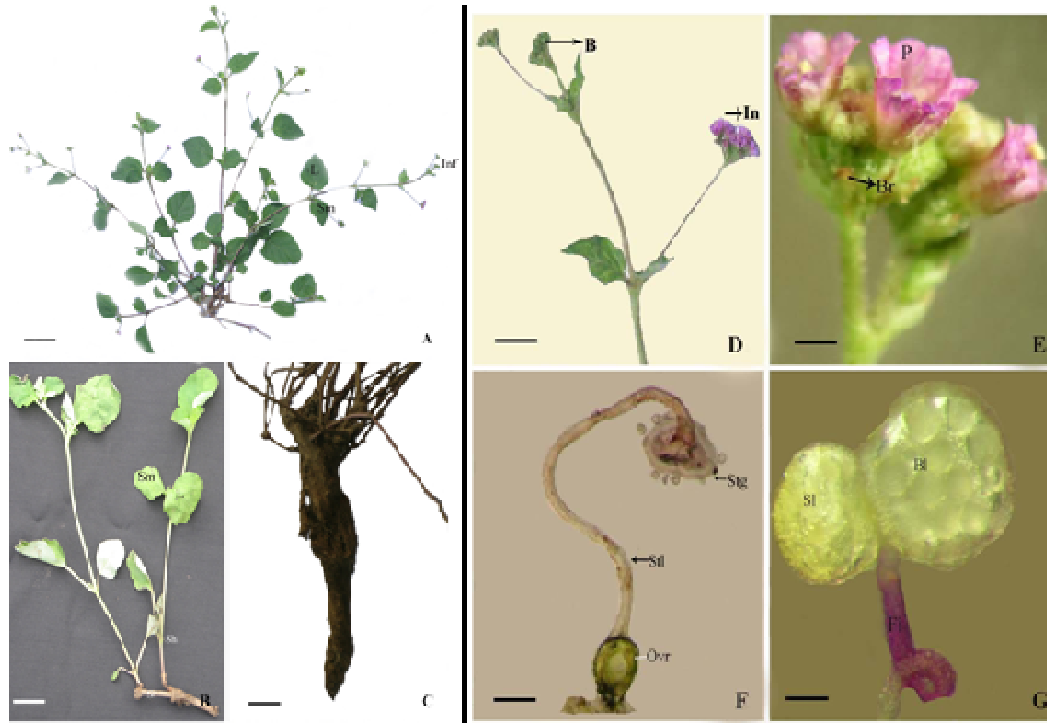


Figure 1. A-C: (A) *B. diffusa* plant, (B) Plant with Germinated shoots from stolon during rainy season, (C) Stout root of the plant. Figure D-G: (D) Inflorescence twig of *B. diffusa* with buds and flowers, (E) An umbel showing pink perianth of flower with green bracts at the base of ovary, (F) Gynoecium showing stigma with adhering pollen, style and ovary, (G) Stamen with two unequal lobes of anther connected by the pink colour filament. A = 4 cm; B = 1.46 cm; C = 3.57 cm; D = 1.9 cm; E = 0.77 cm; F = 0.023 cm; G = 0.0019 μ m. [Inf = Inflorescence; L = Large leaf; S = Sylleptic; Sm = Small leaf; St = Stolon; Sh = Shoot, B = Bud; Bl = Big lob; Ct = cotyledonary leaf; Fi = Filament; Fr = Fruit; Inf = Inflorescence; Sm = Small leaf; Stg = Stigma; Stl = Style, Ovr = Ovary].

herb 0.88% and in root 1.18%), ornithine (total amino acid in herb 0.35% and in root 0.5%), serine (total amino acid in herb 0.73% and in root 0.83%), threonine (total amino acid in herb 0.72% and in root 0.79%), asparagine (total amino acid in herb 0.33% and in root 0.00%), glycine (total amino acid in herb 0.75% and in root 0.00%), valine (total amino acid in herb 0.00% and in root 0.75%), tryptophane (total amino acid in herb 0.53% and in root 0.65%), tyrosine (total amino acid in herb 0.61% and in root 0.72%) (Anonymous, 1999). The main rotenoids (known as boeravinones) present in the root of *B. diffusa* are shown in Figure 2.

Ujowundu et al. (2008) reported about the nutritional and anti-nutritional compositions of *B. diffusa* (Table 1).

PHARMACOLOGICAL STUDIES

Chopra (1923) and Nadkarni (1954) reported and described the diuretic properties and alkaloidal nature of punarnavine. Agarwal and Dutt (1936) investigated and reported about the pharmacology and therapeutics properties of the plant. Srivastava et al. (1979) reported the fibrinolytic activity by 50% freeze dried ethanolic

extract of *B. diffusa* (L). Awasthi and Menzel (1986) reported that an extract obtained from the roots of *B. diffusa* plants, inhibits the infection of several plant viruses and was tested by the agar diffusion hole method for its action on RNA-containing bacterial viruses. According to Rai and Upadhyay (1988) the leaf extract of *B. diffusa* shows *in vitro* antifungal activity against *Microsporon nanumi*.

Chandan, et al. (1991) investigated that an alcoholic extract of the whole plant (*B. diffusa*) exhibited hepatoprotective activity against experimentally induced carbon tetrachloride hepatotoxicity in rats and mice. The extract also produced an increase in normal bile flow in rats suggesting a strong choleric activity. Singh et al. (1991) reported teratogenic effects by the ethanolic extract of *B. diffusa* on litter size and survival rate of foetuses in rats.

According to Singh et al. (1992) *B. diffusa* is clinically proved as a useful and safe drug in the patients of nephritic syndrome. While Murthy et al. (1992) found that the aqueous and acetone extract of *B. diffusa* roots increased the liver ATPase activity in albino rats. Rawat et al. (1997) investigated hepatoprotective activity of roots collected during three seasons. The roots extracts

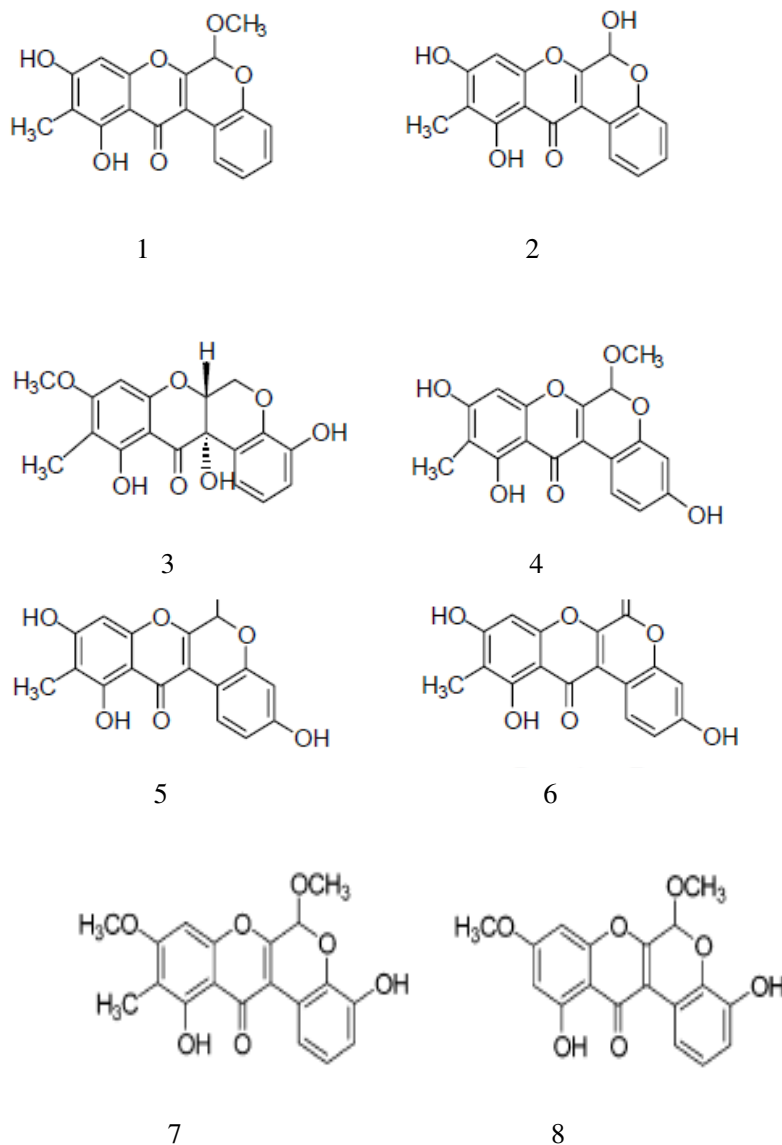


Figure 2. Main rotenoids (known as boeravinones) present in the root of *B. diffusa* are: 1. Boeravinone A, 2. Boeravinone B, 3. Boeravinone C, 4. Boeravinone D, 5. Boeravinone E, 6. Boeravinone F, 7. Boeravinone G, 8. Boeravinone H. (Kadota et al., 1988a,b, 1989; Lami et al., 1990, 1991; Borelli et al., 2005).

were examined in thioacetamide intoxicated rats and proved that the aqueous form of the drug (2 ml/kg) had more hepatoprotective activity than the powder form and this was probably due to the better absorption of the liquid form through the intestinal tract.

Hiruma-lima et al. (2000) reported significant immunomodulatory activities and antinociceptive effect of the aqueous extracts of *B. diffusa* leaves. According to Mehrotra et al. (2002) the ethanolic extract of *B. diffusa* was capable to inhibit T-cell mitogen phytohemagglutinin and concanavalin A-stimulated proliferation of human peripheral blood mononuclear cells (PBMC).

Bharali et al. (2003) reported about the cancer chemopreventive property of *B. diffusa* against skin papillomagenesis in 6-7 weeks old male induced by 7,12-dimethyl benz(a) anthracene (DMBA) Swiss albino mice. Nalamolu et al. (2004) and Satheesh and Pari (2004) reported the significant antidiabetic activity from the chloroform extract of *B. diffusa*. Agrawal et al. (2004) reported that there are some antifungal phytochemical moieties in the roots of *B. diffusa* plant that decrease the sporulation of target fungal species with increased supplementation of the phytoextract. Pandey et al. (2005) reported a selective immunosuppressive activity from the

Table 1. Composition of leaf of *B. diffusa*.

Leaf composition	Percent (%)
Moisture	82.2
Protein	6.1
Fats	0.9
Carbohydrates	7.2
Calcium	0.667
Phosphorous	0.99
Ash	0.96
Fibre	1.56

leaf extracts of *B. diffusa*.

Borrelli et al. (2006) reported a significant spasmolytic activity in the guinea pig ileum by the methanolic extract of *B. diffusa* roots, probably through a direct effect on the smooth muscle. Manu and Kuttan (2007) reported about the enhanced effect of Punarnavine on the cell-mediated immune (CMI) response against metastatic progression of B16F-10 melanoma cells in mice. Mili (2007) reported the antioxidant activity and genoprotective actions. While Sumanth and Mustafa (2007) reported immunomodulatory activities from the ethnolic extract of *B. diffusa* roots. Velmurugan et al. (2010) and Umamaheshwari et al. (2010) reported that the *B. diffusa* leaves have potent antibacterial activity against various Gram-negative and Gram-positive bacteria which might be due to the phytochemicals present in the leaves.

CONCLUSION

Throughout the millennia *B. diffusa* has evolved into a miracle medicinal plant having a plethora of chemical constituents effective against a large number of ailments. The plant finds considerable importance in the traditional herb based remedies the world over. In Ayurvedic and Unani the plant finds use as a cure for 22 ailments. In Brazil pharmacopeia 23 uses have been described for the plant.

While in Africa and Middle East the plant is prescribed for 14 ailments. Despite several uses listed for this plant and the numerous compounds the plant harbours, *B. diffusa* has not been able to catch the fancy of the pharmaceutical industry. The plant and its importance requires to be catalogued properly so that people become more aware of it. A detailed study of the various compounds present in *B. diffusa* and their pharmaceutical importance requires to be carried out such that a drug with multiple effects can be made available in near future.

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