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Review Paper

A Review: Pharmacological and phytochemical Perspectives of *Buddleja asiatica*

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ABSTRACT

Nepal is rich in medicinal plant diversity, yet many species remain insufficiently studied. Buddleja asiatica, commonly known as butterfly bush, is traditionally used to treat inflammation, rheumatism, skin diseases, and malaria. Recent studies demonstrate that its methanolic extracts contain high levels of phenolics and flavonoids, contributing to strong antioxidant activity and moderate α-amylase inhibition, suggesting potential antidiabetic effects. The plant also exhibits antibacterial and antifungal properties, particularly against Staphylococcus aureus. Phytochemical investigations have identified numerous bioactive constituents, including flavonoids, iridoids, and terpenoids. These findings support its traditional applications and highlight its promise for future pharmacological and therapeutic development.

INTRODUCTION

Nepal is a geographically small yet ecologically extraordinary country situated between India and China. Its landscape ranges from lowland plains to the towering peak of Mount Everest, creating sharp variations in altitude, climate, and ecosystems. This environmental diversity has allowed thousands of plant species to thrive, many of which are deeply integrated into traditional healthcare practices. More than 700 plant species are used in Nepalese folk medicine, supporting rural livelihoods and serving as primary healthcare resources for many communities (Chemjong & Subba, 2022)**.**Among these valuable medicinal plants, *Buddleja asiatica*, commonly known as butterfly bush, has gained attention for both its traditional importance and emerging scientific relevance. Belonging to the genus *Buddleja*, which includes around 100 species distributed across Asia, Africa, and the Americas, *B. asiatica* is an evergreen shrub or small tree that can grow up to eight meters tall. It is recognized for its fragrant flowers and resilience in diverse environments. In Nepal, the plant also carries cultural value, as its

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leaves and flowers are sometimes used in religious practices (Chemjong & Subba, 2022).

For generations, different parts of *Buddleja asiatica*—including roots, leaves, stems, and flowers—have been used in traditional remedies. Communities have relied on it to manage conditions such as fever, diarrhea, inflammation, rheumatism, skin disorders, and malaria. Root preparations have been used as tonics, while leaf extracts have been applied for wound care and as antiseptics. In some traditional systems, the plant has also been associated with hypotensive and antispasmodic effects. These longstanding applications reflect a deep-rooted trust in the plant's healing potential (Karki & Sapkota, 2023).

Scientific investigations have begun to validate many of these traditional claims. Phytochemical studies reveal that *B. asiatica* contains a variety of bioactive compounds, including flavonoids, iridoids, terpenoids, saponins, and other phenolic substances. These compounds are known for their antioxidant, antimicrobial, anti-inflammatory, and analgesic properties. Experimental research has also suggested smooth muscle relaxant effects, possibly linked to calcium channel modulation, along with notable free radical scavenging activity (Nafees et al., 2022; Karki & Sapkota, 2023).

With increasing global interest in natural and plant-based medicines, species like *Buddleja asiatica* present promising opportunities for drug discovery and development. However, although laboratory findings are encouraging, further detailed pharmacological and clinical studies are necessary to confirm safety, dosage, and therapeutic efficacy. Continued research will help bridge traditional knowledge with modern science, unlocking the full medicinal potential of this valuable plant (Nafees et al., 2022).

1. History and Distribution

Buddleja asiatica is widely distributed throughout the tropical and subtropical regions of Southeast Asia, particularly in countries such as Thailand, Vietnam, Malaysia, Indonesia, and the Philippines, where the species is considered native (Nafees et al., 2022). The plant was first reported in Hawaii in 1908, after which it gradually spread across several islands. Its introduction is believed to have been intentional because of its pleasantly fragrant flowers, which made it attractive as an ornamental plant. Over time, the species expanded rapidly, and its seeds were likely dispersed through vehicles, birds, and construction equipment, facilitating its wider distribution (Global Invasive Species Database, 2023). The plant was later introduced to the United Kingdom in 1873, where it gained popularity as an ornamental shrub. In several Western European countries, *Buddleja asiatica* is cultivated not only for decorative purposes but also for its use in the perfume industry, owing to its sweet fragrance (Royal Horticultural Society, 2021). However, its ecological impact varies across regions. For example, in the state of Victoria in Australia, the species is regarded as a potential invasive weed because of its ability to spread rapidly and compete with native vegetation (Victoria State Government, 2022).

In India, *Buddleja asiatica* is mainly found in the hilly regions of the Himalayan range. Its distribution extends from the Indus River region eastward through Nepal and into parts of West Bengal, typically growing at elevations of around 3000 feet above sea level. From this region, its occurrence further extends southward toward parts of the Eastern Ghats of South India, indicating its adaptability to diverse climatic and ecological conditions (Flora of India, Botanical Survey of India).

2. Cultivation

Buddleja asiatica is a fast-spreading shrub capable of aggressively colonizing habitats and competing with native vegetation; it readily naturalizes in disturbed areas and has become invasive in some tropical regions where it has been introduced (Susiarti et al., 2014). The plant primarily propagates through natural dispersal mechanisms: it produces numerous small, winged seeds contained in brown capsules, which are pollinated by insects and can be dispersed by wind over large geographic areas (Fern et al., 2010). Apart from sexual reproduction through seeds, *B. asiatica* can also be propagated vegetatively, as stem or side-shoot cuttings root readily under cultivation, providing an additional and efficient method for multiplying the plant (EarthOne et al., 2010). Under controlled cultivation conditions, the small seeds are usually sown in prepared soil beds and watered regularly; germination generally occurs within about 3–5 weeks under suitable conditions (Fern et al., 2010). Once seedlings grow sufficiently, they are typically transferred into pots for further growth. Under favorable environmental conditions, particularly at lower altitudes, the plants can be successfully raised within a few months (Susiarti et al., 2014). Vegetative propagation through cuttings of semi-hardwood or young shoots is also commonly used in horticulture to increase planting material (EarthOne et al., 2010).

Table 1: Taxonomical classification of Buddleja asiatica

Kingdom	Plantae
Subkingdom	Tracheobionta
Division	Magnoliophyta
Class	Dicotyledons
Subclass	Asteridae
Family	loganiaceae

Scientific name: Buddleja asiatica Lour
Synonym: Buddleja neemda Ham. ex Roxb.
Common Names: Dogtail, Asian Butterfly Bush.

Table 2: Vernacular names:

Indonesia	Jugul, Daun putihan, Kayu saludang
China	Bai bei feng, Bai yu wei
Vietnam	B[oj] ch[os], T[us]y ng[uw] th[ar]o
Philippines	Malasambung
India	Hindi: Neemda, dhurbana Bengali: Newarpati, bhimsenpati Kannada: Karakan, karakani Tamil: Karkkattan Oriya: Ninda

3. Plant Description

3.1. Leaves

The leaves are lanceolate to ovate in shape with a distinct pointed apex and measure approximately 5–9 cm in length and 1–2.5 cm in width. The margins are serrulate, and the lower surface is often tawny or whitish pubescent. In some instances, the leaves appear oblanceolate with an acuminate-caudate apex and an attenuated base. The petiole length ranges from 3–9 mm. Leaves are arranged opposite or sub-opposite along the stem. The leaf surface may be smooth or slightly pubescent, with the upper surface dark green and the lower surface comparatively lighter in color.

3.2. Stem

Young stems are typically quadrangular (four-angled) in cross-section and may be covered with fine hairs. As the plant matures, the stems gradually become woody and develop a brownish-grey coloration.

3.3. Flower

The flowers are arranged in dense terminal or axillary inflorescences, usually forming panicles or spike-like clusters. They are commonly white or pale lilac, occasionally displaying a yellow throat. The flowers emit a pleasant fragrance, which helps attract pollinating insects such as butterflies. The flowering period generally occurs from winter to early spring, although it may vary depending on geographical location.

3.4. Fruits

The fruit is a small, ellipsoid capsule that is dry and dehiscent, typically splitting into two valves upon maturity. These capsules contain numerous minute seeds.

3.5. Seeds

The seeds are very small and winged, which facilitates dispersal by wind. They are approximately 0.3 mm in size and generally sub globose in shape, measuring about 3–4 mm in length.

3.6. Roots

The plant possesses a fibrous root system that supports efficient nutrient and water absorption. In certain conditions, the roots may also produce suckers, enabling vegetative propagation and spread of the plant. (Bhutia et al., 2025)

4. Phytochemistry

Phytochemical studies on *Buddleja asiatica* have revealed a remarkable diversity of bioactive compounds, which helps explain its wide range of traditional medicinal uses (Susiarti et al., 2014; Fern et al., 2010). Detailed chromatographic investigations of methanolic extracts, particularly from the leaves and aerial parts, have led to the isolation of several important classes of secondary metabolites (EarthOne et al., 2010). One of the major groups identified is phenylethanoid glycosides, including acteoside (E-acteoside), isoacteoside, and verbascoside. These compounds have been structurally characterized using advanced spectroscopic techniques such as UV spectroscopy, electrospray ionization mass spectrometry (ESI-MS), and proton and carbon nuclear magnetic resonance (^{1}H and ^{13}C NMR) (Li et al., 2012). Acteoside, in particular, demonstrated significant cytotoxic activity against HepG2 liver cancer cell lines, indicating potential anticancer properties. These glycosides are also widely recognized for their antioxidant and anti-inflammatory activities (Zhang et al., 2015).Sterols and triterpenes constitute another important category of compounds found in *B. asiatica*. Fractionation of ethyl acetate and alcoholic extracts has identified lignoceric acid, stigmasterol, taraxerol, α-amyrin, β-sitosterol glycosides, and stigmasterol-O-glucoside. Notably, a new sterol named buddlejol was isolated and structurally characterized as a stigmastane derivative (Kumar et al., 2013). These compounds are often associated with anti-inflammatory, hepatoprotective, and membrane-stabilizing effects. Iridoid glucosides are also prominent, including catalpol, methylcatalpol, aucubin, and a new iridoid glucoside derivative, which exhibit antioxidant, anti-inflammatory, and potential neuroprotective activities (Wang et al., 2014). A triterpene saponin, mimengoside A, has also been reported, contributing to the pharmacological profile of the plant. Analysis of the essential oils from fresh aerial parts has revealed several volatile constituents, including n-tridecane, 5-methylundecane, β-caryophyllene oxide, citronellol, and β-caryophyllene. These compounds not only contribute to the plant's fragrance but also demonstrate antimicrobial and antifungal properties (Patil et al., 2015).Phenylpropanoid esters**,** collectively called asiatisides (A–D), have been isolated from the aerial parts, including acetylated and methoxylated rhamnose derivatives, as well as p-methoxycinnamic acid, ferulic acid, and methyl ferulate, which are linked to antioxidant and anti-inflammatory effects (Lee et al., 2016).Flavonoids such as apigenin, acacetin-7-O-β-D-glucoside, apigenin-7-O-β-D-glucoside, linarin, quercetin, kaempferol, rutin, and luteolin have been identified from different extracts. These flavonoids are well known for their antioxidant, antimicrobial, and anti-inflammatory activities (Zhao et al., 2017). Additionally, two new triterpenoids, alongside known compounds such as maslinic acid, β-amyrin, oleanolic acid, and oleanolic aldehyde, have been reported. Miscellaneous compounds, including buddlin (a cyclopentanoid lactone), benzoate derivatives, and volatile constituents such as fenchone, anethole, phytol, sulfolane, and ionol derivatives, further highlight the chemical richness of the plant. Collectively, the broad spectrum of phytoconstituents in *Buddleja asiatica* supports its ethnomedicinal relevance and underscores its potential as a source of bioactive compounds for pharmaceutical research and drug development (Susiarti et al., 2014; Li et al., 2012).

4.1. Phytochemical screening

Methanol extract extractive value was found to be 23.85%. The phytochemical analysis of extracts reveals the presence of alkaloids, glycosides, flavonoids, phenol, tannin, reducing sugar, and the absence of steroids and sterols, saponins, protein, and amino acid. (Bhutia et al., 2025)

Table 3: Phytochemical screening of methanol extract of Buddleja asiatica.

Sr.no.	Class of compound	Name of test	Methanol extract
1.	Alkaloids	Wagner's test	+
2.	Glycosides	Glycoside test	+
3.	Flavonoids	Shinoda test and lead acetate test	+
4.	Phenol and tannin	Lead acetate test	+
5.	Steroids and sterols	Salkowski's test	-
6.	Reducing sugars	Fehling's test	+
7.	Saponins	Honey comb test	-
8.	Protein and amino acid	Biuret test and ninhydrin test	-

5. Pharmacological Activities of Buddleja asiatica

With the global rise in chronic illnesses, including cardiovascular disorders, cancer, liver diseases, respiratory conditions, and neurodegenerative disorders such as Alzheimer's disease, there is an ongoing search for safer and more effective therapeutic agents (Susiarti et al., 2014; Li et al., 2012). In this context, *Buddleja asiatica* has attracted increasing scientific attention due to its broad spectrum of pharmacological activities, which are supported by various experimental studies, including antioxidant, anti-inflammatory, hepatoprotective, antimicrobial, and cytotoxic effects (Zhang et al., 2015; Kumar et al., 2013; Wang et al., 2014).

5.1. Antibacterial activity

Extracts from the whole plant of *Buddleja asiatica* have demonstrated notable antibacterial effects against several human pathogens. Standard laboratory evaluations of different solvent fractions — including chloroform, ethyl acetate, and n-butanol extracts — revealed differential activity: the chloroform fraction showed measurable inhibitory effects against *Shigella flexneri* and *Shigella boydii*, while ethyl acetate and n-butanol fractions exhibited significant activity against Gram-negative bacteria in vitro (Ali et al., 2011). Additionally, essential oil extracted from the leaves by hydrodistillation exhibited significant antibacterial action against a range of bacterial strains including *Escherichia coli*, *Bacillus subtilis*, *Staphylococcus aureus*, *Shigella boydii*, and *S. flexneri*, supporting the plant's traditional use in treating infections (Khan et al., 2021). These findings underscore the broad antimicrobial potential of both polar and non-polar extracts of *B. asiatica* and justify further exploration of its phytochemicals as natural antibacterial agents.

5.2. Antifungal activity

Various extracts of *Buddleja asiatica* have been evaluated for antifungal effects against pathogenic fungi, demonstrating promising inhibitory potential in vitro. In one study, crude extracts and their solvent fractions were tested against a panel of fungal pathogens; the chloroform extract displayed significant antifungal activity against *Fusarium solani* and *Microsporum canis*, while other fractions showed moderate to lesser activity against additional fungi. The crude extract and certain fractions also exhibited inhibitory effects, highlighting the role of non-polar constituents in antifungal efficacy (Ali et al., 2011). Further research on essential oil derived from the plant's leaves reported marked inhibitory effects, particularly against *Aspergillus flavus*, and also showed activity against *M. canis* and *F. solani*, supporting its potential as a natural source of antifungal agents in traditional medicine (Khan et al., 2013). These findings underscore *B. asiatica*'s considerable antifungal potential and justify continued investigation into its bioactive components for therapeutic applications.

5.3. Antispasmodic activity

Experimental studies using isolated rabbit jejunum preparations have demonstrated that extracts of *Buddleja asiatica* produce a concentration-dependent relaxation of smooth muscles (Ali et al., 2011). This spasmolytic effect appears to be mediated via calcium channel blockade, as the extract effectively reduced both spontaneous and high-potassium-induced contractions. These results suggest that the plant may have therapeutic potential in the management of gastrointestinal spasms and related disorders, supporting its traditional medicinal use in treating abdominal cramps and colic (Ali et al., 2011; Khan et al., 2013).

5.4. Cytotoxic activity

Methanolic leaf extracts of *Buddleja asiatica*, as well as isolated compounds such as acteoside (E-acteoside), have shown cytotoxic activity against HepG2 liver cancer cell lines (Zhang et al., 2015; Li et al., 2012). These findings suggest the plant may possess anticancer potential, potentially mediated through mechanisms such as induction of apoptosis and inhibition of cancer cell proliferation. However, further in-depth preclinical and clinical studies are required to validate its therapeutic relevance and determine safety profiles for human applications.

5.5. Enzyme inhibitory activity

Buddleja asiatica has demonstrated promising enzyme inhibitory properties, supporting its potential therapeutic applications. A newly identified sterol, buddlejol, was reported to act as a competitive inhibitor of α-chymotrypsin, an enzyme implicated in certain liver disorders, indicating possible hepatoprotective activity (Kumar et al., 2013). Additionally, leaf essential oil exhibited inhibitory activity against acetylcholinesterase (AChE) and butyrylcholinesterase (BChE), suggesting potential relevance in the management of neurodegenerative disorders, including Alzheimer's disease (Khan et al., 2013). These findings highlight the enzyme modulatory effects of both non-polar constituents and secondary metabolites from *B. asiatica*, warranting further investigation for drug development.

5.6. Mosquito repellent activity

Petroleum ether extracts of *Buddleja asiatica* have demonstrated mosquito repellent properties, providing several hours of protection against mosquito bites in experimental studies (Patil et al., 2015). This activity suggests the potential application of the plant as a natural repellent for preventing mosquito-borne diseases such as dengue fever, malaria, and chikungunya. The repellent effect is likely due to volatile compounds present in the non-polar extracts, highlighting its value as a sustainable and eco-friendly alternative to synthetic repellents.

5.7. Hypotensive activity

Methanolic leaf extracts of certain medicinal plants have been shown to produce a gradual and sustained reduction in blood pressure in experimental animal models, with evidence suggesting that this hypotensive effect may be mediated in part through modulation of autonomic adrenergic receptors (Ismail et al., 2013).

5.8. Anti-inflammatory and antioxidant activity

Stem extracts have demonstrated inhibition of cyclooxygenase (COX) enzymes, supporting anti-inflammatory potential (Patel et al., 2018). Flower extracts rich in flavonoids, including hesperetin derivatives, showed significant antioxidant activity by reducing lipid peroxidation (Kumar et al., 2017).

5.9. Antihepatotoxic activity

Ethanolic extracts of flowers and roots were evaluated in animal models with chemically induced liver injury; the extracts significantly reduced elevated liver enzymes such as AST and ALT, indicating protective effects on liver function (El-Domiaty *et al.*, 2009). Overall, the diverse pharmacological activities of *Buddleja asiatica* validate many of its traditional uses and highlight its potential as a promising source of natural therapeutic agents. Further clinical research is needed to fully establish its safety and efficacy.

5.10. Antioxidant activity

Buddleja asiatica is rich in bioactive compounds such as flavonoids and phenolic constituents, which play a crucial role in protecting the body against oxidative stress by neutralizing free radicals and thereby preventing cellular damage linked to aging and chronic diseases. Various in-vitro studies have demonstrated strong free radical scavenging activity of methanol extracts using assays such as DPPH, nitric oxide scavenging, hydrogen peroxide scavenging, hydroxyl radical scavenging, superoxide anion scavenging, CUPRAC, metal ion chelation, xanthine oxidase inhibition, and lipid peroxidation inhibition (Sundararajan et al., 2017). In addition, in-vivo experiments conducted on healthy rats showed that oral administration of methanolic extracts at doses of 250 and 500 mg/kg for 21 days significantly enhanced antioxidant enzyme levels (e.g., catalase and superoxide dismutase), reduced lipid peroxidation, and improved the ferric reducing ability of plasma (Sundararajan et al., 2018). These findings indicate the plant possesses potent antioxidant potential and may serve as a natural free radical scavenger.

5.11. Cytoprotective activity

Methanolic extracts of the aerial parts of *Buddleja asiatica* yielded several known compounds and a novel iridoid glycoside, *buddlejasiaside A*, which demonstrated strong cytoprotective activity against glutamate-induced toxicity in mouse hippocampal neuronal cells (HT22), with half-maximal effective concentration (EC_{50}) values in the low micromolar range, indicating potential neuroprotective properties that may be relevant to neurodegenerative disorders (Bhutia et al., 2026).

5.12. Calcium channel antagonist action

Studies on *Buddleja asiatica* have shown that crude extracts cause concentration-dependent relaxation of both spontaneous and high potassium (80 mM)-induced contractions in isolated rabbit jejunum preparations, indicating spasmolytic and calcium channel antagonist (Ca^{2+} antagonist) activity (Ali et al., 2011). These findings suggest that the antispasmodic action of *B. asiatica* may be mediated at least in part through blockade of extracellular calcium influx into smooth muscle cells, supporting its potential use in treating gastrointestinal spasms and smooth muscle-related disorders.

5.13. Antinociceptive activity

Ethanolic extracts of the bark and leaves of *Buddleja asiatica* exhibited significant pain-relieving and muscle relaxant effects in animal models, as demonstrated by dose-dependent reduction of acetic acid-induced writhing and marked skeletal muscle relaxant responses in behavioural tests (Barkatullah *et al.*, 2016). The antinociceptive effects were evident across increasing dose levels, indicating possible involvement of mechanisms such as modulation of opioid receptors, calcium channels, and neurotransmitter pathways, though the precise biochemical targets require further elucidation (Barkatullah *et al.*, 2016).

5.14. Anti-Acetylcholinesterase and Anti-Butyrylcholinesterase Activity

Leaf essential oil of *Buddleja asiatica* demonstrated strong inhibitory activity against acetylcholinesterase (AChE) and butyrylcholinesterase (BChE), enzymes associated with Alzheimer's disease, with IC_{50} values indicating substantial enzyme inhibition compared with standard reference compounds, suggesting potential cognitive benefits of the plant's phytoconstituents (Khan et al., 2014).

5.15. Other Traditional Uses

Traditionally, *Buddleja asiatica* has been used in various folk medicines to support women's health and general wellness. Ethnobotanical literature reports that the plant has been employed to induce uterine contractions and reduce labor pain, promote postpartum recovery, alleviate headaches, and even support weight management, reflecting its broad use in traditional systems of medicine (Bhutia *et al.*, 2026). These uses, while grounded in long-standing practice, remain largely anecdotal and highlight the need for further clinical investigation to establish safety and efficacy.

Conclusion

Buddleja asiatica stands out as a valuable medicinal plant with a long history of traditional use and growing scientific support. The wide range of phytochemicals identified in this species, including flavonoids, iridoids, terpenoids, and phenolic compounds, contributes to its diverse biological activities. Experimental studies have demonstrated its antioxidant, antimicrobial, anti-inflammatory, hepatoprotective, enzyme inhibitory, and cytoprotective properties, many of which align closely with its traditional applications. Despite these promising findings, most of the available evidence is based on in vitro and animal studies. There is still a clear need for well-designed clinical research to confirm its safety, efficacy, and appropriate dosage in humans. Additionally, further work is required to isolate specific active compounds, understand their mechanisms of action, and evaluate potential side effects or interactions. Overall, Buddleja asiatica represents a promising natural resource for the development of new therapeutic agents. Integrating traditional knowledge with modern scientific approaches could help unlock its full potential, contributing to safer and more sustainable healthcare solutions in the future.

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