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Review

Review on Pharmacognostical phytochemical and pharmacogenetic activity of *Heliotropium Species*

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Abstract

Heliotropium species, belonging to the Boraginaceae family, comprise a diverse group of medicinal plants widely distributed across tropical and subtropical regions. Traditionally, various species have been used for treating wounds, inflammation, respiratory ailments, and skin infections. Pharmacognostical studies reveal distinct morphological and anatomical features useful for species identification and authentication. Phytochemical investigations have identified the presence of bioactive compounds such as flavonoids, phenolics, tannins, saponins, and notably, pyrrolizidine alkaloids (PAs). These compounds contribute to demonstrated antimicrobial, anti-inflammatory, antioxidant, and cytotoxic activities in preliminary pharmacological studies. However, the widespread presence of hepatotoxic PAs poses serious safety concerns. Pharmacogenetic research highlights the role of cytochrome P450 enzymes in bioactivating these alkaloids, emphasizing individual variability in susceptibility to toxicity. This dual nature of therapeutic potential and toxic risk necessitates caution in medicinal use and calls for deeper exploration into isolating safe bioactive compounds. This review consolidates current knowledge on the pharmacognostical, phytochemical, and pharmacogenetic aspects of Heliotropium species, and underscores the need for further research focused on safety, efficacy, and potential pharmaceutical applications.

Keywords: Heliotropium, Pharmacognosy, Phytochemicals, Pyrrolizidine alkaloids, Pharmacogenetics, Toxicity, Traditional medicin, Antimicrobial activity, Anti-inflammatory, Hepatotoxicity

INTRODUCTION

Heliotropium inflorescences oriented their flower rows toward the sun. The Greek word "Helios" means "sun," while the term "tropium" is derived from the Greek word "trope in." This word's meaning is "to turn"
The Boraginaceae family includes Heliotropium

The genus Heliotropium, belonging to the family Boraginaceae, comprises over 300 species of herbs and shrubs widely distributed across tropical and subtropical regions of the world. Several species are well known in ethnomedicine for their use in treating ailments such as wounds, inflammation, skin infections, and respiratory disorders. These traditional uses have prompted increasing scientific interest in exploring the pharmacognostical features, phytochemical composition, and pharmacological potential of Heliotropium species.

Phytochemical studies have revealed a variety of bioactive secondary metabolites, including flavonoids, alkaloids, phenolic compounds, tannins, and saponins. However, many species also produce pyrrolizidine alkaloids (PAs), which are of major concern due to their hepatotoxic, genotoxic, and carcinogenic properties. These compounds undergo metabolic activation in the liver, leading to serious health risks.
Additionally, pharmacogenetic factors, particularly individual variations in cytochrome P450 enzymes, influence the metabolism and toxicity of PAs, highlighting the need to understand genetic susceptibility in assessing the medicinal safety of Heliotropium. This review aims to consolidate current knowledge on the morphological characteristics, phytochemical constituents, pharmacological activities, and pharmacogenetic implications of Heliotropium species.

TAXONOMICAL CLASSIFICATION OF HELIOTROPIUM TYPES

1. Heliotropium Indicum

Domain	Eukaryota
Kingdom	Plantae
Phylum	Spermatophyta
Subphylum	Angiospermae
Class	Dicotyledonae
Order	Boraginales
Family	Boraginaceae
Genus	Heliotropium
Species	Heliotroium Indicum
Botanical name	Heliotroium indicum Linn.

Fig 1: Heliotropium Indicum Linn

2. Heliotropium Ovalifolium

Domain	Grey leaf heliotrope
Kingdom	Plantae
Phylum	Tracheophyta
Subphylum	Streptophyta
Class	Magnoliopsida
Order	Braginales
Family	Boraginaceae
Genus	Heliotropium

Species	Heliotropium ovalifoium forssk
Botanical name	Heliotropium ovalifolium Forssk.

Fig 2: Heliotropium Ovalifolium Forssk

3. Heliotropium Strigosum

Domain	Eukaryote
Kingdom	Plantae
Phylum	Tracheophyta
Subphylum	Angiosperermae
Class	Magnoliopsida
Order	Boraginales
Family	Boraginaceae
Genus	Heliotropium
Species	Heliotropium Strigosum Willd.
Botanical name	Euploca strigosa Willd.

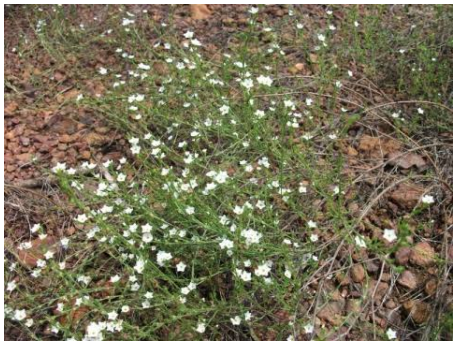

Fig 3: Heliotropium Strigosum Willd

4. Heliotropium Curassavicum

Domain	Eukaryota
Kingdom	Plantae
Phylum	Tracheophyta
Subphylum	Angiospermae
Class	Magnoliopsida
Order	Boraginales
Family	Boraginaceae
Genus	Heliotropium
Species	Heliotropium Curasssavicum
Botanical name	Heliotropium Curassavicum Linn.

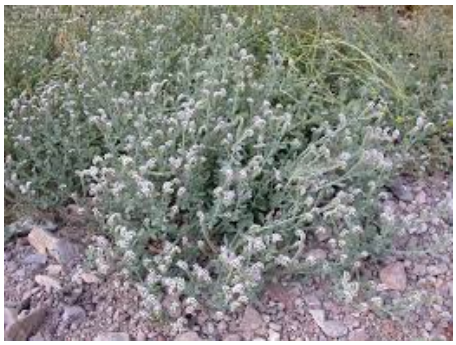

Fig 4: Heliotropium Curassavicum Linn

5. Heliotropium Europaeum

Domain	Eukaryota
Kingdom	Plantae
Phylum	Tracheophyta
Subphylum	Spermatophyta
Class	Dicotyledonae
Order	Boraginales
Family	Heliotropiaceae
Genus	Heliotropium
Species	Heliotropium Europaeum
Botanical name	European turnsole

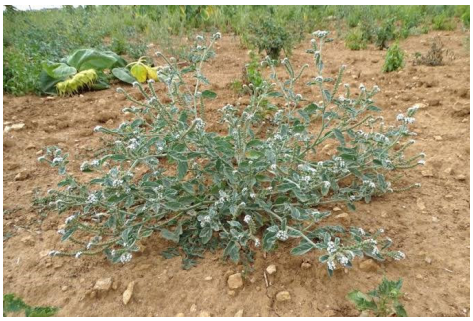

Fig 5: Heliotropium Europaeum

6. Heliotropium Arborescens

Domain	Eukaryota
Kingdom	Spermatophyta
Phylum	Tracheophyta
Subphylum	Angiospermae
Class	Magnoliopsida
Order	Boraginales
Family	Heliotropiaceae
Genus	Heliotropium
Species	Heliotropium Arborescens
Botanical name	Heliotropium Arborescens L.

Fig 6: Heliotropium Arborescens L

7. Heliotropium Amplexicaule

Domain	Eukaryota
Kingdom	Plantae
Phylum	Spermatophyta
Subphylum	Tracheophyta
Class	Dicotyledonae
Order	Boraginales
Family	Boraginaceae
Genus	Heliotropium
Species	Heliotropium Amlexicaule Vhal.
Botanical name	Heliotropium Amplexicaule

Fig 7: Heliotropium Amplexicaule Vhal

8. Heliotropium Angiospermum

Domain	Eukaryota
Kingdom	Plantae
Phylum	Tracheophyta
Subphylum	Angiospermae
Class	Eudicots
Order	Boraginales
Family	Boraginaceae
Genus	Heliotropium
Species	Heliotropium Angiospermum
Botanical name	Heliotropium Angiospermum Murray

Fig 8: Heliotropium Angiospermum

9. Heliotropium Anomalum

Domain	Eukaryota
Kingdom	Plantae
Phylum	Tracheophyta
Subphylum	Magnoliopsida
Class	Dicotyledonae
Order	Boraginales
Family	Boraginaceae
Genus	Heliotropium
Species	Heliotropium Anomalum
Botanical name	Heliotropium Anomalum Hook & Arn

Fig 9: Heliotropium Anomalum

10. Heliotropium Zeylanicum

Domain	Viridiplantae
Kingdom	Plantae
Phylum	Tracheophyta
Subphylum	Dicotyledonae
Class	Magnoliopsida
Order	Boraginales
Family	Boraginaceae
Genus	Heliotropium
Species	Heliotropium Zeylanicum
Botanical name	Heliotropium Zeylanicum (Burm.f.)Lam

Fig 10: Heliotopium Zeylanicum

GEOGRAPHICAL DISTRIBUTION:

1.Heliotropium indicum

Native to Asia, Heliotropium indicum, commonly called Indian heliotrope, has spread to various continents, including Africa, the Americas, and the Pacific islands. Tropical and subtropical areas are home to this plant species.

Regional Distribution

Asia: Originally from Asia, it is found all throughout India, including the states of Tamil Nadu, Karnataka, Kerala, Odisha, and Andhra Pradesh. Africa: Acquired citizenship in a number of African nations.
Americas: Located in Massachusetts and other locations of the United States.
Pacific Islands: Found in a number of Pacific island countries.

Worldwide Presence

The dispersion of the plant comprises.
The tropical Himalayas
India
Myanmar, China, Malaysia, the Ryukyu Islands, and America (as an invasive species)

2.Heliotropium Ovalifolium

North Africa: Egypt and Libya; Arabia (Oman: Dhofan); southeast Asia; tropical Africa: Somalia, New Guinea, Madagascar and Mascarene Islands; with slight extension to Australia and Europe (in Turkey). **Yemen:** Taiz, Bura'a, Lahj, Tihama and Socotra

Native Range: The exact native range is not specified, but it's widely distributed across tropical and subtropical areas.

India: Found in multiple districts across Tamil Nadu, including Coimbatore, Madurai, Nilgiri, Salem, Tirunelveli, and Tiruvannamalai. It's also present in other Indian regions, such as Guntur District in Andhra Pradesh.

Global Distribution: Heliotropium ovalifolium is reported in Africa, though specific countries aren't detailed in available sources. Its adaptability to dry localities and plains suggests a potential presence in regions with similar climates.

Habitat Preferences: This plant thrives in dry localities and plains, often growing as an herb or under shrub. Its ability to tolerate various environments makes it a widespread species.

3.Heliotropium strigosum

Egypt; tropical region of Africa; Saudi Arabia (Najran and Hejaz); Asia: Pakistan, Iran, India and Sri-Lanka; and eastern Asia: China and Japan. Yemen: Taiz, Lahj, Tihama, Abyen, Hadhramaut and Socotra.

Native Range: The exact native range is not specified, but it's widely distributed across tropical and subtropical regions.

Asia:

India: Found throughout Andhra Pradesh, Karnataka (Chikkamagaluru district, Uttara Kannada district), and Tamil Nadu.

Other Asian countries: Present in Afghanistan, Thailand, Southern China, and Sri Lanka.

Africa: Native to Africa, with specific varieties like Heliotropium strigosum Willd. var. trichocarpa Monod found in grasslands, woodland margins, and rocky outcrops.

Global Distribution: Heliotropium strigosum is adapted to various environments, including disturbed

areas, open fields, and roadsides, often thriving in well-drained soils with full sun to partial shade.

4.Heliotropium Curassavicum

Heliotropium curassavicum, also known as Seaside Heliotrope or Salt Heliotrope, is native to the Americas, specifically from Canada to Argentina, including the West Indies and Hawaii. However, it has naturalized in many tropical and subtropical regions globally.

Global Distribution:

Native Range: Americas, from Canada to Argentina

Introduced and Invasive: Africa, Asia, Australia, Europe

Specific Countries:

Asia: India (Delhi, Haryana, Rajasthan, Panipat), Iraq (Basrah Province) **Other Regions:** Caribbean, Lucayan Archipelago, Pacific Islands

5.Heliotropium Europaeum

Mediterranean area northwards to central and southern Europe; Asia: south Russia, Caucasia, Iran, Turkey, Afghanistan, Pakistan and India; Saudi Arabia (Najran and Al Damam) and north Africa (especially in Libya). Yemen: Taiz, Lahj, Dhamar, Sanaa, Ibb and Hiddah.

Specimens examined Yemen. Hamood s.n., Tor El-Baha, 2 Feb 2011; El Naggar s.n., Taiz,; Apr 2009; El Naggar s.n., Taiz, Mar 2005; El Naggar s.n., El-Hoban 2008; El Naggar s.n., El-Hoban, May 2007

Europe: Native to various parts of Europe, including:

Eastern Europe: Countries like Ukraine, Russia (South European Russia), and Romania

Middle Europe: Countries like Austria, Germany, Hungary, and Switzerland

Southern Europe: Countries like Albania, Bulgaria, Greece, Italy, and Spain **Southwestern Europe:** Countries like France and Portugal

Asia: Found in:

Western Asia: Countries like Turkey, Iraq, Lebanon, Syria, and Palestine

Middle Asia: Countries like Kazakhstan

Indian Subcontinent: Countries like India and Pakistan

Africa: Native to:

Northern Africa: Countries like Algeria, Egypt, Libya, Morocco, and Tunisia

Northeast Tropical Africa: Countries like Eritrea and Ethiopia

Introduced and Naturalized: Found in other parts of the world, including:

Australia: Specifically in New South Wales, South Australia, and Victoria

North America: Countries like the United States, particularly in states like California, Illinois, Massachusetts, New Jersey, New York, Ohio, Pennsylvania, and Texas

6.Heliotropium Arborescens

Heliotropium arborescens, commonly known as garden heliotrope, is native to Peru and parts of South America, but its geographical distribution has expanded due to its popularity as an ornamental plant. Here's a breakdown:

Native Range:

South America

Primarily Peru

Naturalized / Introduced Regions:

North America:

Widely cultivated in the United States, especially in warmer southern states.

Sometimes found growing wild in California, Florida, and Texas.

Europe:

Grown in gardens, especially in Southern and Western Europe.

Australia:

Found in gardens and occasionally naturalized.

Asia:

Cultivated in temperate regions.

Africa:

Grown ornamentally in temperate to subtropical areas.

Climate Preference:

Prefers subtropical to tropical climates.

Grown as a perennial in warm areas and as an annual in cooler climates.

7.Heliotropium Amplexicaule

Heliotropium amplexicaule (commonly known as blue heliotrope) has a different distribution compared to H. arborescens. Here's its geographical breakdown:

Native Range:

South America

Native to Argentina, Paraguay, and Brazil

Introduced / Invasive Regions:

Australia:

Highly invasive, especially in New South Wales and Queensland

Major weed in pastoral areas, toxic to livestock

United States:

Found in California, Texas, and other southern states

Considered a weed in rangelands and disturbed sites

South Africa:

Present and spreading in some regions

Mediterranean & parts of Europe:

Occasionally introduced and grown, but not widespread

Habitat Preference:

Thrives in disturbed soils, roadsides, pastures, and open grasslands

Prefers warm, dry climates

8.Heliotropium Angiospermum

Heliotropium angiospermum, commonly known as scorpion tail or seaside heliotrope, is native to the tropical and subtropical Americas and has spread widely in similar climates.

Native Range:

Florida (USA)

Caribbean islands

Mexico

Central America

Northern South America

Naturalized / Introduced Regions:

Hawaii (naturalized)

Parts of Southeast Asia and Pacific islands

Occasionally seen in West Africa and other coastal tropical regions

Habitat Preference:

Thrives in coastal zones, sandy soils, disturbed areas, roadsides, and beach dunes

Tolerant of saline environments and dry conditions

9.Heliotropium Anomalum

Heliotropium anomalum, commonly known as Polynesian heliotrope or ʻāhinahina in Hawaiian, is a coastal plant species native to the Pacific Islands.

Native Range:

Hawaiian Islands

Micronesia

Polynesia

Melanesia

Australia (coastal northern regions)

Southeast Asia (some coastal parts)

Indian Ocean islands (e.g., Cocos Islands)

Habitat:

Found in coastal dunes, beachfronts, coral atolls, and dry coastal scrublands

Thrives in sandy, salty, and sunny environments

Notable Subspecies:

Heliotropium anomalum var. argenteum — endemic to Hawaii, especially Oʻahu and Kauaʻi

This plant is salt-tolerant and plays a role in coastal stabilization.

10.Heliotropium Zeylanicum

Heliotropium zeylanicum, also known as Sri Lankan heliotrope, has a widespread distribution across tropical and subtropical regions of the Old World.

Native Range:
South Asia: India, Sri Lanka
Southeast Asia: Thailand, Vietnam, Malaysia, Indonesia, Philippines
East Asia: Southern China, Taiwan
Papua New Guinea
Egypt; Arabia; Pakistan; India; tropical Africa; south Africa; Madagascar and Mascarene Islands. Yemen: Taiz, Sana'a, Tihama, Lahj and Socotra. Specimens examined Yemen. El Naggar and Hamood s.n., Taiz, 31 May 2012; Hamood s.n., Tor El-Baha, 9 Nov 2009; El Naggar s.n., El-Hoban, Apr 2009; El Naggar s.n., Habil Al-Salman, Taiz, Oct 2008; El Naggar s.n., El-Hoban, Apr 2008; El Naggar s.n., Taiz, Oct 2006; El Naggar s.n., Wadi El-Enabi, Ibb, Oct 2005

ETHNOMEDICINAL USES OF DIFFERENT SPECIES OF *Heliotrope*

S.No	Name Of The Species	Common Names	Phytochemical Constituents	Ethno Medicinal Uses
1.	Heliotropium Indicum	Haturi(Hindi) Thelkodukku(Tamil) Indianheliotrope, Indian turnsole(English)	Pyrrolizidine alkaloids, Flavonoids, Terpenoids, Saponins	Wound healing, skin infections, rheumatism, and menstrual disorders
2.	Heliotropium Ovalifolium	Siruthelkodukku(Tamil) Grey leaf heliotrope(English) Nugu danti(Telugu)	Tannins, Alkaloids, Reducing susgars, and Fatty acids	Treatingwounds,inflammatory conditions, skin diseases, syphilis, and pain
3.	Heliotropium strigosum	Desert helitrope Strigose heliotrope Hairy heliotrope	Glycosides,steroids,tannins,terpenoids	Diuretics, laxative, and for treating eye pain, sore eyes, and gum boils
4.	Heliotropium curassavicum	Salt heliotrope Quail plant Smooth heliotrope Monkey tail (in some regions)	Pyrrolizidine alkaloids, Flavonoids, Tannins, Saponins, Steroids, Phenolic compounds	Skin and Wound Healing, Anti-inflammatory, Respiratory Issues, Gastrointestinal Uses
5.	Heliotropium europaeum	Turn-sole (historical name) Summer heliotrope	Pyrrolizidine Alkaloids, Flavonoids, Phenolic Compounds, Saponins (in small amounts	Skin Conditions, Fever and Infections, joint pain, swelling, rheumatism
6.	Heliotropium Arborescens	Cherry pie plant Common heliotrope Turnsole (historical)	Volatile Aromatic Compounds, Phenolic Compounds, Flavonoids	Sedative/Calming Agent, minor skin issues, such as sores or rashes, cough, bronchitis, or stomach discomfort
7.	Heliotropium Amplexicaule	Clasping heliotrope Summer heliotrope (occasionally)	Pyrrolizidine alkaloids, Flavonoids, Tannins, Phenolic acids	Antimicrobial, Antioxidant Activity, Allelopathic Effects,
8.	Heliotropium Angiospermum	Seaside heliotrope Wild heliotrope Turnsole (less commonly)	Pyrrolizidine alkaloids, Flavonoids, Tannins, Saponins, Phenolic compounds	Wound Healing & Skin Issues, Digestive Complaints, Respiratory Ailments
9.	Heliotropium Anomalum	Scorpion tail Hawaiian heliotrope (in Hawaii)	Pyrrolizidine alkaloids, Flavonoids, Tannins, Saponins, Phenolic compounds	Wound Healing and Skin Care, Traditional Ceremonial Uses
	Heliotropium	Sri Lankan	Pyrrolizidine alkaloids,	Wound Healing and Skin

10.	Zeylanicum	heliotrope Zeylan heliotrope	Flavonoids, Tannins, Saponins, Phenolic compounds	Disorders, Respiratory Conditions, Anti-inflammatory and Pain Relief, Digestive Ailments

PHARMACOLOGICAL ACTIVITIES

S.No	Name Of The Species	Part Used	Phytochemical Constituents	Pharmacological Activity
1.	Heliotropium indicum Linn	Leaf,stem,and root	Pyrrolizidine alkaloids, Flavonoids, Terpenoids, Saponins	Antioxidant activity
2.	Heliotropium Ovalifolium	Whole plant	Pyrrolizidine alkaloids and naphthalene derivatives	Anti-inflammatory and analgesic property
3.	Heliotropium Strigosum	H.Strigosum juice	Glycosides,steroids,tannins,terpenoids	Snake bites,eye sores and gum boils
4.	Heliotropium Curassavicum	Whole plant	Pyrrolizidine alkaloids, Flavonoids, Tannins, Saponins, Steroids, Phenolic compounds	Antimicrobial Activity, Wound healing
5.	Heliotropium Europaeum	Stem and leaf	Pyrrolizidine Alkaloids, Flavonoids, Phenolic Compounds, Saponins	Cytotoxic Activity Antioxidant Properties
6.	Heliotropium Arborescens	Leaf extract	Volatile Aromatic Compounds, Phenolic Compounds, Flavonoids	Anti-inflammatory (Topical) Cytotoxicity
7.	Heliotropium Amplexicaule	Leaves and root	Pyrrolizidine alkaloids, Flavonoids, Tannins, Phenolic acids	Allelopathic Effects Antimicrobial Activity
8.	Heliotropium Angiospermum	Whole plant	Pyrrolizidine alkaloids, Flavonoids, Tannins, Saponins, Phenolic compounds	Anti-inflammatory Properties, Wound Healing
9.	Heliotropium Anomalum	Leaf,stem,and root	Pyrrolizidine alkaloids and naphthalene derivatives	Antimicrobial Activity, Antioxidant Properties
10.	Heliotropium Zeylanicum	Whole plant	Pyrrolizidine alkaloids, Flavonoids, Terpenoids, Saponins	Cytotoxic/Genotoxic Effects, Antimicrobial Activity

CONCLUSION

Heliotropium species represent a diverse genus rich in bioactive phytochemicals, particularly flavonoids, phenolic compounds, tannins, and saponins, which contribute to their antimicrobial, anti-inflammatory, antioxidant, and wound-healing properties demonstrated in traditional medicine and experimental studies. However, the genus is also characterized by the presence of pyrrolizidine alkaloids (PAs), which undergo metabolic activation in the liver, leading to hepatotoxicity, genotoxicity, and carcinogenicity. This dual nature valuable pharmacological potential but high toxic risk limits their safe medicinal application. Pharmacogenetic insights reveal that individual variations in cytochrome P450 enzymes influence susceptibility to PA toxicity, underlining the importance of genetic factors in evaluating safety. While ethnomedicinal practices highlight their therapeutic relevance, modern pharmacology demands cautious investigation**,** focusing

on isolation of non-toxic compounds, structure modification, and safe dosage studies. Heliotropium species remain a promising but hazardous group of medicinal plants, requiring further phytochemical characterization, pharmacological validation, and toxicological assessments before any clinical or pharmaceutical application can be considered.

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