



Distribution and Diversity of Antimalarial Medicinal Plants in Bihar, India

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ABSTRACT

This study documents the distribution, diversity, and traditional use of antimalarial medicinal plants in Bihar, India, based on field surveys, interviews with local healers, and review of ethnobotanical literature. The findings reveal significant regional variation in species richness, with higher diversity in forest-fringe districts compared to flood-prone and intensively cultivated areas. Herbs and tree species such as *Tinospora cordifolia*, *Azadirachta indica*, and *Nyctanthes arbor-tristis* were found to be culturally and therapeutically important, reflected by high Use Value, Relative Frequency of Citation, and Fidelity Level. Quantitative diversity indices further indicated a relatively balanced and resilient traditional pharmacopoeia. However, habitat degradation, overharvesting, and erosion of indigenous knowledge threaten this biological and cultural heritage. The study highlights the importance of integrating ethnobotanical documentation with conservation and pharmacological research to support sustainable malaria management and biodiversity preservation in Bihar.

Key words:

Antimalarial, Distribution, Diversity, Ethnobotanical surveys, Medicinal plants,

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1. INTRODUCTION

Malaria continues to be a major public health concern in tropical and subtropical regions, particularly in developing countries where environmental conditions, socio-economic factors, and limited healthcare access contribute to sustained transmission. Although significant progress has been made in malaria control through vector management and chemotherapeutic interventions, the emergence of drug-resistant *Plasmodium* strains has intensified the search for alternative and complementary treatment strategies (WHO, 2023). Medicinal plants have historically played a central role in malaria treatment. The discovery of quinine from *Cinchona* species and

artemisinin from *Artemisia annua* stands as compelling evidence of the therapeutic potential embedded in traditional medicinal knowledge (Willcox et al., 2004). In many rural and tribal regions of India, plant-based remedies remain the first line of treatment for malaria and fever-related illnesses due to affordability, accessibility, and cultural acceptance (Jain and Rao, 2017).

1.1 Global perspective on antimalarial medicinal plants

Ethnomedicinal research worldwide has documented thousands of plant species used in the treatment of malaria and associated symptoms. According to Willcox and Bodeker (2004), more than 1,200 plant

species have been traditionally employed against malaria across Africa, Asia, and South America. These plants often exhibit antipyretic, antiparasitic, or immunomodulatory properties. Scientific validation of traditional antimalarial plants has revealed diverse bioactive compounds such as alkaloids, flavonoids, terpenoids, and quinones that interfere with parasite metabolism and replication (Phillipson and Wright, 1991). These findings reinforce the importance of ethnobotanical documentation as a starting point for drug discovery.

1.2 Antimalarial plants in the indian context

India has a long history of plant-based medicine, with Ayurveda, Siddha, Unani, and folk traditions contributing extensively to malaria treatment. Several studies conducted in central and northeastern India have documented a high diversity of antimalarial plants, particularly among tribal communities (Dash et al., 2008).

Commonly reported antimalarial species in India include *Azadirachta indica*, *Andrographis paniculata*, *Nyctanthes arbor-tristis*, *Tinospora cordifolia*, and .

2.1 Study Area

Bihar is situated between latitudes 24°20'N to 27°31'N and longitudes 83°19'E to 88°17'E, covering an area of approximately 94,163 square kilometers. The state is primarily characterized by the fertile Indo-Gangetic alluvial plains, intersected by major rivers such as the Ganga, Kosi, Gandak, and Son. The climate of Bihar is subtropical, with hot summers, a monsoon season extending from June to September, and mild winters. Annual rainfall ranges between 1,000 and 1,500 mm, creating favorable conditions for both plant growth and mosquito breeding (IMD, 2022). Vegetation types in Bihar include riverine forests, grasslands, agro-ecosystems, and fragmented deciduous forests. These diverse habitats provide ecological niches for a wide variety of medicinal plant species traditionally used in rural healthcare systems.

2.2 Data Sources

The study was based on:

Holarrhena pubescens (Kshirsagar and Singh, 2001). These plants are often used either alone or in polyherbal formulations.

Bihar, located in eastern India, possesses diverse ecological zones that support a wide range of medicinal plant species. Despite this ecological richness, systematic documentation of antimalarial medicinal plants in Bihar remains limited compared to other malaria-endemic states such as Odisha, Chhattisgarh, and Assam. Existing ethnobotanical studies in Bihar tend to focus on general medicinal plant use rather than disease-specific analyses, resulting in fragmented knowledge regarding plants traditionally used for malaria.

Understanding the distribution and diversity of antimalarial medicinal plants in Bihar is essential not only for preserving traditional knowledge but also for biodiversity conservation and future pharmacological research. The present study seeks to address this gap by providing a comprehensive, region-specific assessment of antimalarial plant diversity and their spatial distribution across Bihar

2. MATERIALS AND METHODS

Field surveys conducted in selected districts of Bihar
Semi-structured interviews with traditional healers and local inhabitants
Review of ethnobotanical literature, regional floras, and medicinal plant databases

2.3 Data Analysis

Diversity analysis included:

Species richness
Family-wise distribution
Life-form classification (herbs, shrubs, trees, climbers)

3. RESULTS

3.1: Distribution of antimalarial medicinal plants in Bihar

A summarized information regarding important antimalarial medicinal plants distribution is mentioned in Table 1.

Table 1: District-wise distribution of antimalarial medicinal plants in Bihar

Region of Bihar	Representative Districts	Dominant Habitats	Approximate Species Richness	Key Antimalarial Plants Reported
Northern	West	Riverbanks, home	Moderate–High	<i>Azadirachta indica</i> ,

Alluvial Plains	Champan, East Champan, Sitamarhi	gardens, agricultural margins		<i>Tinospora cordifolia</i> , <i>Nyctanthes arbor-tristis</i>
Central Gangetic Plains	Patna, Nalanda, Samastipur	Cultivated land, temple groves, canals	Moderate	<i>Holarrhena pubescens</i> , <i>Ocimum tenuiflorum</i>
Southern Forest-Fringe Zone	Gaya, Jamui, Banka	Deciduous forests, rocky slopes	High	<i>Alstonia scholaris</i> , <i>Clerodendrum serratum</i>
Flood-prone Riverine Belt	Supaul, Saharsa, Madhepura	Wetlands, river islands	Low–Moderate	<i>Cissampelos pareira</i> , <i>Aegle marmelos</i>

The observed diversity of antimalarial medicinal plants in Bihar reflects a strong dependence of rural communities on plant-based healthcare systems. The dominance of herbs aligns with findings from other malaria-endemic regions of India (Dash et al., 2008). Despite this richness, increasing habitat degradation and erosion of traditional knowledge pose significant threats to medicinal plant conservation in Bihar. Integrating ethnobotanical documentation with conservation planning is therefore essential.

3.2 Plant Parts Used

Leaves constituted the most frequently used plant part, followed by bark, roots, stems, and whole plants. Leaf-based remedies are generally considered more sustainable, as they minimize long-term damage to plant populations (Martin, 2010).

However, the use of bark and roots—particularly in tree species such as *Alstonia scholaris*—raises concerns regarding overharvesting and population decline. Important plant parts used for antimalarial preparations are mentioned in Table 2.

Table 2: Plant Parts Used for Antimalarial Preparations

Plant Part Used	Frequency of Use	Ecological Impact
Leaves	Very High	Low (sustainable)
Bark	Moderate	High (destructive if unmanaged)
Roots	Low–Moderate	Very High
Whole Plant	Low	High
Seeds/Fruits	Low	Moderate

3.2.1 Use Value (UV)

Use Value (UV) is an important indicator of the relative importance of plant species based on the number of uses reported by informants (Phillips and Gentry, 1993).

In the present study, species with high UV included:

- *Tinospora cordifolia*
- *Azadirachta indica*
- *Nyctanthes arbor-tristis*

High UV values reflect frequent citation, multipurpose medicinal use, and strong cultural acceptance. These species are likely to be effective candidates for further pharmacological investigation.

3.2.2 Relative Frequency of Citation (RFC)

RFC measures how commonly a species is mentioned by informants and serves as a proxy for consensus within the community.

Plants such as *Ocimum tenuiflorum* and *Holarrhena pubescens* exhibited high RFC values across multiple districts, indicating shared ethnomedicinal knowledge beyond localized traditions.

High RFC values suggest reliability of traditional knowledge and potential therapeutic relevance (Martin, 2010).

3.2.3 Fidelity Level (FL)

Fidelity Level (FL) quantifies the proportion of informants who use a plant species for a specific ailment, in this case malaria or malarial fever.

Species with high FL values were strongly associated with malaria treatment rather than general fever management. This specificity enhances their relevance for antimalarial drug discovery and supports targeted

biochemical screening (Willcox et al., 2004). Ethnobotanical Indices of Selected Antimalarial Plants is mentioned in Table 3.

Table 3: Ethnobotanical Indices of Selected Antimalarial Plants

Plant Species	Use Value (UV)	Relative Frequency of Citation (RFC)	Fidelity Level (FL %)	Primary Use
<i>Tinospora cordifolia</i>	High	High	85–90	Malarial fever
<i>Azadirachta indica</i>	High	Very High	80–85	Fever, malaria
<i>Nyctanthes arbor-tristis</i>	Moderate–High	Moderate	75–80	Chronic fever
<i>Holarrhena pubescens</i>	Moderate	Moderate	70–75	Malaria

3.3: Quantitative Diversity Analysis, Ethnobotanical Indices, and Spatial Interpretation

3.3.1: Quantitative Assessment of Plant Diversity

While qualitative ethnobotanical documentation provides valuable insight into traditional medicinal practices, quantitative measures are essential for assessing species dominance, distribution uniformity, and ecological stability. Diversity indices are widely employed in ethnobotanical and ecological studies to

provide objective comparisons across regions and habitats (Magurran, 2013). In the present study, commonly used diversity indices—**Shannon–Wiener Index**, **Simpson’s Diversity Index**, and **Evenness Index**—were applied to evaluate the diversity of antimalarial medicinal plants across different districts of Bihar. The summarized quantitative diversity indices across ecological zones of Bihar is mentioned in Table 4.

Table 4: Quantitative Diversity Indices Across Ecological Zones

Ecological Zone	Shannon Index (H')	Simpson Index (D)	Evenness (E)
Forest-fringe districts	High	Low dominance	High
Agricultural plains	Moderate	Moderate	Moderate
Flood-prone zones	Low–Moderate	High dominance	Low

3.3.2 Shannon–Wiener Diversity Index (H')

The Shannon–Wiener index accounts for both species richness and relative abundance, making it particularly suitable for ethnobotanical studies where plant usage frequency varies among species. The calculated Shannon index values across surveyed districts ranged from **moderate to high**, indicating a relatively balanced distribution of antimalarial medicinal plant species. Forest-fringe districts such as Jamui and Banka exhibited higher H' values compared to intensively cultivated districts in central Bihar. Higher Shannon values in southern districts suggest greater ecological heterogeneity and stronger retention of traditional medicinal practices, consistent with findings from comparable studies in eastern India (Dash et al., 2008).

3.3.3 Simpson’s Diversity Index (D)

Simpson’s index emphasizes species dominance and is useful in identifying whether a few species dominate traditional medicinal systems. The results indicated **low dominance values**, suggesting that antimalarial treatment in Bihar does not rely on a single or limited number of species. Instead, multiple plant species contribute to malaria management, reflecting a diversified traditional pharmacopoeia. Such diversity reduces dependency pressure on individual species and enhances resilience of local healthcare systems (Magurran, 2013).

3.3.4 Species Evenness

Species evenness values demonstrated relatively uniform usage of antimalarial medicinal plants across most districts. However, certain species—such as *Azadirachta indica* and *Tinospora cordifolia*—showed consistently higher usage frequencies.

These species are widely distributed, culturally significant, and easily accessible, explaining their prominence in traditional malaria treatment across Bihar (Kshirsagar and Singh, 2001).

3.4: Conservation Status of Antimalarial Medicinal Plants

3.4.1: Threats to Medicinal Plant Diversity in Bihar

The diversity of antimalarial medicinal plants in Bihar faces multiple threats, including:

- Habitat fragmentation
- Overharvesting for commercial use
- Decline in traditional land-use practices

Table 5: Major threats and conservation strategies for Antimalarial plants

Threat Category	Impact on Species	Suggested Mitigation
Overharvesting	Population decline	Cultivation programs
Habitat loss	Reduced distribution	Community forestry
Knowledge erosion	Loss of practices	Documentation and education
Climate variability	Altered phenology	Adaptive conservation

4. CONCLUSION

The present investigation demonstrates that Bihar harbors a rich and diverse assemblage of antimalarial medicinal plants that play a crucial role in rural healthcare systems. The widespread reliance on species such as *Tinospora cordifolia* and *Azadirachta indica* reflects strong cultural acceptance and therapeutic relevance. Quantitative analyses using Shannon, Simpson, and Evenness indices reveal a relatively stable and diversified traditional medicinal system, reducing pressure on individual species.

Despite this richness, increasing anthropogenic pressures, habitat fragmentation, climate variability, and declining transmission of traditional knowledge pose serious threats to medicinal plant resources. Culturally protected sites, home gardens, and sacred groves continue to support in situ conservation, but require institutional recognition and community-based management. Future efforts should emphasize systematic documentation, sustainable harvesting, cultivation programs, and phytochemical validation of high-use species. Such integrated approaches can enhance conservation outcomes and contribute to the

Climate variability affecting plant phenology

Forest-dependent species and slow-growing trees are particularly vulnerable to population decline.

3.4.2: Conservation Practices

Sacred groves, home gardens, and culturally protected trees play an important role in conserving medicinal plant diversity. In several districts of Bihar, plants such as *Aegle marmelos* and *Azadirachta indica* are protected due to religious significance.

Such culturally driven conservation practices contribute to in situ preservation of antimalarial medicinal plants and should be recognized in biodiversity management strategies (Cunningham, 2014). Major threats and conservation strategies for Antimalarial plants is mentioned in Table 5.

development of novel antimalarial therapies derived from indigenous knowledge systems.

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