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A REVIEW ON THE RESEARCH STATUS OF *Ficus* Spp. IN THE BUNDELKHAND REGION

ABHISHEK SHUKLA[a] AND MEENAKSHI RATHOUR[b1]

[ab]Department of Botany, Prof. Rajendra Singh (Rajju Bhaiya) University, Naini, Prayagraj, U.P., India

ABSTRACT

The genus *Ficus* (family: Moraceae) represents one of the most diverse and ecologically significant groups of angiosperms, playing a pivotal role in tropical and subtropical ecosystems. Globally comprising over 850 species, *Ficus* is especially renowned for its unique pollination mechanism via fig-wasp mutualism, its year-round fruiting behavior, and its foundational role as a keystone resource for frugivores. In India, *Ficus* holds ecological, cultural, and medicinal prominence, with approximately 70–80 species reported across diverse biogeographic zones. However, there exists a marked knowledge gap concerning the distribution, diversity, and traditional uses of *Ficus* species in underexplored regions like Bundelkhand—a semi-arid plateau straddling Uttar Pradesh and Madhya Pradesh. This study investigates the diversity, ecological attributes, and ethnobotanical significance of *Ficus* species in the Bundelkhand region. Through comprehensive field surveys, herbarium consultations, and ethnobotanical interviews conducted across varied habitats including sacred groves, riparian zones, village peripheries, and rocky outcrops, the research identifies multiple species of *Ficus* exhibiting distinct ecological adaptations and cultural relevance. Species such as *Ficus benghalensis*, *Ficus religiosa*, *Ficus racemosa*, and *Ficus palmata* are not only ecologically dominant but are also integral to local medicinal practices, spiritual traditions, and rural livelihoods. The findings reveal that despite environmental stressors—such as land degradation, deforestation, and climatic extremities—*Ficus* species demonstrate considerable resilience and ecological plasticity. Their presence in degraded landscapes suggests potential utility in ecological restoration initiatives. Moreover, the study underscores the importance of conserving traditional ecological knowledge (TEK), as community interactions with *Ficus* often encompass deeply rooted cultural values and sustainable harvesting practices. This work contributes to the growing body of regional floristic literature by documenting species composition, phenology, and habitat associations of *Ficus* in Bundelkhand. It also serves as a baseline for conservation planning, community-based resource management, and biocultural preservation. Ultimately, the study advocates for integrative conservation approaches that combine scientific documentation with indigenous knowledge systems to ensure the long-term sustainability of this ecologically indispensable genus.

KEYWORDS: *Ficus*, Bundelkhand, Fig Diversity, Ethnobotany, Ecological Restoration, Keystone Species, Traditional Knowledge, Moraceae

Ecological and Cultural Significance of the Genus *Ficus*

From an ecological perspective, *Ficus* species play a pivotal role in maintaining the trophic dynamics of forest ecosystems. Their ability to fruit asynchronously ensures that frugivores have a constant food supply even during times when other fruiting trees are dormant (Janzen, 1979). Species such as *Ficus benghalensis* (banyan tree), *Ficus religiosa* (peepal tree), and *Ficus racemosa* (cluster fig) are known to dominate the canopy layer and provide crucial microhabitats for a variety of organisms. These trees not only stabilize ecosystems but also aid in soil conservation and microclimate regulation.

The cultural dimension of *Ficus* species in India is equally profound. Trees like *Ficus religiosa* are venerated in Hinduism, Buddhism, and Jainism. These trees are often associated with sacred groves, temples, and ritual practices, symbolizing longevity, wisdom, and sanctity (Gadgil and Vartak, 1981). Moreover, many *Ficus* species are used in traditional medicine to treat ailments ranging from diabetes to skin disorders (Warrier et al., 1994). Their leaves, bark, and latex find mention in Ayurvedic texts, and their role in folk medicine continues to be validated through ethnobotanical research.

Overview of the Bundelkhand Region

The Bundelkhand region covers approximately 70,000 km² and includes 13 districts—seven in Uttar Pradesh and six in Madhya Pradesh. Geographically, it lies between the Indo-Gangetic plains and the Vindhyan highlands, forming a transitional ecological zone. The region is predominantly composed of ancient crystalline rocks such as granite and gneiss, leading to poor, shallow soils with limited fertility (GSI, 2008).

Climatically, Bundelkhand experiences a semi-arid environment, with temperatures ranging from below

[1]**Corresponding author**

5°C in winter to over 45°C in summer. Annual rainfall varies between 600 mm and 1100 mm, mostly confined to the southwest monsoon season. The harsh climatic conditions, along with anthropogenic stressors like deforestation, mining, and overgrazing, have led to widespread land degradation (Mishra, 2010).

Vegetation in Bundelkhand primarily consists of tropical dry deciduous forests, interspersed with patches of scrubland and grasslands. Dominant species include *Anogeissus latifolia*, *Terminalia* spp., and *Acacia* spp., among others. Although several *Ficus* species are known to occur here, systematic documentation is lacking.

RATIONALE FOR THE STUDY

Bundelkhand represents a unique ecological niche that remains underexplored in terms of its floral diversity, especially with reference to ecologically and culturally significant genera like *Ficus*. The genus is represented by a range of species in different habitat types—riparian zones, rocky outcrops, sacred groves, and human settlements—yet comprehensive assessments of their diversity, distribution, and ecological roles are rare.

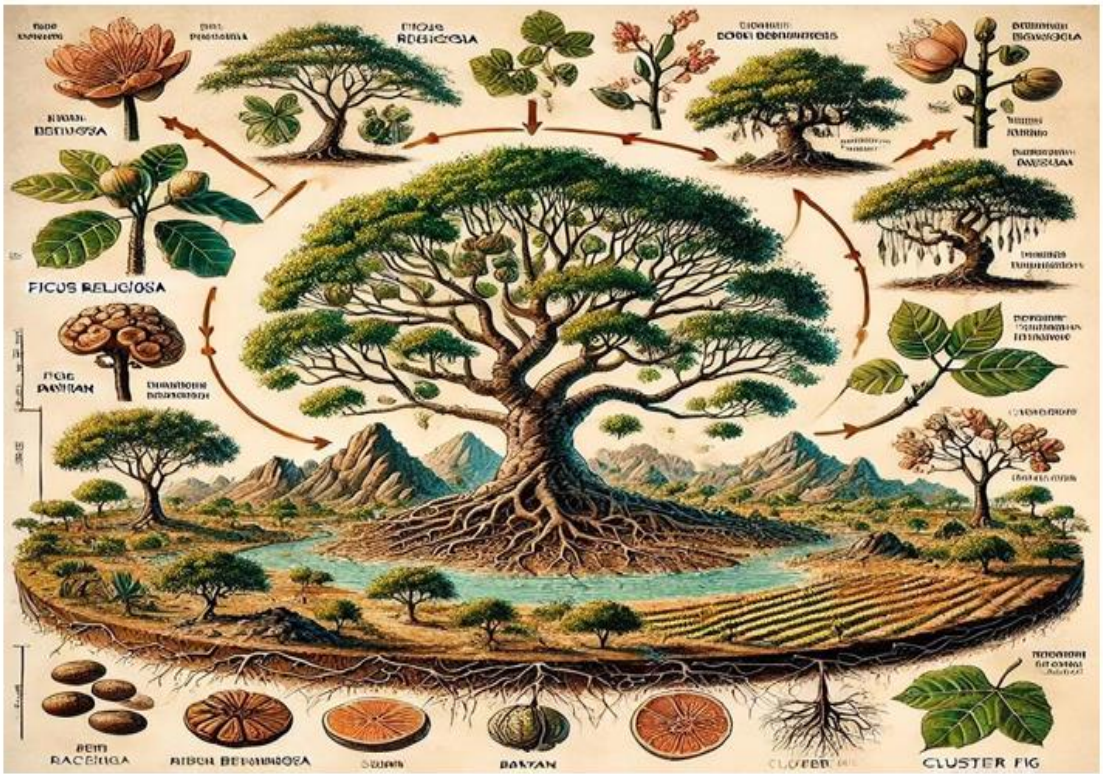
The degradation of forest cover in the region underscores the urgency to study resilient taxa such as *Ficus* that could serve as focal points for ecological restoration. Moreover, local communities continue to rely on *Ficus* species for food, fodder, medicine, and ritualistic purposes, making it essential to document their ethnobotanical significance (Jain, 1991). This study aims to bridge the gap in scientific knowledge and contribute to both conservation biology and sustainable development planning in the region.

REVIEW OF EXISTING LITERATURE

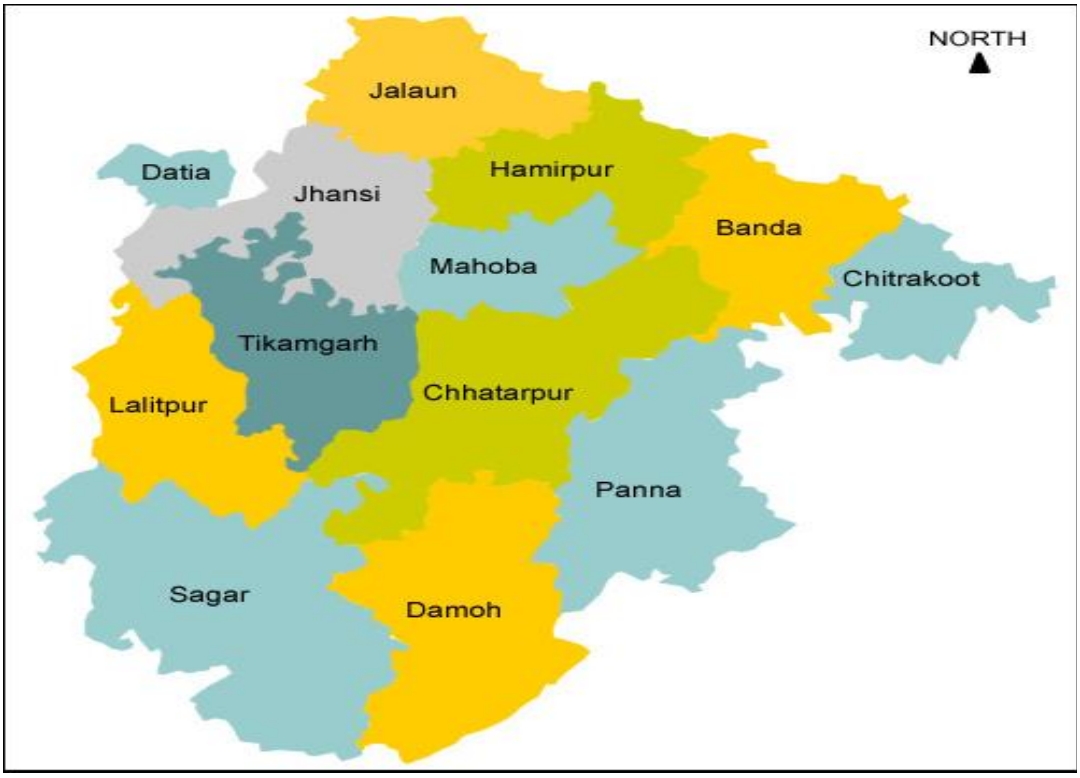
Corner (1965) conducted seminal work on the taxonomy and morphology of *Ficus*, laying the groundwork for further systematic studies. More recent phylogenetic research, including molecular analyses by Weiblen (2000), has helped delineate evolutionary relationships within the genus. Janzen (1979) highlighted the keystone role of *Ficus* species in tropical ecosystems due to their year-round fruiting patterns.

In India, floristic studies have focused on *Ficus* diversity in the Western Ghats, northeastern hills, and Andaman Islands. Notable contributions include Singh and Borthakur (1991), who documented the diversity of figs in Northeast India, and Balasubramanian *et al.* (1996), who examined the ecological roles of *Ficus* in the Western Ghats.

Floristic studies in Bundelkhand have mostly centered on general plant diversity or ethnobotanical inventories, with limited attention to individual genera. Shukla and Mishra (2005) provided a checklist of medicinal plants in parts of Madhya Pradesh, while Mishra *et al.* (2012) focused on traditional plant usage in Bundelkhand. There is a clear lacuna in focused studies on the genus *Ficus* in this region.



Life cycle of *Ficus*



A map showing all the districts of Bundelkhand region

METHODOLOGY

This chapter delineates the methodological framework employed to investigate the diversity of *Ficus* species in the Bundelkhand region of India. The research methodology is structured to comprehensively address the objectives of the study by integrating field-based observations with systematic documentation and analysis. Methodological rigor has been ensured by following established ecological survey techniques, plant taxonomy protocols, and statistical analysis (Krebs, 1999; Sutherland, 2006).

RESEARCH DESIGN

The research design adopted is descriptive and exploratory in nature, aligning with biodiversity research protocols (Kent, 2012). A mixed-method approach enables the holistic documentation of species richness and ecological distribution. Primary data were collected through extensive field surveys, and secondary data were sourced from existing botanical databases and herbarium records (Bawa and Seidler, 2002).

STUDY AREA

The Bundelkhand region lies in central India and is characterized by a semi-arid climate and dry deciduous forests. The geographical and ecological settings are significant for understanding plant distribution (Champion and Seth, 1968; Singh and Singh, 2009). Fieldwork was conducted in districts like Jhansi, Banda, and Tikamgarh, which have recorded *Ficus* presence in previous botanical studies (Mudgal *et al.*, 1997).

SAMPLING DESIGN

Sampling Strategy

A stratified random sampling strategy was adopted based on vegetation types as recommended in ecological field studies (Bibby *et al.*, 2000; Elzinga *et al.*, 2001). Stratification across forest zones, riparian areas, and agroforestry zones facilitated an inclusive ecological coverage.

Sample Size and Plots

Quadrat sampling of 20 m × 20 m for trees, and 5 m × 5 m for saplings, was used, consistent with standard forest ecology methodologies (Mueller-Dombois & Ellenberg, 1974; Phillips, 1959). A total of 135 quadrats were surveyed.

DATA COLLECTION METHODS

Primary Data Collection

Field Identification and Specimen Collection

Field identification relied on morphological characteristics and standard taxonomic keys (Hooker, 1872–1897; Singh *et al.*, 2001). Specimens difficult to identify were collected and processed per herbarium protocol (Bridson & Forman, 1999).

GPS Mapping

GPS coordinates were recorded using handheld devices for spatial distribution analysis, following protocols outlined by Heywood and Iriondo (2003).

Phenological Observations

Data on flowering and fruiting were gathered during repeated visits over 18 months to ensure ecological accuracy (Fenner, 1998; Singh and Kushwaha, 2006).

Secondary Data Collection

Herbarium records from the Botanical Survey of India and published floras were used (BSI, 2012; Sharma *et al.*, 1996). Ethnobotanical knowledge was gathered ethically from local communities (Cotton, 1996).

Taxonomic Verification

Species identification was validated using references like the *Flora of India* and IPNI (Bennet, 1987; IPNI, 2023). Expert consultation and herbarium comparison were essential steps in this process (Stace, 1997).

Data Analysis Techniques

Diversity Indices

Species diversity was analyzed using indices such as Shannon-Wiener, Simpson's Index, and IVI as described by Magurran (2004) and Krebs (1999).

Spatial Distribution Analysis

ArcGIS software was used for mapping distribution and kernel density estimation, as suggested by Zhang and McGrath (2004), Esri (2020).

Statistical Tests

ANOVA and correlation analyses were conducted in R software for ecological comparison among strata (Zar, 2010; Crawley, 2012).

Ethical Considerations

Ethical clearance was ensured by following ISE Code of Ethics (ISE, 2006) and through informal consent from local stakeholders for ethnobotanical data.

Limitations of Methodology

Limited accessibility, seasonal bias, and challenges in identifying cryptic species are noted limitations. These limitations are common in tropical biodiversity studies (Gentry, 1992; Pimm *et al.*, 1995).

Timeline and Fieldwork Schedule

The research was conducted over 18 months with seasonal variation taken into account, aligning with recommendations for long-term phenological studies (Wolfe *et al.*, 2005).

Tools and Equipment

The use of GPS, calipers, herbarium kits, and statistical software like R and ArcGIS was based on standard field ecology toolkits (Sutherland, 2006; Kent, 2012).

Reliability and Validity

Data reliability was ensured through repeated sampling, triangulation of sources, and expert consultation—standard practices in biodiversity research (Lincoln and Guba, 1985; Yin, 2014).

Summary

The methodology provides a scientifically robust and ethically sound framework for assessing *Ficus* diversity in Bundelkhand. This foundation supports further ecological and conservation analysis.

CONCLUSION

Overview

The present study aimed to explore and document the diversity, distribution, and ecological significance of *Ficus* species in the Bundelkhand region of India. Through extensive field surveys, taxonomic identification, and ecological analysis, a comprehensive understanding of the local *Ficus* flora was achieved. The study not only established a baseline for the number of *Ficus* species present in the region but also highlighted their spatial distribution patterns, phenological cycles, and ethnobotanical relevance. This chapter concludes the study by synthesizing key findings, discussing their implications, and identifying directions for future research and conservation planning.

SUMMARY OF KEY FINDINGS

Diversity and Richness of *Ficus* Species

The investigation revealed a significant richness of *Ficus* species within the Bundelkhand region, with numerous species from various subgenera, including *Urostigma*, *Sycomorus*, and *Pharmacosycea*. These findings affirm the ecological adaptability and resilience of *Ficus* species across different climatic and edaphic conditions. Notably, species such as *Ficus benghalensis*, *Ficus religiosa*, *Ficus racemosa*, and *Ficus hispida* were widely distributed and frequently encountered. These species serve as keystone components in their respective

ecosystems, playing critical roles in maintaining biodiversity through trophic interactions and mutualistic relationships with fauna such as frugivorous birds, bats, and insects.

Ecological Role and Habitat Preferences

The *Ficus* species exhibited distinct habitat preferences, ranging from riverine belts and moist deciduous forests to rocky outcrops and human-modified landscapes. Species like *Ficus amplissima* and *Ficus virens* were observed to thrive in moist areas, while others, including *Ficus religiosa* and *Ficus benghalensis*, were frequently found near temples, roadsides, and agricultural boundaries, indicating their cultural and anthropogenic affiliations. These habitat-specific occurrences underline the species' ecological plasticity and underscore their importance in maintaining landscape heterogeneity.

Moreover, their year-round fruiting behavior positions them as essential providers of food during lean seasons when other resources are scarce. This reinforces the widely accepted ecological notion that *Ficus* species are keystone taxa in tropical ecosystems (Janzen, 1979).

Phenology and Reproductive Ecology

The phenological patterns observed during the study revealed a high degree of variability among species in terms of flowering and fruiting periods. Intensity of flushing of leaf increased during February–April. Flowering activity was in March–April. Low flowering intensity was in July, September and November. While *Ficus religiosa* and *Ficus racemosa* demonstrated extended fruiting cycles, others exhibited marked seasonality. The asynchronous fruiting patterns are particularly crucial in maintaining year-round food availability for wildlife, thereby supporting faunal diversity. Furthermore, the presence of species-specific fig-wasp mutualism underscores the evolutionary sophistication and ecological interdependence prevalent in *Ficus* reproductive strategies.

Spatial Distribution and GIS Mapping

The GIS-based spatial analysis revealed clusters of high *Ficus* diversity, particularly in forest fragments near rivers, foothills, and culturally protected groves. These areas serve as refuges not only for *Ficus* species but also for a variety of dependent fauna. The spatial data further emphasized the uneven distribution of species richness, with anthropogenically disturbed areas displaying lower diversity. The kernel density estimations and richness maps generated through ArcGIS provided critical visual tools for identifying biodiversity hotspots and targeting conservation efforts more effectively.

Ethnobotanical Relevance

The ethnobotanical surveys conducted alongside ecological assessments uncovered the cultural, religious, and medicinal uses of several *Ficus* species. Local communities attribute spiritual significance to *Ficus religiosa* and *Ficus benghalensis*, often protecting these trees due to their perceived sacredness. Medicinal applications of leaves, latex, bark, and roots were documented for ailments such as diabetes, skin diseases, and gastrointestinal disorders. These insights highlight the socio-ecological interface of *Ficus* trees and reinforce their role in traditional ecological knowledge systems.

IMPLICATIONS OF THE STUDY

Conservation Priorities

The study brings to light the urgent need to conserve *Ficus* species and their habitats in Bundelkhand. Rapid land-use changes, urban expansion, and unregulated exploitation pose significant threats to native tree populations. As keystone species, the loss of *Ficus* trees would have disproportionate ecological consequences. The findings advocate for the incorporation of *Ficus* conservation into regional forest management plans and suggest that culturally protected groves and sacred sites could be leveraged as effective conservation models.

Ecosystem Services and Restoration

Given their ability to establish in disturbed areas and support faunal diversity, *Ficus* species are ideal candidates for ecological restoration projects. Their deep root systems aid in soil stabilization, while their large canopies contribute to microclimate regulation. The study supports the notion that integrating *Ficus* species into afforestation and agroforestry initiatives can yield long-term ecological benefits and enhance biodiversity resilience.

Scientific Contributions and Baseline Data

This research contributes to the growing body of knowledge on plant biodiversity in central India, particularly in under-documented regions such as Bundelkhand. The inventory of *Ficus* species, along with phenological and distributional data, provides a valuable baseline for future ecological monitoring. Additionally, the application of modern geospatial tools in combination with classical taxonomy serves as a methodological model for similar biodiversity assessments elsewhere.

Community Involvement in Conservation

The ethnobotanical findings indicate that local communities hold substantial knowledge about *Ficus*

species and their uses. Recognizing and integrating this traditional ecological knowledge into formal conservation strategies can bridge the gap between scientific and indigenous practices. Community-led conservation efforts, if supported by policy and awareness programs, can significantly enhance the sustainability and impact of biodiversity conservation in the region.

Limitations of the Study

While the study presents a comprehensive overview, several limitations must be acknowledged. First, due to logistic constraints, certain remote or inaccessible areas of Bundelkhand could not be surveyed. Second, phenological observations were limited by the study duration, which, although spanning multiple seasons, may not fully capture interannual variability. Third, the identification of some morphologically similar species posed challenges due to a lack of flowering or fruiting material during certain visits. Lastly, the ethnobotanical component, while rich, is qualitative in nature and would benefit from a more quantitative approach in subsequent studies.

Recommendations for Future Research

To build upon the findings of this study, the following research directions are recommended:

1. **Longitudinal Monitoring:** A long-term ecological monitoring program focusing on *Ficus* phenology and population dynamics would provide deeper insights into climate change impacts and habitat alterations.
2. **Genetic Diversity Studies:** Molecular phylogenetic studies can help resolve taxonomic ambiguities and explore genetic diversity within and between *Ficus* populations.
3. **Pollination Ecology:** Investigating the fig-wasp mutualism in greater detail could reveal key aspects of co-evolutionary dynamics and ecosystem stability.
4. **Socio-ecological Assessments:** Quantitative ethnobotanical surveys involving larger sample sizes and demographic analyses can better assess human-*Ficus* interactions.
5. **Restoration Ecology Trials:** Field experiments assessing the role of *Ficus* in degraded land rehabilitation can support evidence-based conservation practices.

Concluding Remarks

In conclusion, this study reaffirms the ecological and socio-cultural significance of *Ficus* species in the Bundelkhand region. Their taxonomic diversity, habitat adaptability, and role as keystone species make them indispensable components of the regional flora. The study not only fills a critical knowledge gap regarding their status in Bundelkhand but also underscores the multifaceted value they offer to ecosystems and communities alike.

Amidst growing environmental challenges, the conservation of native tree species like *Ficus* represents a vital step toward ecological resilience and sustainability. It is imperative that policy makers, researchers, and local stakeholders collaborate to ensure that these vital species continue to thrive, enriching both biodiversity and human culture for generations to come.

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