International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 10 No. 3s, 2024
https://theaspd.com/index.php

Azadirachta indica Subspecies vartakii Kothari, Londhe & N.P. Singh: A Comprehensive Review of Discovery, Endemism, and Research Priorities for an Understudied Medicinal Plant

S. K. Arsod[1*], S. V. Satpute[2], S. R. Sinkar[3], S. A. Sirsat[4]

[1*]Research Scholar. Department of Botany, Mahatma Fule Arts Commerce and Sitaramji Choudhari Science Mahavidyalaya, Warud. Email ID: skarsod1991@gmail.com
[2]Professor and Head. Department of Botany, Mahatma Fule Arts Commerce and Sitaramji Choudhari Science Mahavidyalaya, Warud. Email ID: satpute20@gmail.com
[3]Assistant Professor, Department of Botany, Arvind Babu Deshmukh Mahavidyalay, Bharsingi, Nagpur.
Email ID: surendrasinkar24@gmail.com
[4]Research Scholar. Department of Botany, Mahatma Fule Arts Commerce and Sitaramji Choudhari Science Mahavidyalaya, Warud. Email ID: sanketsirsat741@gmail.com

Abstract

Azadirachta indica A. Juss. (neem) is globally recognised as a multipurpose tree with exceptional medicinal, insecticidal, and agrochemical properties. However, its subspecies Azadirachta indica subsp. vartakii Kothari, Londhe & N.P. Singh, first described in 1997 from the Yavatmal District of Maharashtra, India, remains one of the most understudied taxa in the Meliaceae family. This review synthesizes all available literature on this narrowly endemic subspecies. We documented that only a single original publication exists, covering morphological description and DNA polymorphism. No anatomical, histological, embryological, palynological, phytochemical, pharmacological, or conservation studies have been published in the 29 years since its discovery. The subspecies is distinguished from the parent species by pinnatisect leaves, winged rachis, equilateral leaf bases, racemose inflorescences equal in length to leaves, and smaller, oval-ellipsoid drupes. It grows under extreme seasonal conditions (6 - 44°C, 900 mm rainfall) on calcareous grayish-black soils. Based on its phylogenetic proximity to A. indica and membership in the biochemically rich Meliaceae family, we argue that this subspecies represents an urgent priority for comprehensive investigation. This review establishes a baseline of current knowledge, identifies critical research gaps across 12 domains, and provides a roadmap for future studies in taxonomy, anatomy, phytochemistry, pharmacology, and conservation.

Keywords: Azadirachta indica subsp. vartakii, Meliaceae, Review, Warud, Amravati, MS.

1. INTRODUCTION

1.1 THE GLOBAL SIGNIFICANCE OF NEEM

Azadirachta indica A. Juss., commonly known as neem, is native to the Indian subcontinent and has been cultivated across tropical and subtropical regions worldwide. The United States National Academy of Sciences (1992) published a landmark report entitled "Neem – A Tree for Solving Global Problems," reflecting its extraordinary potential. Neem produces over 300 secondary metabolites, including the well-known limonoid azadirachtin, which exhibits potent antifeedant, insecticidal, and antifungal properties (Kraus, 1995; Koul & Wahab, 2004). Traditional medicine systems in India, Iran, and China have utilised neem for centuries to treat malaria, peptic ulcers, intestinal worms, diabetes, inflammation, and dental caries (Biswas et al., 2002; Khare, 2007; Gupta et al., 2017).

Almost every part of the neem tree – seeds, leaves, roots, bark, trunk, and branches – has documented applications (Chaturvedi et al., 2003). Neem oil, rich in azadirachtin, is commercially used as a natural insecticide and pesticide (Boeke et al., 2004). Neem wood serves as fuel and is used in the construction of furniture, boats, and artefacts (Mitra, 1962; Anonymous, 1985).

1.2.THE PROBLEM OF ADULTERATION

Despite its medicinal importance, neem faces a significant challenge: adulteration with Melia azedarach L. (Chinaberry), a related species in the Meliaceae family. In herbal markets, across India and other countries, these two taxa (A. indica and M. azedarach) are often sold under the same trade name "Neem" due to morphological similarities (Ahmad et al., 2010; Khan et al., 2011). This misidentification compromises therapeutic efficacy and

poses safety risks because M. azedarach contains toxic compounds that are absent in A. indica. Authentic botanical identification, including morphological and microscopic characterization, is therefore essential for pharmacognosy (Ahmad et al., 2008, 2009).

1.3.DISCOVERY OF SUBSPECIES (A. INDICA SUBSP. VARTAKII)

Against this backdrop, Kothari, Londhe and N.P. Singh (1997) reported a new subspecies of Azadirachta indica from the Amravati District of Maharashtra, India, naming it Azadirachta indica subsp. vartakii. The subspecies was collected from Rani-Amravati village in Warud Tahsil and distinguished from the parent species by several consistent morphological characters. This discovery added a new endemic taxon to the Indian flora, but remarkably, no substantial research has followed in the subsequent 29 years.

1.4.OBJECTIVES OF THIS REVIEW

This review has three primary objectives: (1) to synthesise all available published information on A. indica subsp. Vartakii, (2) Theoretical Significance: Why this subspecies matters to identify critical knowledge, gaps across taxonomic, anatomical, phytochemical, pharmacological, and conservation domains; and (3) to provide a prioritized research agenda for future investigations.

2.TAXONOMIC STATUS AND MORPHOLOGICAL CHARACTERIZATION

2.1. FAMILY PLACEMENT

Both the parent species and the subspecies belong to the family Meliaceae, a family of flowering plants distributed throughout tropical and warm-temperate regions. The family comprises approximately 53 genera and 1,350 species (Bhattacharyya et al., 1998; Reveal et al., 1999). The Meliaceae is well-known for producing limonoids (triterpenoids) with insecticidal, antifeedant, and medicinal properties.

2.2. DISTINGUISHING MORPHOLOGICAL CHARACTERS

Based on the original description by Kothari et al. (1997), A. indica subsp. vartakii differs from the typical A. indica A. Juss. in the following characters:

Character	**A. indica**	**A. indica subsp. vartakii**
Leaf division	Pinnate	Pinnatisect (more deeply divided)
Rachis	Unwinged	Distinctly winged
Leaf base	Inequilateral	Equilateral
Leaf apex	Acute to acuminate	Linear acuminate
Inflorescence length	Shorter than leaves	As long as leaves
Inflorescence type	Panicle	Raceme
Drupe shape	Ovoid to ellipsoid	Smaller, oval-ellipsoid

These morphological differences were consistent across multiple collections and were considered sufficient for

subspecific rank. The subspecific epithet vartakii is dedicated in honor of the late Dr. V. D. Vartak, former Director of the Agharkar Research Institute (ARI), Pune, and Advisor for Environmental Protection. It recognizes his seminal contributions to plant taxonomy, the conservation of sacred groves, ethnobotany, and biodiversity protection in Western India.

2.3.DNA POLYMORPHISM

Kothari et al. (1997) studied DNA polymorphism supporting the subspecific distinction, though the specific molecular markers and analytical methods were described only briefly. No subsequent molecular studies have been conducted. The relationship of this subspecies to other Azadirachta species and to Melia azedarach remains unexplored using modern phylogenetic methods.

2.4 TAXONOMIC STATUS: CURRENT CONSENSUS

Azadirachta indica subsp. vartakii was recorded and collected from Warud Tehsil, Amravati District, Maharashtra, India. Voucher specimens were deposited at the Central National Herbarium, Botanical Survey of India, Kolkata (Accession Nos. BSI/CAL0000253810 and BSI/CAL0000253812) and the Herbarium of Dr. Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar, India (Accession No. 01406).

However, no recent taxonomic revision of the genus Azadirachta has included material of A. indica subsp. Vartakii. Its status as a true subspecies (rather than an ecotype or extreme morphological variant) awaits verification through common garden experiments and molecular phylogenetics.

3.GEOGRAPHICAL DISTRIBUTION AND HABITAT

3.1.LOCALITY AND RANGE

Subsp. vartakii is known only from the type locality: Rani-Amravati village, Warud Tahsil, Amravati District, Maharashtra, India. Subsequent surveys by Satpute (2017) confirmed its presence in Warud Tahsil but did not extend its known range. The subspecies is therefore classified as narrowly endemic – a taxon restricted to a single tahsil or similarly small geographic are

3.2.GEOGRAPHIC COORDINATES AND TOPOGRAPHY

Warud Tahsil lies between 20.30°N to 21.50°N latitude and 75.35°E to 78.27°E longitude. The tahsil forms the border between Maharashtra and Madhya Pradesh, with the northern boundary comprising the mountainous stretch of the Satpura Hills. This region is biogeographically significant as a natural corridor for wildlife between the Melghat Tiger Project (Maharashtra) and Pench National Park (Madhya Pradesh).

3.3.CLIMATE

The climate of Warud Tahsil is characterized by extreme seasonality:

Parameter	Value
Winter minimum temperature	~6°C
Summer maximum temperature	~44°C
Average annual precipitation	~900 mm
Precipitation pattern	Monsoon-dominated (June–September)

This climate imposes significant physiological stress on plants, including summer drought, high thermal load,

and winter chilling. These conditions likely shape the anatomical and physiological traits of A. indica subsp. vartakii

3.4. EDAPHIC CONDITIONS

The soil of the Warud region is calcareous, grayish-black, with varying depth and texture. The light soil occurring along the foothills of the Satpura Range is particularly characteristic of the
subspecies' habitat. Soil pH, organic carbon content, and nutrient status have not been systematically characterised.

3.5. ASSOCIATED VEGETATION

The Warud range forest area, a southern offshoot of the Satpura Range, supports diverse flora and fauna. However, no detailed phytosociological study has documented the plant community associated with A. indica subsp. vartakii. Such information would be valuable for understanding its ecological niche and for designing in situ conservation strategies.

4.CURRENT STATE OF KNOWLEDGE:

4.1. PUBLISHED LITERATURE:

Despite the subspecies being described in 1997, a comprehensive literature search (Web of Science, Scopus, Google Scholar, and Indian journals) reveals that only one research article exists specifically on A. indica subsp. vartakii – the original description by Kothari et al. (1997). No subsequent papers have addressed any aspect of its biology.

4.2. RESEARCH DOMAINS: UNEXPLORED VS. EXPLORED

We have categorised research domains relevant to A. indica subsp. vartakii as follows:

Domain	Status	Publications
Taxonomy (original description)	Explored	1 (Kothari et al., 1997)
DNA polymorphism	Partially explored	1 (Kothari et al., 1997)
Morphology	Explored	1 (Kothari et al., 1997)
Ethnobotany	Explored	1 (Satpute, 2017)

4.3. COMPARISON WITH PARENT SPECIES A. INDICA

In stark contrast to A. indica subsp. vartakii, the parent species A. indica has been the subject of thousands of publications. A partial list of topics studied in A. indica includes:

- Wood anatomy (Oyedeji Amusa et al., 2020; Nair, 1991)
- Leaf anatomy (Zin & Oo, 2011; Mensah, 2012)
- Vascular cambium and secondary xylem (Rajput & Rao, 2008)
- Somatic embryogenesis (Thengane et al., 1995; Singh & Chaturvedi, 2013)
- Micropropagation (Eeswara et al., 1998; Chaturvedi et al., 2004; Bello et al., 2022)
- Androgenic haploids (Chaturvedi et al., 2003)
- Cryopreservation (Chaudhury & Chandel, 1991)
- Seed germination (Chaney & Knudson, 1988; Dubey & Padwar, 2020)
- Phytochemical characterization (Saleem et al., 2018; Yang et al., 2018)

- Antibacterial, antifungal, antiviral, anti-inflammatory, antidiabetic, antimalarial activities (numerous studies)

6. THEORETICAL SIGNIFICANCE: WHY A. INDICA SUBSP. VARTAKII MATTERS

6.1.FOR CONSERVATION BIOLOGY

Narrow endemics like A. indica subsp. vartakii are disproportionately vulnerable to extinction due to habitat loss, climate change, and stochastic events. Understanding their biology is essential for effective conservation. A. indica subsp. vartakii serves as a flagship species for the Satpura Hills ecosystem – conserving it will conserve the entire habitat.

6.2.FOR PHARMACOGNOSY AND BIOPROSPECTING

The Meliaceae family is a proven source of bioactive limonoids. A. indica subsp. vartakii may produce novel compounds or higher concentrations of known compounds compared to A. indica. Its narrow endemism suggests possible unique chemical adaptations to local biotic and abiotic pressures.

6.3.FOR EVOLUTIONARY BIOLOGY

A. indica subsp. vartakii represents an incipient speciation event within the genus Azadirachta. Studying its morphology, anatomy, and genetic divergence from A. indica can illuminate speciation processes in tropical trees – a poorly understood area of evolutionary biology.

6.4.For Climate Change Research

The extreme climate of Warud (6–44°C) makes A. indica subsp. vartakii a potential model for studying plant adaptation to temperature extremes. Its anatomical and physiological traits could reveal mechanisms of thermal tolerance relevant to climate-resilient agriculture.

7.CONCLUSION

A. indica subsp. vartakii Kothari, Londhe & N.P. Singh is a scientific orphan. Described in 1997 from Rani-Amravati, Dist. Yavatmal, Maharashtra, and subsequently reported from Warud tehsil, Dist. Amravati has received almost no research attention in the intervening 29 years. Only a single publication exists that documents its morphology and DNA polymorphism. No anatomical, histological, phytochemical, pharmacological, or conservation studies have been conducted. The subspecies is narrowly endemic, grows under extreme seasonal climate, and is threatened by habitat loss.

This review establishes a baseline of current knowledge or, more accurately, the lack thereof. The subspecies' phylogenetic proximity to the globally significant neem tree, combined with its unique morphological characters and endemism, makes it a priority for comprehensive study.

REFERENCES

1. Ahmad, M., et al. (2008, 2009, 2010). Various journals.
2. Anonymous. (1980, 1985). Government reports.
3. Bello, A.M., et al. (2022). International Journal of Horticultural Science and Technology, 9(2), 237-245. Bhattacharyya, et al. (1998). Taxonomy of Angiosperms.
4. Biswas, K., et al. (2002). Current Science, 82(11), 1336-1345. Boeke, S.J., et al. (2004). Journal of Pest Science, 77(1), 1-11.
5. Chaney, W.R., & Knudson, D.M. (1988). International Tree Crops Journal, 5(3), 153-161. Chaturvedi, R., et al. (2003). Plant Cell Reports, 21, 531-537.
6. Chaturvedi, R., et al. (2004). Plant Science, 166(2), 501-506.
7.
8. Chaudhury, R., & Chandel, K.P.S. (1991). Indian Journal of Plant Genetic Resources, 4(2), 67-72. Dubey, S., & Padwar, G.K. (2020). International Journal of Current Microbiology and Applied Sciences, 9(8), 2718-2727.
9. Eeswara, J.P., et al. (1998). Plant Cell Reports, 17, 215-219. Gupta, S.C., et al. (2017). Phytomedicine, 34, 14-20.
10. Khan, S., et al. (2011). African Journal of Pharmacy and Pharmacology, 5(2), 198-204. Khare, C.P. (2007). Indian Medicinal Plants. Springer.
11. Kothari, M.J., Londhe, A.N., & Singh, N.P. (1997). Nelumbo, 39(1-4), 181-186. Koul, O., & Wahab, S. (2004). Neem: Today and in

the New Millennium. Kluwer. Kraus, W. (1995). In The Neem Tree (pp. 35-88). VCH.
12. Kshirsagar, S.R. (2013). International Journal of Bioassays, 2(12), 1515-1520.
13. Mensah, (2012). Research Journal of Botany, 7(1), 1-12.
14. Mitra, C.R. (1962). The Neem Tree. Indian Central Oilseeds Committee. Nair, N.C. (1988). Flora of India. Botanical Survey of India.
15. Nair, M.N.B. (1991). IAWA Journal, 12(3), 251-262.
16. Oyedeji Amusa, T., et al. (2020). IAWA Journal, 41(3), 275-298. Rajput, K.S., & Rao, K.S. (2008). Flora, 203(3), 228-236.
17. Reveal, J.L., et al. (1999). Botanical Review, 65(4), 321-333.
18. Saleem, S., et al. (2018). Phytotherapy Research, 32(7), 1241-1272. Satpute, S.V. (2017). Ph.D. Thesis, Sant Gadge Baba Amravati University.
19. Singh, M., & Chaturvedi, R. (2013). In Somatic Embryogenesis and Gene Expression. Narosa. Thengane, S., et al. (1995). In Somatic Embryogenesis in Woody Plants (Vol. 2, pp. 357-374). Yang, L., et al. (2018). Molecules, 23(4), 762.
20. Zin, T., & Oo, Z. (2011). Journal of the Myanma Academy of Arts and Science, 9(5), 1-12.