



Evolutionary Significance of the Deccan Intertrappean Flora: A Review of Modern Angiosperm Origins and Global Migration

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ABSTRACT

The Deccan Intertrappean beds of Central India preserve a high-resolution terrestrial archive of angiosperm diversification during the Late Cretaceous to Early Paleocene transition. This review synthesizes seminal paleobotanical investigations that have established the Indian subcontinent as a primary evolutionary "cradle" for several modern plant lineages. Critical records including the oldest known fossils of the rice tribe (Poaceae), the grape family (Vitaceae), the leaf-flower family (Phyllanthaceae), and the earliest record of the genus *Cocos* (Arecaceae) collectively underscore the role of the Indian Plate as a "biotic ferry." These findings provide robust evidence for the "Out-of-India" hypothesis, suggesting that Gondwanan lineages diversified in isolation during India's northward drift before dispersing globally following the collision with Eurasia. Anatomical evidence from these fossil assemblages indicates that complex, multi-stratal tropical evergreen forests thrived under humid, megathermal conditions amidst the episodic pulses of Deccan volcanism. These records serve as essential temporal anchors for molecular dating and remain vital for reconstructing the historical phytogeography of modern global floras.

Keywords: Deccan Intertrappean, Out-of-India Hypothesis, Maastrichtian-Danian, Angiosperm Evolution, Paleobiogeography.

INTRODUCTION

The Deccan Volcanic Province (DVP) of central and western India represents one of the most extensive continental flood basalt events in Earth's history, covering an estimated 500,000 km. Stratigraphically, the Geological Survey of India (GSI) categorizes these flows into several groups, including the Sahyadri, Amarkantak, Malwa, and Satpura groups. Within this volcanic framework, the Intertrappean bed sedimentary successions deposited during quiescent intervals between lava flows preserve a unique and high-resolution record of the biota inhabiting the Indian subcontinent during its northward drift. These beds offer critical insights into the 'Out-of-India' hypothesis, which proposes that several modern plant lineages originated or diversified on the rafting Indian Plate before dispersing globally following the collision with Eurasia.

Stratigraphic and Paleoclimatic Context

The Intertrappean sediments, primarily of Maastrichtian to early Paleocene age, consist lithologically of petrified black cherts, shales, and limestones. These deposits represent lacustrine to fluvial environments that supported complex, multi-stratal tropical forest ecosystems. Quantitative analysis using the Climate Leaf Analysis Multivariate Program (CLAMP) on Deccan leaf assemblages has predicted a Mean Annual Temperature (MAT) of 23.4°C $\pm$ 2.3°C and high relative humidity (approximately 75.6%), consistent with modern tropical wet evergreen to semi-evergreen forests.

Key Floral Lineages and the 'Out-of-India' Model

Recent palaeobotanical investigations have identified several "first records" that establish India as a primary centre for modern angiosperm diversification.

Phyllanthaceae: The Singpur Record

The discovery of *Phyllanthocarpon singpurensis* from the Singpur locality in Madhya Pradesh confirms the presence of the family Phyllanthaceae in India approximately 66 million years ago. As described by Kapgate et al. (2017), the fossil is a tricarpetate, septicidal capsule measuring 2.8 mm in diameter, possessing two ellipsoidal seeds per locule. The pericarp includes two main uniseriate layers composed primarily of columnar cells. This record provides a critical early calibration point for the euphorbioid clade within the Malpighiales and confirms the family's establishment in India well prior to its tectonic fusion with Eurasia.

Vitaceae: The *Indovitis* Record

The oldest known fossil evidence for the grape family (Vitaceae) is documented from the Deccan Intertrappean cherts. Manchester et al. (2013) described *Indovitis chitaleyae* based on immature fruits and isolated mature seeds featuring diagnostic paired ventral infolds and a dorsal chalaza, features characteristic of the order Vitales. This find pushes the vitaceous record back to the Late Cretaceous (Maastrichtian), approximately 10 to 15 million years before the India-Asia collision. This discovery serves as a cornerstone for the 'Out-of-India' hypothesis, suggesting a possible Southern Hemisphere origin for the family followed by Eocene radiation into the Northern Hemisphere.

Areaceae: Coastal Palms and Genus *Cocos*

The genus *Cocos* (coconut) is represented in the Deccan record by *Cocos binoriensis*, recovered from the Binori Reserve Forest in Seoni District. As reported by Srivastava and Srivastava (2014), this 3-dimensionally preserved drupe represents the world's oldest fossil record of *Cocos*. The fruit is ovoid with clearly visible longitudinal ridges and a fibrous mesocarp. Its occurrence alongside other mangrove elements like *Nypa* and *Sonneratia* confirms the proximity of a marine incursion or sea arm in central India during the K-Pg transition, indicating warm, humid coastal conditions.

Poaceae: Early Origin of the Rice Tribe

Traditional models of grass evolution were significantly revised following the discovery of phytoliths (microscopic silica bodies) within titanosaurid dinosaur coprolites from the Lameta Formation at Pisdura. Prasad et al. (2011) identified these fossils as belonging to the rice tribe, Oryzae (subfamily Ehrhartoideae), suggesting that the grass family had already achieved substantial diversification by the Late Cretaceous. These findings indicate that crown-group Poaceae were present in Gondwanan fragments before India's geographic isolation and challenge the earlier assumption that grasses were rare in Mesozoic ecosystems.

DISCUSSION AND SIGNIFICANCE

The collective evidence from these diverse lineages reinforces the role of the Indian Plate as a "biotic ferry". During its 35-million-year isolation, India acted as a refugium and a center of early diversification for modern angiosperm families. The "surprisingly modern" anatomical traits observed in Deccan woods, such as those discussed in the works of Metcalfe and Chalk (1950) and Chattaway (1939), highlight the importance of tropical environments in driving plant evolution. Furthermore, these records provide essential temporal anchors for molecular dating, proving that the roots of several modern global floras are found within the Deccan Intertrappean sequences of Central India.

Conflict of interest

The authors declare no competing interests.

Data Availability Statement: Not applicable.

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