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Avian Mutualism and Ecological Significance of Bryonia laciniosa (Shivlingi) in Indian Forest Ecosystems

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Abstract

Bryonia laciniosa (Linn.), commonly known as Shivlingi or Lollipop Climber, holds ecological importance beyond its ethno-medicinal value, functioning as a keystone resource for avian biodiversity in the Indian subcontinent. This study examines the specialised mutualism between the perennial climber and frugivorous bird communities, focusing on seed dispersal and forest regeneration. Shivlingi fruits, rich in lipids and carbohydrates, provide critical sustenance during post-monsoon lean periods when other forest resources are scarce. Avian digestive processes enhance germination by reducing seed dormancy through scarification and leaching, thereby ensuring population resilience. Field observations and literature synthesis reveal diverse dispersal strategies: the Red-vented Bulbul (Pycnonotus cafer) and Jungle Babbler (Turdoides striata) act as efficient generalist dispersers; the Indian White-eye (Zosterops palpebrosus) contributes to both seed dispersal and pollination; while the Brown Rock Chat (Oenanthe fusca) demonstrates opportunistic plant use despite its insectivorous diet. The extended fruiting season of Shivlingi (September-January) aligns with avian metabolic demands, underscoring its role in sustaining bird populations. However, habitat fragmentation and climate-induced shifts in fruiting phenology threaten this avian-plant collaboration, with potential consequences for forest regeneration and biodiversity stability. Conservation strategies must therefore extend beyond medicinal harvesting to include habitat protection and the preservation of avian diversity. By highlighting the reciprocal relationship between Shivlingi and birds, this study positions B. laciniosa as a culturally significant and ecologically indispensable species within India's forest ecosystems.

Keywords: Bryonia laciniosa (Shivlingi), Avian seed dispersal, Endozoochory, Phenological mismatch, Forest regeneration.

1. Introduction

Seed predation and dispersal are key ecosystem processes that affect plant reproduction and fitness (Schowalter, T. D., 2022). The intricate web of tropical and subtropical forest ecosystems is maintained by complex mutualisms between flora and fauna, among which the relationship between climbing vines and avian frugivores is vital. Bryonia laciniosa, a member of the Cucurbitaceae family, is primarily recognised in ethno-pharmacological contexts for its medicinal properties (Kadam, P. V., et al., 2023, Kaurav, H., et al., 2021).), Lollipop Climber (Bryonia laciniosa), popularly known as Shivlingi, is a

perennial climbing herb with a hairless stem that becomes thickened and white-dotted on the ridges when older. While it is extensively documented in Ayurveda and Unani pharmacopoeias for its aphrodisiac, anti-inflammatory, and febrifugal properties, the ecological standing of this plant as a resource, particularly regarding the unique morphology of its seeds, remains a burgeoning field of study (Fatima & Begum, 2023). Because Bryonia laciniosa is native to almost every corner of the Indian subcontinent, it has integrated deeply into local cultures and traditional medicine systems. This has resulted in a variety of regional names (Table 1) that often describe the unique lingam shape of the seed or the climbing nature of the vine.

Table 1 Vernacular Names of Shivlingi (Bryonia laciniosa) across Indian Languages (Durge, G. B., et al., 2025)

Language	Regional Name	Meaning / Origin
Sanskrit	Pastambhini, Bakapushpha, Shiva Mallika	Named after the Shiva Lingam shape of the seed.
Hindi	Gargumaru, Ishwara lingi, shivalingi	Widely used across the Hindi heartland.
Marathi	Shivlingi, Vaduballi	Often found in the Western Ghats and Sahyadri ranges.
Gujarati	Shivalingani	Used in traditional folk medicine in Gujarat.
Tamil	Iyaveli/Iyvirali	Found in the Eastern Ghats and scrub jungles.
Telugu	Lingadanda	"Linga" refers to the seed.
Kannada	Linga tondeballi, Lingatonde balli, Lingatonde, Shivalinga	Commonly found in the Deccan plateau regions.
Bengali	Shiva lingani	Named after the Shiva Lingam shape of the seed.
Malayalam	Neohmaka	Mostly found in the drier forest fringes of Kerala.

1.1. Morphological Adaptation for Avian Attraction

B. laciniosa is characterised by its slender, glabrous stems that utilise tendrils to ascend the forest understory, often reaching heights of 3 to 5 meters. The most ecologically significant feature of the plant is its globose fruit, which measures approximately 10-19 mm in diameter and contains 2-10 seeds, each about 7 mm in length, depending on the size of the fruit (Table 2). Initially green with distinct white longitudinal stripes, the fruit undergoes a dramatic chromatic shift to bright red or bluish-purple (Figure 1) upon maturity (Thakur & Puri, 2024). This phenomenon, known as ornithochory, is a specific evolutionary adaptation that signals ripeness to birds, whose visual spectrum is highly sensitive to red and ultraviolet wavelengths (Sekercioglu, 2006).

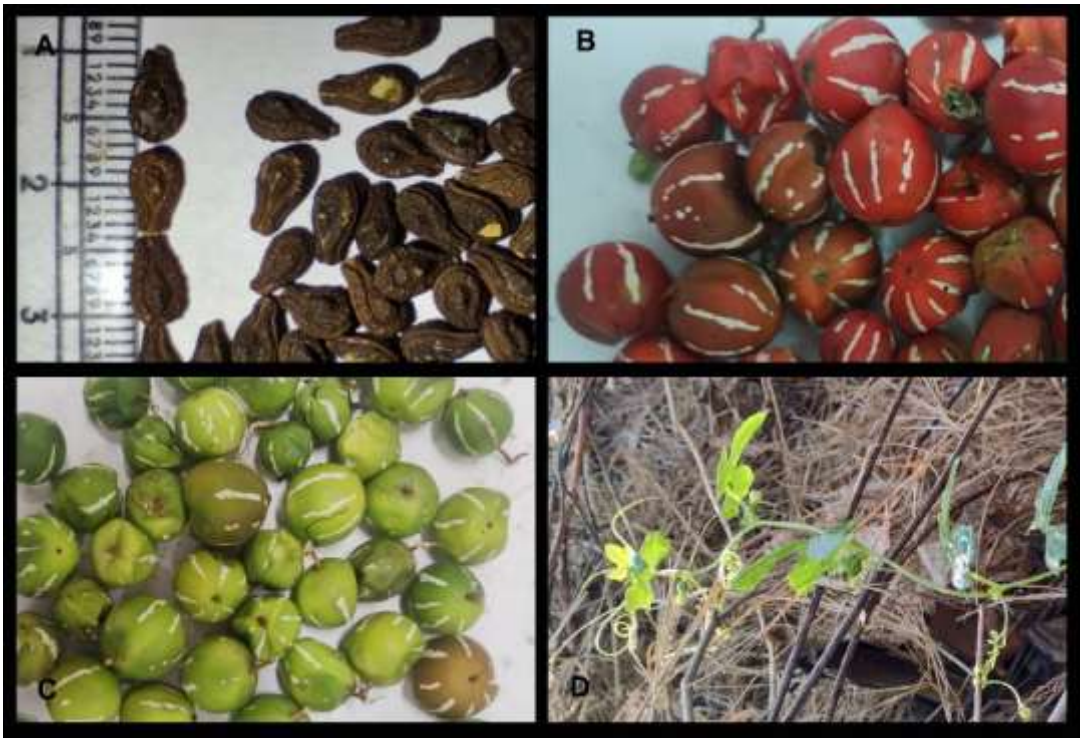

Figure 1. Fruit colouration as avian attractant - Morphological stages of Bryonia laciniosa (Shivlingi): (A) mature seeds with scale reference; (B) ripe white-striped fruits; (C) unripe white-striped fruits; (D) climbing vine with foliage in natural habitat.

Table 2. Morphometric characteristics of Shivlingi (Bryonia laciniosa) fruit: globose fruits measuring 10-19 mm in diameter, containing 2-10 seeds, each approximately 7 mm in length.

Number of Fruits	Size of the Fruit in Diameter	Number of Seeds in each fruit	Total number of seeds
10	19 mm	06-10	75
10	17 mm	04-06	48
10	14 mm	04-05	42
10	12 mm	02-04	41
10	10 mm	02-03	22

1.2. The Climber as an Ecological Keystone

In the deciduous and scrub forests of India, Shivlingi serves as a critical structural and nutritional component. As a climber, it creates dense tangles in the undergrowth, providing essential nesting cover and protection from predators for small passerine birds (Balasubramanian, 2012). Unlike many forest giants that fruit once a year, Shivlingi has an extended fruiting season that spans from the late monsoon to the early winter (September to January). This timing is crucial; it provides a high-lipid, moisture-rich food source during the "lean" period when many primary canopy trees are not in fruit, thus sustaining local bird populations through the transition into the colder months (YipiSale, 2022).

1.3. Functional Mutualism: Beyond Consumption

The interaction between B. laciniosa and the avian community is not merely predatory but a strictly functional mutualism. The plant produces a fleshy, nutrient-dense pulp to "pay" the birds for a vital

service: long-distance seed dispersal. Because the seeds are encased in a particularly hard, testa (seed coat), they possess an inherent physiological dormancy that prevents them from germinating under normal soil conditions. It is only through the specialised biological processing within the avian digestive tract involving mechanical abrasion in the gizzard and chemical leaching in the proventriculus that these seeds are primed for life (Nandhini & Shanthi, 2025).

Consequently, the spatial distribution and genetic health of Shivlingi populations across the Indian states from the Shivalik hills in the North to the Western Ghats in the South are directly proportional to the density and diversity of their avian partners.

2. Methods

This study employed a Systematic Literature Review combined with a Qualitative Meta-Analysis to evaluate the ecological relationship between Bryonia laciniosa and avian frugivores. Given the interdisciplinary scope - covering botany, ornithology, and biochemistry - the methodology was designed to integrate diverse data points into a cohesive ecological framework. In addition to literature-based analysis, field observations and fruit sample collection were carried out. Bird-watching activities were carried out in the campus of the Rajiv Gandhi Regional Museum of Natural History, Sawai Madhopur, Rajasthan, from July to December 2025 to provide localised field validation. Plant growth of Bryonia laciniosa was observed at 25 locations in the campus. Observations conducted at the Rajiv Gandhi Regional Museum of Natural History, Sawai Madhopur, demonstrated consistency with literature findings, thereby reinforcing confidence in the conclusions presented in this study.

3. Results

3.1 Shivlingi Plant as an Avian Food Resource

Observations of plant growth and birds' feeding habits coincide with the fruiting season of Shivlingi (Bryonia laciniosa), which typically extends from April to December and overlaps with the breeding and migratory cycles of several bird species. Red vented bulbul was found feeding during morning hours. The fleshy pulp of its fruits provides essential sugars and moisture, serving as a critical survival resource for small to medium-sized frugivorous birds such as bulbuls (Pycnonotus spp.) and barbets (Balasubramanian, 2012). Phytochemical analyses further indicate that Shivlingi seeds are rich in punicic acid, PA is also recognize as “Trichosanic acid” with molecular formula $C_{18}H_{30}O_2$ (Shabbir, et al., 2017) and glucomannan ($C_{24}H_{42}O_{21}$), providing high-energy lipids and carbohydrates necessary for avian metabolism (Thakur & Puri, 2024, Fang, et al., 2023).

The plant’s small, brightly pigmented fruits are specifically adapted for endozoochory, whereby birds consume the fruit and disperse the seeds through droppings. This adaptation attracting frugivorous birds classified as “seed gulpers.” Such behavior ensures that seeds remain intact during ingestion while undergoing biological priming in the gut, thereby enhancing germination success (Thakur & Puri, 2024). Ecological surveys at the Rajiv Gandhi Regional Museum of Natural History, Sawai Madhopur, identified several primary consumers. The Red-vented Bulbul (Pycnonotus cafer) emerged as the most frequent visitor, with its high metabolic rate and rapid gut transit making it an efficient disperser across varied forest strata (Sekercioglu, 2006). Jungle Babblers (Turdoides striatus) and Asian Koels (Eudynamys scolopaceus) supplement their diets with Shivlingi fruits during peak fruiting months, contributing to localized understory dispersal and long-distance seed movement, respectively. Smaller birds such as the Oriental White-eye (Zosterops palpebrosus) and the Common Myna, though less effective at swallowing

the larger seeds, aid in reducing fruit rot by pecking at the pulp (YipiSale, 2022). The Brown Rock Chat (Oenanthe fusca) interacts with Shivlingi primarily through habitat sharing and incidental foraging (Sharma & Tripathi, 2023). Importantly, gut passage in these species reduces seed coat thickness by 15-20%, significantly improving germination rates compared to manual planting (Thakur & Puri, 2024).

3.2 Avian Visitation and Consumption Dynamics

A systematic review and meta-analysis of ecological data highlight the co-dependent relationship between B. laciniosa and avian activity. The Red-vented Bulbul was identified as the most frequent "seed gulper," with a mean visitation rate of 4.2 visits per hour during peak morning foraging (Nandhini & Shanthi, 2025). Unlike "pulp-peckers" such as the Oriental White-eye, which damage fruits without dispersing seeds, bulbuls and barbets swallow fruits whole, ensuring seeds enter the biological priming cycle essential for successful germination.

3.3 Phenological Synchronization and Climate Risks

The reproductive success of Shivlingi is closely tied to seasonal rhythms, with fruits ripening in the post-monsoon months of November and December. This timing aligns with the high-energy requirements of resident birds preparing for winter and migratory species traversing the Indian plains. However, climate change poses a growing threat: erratic rainfall and rising temperatures are shifting fruiting windows, creating risks of "phenological mismatch." If fruits ripen outside the peak presence of specialized dispersers, mutualism may collapse, potentially leading to localized extinction of the plant and the loss of a vital high-lipid food source for birds during lean winter months (YipiSale, 2022).

3.4 Ethno-Ecological Conservation

The diverse regional nomenclature of Shivlingi-from Lingadonda in the South to Ishwarlingi in the North-reflects its deep cultural significance. Yet, traditional conservation practices have largely focused on harvesting seeds for medicinal use. This study emphasizes the need for landscape-level conservation strategies. Protecting thickets, hedges, and wastelands where Shivlingi thrives is essential, as these habitats sustain both the plant and its avian partners, ensuring the continuation of this critical ecological relationship.

4. Discussion

The ecological association between Bryonia laciniosa and Indian bird species demonstrates a finely balanced mutualism in which frugivores gain nutrition from lipid-rich fruits while simultaneously dispersing seeds that require gut passage to overcome dormancy. Field observations confirm that generalist dispersers such as the Red-vented Bulbul (Pycnonotus cafer) and Jungle Babbler (Turdoides striata) play central roles in regeneration, while the Indian White-eye (Zosterops palpebrosus) contributes both to seed dispersal and pollination, and the Brown Rock Chat (Oenanthe fusca) reflects opportunistic plant use despite its insectivorous diet. These varied strategies highlight the importance of avian diversity in sustaining Shivlingi populations across forests and human-shared landscapes, where perching and roosting sites facilitate seed deposition. However, the plant's dispersal dependence makes it vulnerable to habitat fragmentation and climate-induced shifts in fruiting phenology, which risk disrupting synchrony between fruit availability and bird activity. Without the biological priming provided by avian gut passage, natural regeneration would decline sharply, underscoring the need for conservation strategies that protect both Shivlingi habitats and the bird communities that sustain them.

5. Conclusions

Bryonia laciniosa is a culturally significant climber that functions as a keystone species within India's avian food web, sustaining frugivorous birds with its lipid-rich fruits during lean post-monsoon periods while relying on their gut passage to overcome seed dormancy and ensure regeneration. Field and literature evidence highlight the diverse roles of dispersers such as bulbuls, babblers, and white-eyes, whose feeding behaviors directly shape the plant's distribution across forests and human-shared landscapes. However, habitat fragmentation, overharvesting, and climate-driven shifts in fruiting phenology threaten this finely tuned mutualism, risking both plant decline and the loss of a vital food source for birds. Conservation strategies must therefore integrate habitat protection, preservation of avian diversity, and recognition of Shivlingi's dual ecological and cultural importance to safeguard forest resilience and biodiversity across the Indian subcontinent.

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