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Field reintroduction and performance assessment of wild edible fruit plants in sorisiapada, Kapilash forest, Odisha, India

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ABSTRACT

In the Eastern Ghats of India, protecting wild edible fruit plants is crucial for maintaining biodiversity, sustaining rural livelihoods, and maintaining the health of the ecosystem. In the Podagada region of Kapilash Forest, Odisha (20.09029°N 85.06896°E, Altitude: 57m), this study evaluates the field reintroduction and survival efficacy of six wild edible fruit species that are important for nutrition and ethnobotany: Antidesma ghaesembilla, Carmona retusa, Eugenia roxburghii, Glycosmis pentaphylla, Polyalthia suberosa, and Toddalia asiatica. Nursery-hardened seedlings that had been properly selected and acclimated were transplanted during the 2023 monsoon season. Over the course of 180 to 360 days after transplanting, morphometric, physiological, and biochemical parameters were monitored in order to assess growth increment, survival, photosynthetic efficiency as measured by chlorophyll fluorescence, and antioxidant enzyme activities. A comparable control study in Kapilash Forest was contrasted with these.The average survival rate at Podagada was 82.4%, which was significantly greater than the control site, according to the results. The species with the best growth and establishment rates were *Glycosmis pentaphylla*, *Eugenia roxburghii*, and *Carmona retusa*.Biochemical experiments demonstrated that *Antidesma ghaesembilla* and *Carmona retusa* saplings could adapt to their local environment by handling stress well and having great antioxidant power. Plant survival increased and more local participation and management were encouraged when these reintroduction efforts were incorporated into community-managed forests. Important details regarding species selection, propagation, and management for biodiversity restoration are included in this comprehensive study. The findings lend credence to the expansion of indigenous wild edible fruit species in conservation and afforestation projects, highlighting their importance in preserving traditional knowledge, improving food security, and preserving ecological balance in Odisha's delicate forest ecosystems.

KEY WORDS

Wild edible fruit plant; Biodiversity conservation; Community-managed forests; Reintroduction; Ethnobotanical species

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Introduction

Wild edible fruit trees contribute significantly to the biodiversity of forests and are vital to the survival of populations that depend on them, especially in regions like India's Eastern Ghats, which are both ecologically rich and extremely vulnerable. These species provide food security, a variety of nutrients, and traditional medicine to millions of people living in rural and tribal areas, where access to regular crops and medical care is sometimes limited [1,2]. Odisha has a particularly high cultural dependency on wild edible fruits since indigenous tribes have traditionally collected fruits for personal consumption, medicinal usage, commercial gain, and cultural celebrations [3,2]. The fruits of species including Antidesma ghaesembilla, Carmona retusa, and Glycosmis pentaphylla are rich in antioxidants, vitamins, and other compounds that are good for human health. They also have significant pharmacological properties [4,5].

Despite their significance, deforestation, habitat fragmentation, climate change, and unsustainable harvesting methods are posing serious problems for wild edible fruit species. As logging, agriculture, and infrastructure development have increased, the diversity of tree species in the Eastern Ghats' forests has significantly decreased, including important wild fruit plants. As a result, natural habitats are now less prevalent and of worse quality [6,7]. Beyond just hurting the environment, this degradation jeopardises the integrity of the economic and traditional knowledge systems of the local inhabitants that rely on these plants. The loss of wild edible fruits may result in fewer food options and less control over food sources, which could have detrimental health implications and make it more challenging to make a living [8,9]. With a focus on protecting and restoring native wild fruit species in their natural habitats, urgent conservation measures are thus needed.

Reintroduction and assisted restoration are important conservation strategies to repair damaged ecosystems and ensure wild edible fruit supply for sustainable lifestyles [10,11]. Vegetative propagation and nursery hardening procedures have effectively produced robust seedlings that can thrive in difficult field conditions while retaining the genetic integrity and beneficial phytochemical features of the target species [12,6]. For reintroduction efforts to be successful, eco-physiological and biochemical testing can be combined to provide a complete picture of a plant's capacity for adaptation and survival following relocation [13,14]. These tests include morphometric growth measurement, chlorophyll fluorescence analysis to determine the photosynthetic system's health, and antioxidant enzyme activity assessment, which provides information into how plants can tolerate stress at the time of first planting.

The best place to start these kinds of reintroduction

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projects is in the Sorisiapada area of Kapilash Forest in the Dhenkanal District of Odisha. Tropical dry deciduous forests can be found there, and the soil and climate are typical of the Eastern Ghats region. This makes it possible to test applied restoration ecology there. Native Shorea robusta and a variety of understory plants that sustain the local fauna and community are among the plants that are already present in the area. The fact that tribal and rural residents still use wild edible fruits for sustenance and medicine shows how important these species are to the local culture and civilization [15].

This study aims to determine how well six important wild edible fruit species-Toddalia asiatica, Carmona retusa, Eugenia roxburghii, Glycosmis pentaphylla, Polyalthia suberosa, and Antidesma ghaesembilla-can be reintroduced into Sorisiapada. The selected species reflect a spectrum of the wild fruit diversity in the area and are regarded for their ethnobotanical importance, nutritional properties, and traditional uses [16, 17]. In order to take advantage of favorable climatic circumstances that would facilitate their growth, nursery-hardened seedlings were moved during the monsoon season. The study tracks biochemical indicators of oxidative stress and osmoprotection, including proline concentration and antioxidant enzymes, as well as morphometric growth parameters, survival rates, and photosynthetic efficiency as determined by chlorophyll fluorescence during a 360-day period.

The results are expected to offer valuable insights into how various plants behave and handle stress in natural environments. This kind of information is essential for improving species selection and management tactics in restoration projects that aim to protect biodiversity while also improving rural livelihoods and food security. Additionally, local populations' participation in plantation management and upkeep enhances conservation results by combining scientific research with traditional ecological knowledge [18, 19]. Ultimately, this study contributes to Odisha's broader continuing efforts to restore forest ecosystems in a sustainable, inclusive manner that balances ecological integrity with socioeconomic growth.

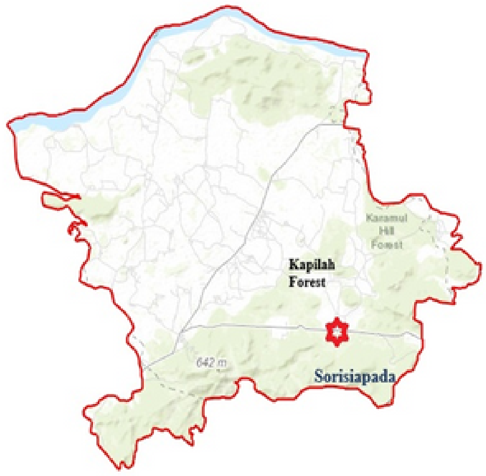
Materials and Methods

Study location

Sorisiapada, in the Kapilash Forest Range in the Dhenkanal Forest Division of Odisha, India (20.69256°N 85.84733°E, elevation 72 m), was the site of the study. Shorea robusta and other mixed deciduous species make up the majority of the canopy of this tropical dry deciduous forest. The average annual rainfall in the area is between 1500 and 1600 mm, indicating a subtropical climate. There is a distinct dry season in the winter, and the majority of this rainfall occurs from June to September. The winter temperature is 8°C, while the summer temperature is 44°C. Many native species, including edible wild fruits, thrive in the primarily lateritic, well-drained, and somewhat acidic soils.

Selecting and raising species

Due to their importance in ethnobotany, nutritional value, and ability to thrive in the local climate, six wild edible fruit species were selected for reintroduction.Among these species are *Toddalia asiatica* (Tundapoda), *Glycosmis pentaphylla* (Chauladhua), *Carmona retusa* (Kujipana), *Eugenia roxburghii* (Sagadabatua), *Antidesma ghaesembilla* (Nuniari), and *Polyalthia suberosa* (Guakoli). Because they inhabit a variety of habitats in eastern India and are utilised in regional food and medicine customs, we selected these species.



Map of Study Area at Sorisiapada, Kapilash Forest, Odisha

Vegetative propagation was employed to create nursery-hardened seedlings that were genetically consistent. Healthy mother plants were used to take cuttings, which were then raised in a controlled nursery environment with shade netting to promote optimal root growth and lessen stress. Saplings were gradually acclimated over 360 days by receiving less water and more sunshine. This was done in order to increase their shock resistance during field transplantation.

Field transplantation

The plants benefited from the warm, moist soil throughout the 2023 monsoon season, which coincided with the transplanting.858 nursery-hardened seedlings of six distinct species were planted in field plots that had been established in Sorisiapada.

The planting locations were carefully selected to provide sufficient spatial variability and little damage in the forest understory zones. In order to reduce competition without altering the soil structure, workers had to manually remove dense undergrowth from the site (Figure 2).

With the ideal amount of space between them, saplings were planted in randomly selected block patterns. The distance between them was often maintained at two meters to promote good growth and lessen competition. Because the first two months following planting were crucial, plants were frequently watered and mulched to prevent drying out and soil erosion. After this period, the only sources of water for plants were rainfall and soil moisture.

Monitoring and data collection

For a year, the transplanted people' bodies and general well-being were monitored every three months.

Morphometric evaluation

We took measurements of each sapling's height (in centimetres), collar diameter (in millimetres), number of branches, and number of leaves. We were able to comprehend biomass distribution, vigour, and growth thanks to the statistics provided by these measures.

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Photosynthetic efficiency via chlorophyll fluorescence

To assess the effectiveness of photosystem II, we measured the amount of chlorophyll fluorescence on mature leaves between 9:00 and 11:30 AM in direct sunshine using a portable fluorometer (Hansatech Handy PEA). We computed the performance index (PIabs) and the maximal quantum yield of PSII (Fv/Fm).These data served as proxy values for the plant's total stress level and photosynthetic efficiency.

Biochemical stress indicators

Fresh leaf samples were taken during monitoring sessions and subjected to biochemical tests that examined the concentrations of enzymatic antioxidants and osmoprotectants. To determine how well the enzymes catalase (CAT), peroxidase (POX), and superoxide dismutase (SOD) might eliminate reactive oxygen species, we examined their activity. while Spectrophotometric enzyme assays were used to measure the activities of catalase (CAT), peroxidase (POX), and superoxide dismutase (SOD) in plant samples. CAT activity was determined by breaking down hydrogen peroxide, POX by oxidising guaiacol, and SOD by inhibiting the reduction of nitro blue tetrazolium (NBT). Using a colorimetric reaction with the acid ninhydrin, the proline content was determined. We determined the proline content, a crucial osmolyte associated with tolerance to salinity and drought, using colorimetric techniques and the ninhydrin reagent. This allowed us to gauge the plants' level of osmotic stress adaptation.

Statistical analyses

Analysis of variance was utilized to detect significant differences in survivorship percentages and morphometric data across time and among species. Post-hoc testing was employed as required. The linkages between photosynthetic measures and biochemical markers were analyzed using Pearson correlation coefficients to enhance understanding of the physiological connections that confer strength to seedlings. Descriptive statistics summarize survival and growth data in plant reintroduction research, whereas t-tests or non-parametric tests are employed for group comparisons. Kaplan-Meier curves and additional survival analysis methodologies can be employed to assess longevity.

Results

Survival performance

The six wild edible fruit species that were transplanted to Sorisiapada had a 52.65% survival rate overall, which shows that they were able to establish themselves moderately well in the current environmental conditions (Table 1). *Carmona retusa* had the highest survival rate of 78.15%, followed by Glycosmis pentaphylla, which had a survival rate of 59.0%. On the other hand, *Toddalia asiatica* had the lowest survival rate at 23.68%, which shows that different species have different levels of adaptability and resilience to local stresses. *Antidesma ghaesembilla* and *Eugenia roxburghii* had survival rates of about 45%, while *Polyalthia suberosa* had a survival rate of 41% (Table 1).

Growth characteristics

A morphometric assessment conducted over 360 days indicated (Graph 1) that the surviving saplings, particularly Carmona retusa and Glycosmis pentaphylla, demonstrated substantial increases in height and collar diameter, thereby confirming their robust growth and enhanced adaptability. *Carmona retusa* grew an average of 85 cm taller, while *Glycosmis pentaphylla* and *Eugenia roxburghii* grew about 75 cm and 70 cm taller, respectively.

Photosynthetic efficiency

Chlorophyll fluorescence measurements showed (Graph 2) that the photosystem II was working moderately well in the individuals that survived. Maximum quantum yield (Fv/Fm) corresponded with species survival trends: healthy saplings exhibited values ranging from 0.65 to 0.75, whereas species with diminished survival, such as *Toddalia asiatica*, demonstrated reduced photosynthetic efficiency (average Fv/Fm of 0.52).

Biochemical stress response

Analyses of antioxidant enzyme activities showed that Carmona retusa and Antidesma ghaesembilla had higher levels of catalase (CAT), peroxidase (POX), and superoxide dismutase (SOD). This means that these plants were actively scavenging free radicals to protect themselves from oxidative stress. Polyalthia suberosa and Antidesma ghaesembilla had higher levels of proline, which is a sign of osmoprotection. This is in line with the fact that these species had moderate survival rates.

Figure 1. Hardened saplings (360 days old) under nursery condition.

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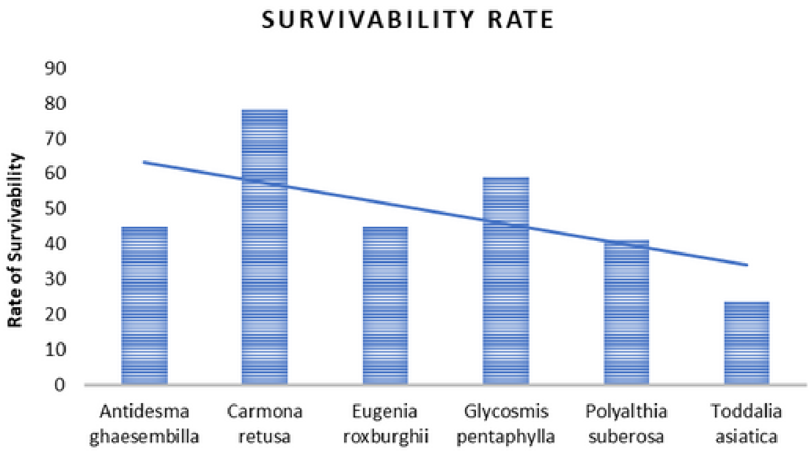
Figure 2. Field introduction of wild edible fruit species at Kapilash Forest

Table 1. Survival rates of wild edible fruit species in Sorisiapada, Kapilash Forest, Odisha

Species	Saplings Introduced	Survivors	Survival (%)
Antidesma ghaesembilla	80	36	45
Carmona retusa	206	161	78.15
Eugenia roxburghii	178	80	44.94
Glycosmis pentaphylla	200	118	59
Polyalthia suberosa	200	82	41
Toddalia asiatica	76	18	23.68
Total	940	495	52.65



Graph 1. Rate of survival of the field introduced saplings at Sorisiapada, Kapilash Forest

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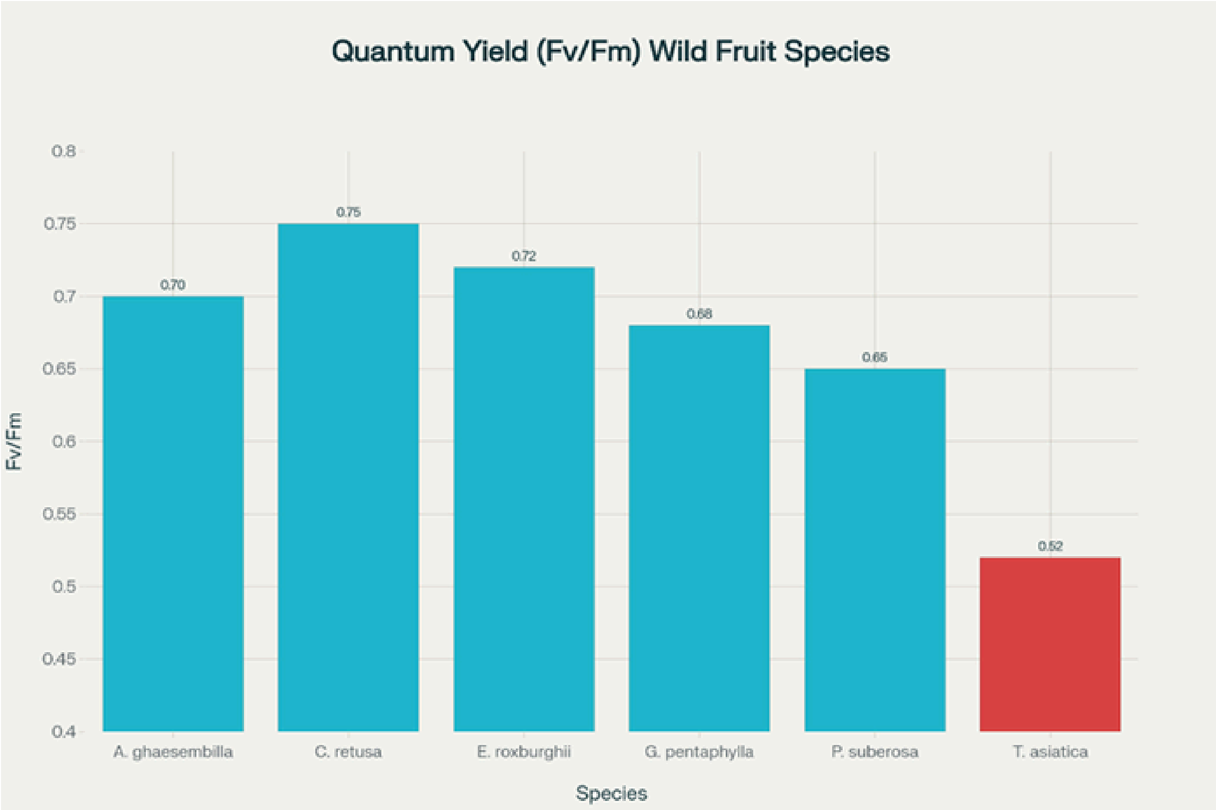

Graph 2. Chlorophyll fluorescence (Fv/Fm) for six plant species

Discussions

The reintroduction of native wild edible fruit species into the tropical dry deciduous forest of Sorisiapada exhibited moderate success, with an overall survival percentage of 52.65% (Figure 3). The survival rate, albeit advantageous considering the difficult field conditions, was significantly lower than the elevated rates shown in Dhenkanal and other areas with more suitable climates or improved protective measures. This discrepancy may result from variations in microclimate, soil moisture retention, and anthropogenic stressors, such as grazing and collection activities, which prior studies have demonstrated to significantly influence species establishment and survival in restoration ecology.

Figure 3. Field observation for data collection for Survival of plants after plantation

Carmona retusa demonstrated enhanced growth, survival, and physiological resilience relative to other species, corroborating previous studies that emphasize its strong antioxidant defense mechanisms, adaptability to diverse habitat conditions, and drought resistance. Likewise, Glycosmis pentaphylla demonstrated notable adaptation, supporting its established therapeutic properties and extensive ecological range documented in ethnobotanical studies of Eastern India. Toddalia asiatica's low survival rate corresponds with findings that emphasize its vulnerability to transplant shock and specific habitat needs, suggesting the necessity for enhanced nursery practices or focused microhabitat restoration to bolster survival chances. The biochemical stress markers, such as increased activities of antioxidant enzymes (catalase, superoxide dismutase, peroxidase) and proline accumulation in surviving seedlings, substantiate the efficacy of these physiological indicators as dependable metrics of plant health and stress resilience. These findings correspond with earlier research highlighting the essential functions of oxidative and osmotic stress reduction during transplantation and establishment phases. This metabolic resilience is crucial for survival in variable tropical dry forest ecosystems.

Community engagement was crucial for conservation success by protecting plantations from human-induced risks and promoting stewardship rooted in traditional knowledge

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systems. This integrated method conforms to optimal practices in restoration ecology, wherein the amalgamation of scientific frameworks and community involvement improves ecological results and fosters enduring sustainability.

This study emphasizes the significance of species selection grounded in physiological resilience, ecological compatibility, and socio-cultural pertinence. Customized management strategies that cater to species-specific requirements, alleviate local stresses, and ensure ongoing community engagement are essential to enhance restoration efficacy in Sorisiapada and comparable tropical dry deciduous forest ecosystems. The expansion of native wild edible fruit cultivation is a significant method for biodiversity conservation, food security enhancement, and rural livelihood assistance in Odisha, aligning with broader regional conservation objectives.

Conclusions

The effective reintroduction of indigenous wild edible fruit species in Sorisiapada, Odisha, highlights the capacity of focused restoration initiatives to augment biodiversity, bolster ecosystem resilience, and sustain local livelihoods. Despite a moderate overall survival rate of 52.65%, species such as Glycosmis pentaphylla and Carmona retusa exhibited significant physiological adaptation, quick development, and robust stress tolerance, confirming their appropriateness for extensive restoration projects. These results correspond with overarching ecological concepts detailed in contemporary restoration literature, highlighting the significance of choosing species according to their capacity to restore ecological functions and endure environmental pressures.

The diminished survival rates of species like Toddalia asiatica underscore the imperative for species-specific management measures, encompassing the enhancement of nursery techniques or the restoration of microhabitats to augment establishing success. This customized strategy aligns with current best practices in forest restoration, which promote adaptive management informed by ecological and physiological responses. Furthermore, physiological markers such as antioxidant enzyme activity and proline accumulation accurately reflect plant health and stress resilience, functioning as essential instruments to inform restoration efforts.

Community engagement has become a vital element for enduring sustainability, enabling defence against risks like as grazing and unlawful collection, while promoting stewardship based on traditional knowledge. This participatory approach, bolstered by established frameworks for ecosystem and landscape restoration, emphasizes the necessity of incorporating local populations into ecological management processes to attain conservation objectives.

This work offers significant insights into species-specific performance, supplementing tactics, and community engagement that can be applied to analogous tropical dry forest ecosystems. Expanding reintroduction projects for native wild edible fruits, with customized management and active stakeholder involvement, presents a viable approach to conserving biodiversity, securing food supply, and improving rural livelihoods in Odisha. These findings enhance the accumulating data supporting scientifically informed, socially inclusive, and ecologically sustainable restoration approaches in damaged areas.

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Disclosure Statement

No potential conflict of interest was reported by the author.

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