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Strategic reintroduction and eco-physiological assessment of wild edible fruit species in Podagada, Nayagarh forest, Odisha

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ABSTRACT

This study investigates the reintroduction and survival of six significant wild edible fruit species in the Eastern Ghats of India. The species were transplanted during the monsoon season in 2023, and their morphometric, physiological, and biochemical parameters were observed over 180 to 360 days. The results showed an average survival rate of 82.4% at Podagada, significantly higher than the control site. Carmona retusa, Eugenia roxburghii, and Glycosmis pentaphylla were the best at establishing themselves and growing among the species. Biochemical tests showed Carmona retusa and Antidesma ghaesembilla saplings had strong antioxidant power and could handle stress well, demonstrating their adaptability to the local environment. However, research on their field reintroduction success, adaptive physiology, and long-term survival in natural environments remains inadequate. Previous studies have primarily focused on ethnobotanical documentation, species distribution, and propagation methods in controlled settings, leaving a significant gap in understanding the performance of these species after transplantation into degraded forest ecosystems. The role of community involvement in sustaining these reintroduction initiatives is also insufficiently studied. A focused investigation on survival efficacy, physiological health, and community-based management of these species is crucial for developing effective strategies for biodiversity restoration and sustainable forest resource management in Odisha's Eastern Ghats.

KEY WORDS

Wild edible fruits; Eastern Ghats; Reintroduction; Survival efficacy; Biodiversity restoration

ARTICLE HISTORY

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Introduction

Wild edible fruit plants are a significant aspect of the biodiversity of forests, the way ecosystems work, and the social and economic life of rural communities, especially in regions like the Eastern Ghats of India. These species offer significant nutritional resources, encompassing vitamins, minerals, and antioxidants, which boost local diets and increase food security for populations relying on forests [1]. Wild edible fruits are not only beneficial for you to eat, but they also have cultural importance and are used a lot in traditional medicine to cure a wide range of health problems, including anaemia, respiratory problems, digestive disorders, and infections [2,3]. The ethnobotanical and pharmacological features of plants such as *Antidesma ghaesembilla*, *Carmona retusa*, and *Glycosmis pentaphylla* emphasise their critical contribution to community health and livelihood strategies [4,5].

These wild fruit trees are very important for the ecosystem and the economy, but they are in risk due of habitat loss, deforestation, and unsustainable harvesting [6]. The fast spread of agriculture, logging, and infrastructure in the Eastern Ghats has caused forest habitats to break apart and get worse, which has led to smaller populations and decreased genetic diversity in essential species [7]. The ensuing loss in availability threatens not only plant biodiversity but also the traditional knowledge and food sovereignty of indigenous and rural communities [8]. So, the best way to stop these tendencies is to utilise conservation strategies that focus on in-situ preservation and active restoration through the reintroduction of wild edible species. Reintroducing seedlings that have been raised in a nursery and hardened by vegetative propagation is a promising strategy to bring back populations in their natural habitats and repair ecosystems that have been destroyed [9]. Vegetative propagation preserves genetic fidelity and improves the vigour and survival rates of transplanted individuals, which is vital in tough field circumstances [10]. Also, integrating physiological and biochemical testing, including detecting chlorophyll fluorescence and antioxidant enzyme activity, enables us determine how well saplings adapt and endure stress after being transplanted, which gives us a sense of their prospects of surviving in the long run [11,12].

In this context, the Podagada area of the Nayagarh Forest Division in Odisha is an ideal spot to put these reintroduction efforts into action and evaluate them. Podagada is located in the tropical dry deciduous woods of the Eastern Ghats. It has a variety of microhabitats that provide the right climate and soil conditions for native wild edible fruit species to grow.Prior study underlines the ecological relevance of this location in conserving regional biodiversity and its dependency by local inhabitants on forest resources [13]. Following their reintroduction as nursery-hardened saplings in Podagada, this study aims to evaluate the survival, growth, and eco-physiological performance of six chosen wild edible fruit species: *Antidesma ghaesembilla*, *Carmona retusa*, *Eugenia roxburghii*, *Glycosmis pentaphylla*, *Polyalthia suberosa*, and *Toddalia asiatica* (Figure 1). The selection of species is determined by their perceived importance for local culture, medicine, and nutrition [14,15]. It is necessary to investigate morphometric growth, photosynthetic efficiency as measured by chlorophyll fluorescence, and biochemical indicators of stress adaptation such as proline accumulation and antioxidant enzyme activity. In addition to helping us develop conservation and restoration strategies that will preserve biodiversity and the well-being of people living in Odisha's

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forested areas the data will help us comprehend how different species adapt.

Antidesma ghaesembilla *Carmona retusa* *Eugenia roxburghii*

Glycosmis pentaphylla *Polyalthia suberosa* *Toddalia asiatica*

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

Materials and Methods

Study Area at Podagada, Nayagarh Forest Division

Study area

Podagada, Nayagarh Forest Division

Podagada, located in the Nayagarh Forest Division of Odisha, lies at 20.09029°N latitude and 85.06896°E longitude at 57 meters altitude. It is characterized by tropical dry deciduous mixed forests with predominant species like Shorea robusta and other native trees. The climate includes hot summers, humid monsoons with average annual rainfall of approximately 1500–1700 mm, and mild winters. The terrain supports well-drained lateritic soils, favorable for diverse native species growth.

The study was carried out in the Podagada area of the Nayagarh Forest Division (Figure 2) in Odisha, which is at 20.09029°N latitude and 85.06896°E longitude and 57 meters above sea level. The natural context of this location is mostly made up of tropical dry deciduous forests. The most frequent tree species are Shorea robusta and mixed deciduous trees that are common in the Eastern Ghats. The climate is sub-humid, with an average annual rainfall of roughly 1500–1700 mm, most of which occurs during the southwest monsoon. The temperature ranges from 8°C in winter to over 40°C in summer [13]. The soils in the area are lateritic and slightly acidic, which makes them excellent for native species to grow.

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

Antidesma ghaesembilla, *Carmona retusa*, *Eugenia roxburghii*, *Glycosmis pentaphylla*, *Polyalthia suberosa*, and *Toddalia asiatica* were chosen because they are significant for nutrition, medicine, and ethnobotany. These plants were selected due to their value to local populations as producers of food and traditional remedies, in addition to their biological functions in forest biodiversity [3,15]. To make sure that the saplings were true to type and had a greater chance of surviving after being relocated, vegetative propagation was used. To make nursery-hardened saplings, cuts and clonal multiplication were used in a controlled nursery setting. Over the course of 360 days, saplings were cared for by gradually reducing the quantity of water they received and increasing the amount of sunlight they received to get them adapted to being outside [6]. During the monsoon season of 2023, 858 seedlings were transported to the Podagada location. The chosen planting scheme made sure that the saplings were spaced out sufficiently to keep competition between and within species to a minimum.Before planting, the area was cleared of dense vegetation using low-impact manual methods to maintain the soil and keep microhabitats intact. The first 60 days of maintenance involved daily watering and mulching to help the plants get adjusted to their new environment. After that, the saplings were left outside in the weather and relied on natural rainfall [6].

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For 360 days after the seedlings were transplanted, they were monitored every three months. To measure growth, we recorded morphometric parameters like plant height, collar diameter, number of branches, and leaf count. We utilised a portable fluorimeter to monitor chlorophyll fluorescence to assess how well the plants were doing physiologically and how they reacted to stress. We looked at two important photosynthetic efficiency indicators: the maximum quantum yield (Fv/Fm) and the performance index (PIabs) [16].We also ran biochemical tests on leaf samples to determine the activity of antioxidant enzymes like catalase (CAT), peroxidase (POX), and superoxide dismutase (SOD), as well as to estimate the amount of proline. These molecular markers reflect how well plants can tolerate stress and how much oxidative stress they are under in the field [12].

The examination of the data involved a statistical comparison of the survival and growth rates of different species to find out which ones were more adaptive and better suited for large-scale restoration initiatives. Descriptive statistics are used to summarise survival and growth data in plant reintroduction studies, while t-tests or non-parametric tests are used to compare groups. Kaplan-Meier curves and other survival analysis techniques can also be used to evaluate longevity [16,17]. This offers a concise and useful assessment of the success of reintroduction. Using a mix of morphological, physiological, and biochemical approaches made it possible to completely analyse seedling performance, which is critical for picking the proper species for forest restoration in similar tropical dry deciduous forest systems[6].Working with local forest authorities and community members made it easier to manage and monitor the plantation, which kept people interested in conservation efforts.

Field experimentation

In the 2023 monsoon, 858 plants were transplanted in Podagada across sites designed with minimal disturbance.Regular care with watering and mulching was provided initially; subsequently, reliance was on natural monsoon rainfall. Plant observations conducted at 3-month intervals over one year.

Data collection

Morphometric metrics recorded included plant height, collar diameter, branching number, and leaf counts (Figure 3). Chlorophyll fluorescence (Fv/Fm and PIabs) measurements investigated photosynthetic performance, 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. In order to measure antioxidant enzyme activity and osmoprotectant levels, which represent the plants' stress responses and adaption processes, fresh leaf tissues were homogenised in the proper buffers and the enzyme extracts were then put through these tests.

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

Results and Discussions

Survival rate and overall establishment

The reintroduction of six wild edible fruit species in Podagada resulted in an overall high survival rate of 82.4%, suggesting excellent adaptation and establishment in the field habitat. The probabilities of survival were substantially different for each species. *Carmona retusa* had the best survival rate at 95.13%, followed closely by *Eugenia roxburghii* at 91.5% and *Glycosmis pentaphylla* at 90.86%. *Polyalthia suberosa* (80.51%) and *Antidesma ghaesembilla* (76.28%) showed moderate survival rates, while *Toddalia asiatica* had the lowest survival rate at 28.91%. These differences illustrate that each species may adapt to the local soil and climate circumstances (Table 1).

Carmona retusa and *Eugenia roxburghii* have a high survival rate, which fits with what has been reported about their ability to handle drought and heat. This makes them attractive candidates for large-scale restoration. The low survival rate of *Toddalia asiatica* may be attributed to its specialised habitat needs and how sensitive it is to being transferred.

Table 1. Survival Rate of Wild Edible Fruit Species in Podagada, Nayagarh Forest.

Species	Survival (%)
Antidesma ghaesembilla	76.28
Carmona retusa	95.13
Eugenia roxburghii	91.50
Glycosmis pentaphylla	90.86
Polyalthia suberosa	80.51
Toddalia asiatica	28.91

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Morphometric growth characteristics

Morphometric Growth Characteristics: Growth parameters were tracked over a one-year period to determine biomass accumulation and structural development post-introduction. The average height gain ranged from 40 to 90 cm across species, with *Carmona retusa* showing the greatest height rise, averaging 85 cm after 360 days. Collar diameter increments followed a similar trend, with *Eugenia roxburghii* and *Glycosmis pentaphylla* demonstrating substantial diameter growth (>3.5 cm increase), suggesting of vigorous vascular development.

Additional traits such as branch number and leaf count exhibited significant increases within the surviving population of each species, denoting healthy physiological development and Vigor. These growth trends underline the quick establishing capability of chosen species in Podagada's forest environments shown in (Figure 4).

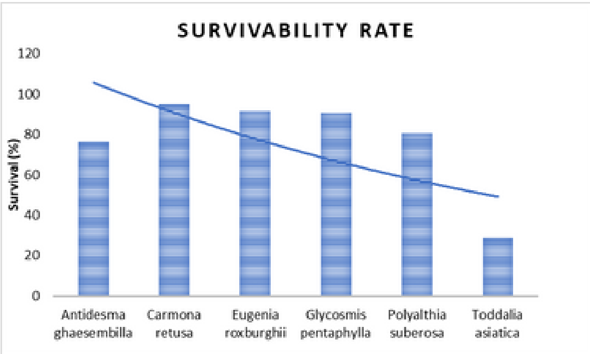

Figure 4. Rate of survival of the field introduced saplings at Nayagarh Forest.

Photosynthetic efficiency

Chlorophyll fluorescence measurements offered crucial insights into the functionality of photosystem II and the general health of the plant. The average maximum quantum efficiency (Fv/Fm) values for *Carmona retusa*, *Eugenia roxburghii*, and *Glycosmis pentaphylla* were between 0.70 and 0.75, which suggests the plants were healthy and not stressed [11]. The readings for *Antidesma ghaesembilla* and *Polyalthia suberosa* were lower but still acceptable (0.60–0.65). The values for *Toddalia asiatica* seedlings were lower (0.52) (Figure 5), which supports the hypothesis that they don't survive well. The performance index (PIabs), which integrates many fluorescence metrics, demonstrated once again that the species with better survival and growth had better photosynthetic performance. This supports the choice of these taxa for restoration success.

Figure 5. Chlorophyll fluorescence (Fv/Fm) and performance index (PIabs) for six plant species .

Biochemical stress markers

Biochemical investigations focusing on antioxidant enzymes and proline buildup revealed insights into sapling stress physiology.Activities of catalase (CAT), peroxidase (POX), and superoxide dismutase (SOD) enzymes were significantly enhanced in *Carmona retusa* and *Antidesma ghaesembilla*, showing active detoxification of reactive oxygen species (ROS) under field stress conditions.These enzymes decrease oxidative damage from drought, high temperature, and light intensity variations, contributing plant resilience.

Proline, an amino acid functioning as an osmoprotectant, accumulated in larger quantities in *Polyalthia suberosa* and *Antidesma ghaesembilla*, suggesting their capacity to endure osmotic stress.Conversely, *Toddalia asiatica* showed low enzymatic and proline reactions, which may explain its poor survivability. *Carmona retusa* led survival, while *Toddalia asiatica* demonstrated intermediate success.

Conclusions

The reintroduction of wild edible fruit species in Podagada, Nayagarh Forest, Odisha, has shown encouraging effects for biodiversity restoration and community advantage. High rates of survival and development, especially in *Carmona retusa*, *Eugenia roxburghii*, and *Glycosmis pentaphylla*, suggest that these plants can rapidly adapt to their circumstances. The physiological and biochemical tests showed that these species can handle environmental stress by using photosynthesis and antioxidants. Community involvement was particularly vital for keeping the plantation up and running and keeping an eye on it. This study highlights the relevance of choosing robust species and combining scientific approaches with local responsibility for sustainable restoration. The results support the idea of planting more native wild edible fruits in forest conservation efforts. This can benefit the ecology and the economy in rural regions while also keeping cultural knowledge alive. This model delivers helpful information for putting back similar forest ecosystems in Odisha and other areas.

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Disclosure Statement

No potential conflict of interest was reported by the author.

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