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Research article

Population Dynamics and Traditional Knowledge of the Siddha Medicinal Plant *Limonia acidissima* L in Savanadurga Forests, Karnataka, India

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Abstract: This study examines the population structure, regeneration patterns, and indigenous ecological knowledge related to *Limonia acidissima* in the Jodukatae site, Savanadurga Forests, Karnataka. The fieldwork, conducted in November 2012, involved the establishment of six 25 × 25-meter plots in areas known for medicinal plant harvesting. Within these plots, trees with a girth at breast height (GBH) greater than 30 cm were measured, and the population was analyzed based on size class distribution. Regeneration was assessed by counting younger individuals with a GBH of less than 20 cm within smaller 3×3-meter subplots. Additionally, semi-structured interviews and focus group discussions were conducted with local community members to gather information on the traditional uses of *L. acidissima* and the perceived changes in its population and forest conditions. The results indicate that the population structure of *L. acidissima* is dominated by mature trees, particularly in the 131-160 cm size class, suggesting a stable population in the study area. Regeneration data revealed ongoing recruitment, though the lower representation of smaller size classes may indicate challenges in maintaining long-term population sustainability. The indigenous ecological knowledge gathered from the local community highlighted the traditional medicinal uses of *L. acidissima*, which include treatments for anorexia, diarrhea, vomiting, cough, bronchitis, and cardiac debility. The integration of ecological data with traditional knowledge underscores the importance of conservation efforts aimed at sustaining *L. acidissima* populations and the traditional practices associated with its use. This study provides a comprehensive understanding of the ecological status and cultural significance of *L. acidissima* in the Savanadurga Forests, offering valuable insights for conservation strategies that incorporate both scientific and indigenous perspectives.

Keywords: Bangladesh, China, India, Lectotype, Myanmar, Nepal, *Polypodium ovatum*, Vietnam

Introduction

India is recognized as one of the top 12 mega-biodiversity countries globally. Among the 18 biodiversity hotspots identified worldwide, two are in India; The Western Ghats and the Eastern Himalayas. The Western Ghats, one of the nine bio-geographic regions of India, boasts a variety of tropical forests ranging from wet evergreen to scrub forests (Nayar, 1996). While many plants have potential medicinal value, only those with established medicinal uses are termed medicinal plants. India has a rich history of utilizing numerous medicinal plants for various purposes, contributing significantly to the global repository of medicinal flora (Kala and Sharma, 2009). This diversity is crucial not only for ecological balance but also for the cultural and medicinal traditions of the region (Rao et al., 2004). However, the sustainability of these medicinal plants is increasingly threatened by habitat loss, overharvesting, and climate change (Ravikanth et al., 2012).

Distribution and Description

Limonia acidissima L., also known as wood apple, is an Indo-Malaysian species thriving in tropical deciduous and scrub forests (Plate 1). In India, it is widespread across the warmer regions and is commonly planted throughout the tropical plains. This deciduous tree can grow up to 15 meters tall and is characterized by its dark brown, rough bark with deep vertical fissures. The tree bears pinnate leaves with 5-7 small, egg-shaped leaflets that have toothed margins and gland dots, emitted a strong aroma when crushed. The leaf stalk is winged, and the tree produces bisexual flowers, with male and female flowers borne separately on the same plant in loose panicles. The flowers are chocolate-brown and scented, leading to the development of spherical, woody berries. The persistence of old fruit and seeds on the ground aids in the identification of the tree (Reddy and Ugle, 2008).

Medicinal Uses

The bark, leaves, fruits, and gum of *L. acidissima* have been traditionally used to treat various ailments such as anorexia, diarrhoea, vomiting, cough, bronchitis, and cardiac debility. These uses highlight the plant's significant role in traditional medicine (Ved and Goraya, 2008).

Study area

Savanadurga state forest which is about 27 km² in area is located between Latitudes 12.847°and 12.945°N Longitudes 77.275° and 77.326°E. The elevation ranges from 800-1080 m. Dry and moist deciduous forest are dominant with scrub grass and rocks covering a large extend of and 77.326°E the south eastern and northern portion (Murali et al., 2003). There are significant numbers of pilgrims visiting a temple within the forest regularly. Savanadurga forests also have common mammal species like Sloth bear and leopard, another large herbivore Elephant. The study was conducted in a site Savanadurka State Forest, Karnataka. These provide contrasting human and ecological settings (Table 1). The communities were once pastoralist and now settled agriculturists; however, people continue to depend on non-timber forest products (NTFPs) such as Magadiberu (*D. hamiltonii*) Shigekai (*Acacia sinuata*), Baelada (*L acidissima*), Neem, (*Azadiracta indica*), *Asparagus racemosa*, *Gymnema sylvastre*, Wild honey, Tamarind (*Tamarindus indica*) and medicinal plants such as *Terminalia chebula*, *Terminalia bellerica* and *Emblica officinalis*. They collect mostly from throughout the forest areas.

Methodology

The field study was conducted in November 2012 at the Jodukatae site within the Savanadurga Forests of Karnataka, India. Six plots, each measuring 25 × 25 meters, were established in areas known for the harvesting of medicinal plants, including *Limonia acidissima*. These plots were selected to capture a range of microhabitats within the harvested areas, allowing for a comprehensive assessment of the population structure of the species. Within each plot, all trees with a girth at breast height (GBH) greater than 30 cm were counted and measured at 1.37 meters above ground level. This data collection facilitated the classification of trees into different size classes, providing insights into the population dynamics of *L. acidissima* in the study area. To assess the regeneration of, smaller subplots of 3 × 3 meters were laid within each of the larger 25 × 25-meter plots. These subplots were used to tally the number of younger individuals, defined as those with a GBH of less than 20 cm but a height of at least 50 cm. This approach allowed for a focused examination of the recruitment patterns within the species, particularly in areas subjected to medicinal plant harvesting. The regeneration data collected provided a critical understanding of the species' capacity to sustain its population in the face of harvesting pressures. In addition to the ecological survey, an assessment of indigenous ecological knowledge was conducted through semi-structured interviews and focus group discussions with local community members in Jodukatae. This qualitative approach aimed to gather information on the traditional ecological knowledge related to *L. acidissima*, including its distribution, harvesting methods, and the perceived changes in forest conditions. Community members provided valuable insights into the historical and current abundance of the species, as well as the factors influencing its regeneration and productivity. The integration of this indigenous knowledge with the quantitative data from the field surveys offered a holistic perspective on the conservation status *of L. acidissima* and the sustainability of traditional harvesting practices in the Savanadurga Forests.

Plate 1: Vegetative parts of *L. acidissima*

Flowering and Fruiting

Flowering of *L. acidissima* occurs from March to September. The observation of trees in full bloom during March in the Savanadurga National Forests underscores this flowering period. However, there

is a noted lack of regeneration in this area, which is a cause for concern regarding the species' sustainability (Reddy and Ugle, 2008).

Results

The population structure of *L. acidissima* at the Jodukatae site in Savanadurga Forests was analyzed based on the size class distribution of individuals with a girth at breast height (GBH) greater than 30 cm (Figure 1). The size class distribution provides insight into the demographic patterns and the recruitment status of the species in the study area. The size class distribution is categorized into five intervals: 70-100 cm, 101-130 cm, 131-160 cm, 161-190 cm, and 241-270 cm. Most individuals were found in the 131-160 cm size class, accounting for approximately 45% of the population. This indicates that the population of *L. acidissima* at the Jodukatae site is predominantly composed of mature individuals, suggesting a stable or mature population structure.The 70-100 cm size class represents about 15% of the population, followed by the 101-130 cm and 161-190 cm size classes, each comprising roughly 10% of the population. The smallest proportion of individuals is found in the 241-270 cm size class, making up about 5% of the population. The low percentage in the larger size class may indicate that there are fewer old or large individuals, potentially due to natural mortality or selective pressures.Overall, the data suggests that *L. acidissima* has a healthy representation in the mid-size classes, which may reflect favorable growth conditions and successful recruitment in the study area. However, the lower presence in the larger size classes could warrant further investigation to understand factors affecting the growth and survival of these trees in the Savanadurga Forests. This size class distribution pattern is typical of a population in a relatively undisturbed habitat, where younger cohorts are progressing to maturity while older individuals decrease in number.

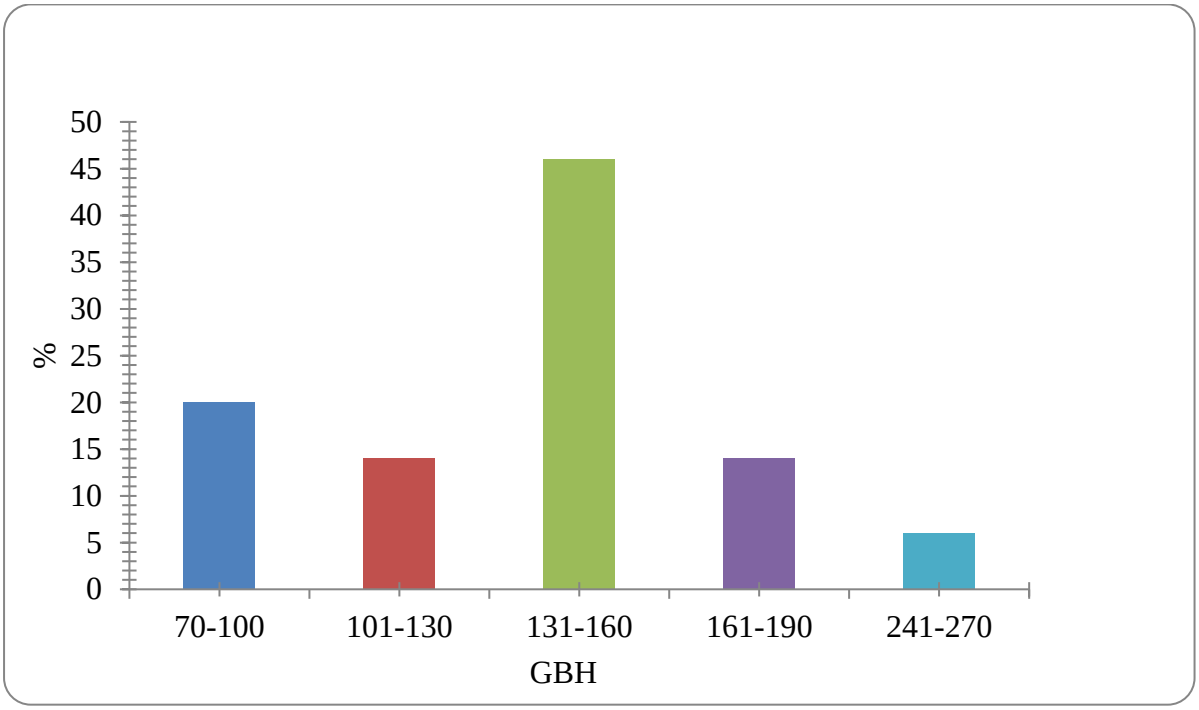

Figure 1**:** Population structure of L *acidissima* percent frequency refers to the relative density of individuals in different size – class (> 30 cm GBH) at Jodukatae site, Savanadurga Forests

Table 1. List of plant species found in Savanadurga Forest, India

Species	Family	Habit
Abrus precatorius	Fabaceae	Perennial Climber
Acacia leucophloea	Mimosaceae	Tree
Albizia amara	Caesalpiniaseae	Tree
Asparagus racemosus	Liliaceae	Climber
Azadirachta indica	Meliaceae	Tree
Butea monosperma	Fabaceae	Tree
Carissa carandas	Apocynaceae	Evergreen Shrub
Cassia auriculata	Caesalpiniaceae	Shrub
Chromolaena odorata	Asteraceae	Sub Shrub
Cipadessa baccifera	Meliaceae	Tall Shrub
Decalepis hamiltonii	Periplocaceae	Large Climbing Shrub
Dodonaea viscosa	Sapindaceae	Shrub
Gloriosa superba	Liliaceae	Vine
Helicteres isora	Sterculiaceae	Shrub
Hemidesmus indicus	Asclepiadaceae	Twining Herb
Lantana camara	Verbenaceae	Shrub
Limonia acidissima	Rutaceae	
Murraya koenigii	Rutaceae	Tree
Pterolobium hexapetalum	Caesalpinaceae	Armed Straggler
Randia dumetorum	Rubiaceae	Shrub
Terminalia paniculata	Combretaceae	Tree
Wrightia tinctoria	Apocynaceae	Tree
Ziziphus oenoplia	Rhamnaceae	Shrub

Discussion

The population structure of *L. acidissima* at the Jodukatae site in Savanadurga Forests reveals critical insights into the demographic trends and ecological status of this species within the region. The predominance of individuals in the 131-160 cm size class suggests that the population is currently

dominated by mature trees, indicating a healthy and stable population structure. This finding aligns with studies conducted in other tropical forests, where mid-sized trees typically constitute a significant portion of the population, reflecting successful recruitment and growth (Sukumar et al., 1992; Condit et al., 1998). The relatively low percentage of individuals in the larger size classes (>160 cm GBH) may reflect natural mortality, selective pressures, or anthropogenic impacts such as selective logging. Previous research has indicated that larger trees are often subject to increased risks due to environmental factors like storms, diseases, and human activities (Laurance et al. 2000; Wadsworth and Zweede, 2006). This could explain the observed decline in the number of larger individuals, suggesting that while the population is stable, it may be experiencing some pressure that limits the survival of older trees. Moreover, the presence of individuals in the smaller size classes (70-100 cm and 101-130 cm) indicates ongoing recruitment, which is essential for the long-term sustainability of the species. The relatively lower percentage in these classes compared to the dominant mid-sized class could suggest either a recent reduction in recruitment rates or high mortality rates among younger individuals. Recruitment patterns are crucial indicators of the resilience of forest species, and a balanced distribution across all size classes is often indicative of a regenerating population (Whitmore, 1990; Chave et al., 2003). The findings from this study are consistent with the general population dynamics observed in tropical forests, where tree species exhibit size-class distributions reflecting various ecological processes, including competition, disturbance, and successional stages (Richards, 1996; Poorter et al., 2008). The significant proportion of *L. acidissima* in the 131-160 cm size class could suggest that the species is in a phase of ecological stability, benefiting from favorable environmental conditions at the Jodukatae site. However, the observed pattern also raises concerns regarding the future of the population, particularly if the recruitment of younger individuals is insufficient to replace the mature trees as they age and die. Conservation efforts should focus on ensuring the continued regeneration of *L. acidissima* through protection of its habitat, prevention of over-exploitation, and monitoring of recruitment trends. This approach is supported by studies that emphasize the importance of maintaining a balanced size-class distribution for the long-term conservation of tree species in tropical forests (Slik et al., 2015; Wright et al., 2003).

Harvest Methods and Challenges

Quality harvesting involves collecting mature fruits known for their taste and medicinal value. Conversely, quantity-oriented harvesting focuses on collecting immature fruits, which can ripen later. The inaccessibility of young fruits at the branch tips often leads to the cutting of branches, thereby affecting the plant's regenerative capacity. For commercial purposes, the entire fruits are collected, leaving no seeds for natural germination, further exacerbating the regeneration issue (Reddy and Ugle, 2008).

Climate Change and Its Impact

Climate change poses an additional threat to the regeneration and sustainability of *L. acidissima*. Changes in temperature and precipitation patterns can alter the flowering and fruiting cycles, potentially reducing the viability of seeds and the overall reproductive success of the species. Moreover, increased frequency and intensity of extreme weather events, such as droughts and floods, can further hinder the

growth and regeneration of this species (Parmesan, 2006; Singh and Thakur, 2014). The Western Ghats, where *L. acidissima* is found, are particularly vulnerable to climate change. Alterations in the microclimate of these forests could lead to shifts in species composition and forest structure, affecting not only *L. acidissima* but also the broader ecosystem (IPCC, 2014).

Regeneration and Conservation

The size class distribution of *L. acidissima* in the fragmented forests of Savanadurga indicates poor regeneration. Studies have shown a low frequency of young trees and a higher frequency of intermediate-sized trees, with an absence of the 30-65 cm size class and higher girth classes (Figure 1). This pattern suggests inadequate regeneration, particularly outside study plots where seedlings and saplings are scarce. In the sampled area, there are only about 40 stems per hectare Conservation efforts are necessary to ensure the sustainability of *L. acidissima*, considering its medicinal importance and the challenges in its natural regeneration. Strategies should include controlled harvesting, habitat preservation, and possibly artificial propagation techniques to bolster its population. Additionally, addressing climate change through mitigation and adaptation strategies is crucial for the long-term survival of this species (Singh and Thakur, 2014).

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