Characteristics and habitat preferences of woody climber lianas on host trees in the Sumber Pawon Forest area, Kediri, East Java

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Abstract. Tropical forests differ from temperate forests in that they have woody climbing lianas, a diverse and prolific vegetation type. In the Sumber Pawon Forest, Kediri, East Java, this study examined the composition, quantity, and distribution of liana species in relation to host tree parameters as canopy cover, bark texture, and diameter at breast height (DBH). Purposive sampling was used to identify liana species by climbing mode: tendrils, twiners, branch twiners, root climbers, and leaners. The survey found 717 lianas from 19 species in 10 families. The most common family was Menispermaceae (37%), followed by Arecaceae (23%), and Piperaceae (16%). Three species have exceptionally high abundances: *Anamirta cocculus* (200 individuals), *Calamus* sp. (146 individuals), and *Piper* sp. (119 individuals). In the forest, twining lianas were the most common climbing mode. It was shown that a single host tree could maintain many lianas, suggesting that host tree traits affect liana growth and colonization. Spearman significance analysis showed that host tree bark texture, DBH, and canopy cover substantially affect liana abundance and distribution (p-values 0.00001, 0.0002, and 0.021). These findings show the ecological importance of host tree features in shaping liana communities, as well as the Sumber Pawon Forests' diverse liana population.

1 Introduction

Lianas, or woody climbing plants, are a prominent and ecologically significant component of tropical forests. Their presence contributes to the structural complexity and biodiversity of these ecosystems, distinguishing tropical forests from their temperate counterparts [1]. Lianas can contribute up to 35% of the woody species and up to 25% of all woody stems in lowland tropical forests, respectively [2]. Lianas use trees (apically dominant, self-supporting woody plants) for structural support to climb to the top of the forest canopy, thus reducing the amount of light that would have been otherwise available for trees. By connecting forest

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strata and competing with trees for light and other resources, lianas play a crucial role in shaping forest dynamics, influencing tree growth, mortality, and regeneration [1]. Despite their ecological importance, lianas have historically received less attention than trees in forest research, particularly in Southeast Asia, where comprehensive studies on their diversity and ecological interactions remain limited.

The distribution and abundance of lianas are influenced by a variety of biotic and abiotic factors, including climate, soil type, disturbance regimes, and host tree characteristics. Among these, host tree traits such as canopy cover, stem texture, and diameter at breast height (DBH) are particularly critical, as they directly affect the ability of lianas to establish, climb, and persist [3]. Different climbing mechanisms, such as twining, tendrils, root climbing, and leaning, also determine how lianas interact with their hosts and the forest structure [4].

In Indonesia, particularly in Java, studies on liana ecology are still emerging, despite the region's rich biodiversity and high conservation value. The Sumber Pawon Forest in Kediri, East Java, represents a unique lowland tropical forest ecosystem that has not been extensively studied regarding its liana flora. Hutan Sumber Pawon is a forest that has been utilized as a natural tourism area and part of the Strategic Environmental Area (KSLH), in accordance with Indonesian Government Regulation No. 15/2010. Sumber Pawon Forest is a protected area set aside to protect ecosystems, flora, and wildlife that are threatened or expected to become extinct and must be protected or preserved. These areas protect the balance of water consumption, which has the potential to result in annual losses, as well as the balance of the macroclimate [5]. Understanding the characteristics, compositions, and ecological preferences of lianas in this area is essential for informing forest management and conservation strategies, especially given increasing anthropogenic pressures.

This study aims to investigate the composition, abundance, and distribution of liana species in the Sumber Pawon Forest, with a specific focus on their climbing mechanisms and associations with host tree characteristics. By examining the relationships between liana abundance and host tree traits, namely canopy cover, stem texture, and DBH, this research seeks to elucidate the ecological factors that influence liana colonization and proliferation. The findings are expected to contribute to a deeper understanding of liana ecology in tropical forests and support efforts to preserve the structural and biological integrity of these ecosystems.

2 Materials and methods

2.1 Study Area

This research was conducted in the Sumber Pawon Forest, Kediri, located in Tempurejo Village, Wates, Kediri, East Java. The Sumber Pawon Forest is a lowland tropical forest (200-250 m.a.s.l.) with a mixed vegetation forest type and with an area of ± 13 Ha. The Sumber Pawon Forest has been made into an Alaska Natural Tourism Area because it has the attraction and uniqueness of natural objects with the presence of rubber trees (*Ficus elastica*) which are hundreds of years old. The Sumber Pawon Forest has the Pawon spring which used by local people for irrigation. The Sumber Pawon Forest has experienced habitat fragmentation due to land conversion into sugar cane fields. In this research, nine sampling points were based on the presence of lianas on the host tree (see **Fig.1**).

2.2 Field Work

2.2.1 Preliminary Survey

The preliminary survey includes preparing data collection tools and observing liana species on host trees. Its aim is to obtain information regarding route accessibility and location points for liana habitats on host trees. Route access information was obtained from the Sumber Pa-

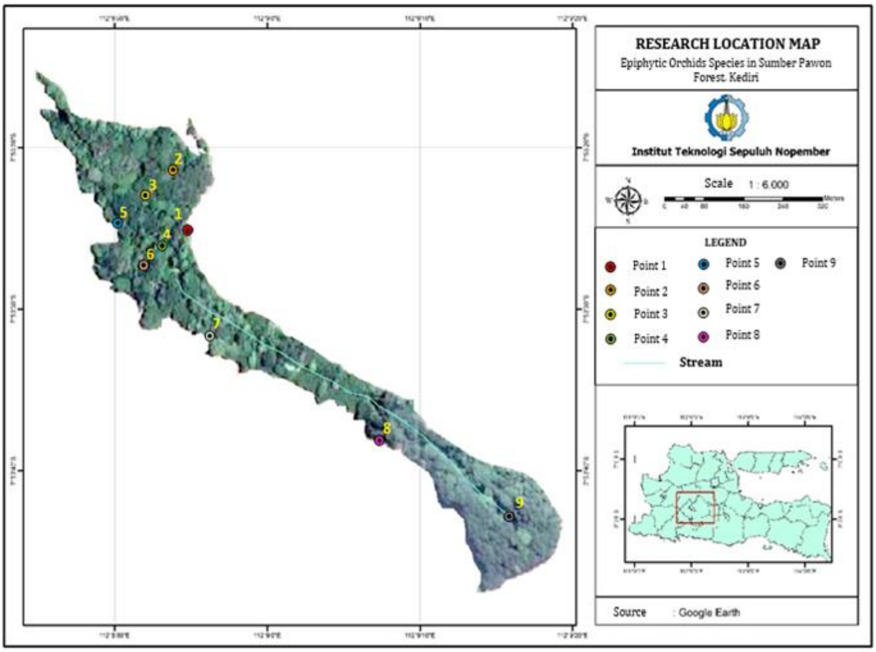


Fig. 1. Location map of data sampling in Sumber Pawon Forest, Kediri, East Java.

won Forest management by conducting direct scouting at the location and studying the location map via the Google Earth application to determine the topographic conditions of the research area. The results of this survey are the access routes that will be taken during research activities to determine the data collection method.

2.2.2 Lianas Data Collection on Host Trees (Vegetation Analysis)

The preliminary survey includes preparing data collection tools and observing liana species on host trees. Its aim is to obtain information regarding route accessibility and location points for liana habitats on host trees. Route access information was obtained from the Sumber Pawon Forest management by conducting direct scouting at the location and studying the location map via the Google Earth application to determine the topographic conditions of the research area. The results of this survey are the access routes that will be taken during research activities to determine the data collection method.

2.2.3 Observation and Identification of The Characteristics and Species of Lianas

The type of plot used is a systematic plot created for the identification of liana plant species along with their host trees [6]. Liana plant species are identified based on climbing mechanisms according to the literature by Sperotto et al. [4]. The identification of liana plant species and their host trees is carried out directly in the field. Liana plant species that cannot be directly identified will be recorded according to their morphology in the observation data form [8]. The identification of species names for liana plants refers to the National Museum of Natural History website on liana and climbing plants of the Neotropics. Host trees were identified directly in the field referring to Trees of Southeast Asia. The traits of liana plants examined in this study are categorized according to their climbing modes [4, 9], as detailed in **Table 1**.

Table 1. The mechanisms by which liana plants ascend involve various structures.

No	Climbing Modes	Characteristics
1	Tendrils	A type of liana plant has a specialized organ in the form of tendrils found on its stems
2	Twiners	Liana plants with stems that wrap around the supporting plant's stem
3	Branch Twiners	Liana plants with twisting branches usually do not have other structural modifications, except for general plant organs
4	Root Climbers	Climbing liana plants utilize additional organs in the form of roots on their stems to attach to supporting tree trunks.
5	Leaners	Leaner lianas have weak stems and rely on other plants for support. These plants lack particular characteristics for clinging to supporting plants. They climb without destroying or clinging to the support.

2.2.4 Determination of Host Trees Characteristic

The parameters of bark texture, trunk diameter, tree height, and canopy cover determine the characteristics of the host tree. The bark of each type of tree has distinctive patterns and physical properties. The texture of the trunk is determined by touching and feeling the surface of the host tree trunk, which is categorized as smooth or rough [10]. Trunk diameter is determined by DBH (diameter breast height) by measuring the circumference of the host tree trunk. Tree height was determined with the CGQ1 hagameter. Canopy cover is determined by analyzing the openness of the tree canopy with the GLAMA (Gap Light Analysis Mobile Application) application. Canopy cover is categorized into 4, including very closed (>75%), closed (51%-75%), open (26%-50%), and very open (0%-25%) [11].

2.3 Data analysis

2.3.1 Ordination Method

The ordination method was employed utilizing the CANOCO Windows 4.5 program. The tabulated data is organized to facilitate the calculation of the gradient length, serving as a basis for data modeling to identify either the linear or unimodal approach. If the length of the gradient result is less than 3, then the linear method is determined using RDA; if the result of the gradient is greater than 4, the unimodal method is determined using CCA. This approach facilitates the visualization of the connections between compositional variables and the abundance of species on the host tree of lianas. At each observation point, preferences for host trees are assessed based on various characteristics, including bark texture, trunk diameter, and tree canopy cover, along with the composition and abundance of lianas. The ordination results are represented in a distribution diagram using CanoDraw.

2.3.2 Correlation Test

The correlation analysis using SPSS 16.0 examined how host tree traits (bark texture, DBH, height, and canopy cover) affect liana abundance. Normality was tested first: data are normal if significance > 0.05, otherwise not. Pearson correlation was used for normal data; Spearman for non-normal data. A p-value < 0.05 indicated a significant relationship between variables.

3 Results and discussion

3.1 Composition and Abundance of Lianas in Sumber Pawon Forest, Kediri

This study revealed that a total of 717 individual lianas were identified. The data suggests that the liana present in the Sumber Pawon Forest comprises approximately 175 individuals/m2. **Fig. 2** below illustrates the prevalence of liana species exhibiting four distinct climbing modes.

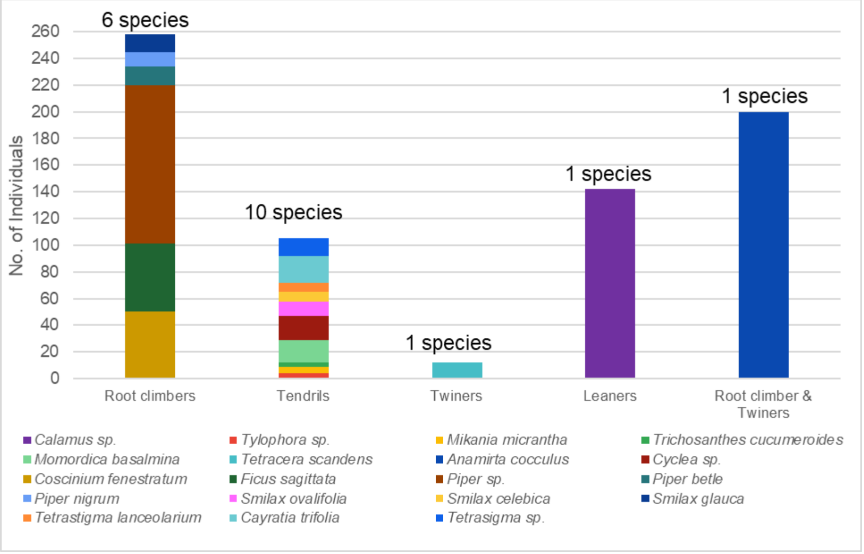


Fig. 2. Number of liana species based on climbing modes in Sumber Pawon Forest.

Fig. 2 shows that the tendril liana species is more numerous in the Sumber Pawon Forest than other lianas. Only one species possesses twiner, leaner, and root climber/twiner climbing modes. Sperotto et al. [4] divided climbing lianas into five types: tendrils, root climbers, twiners, leaners, and branch twiners. This study discovered four separate climbing strategies, as well as lianas that use both. The liana with twining branches is an unexplored climbing form. Tendril climbing species have the largest diversity (10 species), followed by root climber lianas (6 species).

According to the composition and prevalence of liana species detected in the Sumber Pawon Forest (refer to **Fig. 2**), *Anamirta cocculus* (200 individuals), *Calamus* sp. (146 individuals), and *Piper* sp. (119 individuals) are the most abundant (more than 100 individuals). *Trichosanthes cucumeroides*, on the other hand, had the fewest individuals identified, with only three. The environmental factors in a specific place may influence the changes in liana abundance observed there. Diana and Andani's study [11], done in the Wehea Protected Forest of East Kalimantan, revealed that changing levels of canopy cover have a substantial impact on liana abundance, with a notable increase in liana presence observed in regions with open canopy conditions. A subsequent experiment conducted by Hamidun within the lowland forest of Nantu Wildlife Sanctuary revealed that liana species belonging to the genus Calamus prefer lowland habitats over those at higher altitudes. This refers to the heat parameters in their cultivation environment [7]. According to a study conducted by Marhamah in Kalimantan, A. *cocculus* (yellow vine) is a liana species that thrives in lowland forests with high light intensity and medium canopy cover. A. *cocculus* the most prevalent species in the Sumber Pawon Forest, is a climbing plant from Southeast Asia and India [12]. The ability of this species to successfully dominate a vegetation or environment is determined by its rapid growth.

The liana species identified in the Sumber Pawon Forest is *Trichosanthes cucumeroides*, based on its distribution. This species is a liana plant found in tropical and subtropical regions, with its abundance recorded as the lowest in the forest. This species is documented to have its origins in Japan [13]. Given its limited presence, there is a hypothesis that this species may represent a failed introduction. Vivek et al. [14] indicates that not every foreign species introduced into an ecosystem qualifies as an invasive species. Within the Sumber Pawon Forest, T. *cucumeroides* is identified as a non-invasive introduced species.

3.2 Composition, Characteristics, and Preferences of Host Trees

All lianas documented in this study are associated with host trees, reflecting a strong ecological interdependence. Previous research by Simamora [8] indicates that lianas predominantly colonize trees within forest ecosystems, a pattern attributed to their climbing and twining behavior, which enables them to access sunlight in the upper canopy. A single host tree may support multiple liana individuals, thereby fostering competitive interactions among them. Host trees serve as critical structural and ecological supports for lianas, and their morphological and physiological traits can significantly influence liana growth dynamics. The host tree species identified in this investigation are presented in **Table 2**.

Table 2. Analysis of the Composition, Characteristics, and Preferences of Host Trees.

Families	Species of host tree	Bark texture	DBH (cm)	Canopy cover (%)	No.of liana individuals
Apocynaceae	*Alstonia scholaris*	rough	102.097	58.221	60
Apocynaceae	*Tabernaemontana macrocarpa*	smooth	22.850	46.631	62
Euphorbiaceae	*Endospermum peltatum*	smooth	27.925	46.702	50
Fabaceae	*Samanea saman*	rough	132.066	61.074	83
Lamiaceae	*Tectona grandis*	rough	21.576	45.983	33
Malvaceae	*Hibiscus tiliaceus*	rough	89.873	58.024	103
Meliaceae	*Swietenia mahagoni*	rough	41.435	48.116	83
Moraceae	*Castilla elastica*	smooth	112.898	60.025	41
Moraceae	*Ficus elastica*	smooth	139.101	60.424	60

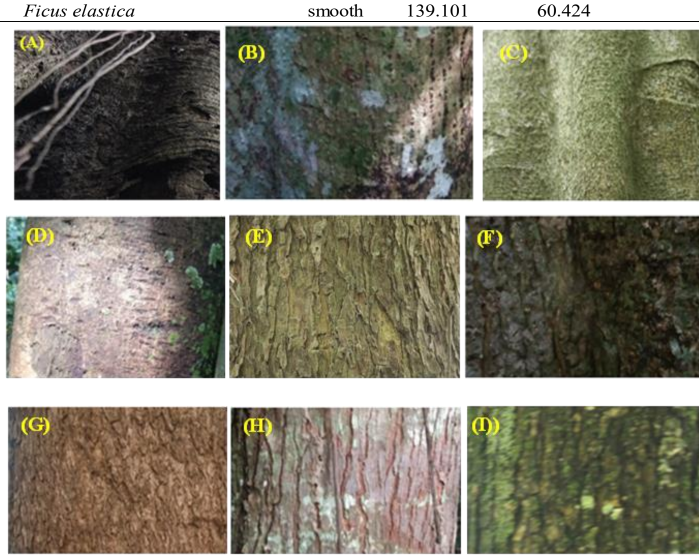
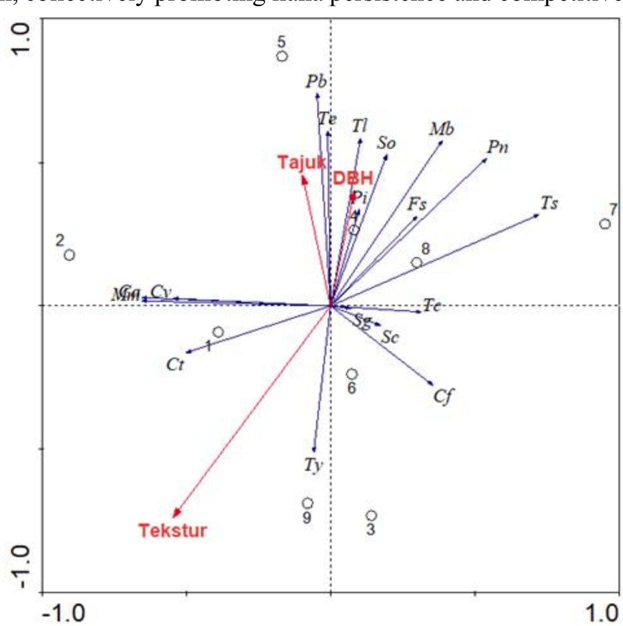


Fig.3. Image showing the texture of a liana tree trunk. Smooth bark texture (A–D): A. *Ficus elastica* (gray, grooved laterally, without gaps); B. *Tabernaemontana macrocarpa* (grayish, vertical grooves); C. *Castica elastica* (gray, smooth, branching marks); D. *Endospermum peltatum* (smooth, watery latex inside). Rough trunk texture (E-I): E. *Samanea saman* (greyish brown, rough, the bark is cracked to form long plates); F. *Alstonia scholaris* (rough, gray-white, grooved and cork-like texture); G. *Tectona grandis* (brownish-gray, slight longitudinal lines, fibrous); H. *Swietenia mahagoni* (reddish-brown, narrow and long cracks); I. *Hibiscus tiliaceus* (brownish-gray, narrow cracks, many lenticels) (Taken with a camera Canon 60D sigma 70-300 mm F/1.4-5.6 DG Macro Lens).

This study evaluates key host tree attributes: bark texture (rough or smooth), diameter at breast height (DBH), and canopy cover. Analysis (**Table 2**) indicates a positive association between DBH and canopy cover, reflecting structural complexity and branching architecture. This finding aligns with Vivek et al. [14], who reported that trees with greater DBH support larger crowns. The highest DBH was observed in *Swietenia mahagoni*, which exhibited a canopy cover of 60.42%, indicative of a dense canopy structure. Bark texture was assessed through tactile examination, and results show a marked preference of lianas for hosts with rough bark surfaces. Representative examples of bark texture are provided in **Fig. 3**.

3.3 Correlation of Liana Species Abundance with Its Distribution to Host Tree Characteristics

Lianas initially emerge as self-supporting plants but, due to their slender stems, rarely exceed 1.5 m in height [4]. To overcome this limitation, they develop specialized climbing structures such as adventitious roots or thorns that facilitate attachment to host trees [14]. This strategy underscores the strong ecological interdependence between lianas and trees. Simamora [8] reported that lianas predominantly colonize trees during the mature growth phase, when canopy light availability is greater than in earlier stages. By climbing, creeping, and twining around trunks, branches, and crowns, lianas optimize access to sunlight in the upper canopy [8]. In this study, host tree traits (bark texture, DBH, and canopy cover) were examined to assess their influence on liana establishment (**Fig. 4**). Rough bark provides mechanical anchorage, while larger DBH and dense canopy cover offer structural stability and enhanced light interception, collectively promoting liana persistence and competitive advantage within



Ca: *Calamus* sp.	Ts: *Tetracera scandens*	Ct: *Cayratia trifolia*
Ty: *Tylophora* sp.	Ac: *Anamirta cocculus*	Cf: *Coscinium fenestratum*
Mm: *Mikania micrantha*	Cy: *Cyclea* sp.	Fs: *Ficus sagittata*
Tc: *Trichosanthes cucumeroides*	Tl: *Tetrastigma lanceolarium*	Pi: *Piper* sp.
Mb: *Momordica basalmina*		Pb: *Piper betle*

Fig. 4. RDA (Redundancy Analysis) triplot graph showing liana distribution and preferences for host tree characteristics.

forest ecosystems.

Fig. 4 illustrates the correlation strength and direction among variables, where arrow length denotes magnitude, parallel arrows indicate positive association, and opposing arrows indicate negative association. Smaller angles between arrows represent stronger positive correlations. The analysis shows that Piper sp., Tetrastigma lanceolarium, and Smilax ovalifolia exhibit a strong association with tree DBH, likely due to their extensive branching patterns. Larger DBH provides structural support for these species, accommodating additional branches [14].

Spearman's non-parametric correlation analysis (**Table 3**) revealed a strong positive association between liana abundance and canopy cover ($r = 0.787$, $p = 0.021$). Although this correlation approaches unity, it is not statistically significant. Liana abundance also showed a significant positive correlation with host tree DBH ($r = 0.574$, $p < 0.05$). Bark texture exhibited a perfect correlation ($r = 1.000$, $p < 0.001$), indicating a highly significant relationship between rough bark and liana presence.

Table 3. P-value and correlation coefficient of host tree characteristics.

Host Tree Characteristic	p-value	Indicator	Correlation coefficient	Indicator
Bark Texture	0,00001	Statistical significance	1,000	Very strong correlation
Stem DBH	0,0002	Statistical significance	0,574	Strong correlation
Canopy Cover	0,021	Statistical significance	0,787	Very strong correlation

The canopy cover parameter shows that the species *Tetrasigma* sp. and *Piper betle* are positively correlated. Although not significant, the canopy cover of the Sumber Pawon Forest influences the growth of these two species. In addition to the non-parametric Spearman correlation test, a trend data visualization for the bark texture parameter was performed using the graph shown in **Fig. 5**.

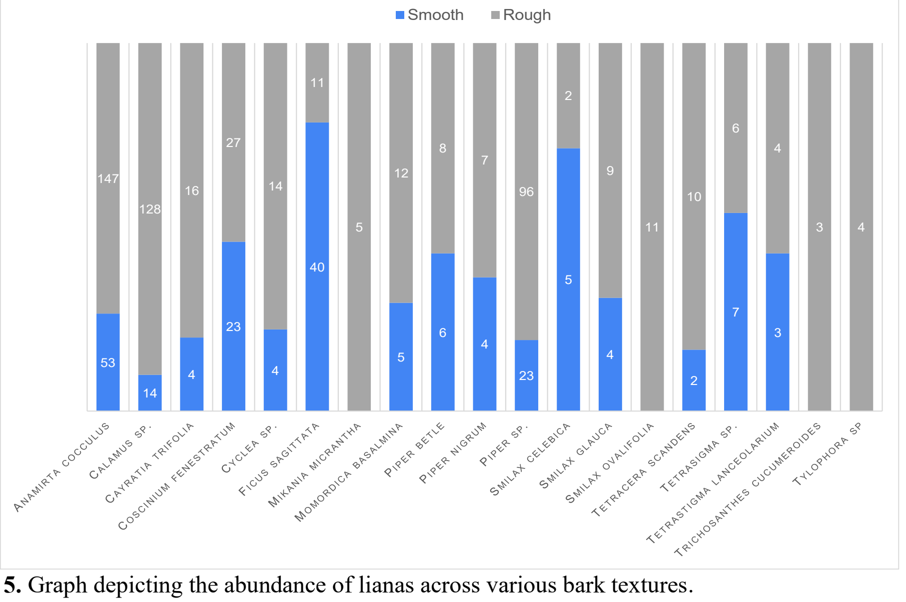


Fig. 5. Graph depicting the abundance of lianas across various bark textures.

The results illustrated in **Fig. 5** indicate that most of liana species identified in this study exhibit a preference for rough-textured tree trunks. The choice of host trees characterized by a rough bark texture showed no significant variation across numerous liana species.

Nonetheless, certain species display distinct variations. This is consistent with findings from Vivek et al., which suggest that liana plants prefer to grow on rough trunks. The preference for rough bark texture among lianas arises from the necessity for climbing roots and tendrils to secure themselves to the irregular surfaces of tree trunks [14].

3.4 Forest Management to Conserve Lianas in Sumber Pawon Forest, Kediri

This study identified both harmful and protective lianas. *Anamirta cocculus*, with its large stem and twining growth, can damage host tree trunks and is considered invasive in Sumber Pawon Forest, Kediri. Twiner lianas are generally more destructive than leaner types [14]. To protect the ecosystem, population control of A. *cocculus* is necessary not just by reducing numbers, but also by utilizing its medicinal potential. Research shows its stem contains alkaloids that inhibit Plasmodium, the malaria-causing microorganism [12].

Although lianas can be harmful, they also play important roles in forest ecosystems. Some species, such as *Piper betle*, *Piper* sp., and *Smilax ovalifolia*, use climbing roots and tendrils without damaging host tree trunks [14]. Their extensive branching helps stabilize fallen trees against strong winds. Lianas are also vital for biodiversity, contributing 25–30% of tropical forest species diversity [2, 6]. They influence carbon dynamics: studies in the Amazon show liana density increases with rising CO_2, indicating their role in CO_2 absorption. However, trees without lianas store about 280% more carbon than those with lianas, highlighting a complex relationship [10, 15]. To conserve lianas and their host trees in Sumber Pawon Forest, now surrounded by sugarcane fields and used for tourism, strict measures are proposed: banning logging, tree destruction, and sugarcane expansion within the forest. These actions aim to prevent habitat fragmentation and protect the ecosystem.

4 Conclusions

The study conducted in the Sumber Pawon Forest, Kediri, East Java, reveals a high diversity and abundance of woody climbing lianas, with 717 individuals representing 19 species across 10 families. The dominance of the Menispermaceae, Arecaceae, and Piperaceae families, along with the prevalence of twining climbing modes, underscores the ecological complexity of liana communities in tropical forests. The significant influence of host tree traits, particularly bark texture and diameter at breast height (DBH), on liana abundance and distribution highlights the role of host tree-liana interactions in forest structure and dynamics. Although canopy cover showed a weaker statistical relationship, its potential ecological relevance warrants further investigation. These findings contribute to a deeper understanding of habitat preferences and climbing strategies among lianas, offering valuable insights for biodiversity conservation and forest management in tropical ecosystems.

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