BIODIVERSITAS
Volume 26, Number 4, April 2025
Pages: 1511-1518

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d260402

Microhabitat preferences of vulnerable plants in the Genus *Saurauia* (Actinidiaceae) on the slopes of Talaga Bodas, West Java, Indonesia

DIANA HERNAWATI, RITA FITRIANI♥, RINALDI RIZAL PUTRA, DIKI MUHAMAD CHAIDIR
Department of Biology Education, Faculty of Teacher Training and Science Education, Universitas Siliwangi. Jl. Siliwangi 24, Tasikmalaya 46115, West Java, Indonesia. Tel./fax.: +62-265-330634, ♥email: ritafitriani@unsil.ac.id

Manuscript received: 31 October 2024. Revision accepted: 21 March 2025.

Abstract. *Hernawati D, Fitriani R, Putra RR, Chaidir DM. 2025. Microhabitat preferences of vulnerable plants in the Genus* Saurauia *(Actinidiaceae) on the slopes of Talaga Bodas, West Java, Indonesia. Biodiversitas 26: 1511-1518. Saurauia* is a genus of ecologically significant plants, with several species classified as vulnerable due to habitat degradation and environmental changes. Despite their conservation importance, studies on their habitat preferences remain limited, particularly in montane ecosystems. This study aims to investigate microhabitat preferences of *Saurauia* species on the slopes of Talaga Bodas, West Java, Indonesia, an area renowned for its rich biodiversity shaped by complex topography and montane ecosystems. This study focuses on examining essential environmental factors such as elevation, light intensity, temperature, humidity, and soil pH affecting the distribution and habitat preferences of these at-risk plants. Field surveys recorded the occurrence of *Saurauia* species in various microhabitats, which was subsequently analyzed using Canonical Correspondence Analysis (CCA) to clarify the connection between environmental factors and species distribution. Three species were identified including *S. microphylla* and *S. bracteosa*, both endemic in Java, and *S. cauliflora*, widespread in Java and Bali, and the IUCN Red List classifies all three species as vulnerable. According to the survey, clear microhabitat preferences were reported, including *S. cauliflora* which flourishes at lower elevations where light intensity is high and temperatures are warmer, *S. microphylla* occupies higher elevations that are cooler and more humid, while *S. bracteosa* shows adaptability to moderate conditions. This study provides critical insights into habitat needs, informing conservation strategies that enhance habitat diversity, ecosystem stability, and mitigate environmental pressures. Safeguarding the unique microhabitats of Talaga Bodas is essential for ensuring the long-term survival of these vulnerable plant species.

Keywords: Microhabitat, *Saurauia*, Talaga Bodas, vulnerable

INTRODUCTION

The genus *Saurauia*, belonging to the Actinidiaceae family, comprises various flowering plants predominantly distributed across tropical and subtropical regions (Pasaribu et al. 2020; Mazo et al. 2021; Daipan et al. 2022). These plants play a significant role in maintaining ecosystems health, contributing to biodiversity, and providing essential services such as habitat for wildlife, soil stabilization, and carbon sequestration. However, despite their ecological importance, many *Saurauia* species are facing an increasing risk of extinction. According to the IUCN Red List, several species within this genus are classified as vulnerable due to habitat loss, climate change, and anthropogenic disturbances (Helmanto et al. 2020a). A recent study reported that population of *Saurauia* species in Indonesia are experiencing significant population decline, with deforestation and land-use changes being the primary drivers (Daipan et al. 2022). This growing threat underscores the urgent need for research on their distribution, habitat preferences, and conservation strategies.

Talaga Bodas, a stratovolcano in West Java, represents an ecologically significant site due to its high plant diversity, unique volcanic soil composition, and varied microhabitats (Putra et al. 2019). Compared to other montane ecosystems in Indonesia, Talaga Bodas features a combination of geothermal activity, high precipitation, and steep elevation gradients, creating distinct environmental niches and supporting a wide range of plant species, including several vulnerable (He et al. 2023). These conditions make it an important location for studying plant adaptation and microhabitat specialization. Preliminary surveys have identified *Saurauia* species growing along the slopes of Talaga Bodas, yet the extent of their distribution, specific environmental requirements, and potential adaptations to volcanic conditions remain poorly understood. Understanding these factors is essential, as studies on tropical montane flora have demonstrated that changes in soil composition, moisture levels, and elevation range can significantly influence plant survival and regeneration (Barczyk et al. 2024).

Microhabitats are localized environments characterized by specific conditions, such as soil composition, moisture levels, and light intensity, which cater to the specialized requirements of certain species (Thakur et al. 2020). The unique montane ecosystem of Talaga Bodas presents a compelling area for examining microhabitat preferences of vulnerable plant species such as *Saurauia*. Studies have shown that plants in tropical montane environments exhibit strong preferences for specific microhabitat conditions, as these interactions significantly influence their growth, reproduction, and overall survival (Jones et al. 2011; Inman-Narahari et al. 2014).

Existing studies on microhabitat preferences among vulnerable plant species, particularly in tropical montane forests, highlight the important role of environmental gradients and niche specificity (Antúnez et al. 2023). For example, studies have shown that tropical montane plants are particularly sensitive to changes in environmental factors, including light availability, soil pH, and nutrient levels (Dalling et al. 2016). These studies suggest that understanding the microhabitat preferences of specific plant species is essential for effective conservation efforts (Kardiman et al. 2019). In the context of the Actinidiaceae family, it is shown that certain species exhibit strong preferences for specific light conditions and moisture levels, adapting their growth to microhabitat variations that provide an optimal combination of these factors (Helmanto et al. 2020a). While investigations on related genera within the Actinidiaceae family have made progress, specific studies focusing on *Saurauia* remain limited, underscoring a significant gap in this genus.

One of the few studies on *Saurauia* habitat preferences found that these species thrive in areas characterized by specific soil structures and nutrient profiles, suggesting that nutrient-rich, well-drained soils are important for their growth (Helmanto et al. 2020a). Furthermore, the unique topography and volcanic activity associated with Talaga Bodas create diverse microhabitats that could influence the distribution and abundance of *Saurauia*. The study by Vellend et al. (2021) emphasized the sensitivity of montane flora to microclimatic changes driven by elevation and slope orientation, suggesting that *Saurauia* species may exhibit specific adaptations to the conditions presented by Talaga Bodas's volcanic landscape.

Despite these results, no systematic study has been conducted to examine the microhabitat requirements of *Saurauia* species in the context of Talaga Bodas. This presents a crucial gap, as understanding the precise environmental conditions that support vulnerable species is essential for effective conservation and habitat management strategies. Therefore, this study aims to investigate the specific microhabitat preferences of *Saurauia* in Talaga Bodas by analyzing variables such as elevation, light intensity, temperature, humidity, and soil pH. By elucidating the preferences, this study will contribute to the development of targeted conservation strategies, potentially enhancing the resilience of *Saurauia* populations in this unique ecosystem.

MATERIALS AND METHODS

Study area

Talaga Bodas spans two districts in West Java Province, Indonesia, i.e.: Garut and Tasikmalaya. This study specifically focuses on the slopes of Talaga Bodas in Tasikmalaya District, which are part of a protected forest area managed under the status of watershed protection forest (*Hutan Lindung*) (Figure 1). The study site is situated at an altitude of approximately 861-1623 m asl, placing it within the montane forest zone. These slopes are characterized by diverse montane forest habitats, shaped by rugged terrain, varying elevations, and the unique composition of volcanic soils. The status as a watershed protection forest plays a crucial role in maintaining ecological stability, regulating water resources, and preserving biodiversity in the region. This location is particularly suitable for examining species adapted to montane ecosystems, as it provides a range of microhabitats that reflect the broader environmental diversity of the Talaga Bodas area.

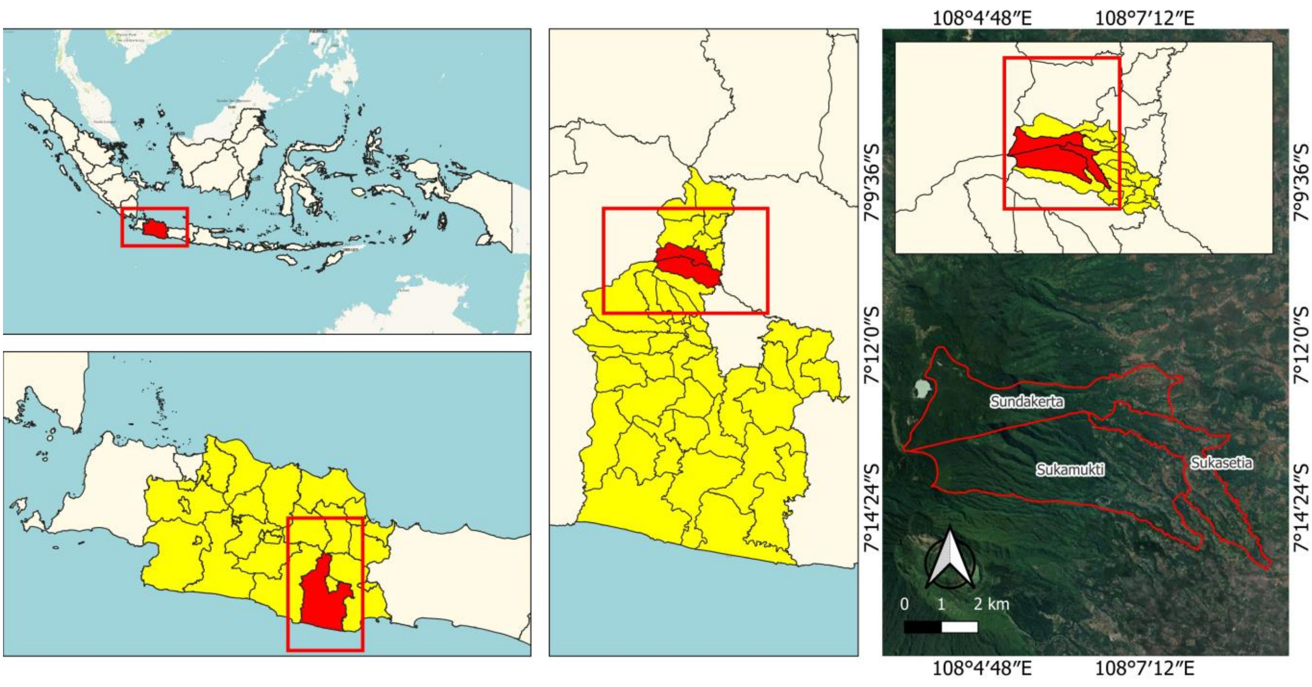

Figure 1. The study area is on the slopes of Talaga Bodas, West Java, Indonesia

Procedures

Field survey and species identification

A field survey was conducted from May to July 2024, spanning a total of 7 survey days and covering an approximate area of 20 kilometers. The survey aimed to identify *Saurauia* species across various habitats and assess their environmental preferences. During the survey, each encountered *Saurauia* individual was identified to the species level based on morphological characteristics with the help of local plant identification guides. Subsequently, species identification was verified using reference materials, and samples were collected if additional verification was needed. For each species encountered, the total number of individuals was recorded. This enumeration allowed for assessing the relative abundance of each *Saurauia* species in the various habitats studied. In addition, the geographical coordinates (latitude and longitude) of each observed individual were recorded using a Global Positioning System (GPS).

Measurement of environmental parameters

At each location where *Saurauia* species were encountered, specific environmental parameters were measured to determine the microhabitat preferences of these plants. The measured parameters included elevation, light intensity, temperature, humidity, and soil pH, as these factors are known to influence the growth and distribution of tropical plant species. Subsequently, elevation was measured using a GPS device with an accuracy of ±5 meters and recorded for each encounter of *Saurauia* species to capture altitudinal variations in species distribution. A handheld light meter was used to measure light intensity in lux at each *Saurauia* encounter site, representing the ambient light conditions. This measurement was taken during daylight hours at each location to assess variations in canopy cover and light exposure. A digital thermo-hygrometer was used to measure the ambient temperature (°C) and relative humidity (%) at each site. To ensure consistency, measurements were recorded during morning and afternoon surveys to capture typical temperature and humidity ranges at each site where *Saurauia* species were encountered. Soil samples were collected at the surface level (0-10 cm depth) near each *Saurauia* individual encountered and analyzed on-site using a portable pH meter. Soil pH provides a better understanding of the acidity or alkalinity of the substrate, an important factor for nutrient availability and plant growth.

Data analysis

Descriptive statistics were calculated for the environmental parameters across all surveyed locations, providing an overview of the average range of conditions (elevation, light intensity, temperature, humidity, and soil pH) associated with *Saurauia* species. In addition, the encounter frequency of each *Saurauia* species was recorded and analyzed to assess their relative abundance in the Talaga Bodas area. To examine statistical differences in these environmental factors among *Saurauia* species, a one-way ANOVA test was conducted with a significance level of α: 5% (0.05). This analysis aimed to determine whether the observed variations in environmental conditions were statistically significant among the different *Saurauia* species. To explore the relationship between *Saurauia* species distribution, encounter frequency, and the measured environmental parameters, Canonical Correspondence Analysis (CCA) was applied. CCA is a multivariate statistical method that enables the evaluation of correlations between species occurrences and environmental gradients, which helps to clarify the microhabitat preferences of each species (Zhuang et al. 2020). The resulting ordination plot displayed both species and environmental variables, allowing for a visual representation of which factors were most influential in determining microhabitat preferences of *Saurauia* species in Talaga Bodas.

RESULTS AND DISCUSSION

***Saurauia* species found**

This study identified three *Saurauia* species on Talaga Bodas, including *Saurauia microphylla* de Vriese (22 individuals), *S. bracteosa* DC. (4 individuals), and *S. cauliflora* Noronha ex DC. (3 individuals). Out of these, *S. microphylla* and *S. cauliflora* are endemic to Java, meaning they are naturally found only in this region. This endemism underscores the ecological significance and limits geographical range, as these species have evolved specifically in Java's unique montane ecosystems. The restricted distribution of these species increases vulnerability to habitat loss and environmental pressures, highlighting the critical need for conservation efforts in their native range. Despite its rarity, *S. bracteosa* inhabits both Java and Bali, offering it a slightly wider range than the other two species. However, due to its dependence on specific montane habitats increasingly threatened by land use changes and habitat fragmentation, *S. bracteosa* faces similar conservation challenges.

According to the IUCN Red List, all three species have been classified as vulnerable, reflecting the ongoing pressures they face due to their limited distribution and habitat specialization. Recognizing their vulnerable status emphasizes the importance of habitat conservation and restoration efforts to ensure the survival of these species. Pictures of each species are presented in Figure 2.

Microhabitat characteristics

To understand the specific conditions favoring the presence of *Saurauia* species, various microhabitat characteristics were recorded at each site where the plants were found. These included elevation, light intensity, temperature, humidity, and soil pH, factors that contribute to defining the ecological niche of each species. These parameters were recorded at each study location and displayed in Table 1 to allow for clear comparisons between microhabitats of *S. microphylla*, *S. bracteosa*, and *S. cauliflora*. This tabulated data offers a foundational understanding of the microhabitat preferences of each species, which is essential for effective conservation and habitat management strategies.

Table 1. The results of measurement data of environmental parameters in Talaga Bodas, West Java, Indonesia

	Environmental parameters	*Saurauia microphylla* (n: 22)			*Saurauia bracteosa* (n: 4)			*Saurauia cauliflora* (n: 3)			ANOVA test (α: 5%)
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
The slopes	Elevation (m asl)	1278	1623	1460.5	1058	1366	1276	861	893	879	0.000
	Light intensity (lux)	122	9840	1226.06	436	3192	1514.75	949	6728	4060	0.106
	Temperature (°C)	21.2	27.1	23.4	23.2	23.7	23.375	26.6	28.5	27.63	0.000
	Humidity (%)	74	89.1	83.04	74.4	87.3	83.425	69.2	77.1	72.33	0.003
	Soil pH	4.7	7	6.36	5.1	6.7	5.95	6.1	6.3	6.23	0.649
High elevation	1720 m asl										
Middle elevation	1400 m asl										
Low elevation	800 m asl										

Figure 2. Front and back view of flowers. A. *Saurauia microphylla*; B. *Saurauia bracteosa*; C. *Saurauia cauliflora*

Although this study was conducted on the slopes of Mount Talaga Bodas, the recorded environmental parameters allow for comparisons across high (1720 m asl), middle (1400 m asl), and low (800 m asl) elevations of Talaga Bodas. These comparisons provide a broader perspective on how elevation influences microhabitat conditions. The observed variations in temperature, humidity, and vegetation structure across elevations reflect the ecological gradients that shape species adaptation and habitat preference. At high elevations, lower temperatures, higher humidity, and dense vegetation create a more stable and shaded microhabitat, potentially favoring species adapted to cool and moist conditions. The middle elevation represents a transitional zone with more fluctuating microclimatic conditions, allowing for potential species overlap. In contrast, the low-elevation sites tend to be warmer, with lower humidity and more open vegetation, which may restrict species that depend on shaded, moisture-rich environments.

To assess whether these environmental factors significantly differed among the studied species, an ANOVA test was conducted. The analysis revealed significant differences in elevation (p: 0.000), temperature (p: 0.000), and humidity (p: 0.003) across the species' habitats. However, light intensity (p: 0.106) and soil pH (p: 0.649) did not show significant variation between species. These findings suggest that elevation, temperature, and humidity play a crucial role in shaping the distribution of *Saurauia* species, while light intensity and soil pH appear to be less influential.

The relationship between *Saurauia* and environmental parameters

Canonical Correspondence Analysis (CCA) was employed to investigate the relationship between environmental parameters and the distribution of *S. bracteosa*, *S. cauliflora*, and *S. microphylla* across different elevations, as shown in Figure 3. CCA biplot displays two primary axes (axis 1 and axis 2) that represent gradients of environmental variation across the sampling sites. Each axis accounts for a portion of the variation in species distribution in relation to environmental variables. Axis 1 has a positive relationship with temperature and light intensity, suggesting that as these two parameters increase, species tend to align positively along axis 1. *Saurauia cauliflora*, located closer to the right side of the CCA plot along axis 1, shows a strong association with these high-temperature and light conditions, indicating its preference for warmer, well-lit habitats typically found at lower elevations (elevation 1). Axis 2 is positively associated with humidity and shows a moderate association with pH. *Saurauia microphylla*, positioned negatively along axis 1 and positively along axis 2, appears to be more closely associated with higher humidity levels and slightly acidic conditions. This positioning implies that *S. microphylla* is adapted to environments with high humidity, possibly indicating a preference for shaded, moist habitats typically found at elevation 3.

Species-environment relationships

Saurauia bracteosa: located near elevation 2 and positioned moderately along both axis 1 and 2, *S. bracteosa* is in a region that reflects intermediate conditions for temperature, light, and humidity. Its positioning suggests it may tolerate a broad range of conditions or prefer an environment that balances these variables, which aligns with moderate elevation settings.

Saurauia cauliflora: the plot places *S. cauliflora* near Elevation 1 and the vectors for light and temperature. This association suggests that the species is likely adapted to habitats with higher temperatures and increased sunlight exposure, conditions typical of lower elevations. The strong alignment with these environmental variables indicates that *S. cauliflora* may have adaptations enabling it to thrive in more open, warmer habitats.

Saurauia microphylla: this species is located towards the negative end of axis 1 and positive on axis 2, indicating its preference for conditions with high humidity and lower pH. The association with these parameters implies that *S. microphylla* is more suited to shaded, humid environments with slightly acidic soils, which are common in higher elevation areas (elevation 3).

Environmental variable influence

The vector for humidity points towards axis 2, indicating that increases in humidity have a strong positive influence along this axis. *Saurauia microphylla* aligns closely with this vector, suggesting its ecological preference for humid environments. Although not as strongly influential as other variables, pH plays a role, particularly for species positioned closer to the lower end of axis 1, such as *S. microphylla*. This species may be more tolerant of slightly acidic conditions, which could be a factor in its habitat selection at higher elevations. Both vectors for temperature and light extend positively along axis 1, influencing species that prefer warmer and brighter environments. *Saurauia cauliflora* is closely associated with these variables, indicating that it favors sunny, warmer locations, likely found at lower elevations. The three elevation levels are distributed across the CCA plot in a way that reflects their unique environmental characteristics. Elevation 1, associated with *S. cauliflora*, corresponds to warmer and lighter conditions, while elevation 3, associated with *S. microphylla*, aligns with higher humidity and lower pH levels. Elevation 2, where *S. bracteosa* is found, reflects intermediate environmental conditions, suggesting this species' adaptability to a broader range of environmental factors.

Discussion

The discovery of three *Saurauia* species, namely *S. microphylla*, *S. bracteosa*, and *S. cauliflora* with vulnerable conservation statuses highlight the ecological significance of the Talaga Bodas area in West Java. These results suggest that the region is still relatively pristine and provides essential habitats for these rare species. The vulnerable status of these plants underscores the necessity for conservation efforts to preserve their habitats, serving as indicators of environmental health and biodiversity. Preserving the ecological integrity of Talaga Bodas is essential, as it serves as a sanctuary for these unique species and sustains the overall biodiversity of the region. Previous studies have shown that regions with high levels of endemism and rare species are often threatened by habitat destruction, emphasizing the need for proactive conservation strategies to protect these vulnerable plants (Gonçalves-Souza et al. 2020; Mokany et al. 2020; Florentín et al. 2022).

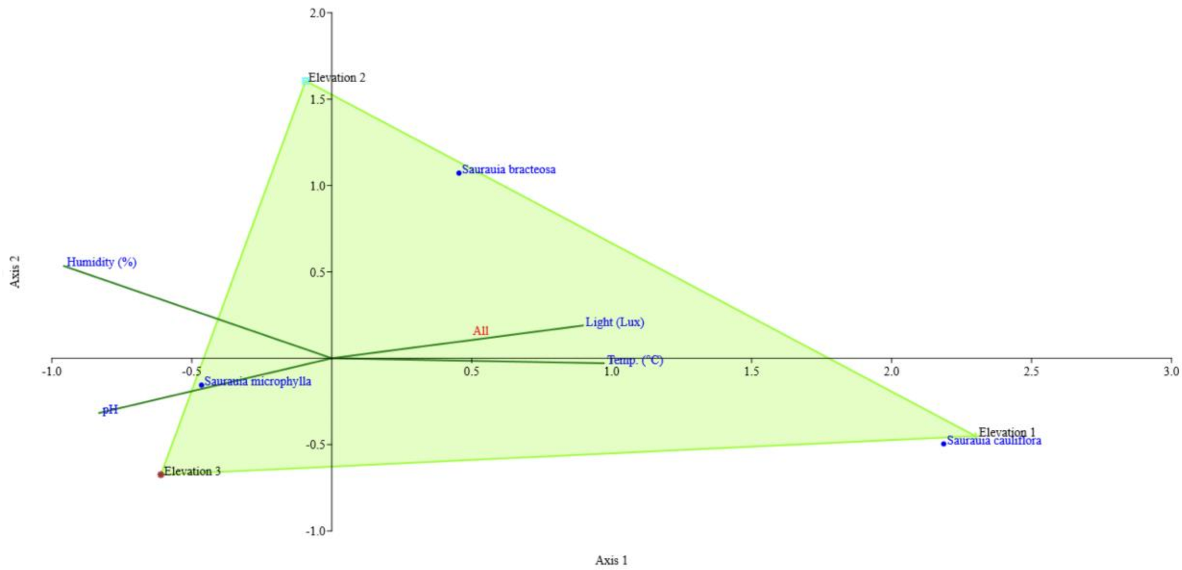

Figure 3. Canonical Correspondence Analysis (CCA) between environmental parameters and the distribution of plant species *Saurauia bracteosa, S. cauliflora*, and *S. microphylla*

The study of microhabitat preferences in *Saurauia* species at Talaga Bodas shows a better understanding of how environmental parameters shape species distributions. Key factors such as elevation, temperature, and humidity appear to be more critical in shaping ecological niches of *S. microphylla*, *S. bracteosa*, and *S. cauliflora*, while light intensity and soil pH have a lesser impact. Similar findings were reported by Helmanto et al. (2020b), who found that elevation was the most influential factor in the presence of the threatened species *S. microphylla* on Mount Slamet, Central Java, Indonesia, where different species exhibited distinct habitat preferences. In this study, temperature and humidity also play crucial roles, as each *Saurauia* species requires different conditions for these factors. These findings highlight the importance of specific environmental conditions in determining species presence and emphasize the need for habitat-based conservation strategies tailored to these ecological requirement (Lin et al. 2017; Walsworth et al. 2019).

CCA results further confirm the importance of these environmental factors in defining species distributions (Ran et al. 2024). CCA results demonstrate that each species exhibits specific adaptations to their preferred microhabitats. For example, *S. cauliflora* is closely associated with lower elevations characterized by higher temperatures and light intensities, suggesting that it thrives in sunnier, warmer environments, while *S. microphylla* is adapted to higher elevations with cooler, shadier, and more humid conditions. While ANOVA highlights the statistical significance of these differences, CCA provides a spatial representation of how these factors collectively influence species placement in their respective microhabitats.

CCA emphasizes the importance of light intensity and temperature as critical determinants for *S. cauliflora*. The placement on the right side of the CCA plot aligns with higher values of these parameters, indicating a preference for warmer habitats that offer ample sunlight. This observation is consistent with previous studies showing that many plant species adapted to lower elevations benefit from increased light availability, which enhances photosynthesis and growth rates (Yang et al. 2023). Conversely, *S. microphylla*, located towards the negative end of axis 1, reflects its preference for conditions with high humidity and slightly acidic soil pH. This species' distribution indicates a strong affinity for shaded, moist environments that are typical of higher elevations, supporting results that such habitats can be crucial for the survival of moisture-dependent flora (Foster et al. 2020; Chauvier et al. 2021). Although soil pH was not significantly different among species according to ANOVA, its influence on species distribution remains relevant when viewed in conjunction with other environmental factors.

CCA shows a significant relationship between humidity and the distribution of *S. microphylla*. Positioned positively along axis 2, this species correlates with increased humidity levels, which are important for its physiological processes. Studies have shown that higher humidity can mitigate water stress, allowing plants to maintain turgor pressure and optimize photosynthetic activity (Chia and Lim 2022). This preference for humid microhabitats highlights the ecological importance of preserving areas with high moisture availability, which are increasingly threatened by climate change and habitat degradation (Dupuis et al. 2020).

The analysis indicates that soil pH plays a role in determining species distribution, particularly for *S. microphylla*. Positioned closer to the lower end of axis 1, this species appears to tolerate slightly acidic conditions, aligning with studies that emphasize the significance of soil chemistry in plant distribution (Zhao et al. 2021; Roe et al. 2022). The slight acidity favored by *S. microphylla* may be associated with specific nutrient availability, which can enhance growth and reproduction in certain habitats. This result highlights the need for targeted conservation efforts that consider soil properties, as they are crucial for maintaining suitable conditions for vulnerable specie (Zeiss et al. 2022).

The elevation gradient delineated by CCA highlights the ecological stratification present in Talaga Bodas. Each elevation level correlates with distinct microclimatic conditions (Wahyuningrum et al. 2022; John et al. 2024), facilitating the coexistence of different *Saurauia* species through niche differentiation. The results suggest that conservation strategies must consider these microhabitat preferences to ensure the preservation of species diversity and ecosystem functionality (Martin et al. 2022). For example, efforts to maintain or restore habitat conditions across various elevations will be important for supporting the unique requirements of each *Saurauia* species and the broader ecological community.

The results of ANOVA and CCA provide a compelling argument for the need to prioritize conservation initiatives that focus on preserving the specific microhabitats associated with each *Saurauia* species. By understanding how environmental parameters influence species distributions, conservationists can more effectively target their efforts, ensuring that critical habitats are protected from threats such as climate change, deforestation, and land-use change. Maintaining these microhabitats not only benefits *Saurauia* species but also contributes to the overall health and resilience of the Talaga Bodas ecosystem.

Implications for conservation

This study suggests that effective conservation strategies should focus on maintaining microhabitat diversity in the Talaga Bodas area. This involves protecting the unique environmental conditions that support the vulnerable *Saurauia* species. Conservation efforts should prioritize areas with high humidity and shaded environments, particularly those at higher elevations, where *S. microphylla* is predominantly found. This approach is in line with the recommendations made in conservation literature, emphasizing the importance of habitat preservation to protect vulnerable species (Dietz et al. 2020; McGuire and Shipley 2022).

The identification of microhabitat preferences can inform habitat management practices. Watershed protection forests play a critical role in maintaining ecosystem services, including water regulation and biodiversity conservation. Therefore, conservation strategies should prioritize habitat preservation. Efforts should focus on habitat restoration, reforestation, and strict protection of ecologically sensitive areas. Engaging local communities in conservation efforts is also crucial, as their involvement can foster a sense of ownership and responsibility toward protecting these vulnerable plants. Education programs focused on the ecological importance of these species may increase awareness and promote sustainable land-use practices (Børresen et al. 2023).

Continuous monitoring and investigations are essential to adaptively manage conservation strategies based on changing environmental conditions and potential threats. As climate change and human activities pose increasing risks to biodiversity, ongoing studies will be important in informing conservation policies that are responsive to the needs of vulnerable species such as *Saurauia*. Collaborative efforts among researchers, conservation organizations, and local communities can enhance the effectiveness of conservation strategies (Di Franco et al. 2020; Fariss et al. 2023) and ensure the long-term survival of these unique species in Talaga Bodas.

In conclusion, the discovery of vulnerable *Saurauia* species in the Talaga Bodas area underscores the ecological significance of this region and the urgent need for conservation efforts. The analysis of microhabitat preferences highlights the importance of preserving diverse environmental conditions to support these species. Proactive conservation strategies, informed by ongoing study and community engagement, are essential to safeguard the future of these unique plants and maintain the overall biodiversity of Talaga Bodas.

ACKNOWLEDGEMENTS

The authors are grateful to the Universitas Siliwangi, Tasikmalaya, Indonesia for funding this study through the Simpemaus internal research grant number 161/UN58.06/PM.00.00/2024.

REFERENCES

Antúnez P, Wehenkel C, Kukunda CB, Hernández-Díaz JC. 2023. Climatic variables differentially influence neotropical plant species of conservation concern. J Sustain For 42 (1): 43-58. DOI: 10.1080/10549811.2021.1944878.

Barczyk M, Acosta-Rojas D, Espinosa CI, Homeier J, Tinoco B, Velescu A, Wilcke W, Schleuning M, Neuschulz E. 2024. Environmental conditions differently shape leaf, seed and seedling trait composition between and within elevations of tropical montane forests. Oikos 2024: e10421. DOI: 10.1111/oik.10421.

Børresen ST, Ulimboka R, Nyahongo J, Ranke PS, Skjaervø GR, Røskaft E. 2023. The role of education in biodiversity conservation: Can knowledge and understanding alter locals' views and attitudes towards ecosystem services? Environ Educ Res 29 (1): 148-163. DOI: 10.1080/13504622.2022.2117796.

Chauvier Y, Thuiller W, Brun P, Lavergne S, Descombes P, Karger DN, Renaud J, Zimmermann NE. 2021. Influence of climate, soil, and land cover on plant species distribution in the European Alps. Ecol Monogr 91 (2): e01433. DOI: 10.1002/ecm.1433.

Chia SY, Lim MW. 2022. A critical review on the influence of humidity for plant growth forecasting. IOP Conf Ser Mater Sci Eng 1257 (1): 12001. DOI: 10.1088/1757-899X/1257/1/012001.

Daipan BPO, Buot IE, Pampolina NM. 2022. Evaluating the species distribution patterns of the genus *Saurauia* Willd. in the Philippines using geospatial analysis. Webbia 77 (2): 307–319. DOI: 10.36253/jopt-13193.

Dalling JW, Heineman K, González G, Ostertag R. 2016. Geographic, environmental and biotic sources of variation in the nutrient relations of tropical montane forests. J Trop Ecol 32 (5): 368-383. DOI: 10.1017/S0266467415000619.

Di Franco A, Hogg KE, Calò A, Bennett NJ, Sévin-Allouet MA, Alaminos OE, Lang M, Koutsoubas D, Prvan M, Santarossa L. 2020. Improving marine protected area governance through collaboration and co-production. J Environ Manag 269: 110757. DOI: 10.1016/j.jenvman.2020.110757.

Dietz MS, Belote RT, Gage J, Hahn BA. 2020. An assessment of vulnerable wildlife, their habitats, and protected areas in the contiguous United States. Biol Conserv 248: 108646. DOI: 10.1016/j.biocon.2020.108646.

Dupuis C, Lejeune P, Michez A, Fayolle A. 2020. How can remote sensing help monitor tropical moist forest degradation? A systematic review. Remote Sens 12: 1087. DOI: 10.3390/rs12071087.

Fariss B, DeMello N, Powlen KA, Latimer CE, Masuda Y, Kennedy CM. 2023. Catalyzing success in community-based conservation. Conserv Biol 37 (1): e13973. DOI: 10.1111/cobi.13973.

Florentín JE, Salas RM, Jarvie S, Svenning JC, Gomez JMD. 2022. Areas of endemism and conservation status of *Galianthe* species (Spermacoceae, Rubiaceae) in the Neotropics. Syst Biodivers 20 (1): 1-20. DOI: 10.1080/14772000.2022.2025946.

Foster AC, Martin PH, Redmond MD. 2020. Soil moisture strongly limits Douglas-fir seedling establishment near its upper elevational limit in the southern Rocky Mountains. Can J For Res 50 (8): 837-842. DOI: 10.1139/cjfr-2019-0296.

Gonçalves-Souza D, Verburg PH, Dobrovolski R. 2020. Habitat loss, extinction predictability and conservation efforts in the terrestrial ecoregions. Biol Conserv 246: 108579. DOI: 10.1016/j.biocon.2020.108579.

He X, Arif M, Zheng J, Ni X, Yuan Z, Zhu Q, Wang J, Ding D, Li C. 2023. Plant diversity patterns along an elevation gradient: The relative impact of environmental and spatial variation on plant diversity and assembly in arid and semi-arid regions. Front Environ Sci 11: 1021157. DOI: 10.3389/fenvs.2023.1021157.

Helmanto H, Zulkarnaen RN, Fikriyya N, Nisyawati, Robiansyah I. 2020a. Population status of *Saurauia* spp. in Slamet Mountain, Central Java. IOP Conf Ser Earth Environ Sci 528 (1): 012009. DOI: 10.1088/1755-1315/528/1/012009.

Helmanto H, Robiansyah I, Zulkarnaen RN, Fikriyya N. 2020b. Habitat preference and spatial distribution model of threatened species *Saurauia microphylla* in Mt. Slamet, Central Java, Indonesia. Biodiversitas 21 (7): 2946-2954. DOI: 10.13057/biodiv/d210710.

Inman-Narahari F, Ostertag R, Asner GP, Cordell S, Hubbell SP, Sack L. 2014. Trade-offs in seedling growth and survival within and across tropical forest microhabitats. Ecol Evol 4 (19): 3755-3767. DOI: 10.1002/ece3.1196.

John A, Olden JD, Oldfather MF, Kling MM, Ackerly DD. 2024. Topography influences diurnal and seasonal microclimate fluctuations in hilly terrain environments of coastal California. Plos One 19 (3): e0300378. DOI: 10.1371/journal.pone.0300378.

Jones MM, Szyska B, Kessler M. 2011. Microhabitat partitioning promotes plant diversity in a tropical montane forest. Glob Ecol Biogeogr 20 (4): 558-569. DOI: 10.1111/j.1466-8238.2010.00627.x.

Kardiman R, Afriandi R, Schmidt LH, Ræbild A, Swinfield T. 2019. Restoration of tropical rain forest success improved by selecting species for specific microhabitats. For Ecol Manag 434: 235-243. DOI: 10.1016/j.foreco.2018.12.028.

Lin YP, Lin WC, Wang YC, Lien W, Huang T, Hsu CC, Schmeller D, Crossman N. 2017. Systematically designating conservation areas for protecting habitat quality and multiple ecosystem services. Environ Model Softw 90: 126-146. DOI: 10.1016/J.ENVSOFT.2017.01.003.

Martin M, Paillet Y, Larrieu L, Kern CC, Raymond P, Drapeau P, Fenton NJ. 2022. Tree-related microhabitats are promising yet underused tools for biodiversity and nature conservation: A systematic review for international perspectives. Front For Glob Change 5: 818474. DOI: 10.3389/ffgc.2022.818474.

Mazo KRF, Mansibang JA, Aribal LG, Tamayo MN. 2021. You 'Sau'Me! A new species and a rediscovery in the genus *Saurauia* (Actinidiaceae) from Zamboanga Peninsula, Mindanao Island, Philippines. Webbia 76 (2): 203-212. DOI: 10.36253/jopt-10712.

McGuire JL, Shipley BR. 2022. Dynamic priorities for conserving species. Science 376 (6597): 1048-1049. DOI: 10.1126/science.abq0788.

Mokany K, Ferrier S, Harwood TD, Ware C, Di Marco M, Grantham HS, Venter O, Hoskins AJ, Watson JEM. 2020. Reconciling global priorities for conserving biodiversity habitat. Proc Natl Acad Sci 117 (18): 9906-9911. DOI: 10.1073/pnas.1918373117.

Pasaribu G, Budianto E, Cahyana H, Saepudin E. 2020. A review on Genus *Saurauia*: Chemical compounds and their biological activity. Pharmacogn J 12 (3): 657-666. DOI: 10.5530/pj.2020.12.97.

Putra RR, Hernawati D, Fitriani R. 2019. Identifikasi tumbuhan lumut di kawasan wisata Gunung Galunggung Kabupaten Tasikmalaya Jawa Barat. Bioma 21 (2): 114-120. DOI: 10.14710/bioma.21.2.114-120.

Ran C, Pan J, Lin Y, Li T, Huang Y, Huang J, Fan S, Fang W, Zhao S, Liu Y. 2024. Utilizing spontaneous plants for sustainable development in residential green spaces: Insights from environmental drivers and niche analysis in Fuzhou City, China. J Environ Management 368: 122219. DOI: 10.1016/j.jenvman.2024.122219.

Roe NA, Ducey MJ, Lee TD, Fraser OL, Colter RA, Hallett RA. 2022. Soil chemical variables improve models of understorey plant species distributions. J Biogeogr 49 (4): 753-766. DOI: 10.1111/jbi.14344.

Thakur MP, Bakker ES, Veen GFC, Harvey JA. 2020. Climate extremes, rewilding, and the role of microhabitats. One Earth 2 (6): 506-509. DOI: 10.1016/j.oneear.2020.05.010.

Vellend M, Béhé M, Carteron A, Crofts AL, Danneyrolles V, Gamhewa HT, Ni M, Rinas CL, Watts DA. 2021. Plant responses to climate change and an elevational gradient in Mont Mégantic National Park, Québec, Canada. Northeast Nat 28: 4-28. DOI: 10.1656/045.028.s1102.

Wahyuningrum H, Mahfudz LD, Muryani R. 2022. Macroclimate at different altitudes on changes in microclimates in a closed house. Jurnal Sain Peternakan Indonesia 17 (2): 126-133. DOI: 10.31186/jspi.id.17.2.126-133.

Walsworth T, Schindler D, Colton M, Webster M, Palumbi S, Mumby P, Essington T, Pinsky M. 2019. Management for network diversity speeds evolutionary adaptation to climate change. Nat Clim Change 9: 632-636. DOI: 10.1038/s41558-019-0518-5.

Yang K, Chen G, Xian J, Chang H. 2023. Divergent adaptations of leaf functional traits to light intensity across common urban plant species in Lanzhou, northwestern China. Front Plant Sci 14: 1000647. DOI: 10.3389/fpls.2023.1000647.

Zeiss R, Eisenhauer N, Orgiazzi A, Rillig M, Buscot F, Jones A, Lehmann A, Reitz T, Smith L, Guerra CA. 2022. Challenges of and opportunities for protecting European soil biodiversity. Conserv Biol 36 (5): e13930. DOI: 10.1111/cobi.13930.

Zhao R, Zhao M, Zhang L, Wang Y, Zhang X, Zhou Y. 2021. An approach to the use of plants for monitoring soil conditions in wetlands in arid areas. Catena 199: 105113. DOI: 10.1016/j.catena.2020.105113,

Zhuang X, Yang Z, Cordes D. 2020. A technical review of canonical correlation analysis for neuroscience applications. Human Brain Mapping 41 (13): 3807-3833. DOI: 10.1002/hbm.25090.