

Article

Not peer-reviewed version

Vegetation Analysis of the Area Surrounding a Wild Nest of Stingless Bees (*Tetragonula laeviceps*, Smith 1857) in Sumedang Regency, West Java

[Susanti Withaningsih](#)*, Valerie Lubay, Fakhrur Rozi, Parikesit Parikesit

Posted Date: 13 September 2023

doi: 10.20944/preprints202309.0827.v1

Keywords: stingless bee; Sumedang; *Tetragonula laeviceps*; vegetation analysis



Preprints.org is a free multidiscipline platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Disclaimer/Publisher's Note: The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.

Article

Vegetation Analysis of the Area Surrounding a Wild Nest of Stingless Bees (*Tetragonula laeviceps*, Smith 1857) in Sumedang Regency, West Java

Susanti Withaningsih^{1,2,3,*}, Valerie Lubay¹, Fakhru Rozi^{2,3} and Parikesit^{1,2,3}

¹ Department of Biology, Faculty of Mathematics and Natural Science, Universitas Padjadjaran, Sumedang 45363, Indonesia.

² Master Program on Sustainability Science and Environmental Studies, Graduated School, Universitas Padjadjaran Jl. Dipati Ukur No. 35 Bandung 40132. Indonesia.

³ Center for Environment and Sustainability Science, Universitas Padjadjaran, Jl. Sekeloa Selatan No. 1, Bandung 40132, Indonesia.

* Correspondence: susanti.withaningsih@unpad.ac.id; Tel.: +62-22-2502176.

Abstract: Indonesia is a mega biodiversity country that has a very abundant diversity of plants. Plant diversity is inseparable from the role of insects that help to pollinate them. One such insect is the stingless bee (*Tetragonula laeviceps*). *Tetragonula laeviceps* is a bee that has a relatively small-to-medium body size and does not have a sting. Sumedang Regency is one of the regencies in the province of West Java; most of the Sumedang area consists of mountains and has protected forest areas with high biodiversity. The purpose of this study is to determine the biodiversity index of the vegetation around the *Tetragonula laeviceps* wild hives based on the composition and structure of the vegetation around the *Tetragonula laeviceps* bee hives. Data collection is carried out using the method of inventory and systematic checkered lines, with a total plot of 320. The results of the study show that the vegetation is composed of 229 plant species from 75 families. The most dominant vegetation type with the highest value of KR, FR, DR, and INP in all plant categories is the Aren tree species (*Arenga pinnata*). The Shannon–Wiener diversity index in this tree category is 3,186, the pole category is 3,107, the sapling category is 3,418, the seedling category is 3,657, and the understory plants category is 3,409, with all of the plant categories included in the high-diversity category.

Keywords: stingless bee; Sumedang; *Tetragonula laeviceps*; vegetation analysis

1. Introduction

Indonesia, as a nation, stands as a remarkable example of mega biodiversity, boasting an extraordinary wealth of diverse plant life within its borders. The intricate interplay between the botanical realm and the vital process of pollination, wherein insects, most notably the esteemed bees, play a pivotal role, is inexorably linked to the rich tapestry of plant diversity. Bees, one of the most remarkable creatures of the insect world, are known to inhabit colonies and are classified within the esteemed Apidae family. In the Indonesian archipelago, a frequently encountered group of bees, which are devoid of stinging capabilities, pertains to the taxonomic classification of the genus *Tetragonula*. In the Sundanese dialect, it is widely acknowledged that the bees belonging to the *Tetragonula* genus are colloquially referred to as "Teuweul" [1].

Indonesia, as a nation of remarkable biodiversity, owes its esteemed status to the expansive array of ecosystems it possesses, encompassing a diverse range from lush tropical rainforests to intricate coastal mangroves. The remarkable ecological diversity present in this particular ecosystem serves as a catalyst for the proliferation of a myriad of plant species, a substantial proportion of which exhibit a strong dependence on insect pollinators for successful reproduction. Amongst the myriad of pollinators that grace our ecosystems, it is the humble bees that assume a pivotal role in the intricate dance of transferring pollen from one floral entity to another, thereby expediting the delicate process of fertilization.

Bees, being highly proficient pollinators, play a pivotal role in upholding the equilibrium and vitality of ecosystems. These organisms not only serve the vital function of facilitating the reproductive processes of diverse botanical taxa, but also exert a profound influence on the intricate

assemblage and relative abundance of coexisting organisms within their respective ecological systems. The intricate network of interdependencies showcased herein underscores the indispensable contribution of bees in upholding and perpetuating biodiversity.

The Apidae family, to which bees belong, encompasses a diverse array of species, each exhibiting a plethora of unique characteristics and behaviors. In the Indonesian archipelago, the genus *Tetragonula* emerges as a noteworthy assemblage of stingless bees that exhibits remarkable prevalence. These diminutive organisms demonstrate intricate social behaviors, culminating in the formation of colonies characterized by elaborate structures and a sophisticated division of labor among their constituents.

In the vernacular Sundanese dialect, it is customary to designate the stingless bees belonging to the *Tetragonula* genus as "*Teuweul*." The Sundanese populace has undoubtedly engaged in extensive interactions and astute observations of these bees across numerous generations, thereby augmenting their profound comprehension of indigenous biodiversity. Comprehending the ecological significance of these bees, particularly in the intricate process of pollination, holds paramount importance for the advancement of conservation endeavors and the promotion of sustainable agricultural practices in the Indonesian context.

Tetragonula, a fascinating genus of bees, exhibits a diminutive to moderate size range and intriguingly lacks the presence of a sting. The distribution of these bees encompasses a range of geographically diverse regions, spanning across Australia, Indonesia, New Guinea, Malaysia, Thailand, the Philippines, India, Sri Lanka, and the Solomon Islands. In accordance with conventional knowledge, these remarkable insects exhibit a proclivity for establishing enduring colonies, wherein they diligently procure pollen and nectar as their primary means of sustenance. The nesting behavior of these organisms typically involves the construction of subterranean dwellings, as well as the utilization of wood cavities, arboreal surfaces, and occasionally even termite mounds as nesting sites [1,2].

The bees under consideration have exhibited remarkable adaptability to their respective habitats, effectively capitalizing on a diverse array of nesting sites and resources to sustain their colonies. The nesting behavior exhibited by these remarkable creatures, characterized by their propensity to construct nests in a multitude of diverse locations, undoubtedly underscores their profound ecological significance as invaluable pollinators and indispensable agents of biodiversity.

The *Tetragonula laeviceps* bees, indeed, manifest remarkably intriguing social behaviors within the confines of their colonies. The intricate interplay and allocation of tasks among individuals exemplify the extraordinary adaptability exhibited by these diminutive organisms. Notwithstanding their dearth of a venomous apparatus, these organisms have undergone evolutionary processes to effectively discharge pivotal functions within their respective ecosystems, primarily by facilitating the crucial process of plant reproduction through the mechanism of pollination.

In Indonesia, one of the regions with a significant population of *Tetragonula laeviceps* bees is located in the Sumedang Regency. The Sumedang Regency is situated in the West Java Province. The majority of Sumedang's area consists of mountains and includes protected forest areas with high biodiversity. Based on information from the local community, *Tetragonula laeviceps* bees are commonly found in forested areas and are classified as wild bees [3].

In a recent study carried out by [4], it was discovered that the Cimalaka subdistrict, situated in the Sumedang Regency, possesses a diverse array of vegetation. This particular area is home to approximately 2,334 individual plants, representing nine distinct species spanning across five families. Notably, the lower plant types exhibited a prominent presence, showcasing their ecological significance as both habitats and nourishment for *Tetragonula* bees. Furthermore, the scholarly investigation conducted by [5] elucidated that within the confines of Cilembu Village, situated in the esteemed Sumedang Regency, a remarkable assemblage of 78 distinct species of understory plants were meticulously documented, spanning across an impressive array of 30 taxonomic families. As a distinguished scholar in the field of biodiversity, it is worth noting that the Sumedang Regency is endowed with a remarkable abundance of plant species, which holds great promise in terms of providing favorable ecosystems for the esteemed *Tetragonula laeviceps* bees.

The intricate interplay between the vast array of plant species holds paramount significance in the intricate tapestry of existence for the esteemed *Tetragonula laeviceps* bees. The dearth of vegetation in the vicinity of *Tetragonula laeviceps* bee colonies may potentially engender grave ramifications for

their long-term sustenance and viability. Therefore, it is of utmost importance to undertake a comprehensive investigation pertaining to the meticulous examination of the botanical composition in the immediate vicinity of the nesting sites inhabited by the indigenous species of stingless bees within the geographical confines of the Sumedang Regency, situated in the esteemed province of West Java. This particular set of data holds utmost significance in comprehending the intricate dynamics of the surrounding flora encompassing the habitats of these stingless hymenopterans and their colonies.

2. Materials and Methods

The methodology employed in this investigation entails the utilization of a survey-based approach. This study was carried out through a series of meticulously planned stages, encompassing a preliminary survey, an intensive survey, and a meticulous identification process. The initial survey was conducted by gathering data pertaining to the geographical distribution of indigenous *Tetragonula* bee colonies within the Sumedang Regency. The comprehensive survey entailed the meticulous collection of vegetation data utilizing the quadrant method in the vicinity of the untamed nests.

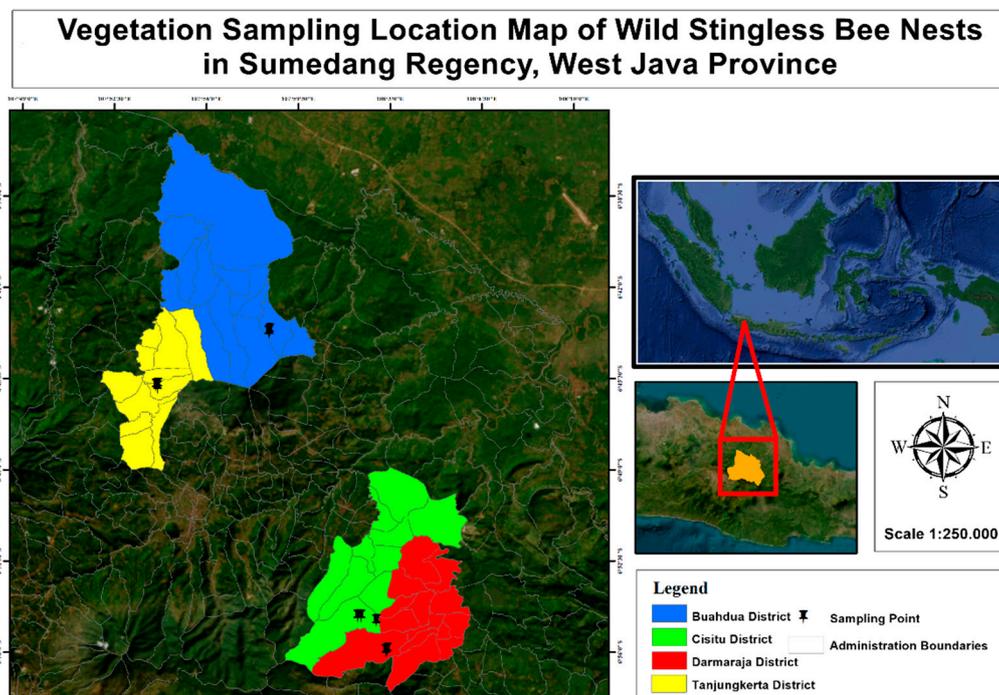


Figure 1. Research area.

In the preliminary phase of sample collection, a method known as random purposive sampling was implemented. Transects spanning a length of 100 meters were meticulously established, taking into account the foraging range of the esteemed stingless bees, which exhibited a remarkable span of distances ranging from 53.61 to 162.21 meters [6]. Furthermore, it is worth noting that the maximum distance attainable from the hive, an impressive 497 meters, was also considered during the establishment of these transects. The sampling area encompassed a substantial expanse of 3140 square meters, constituting a noteworthy 10% proportion of the overall area spanning 3.14 hectares, as derived from the circular region with a radius measuring 100 meters, which incidentally corresponds to the length of the transect. The transect lines were meticulously delineated in four cardinal directions, radiating outward from the epicenter of the nest, thereby establishing a comprehensive spatial framework. The determination of the direction of each transect line was conducted, taking into account the intricate nature of the land cover surrounding the nest point, as well as the level of accessibility to the designated transect area. In accordance with the cardinal directions, a total of ten plots were established using the utmost precision and scientific rigor. Subsequently, a rigorous randomization process was employed to select a subset of eight plots from this meticulously established pool. In the event that there were plant species that were not

encompassed within the designated plot, yet were indeed present within the research area, a comprehensive inventory was undertaken with the primary objective of procuring comprehensive information pertaining to the entirety of plant species in close proximity to the natural habitats of the indigenous stingless bee colonies.

In this study, the plot sizes were classified based on the plant habitus in the following manner:

- A spatial allocation of 10 x 10 meters is recommended for tree species exhibiting a diameter exceeding 20 centimeters.
- For shrub species characterized by a diameter ranging from 10 to 20 centimeters, an area of 8 x 8 meters is deemed appropriate.
- Sapling species, denoted by a diameter below 10 centimeters and a height surpassing 1.5 meters, should be allotted a space of 4 x 4 meters.
- Seedling species, distinguished by a height below 1.5 meters, are advised to be accommodated within a 2 x 2-meter area.
- Ground cover plants, on the other hand, necessitate a smaller allocation of 1 x 1 meter. The specific plant species within this category can be determined utilizing the Braun–Blanquet scale, as outlined by [7].

According to the findings of the survey, the sampling points were meticulously documented and are conveniently displayed in Table 1. It is worth noting that a substantial number of plots, precisely 320, were established for the purpose of this study.

Table 1. Sampling Coordinate Point.

No	Sub-District	Category	Point	Coordinate
1	Tanjungkerta	Wild hive	A1	S6°45'49.4100" E107°54'08.1800"
2	Tanjungkerta	Wild hive	A2	S6°45'43.4879" E107°54'08.8242"
3	Tanjungkerta	Wild hive	A3	S6°45'45.6000" E107°54'04.6500"
4	Cisitu	Wild hive	B1	S6°54'48.1100" E108°02'28.6100"
5	Cisitu	Wild hive	B2	S6°54'37.2300" E108°01'53.3700"
6	Cisitu	Wild hive	B3	S6°54'37.3359" E108°01'46.1346"
7	Darmaraja	Wild hive	C1	S6°55'53.5807" E108°02'54.1009"
8	Darmaraja	Wild hive	C2*	S6°55'56.1466" E108°02'51.1511"
9	Darmaraja	Wild hive	C3*	S6°55'56.6490" E108°02'49.8447"
10	Buah Dua	Wild hive	J1**	S6°43'42.9615" E107°58'22.6786"
11	Buah Dua	Wild hive	J2**	S6°43'42.9965" E107°58'23.0162"
12	Buah Dua	Wild hive	J3	S6°43'38.1687" E107°58'24.8238"

The analysis of vegetation was undertaken by taking into account various parameters, specifically density (D) and relative density (RD), frequency (F) and relative frequency (RF), dominance (D) and relative dominance (RD), the importance value index (IVI), and the species diversity index (H').

3. Results and Discussion

In the region of Kabupaten Sumedang, a significant proportion of its land, precisely 70.37%, is enveloped by lush and verdant forests. This is followed by areas dedicated to cultivation, including fields and plantations, which account for 17.86% of the region's land. Additionally, it is worth acknowledging the presence of water bodies and wetlands, constituting 7.49% of the area, and settlements, encompassing 4.28% of the land [8]. The prevailing landscape of Kabupaten Sumedang is characterized by extensive forested regions, plantations, and agricultural activities, thereby signifying a remarkable propensity for harboring a diverse array of plant species. This, in turn, renders the region highly conducive to fostering the natural habitat of the esteemed stingless bee species known as *Tetragonula laeviceps*. The domiciles of indigenous *Tetragonula* bees within the

jurisdiction of Kabupaten Sumedang are dispersed throughout various sub-districts, specifically Buah Dua, Cisitu, Darmaraja, and Tanjungkerta.

Within each of the aforementioned sub-districts, it is imperative to note that a meticulous selection process was undertaken to identify three distinct nest points for the purpose of data collection. In the sub-districts of Darmaraja and Buah Dua, the prevailing land utilization predominantly manifests as secondary forests. As elucidated by [9], the genesis of secondary forests can be attributed to the anthropogenic intervention of logging activities undertaken by forestry enterprises. The prevalence and constitution of arboreal taxa in secondary woodlands are typically diminished in comparison to their primary, undisturbed counterparts. In the Tanjungkerta sub-district, one observes a prevailing presence of residential settlements. The nesting sites in Tanjungkerta are predominantly situated within the residential compounds. A residential compound, as elucidated by [10], is an expanse of land encompassing a dwelling, meticulously adorned with a diverse array of botanical specimens, be it a solitary species or a harmonious amalgamation of multiple taxa. In the Cisitu sub-district, one can observe a prevalence of mixed gardens as the dominant land use pattern. As per the scholarly work of [11], it has been expounded that mixed gardens exhibit a diverse array of plant species, wherein it is imperative for at least one of the constituents to possess a woody nature. The botanical composition within the designated research sites is primarily characterized by the prevalence of arboreal taxa.

3.1. Composition and Vegetation Structure around Wild *Tetragonula Laeviceps* Hive

The comprehension and delineation of vegetation's composition and structure assume paramount significance in order to facilitate the preservation of stingless bee habitats within the community. According to the findings of our comprehensive investigation, a total of 237 plant species belonging to 75 distinct families have been successfully identified. These species encompass a diverse array of botanical life, with a grand total of 8480 individuals being classified into various growth forms, including trees, poles, shrubs, seedlings, and ground vegetation. The analysis of vegetation was conducted by considering various parameters, such as density (D) and relative density (RD), frequency (F) and relative frequency (RF), dominance (D) and relative density (RD), and the importance value index (IVI).

3.1.1. Tree

From the careful examination and analysis of the vegetation data encompassing various sub-districts, a total of 52 distinct tree species belonging to 25 diverse families have been successfully identified. Within the realm of arboreal taxonomy, it is noteworthy that the tree classification encompasses a quintet of preeminent botanical species. These include the esteemed *Arenga pinnata*, commonly referred to as the Aren palm, the venerable *Tectona grandis*, known colloquially as teak, the illustrious *Ficus annulata*, more commonly recognized as the kiara fig, the distinguished *Swietenia mahagoni*, widely acknowledged as mahogany, and lastly, *Gnetum gnemon*, commonly referred to as melinjo. The findings pertaining to the botanical examination within the arboreal classification in the vicinity of indigenous colonies of stingless bees are duly illustrated in Figure 2.

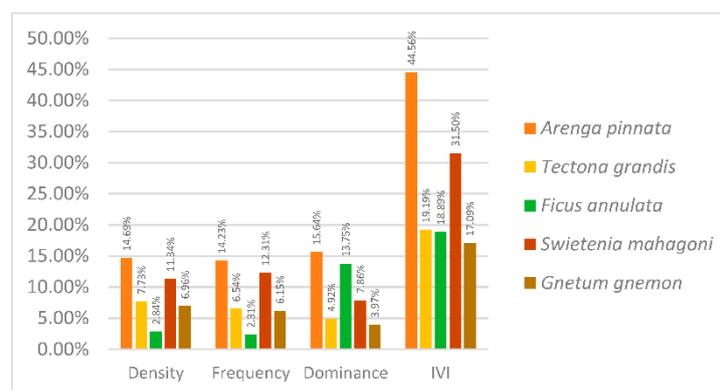


Figure 2. Relative density, relative frequency, relative dominance, and importance value index in the tree category in Sumedang Regency.

According to Figure 2, there are noticeable variances between each species' relative density levels. The total number of members of each species found throughout the entire plot area is represented by relative density. With a relative density of 14.69%, the weren (*Arenga pinnata*) species has the highest value in the tree category. It is followed by the mahogany (*Swietenia mahagoni*), teak (*Tectona grandis*), melinjo (*Gnetum gnemon*), and kiara (*Ficus annulata*) species.

The tree species with the highest relative frequency is Aren (*Arenga pinnata*), followed by mahogany (*Swietenia mahagoni*), teak (*Tectona grandis*), melinjo (*Gnetum gnemon*), and kiara (*Ficus annulata*) at 12.31%, 6.54%, 6.96%, and 2.84%, respectively. The tree species with the highest relative dominance value is Aren (*Arenga pinnata*), followed by kiara (*Ficus annulata*), mahogany (*Swietenia mahagoni*), teak (*Tectona grandis*), and melinjo (*Gnetum gnemon*) at 13.75%, 7.86%, 4.92%, and 3.97%, respectively. Aren (*Arenga pinnata*) has the greatest importance value index (IVI), followed by mahogany (*Swietenia mahagoni*), teak (*Tectona grandis*), kiara (*Ficus annulata*), and melinjo (*Gnetum gnemon*) at 31.50%, 19.19%, 18.89%, and 17.09%. The Aren (*Arenga pinnata*) species has the highest overall values for RD, RF, RD, and IVI in the tree category with an RD of 14.69%, RF of 14.23%, RD of 15.64%, and IV of 44.56%.

Different plants predominate in each sub-district. By examining the IVI value, it is possible to identify the predominant plant species in a given area. When relative density, relative frequency, and relative dominance are added up, the result is the IVI, which is a measurement of how dominating a species is in its ecosystem. Table 1 shows the prevalent plant information for each sub-district.

Table 1. Comparison of dominant tree species by sub-district.

No.	Sub District	Dominant Tree	INP
1	Tanjungkerta	Jati (<i>Tectona grandis</i>)	52,89%
		Kelapa (<i>Cocos nucifera</i>)	49,80%
		Sengon (<i>Albizia chinensis</i>)	35,43%
		Mahoni (<i>Swietenia mahagoni</i>)	28,54%
		Aren (<i>Arenga pinnata</i>)	22,27%
2	Cisitu	Aren (<i>Arenga pinnata</i>)	62,38%
		Mahoni (<i>Swietenia mahagoni</i>)	46,91%
		Sobsis (<i>Maesopsis eminii</i>)	29,77%
		Mangga (<i>Mangifera indica</i>)	21,93%
		Cengkeh (<i>Syzygium aromaticum</i>)	18,79%
3	Darmaraja	Aren (<i>Arenga pinnata</i>)	86,61%
		Kiara (<i>Ficus annulata</i>)	59,51%
		Sempur (<i>Dillenia obovata</i>)	34,55%
		Tisuk (<i>Hibiscus macrophyllus</i>)	30,93%
		Kedoya (<i>Dysoxylum amoroides</i>)	16,19%
4	Buah Dua	Melinjo (<i>Gnetum gnemon</i>)	74,74%
		Mahoni (<i>Swietenia mahagoni</i>)	32,81%
		Nangsi (<i>Villebrunea rubescens</i>)	30,07%
		Kiara (<i>Ficus annulata</i>)	27,28%
		Aren (<i>Arenga pinnata</i>)	14,78%

As seen in Table 1 above, the Aren tree may be found in every sub-district. The family Arecaceae includes the Aren tree (*Arenga pinnata*). Aren is a plant that can thrive in a variety of soil types, including clay, limestone, and sand. However, overly acidic soils are not suitable for this plant's growth. The delicious liquid called "nira," which may be discovered in the flower stem of Aren, gives the plant its economic value. Its fruit can also be used to make kolang kaling. As a result, the

neighborhood has transformed Aren into a farmland [12]. Bees can find food in the nectar and pollen found in its blossoms. Because Aren trees contain nira, a pleasant liquid, honeybees are drawn to them. Stingless bees can find food and places to nest in the research area's abundance of Aren trees. Compared to dead trees or other objects, these bees tend to favor living trees as nesting places [13].

3.1.2. Vertical Plants

A total of 77 species of columnar plants from 29 families were discovered using the vegetation analysis. Awi bitung (*Dendrocalamus asper*), awi gombong (*Gigantochloa pseudoarundinacea*), mahogany (*Swietenia mahagoni*), banana (*Musa paradisiaca*), and tisuk (*Hibiscus macrophyllus*) are the five species that predominate in the category of columnar plants. Figure 3 displays the findings of the vegetation study for the category of columnar plants around the stingless bee nests.

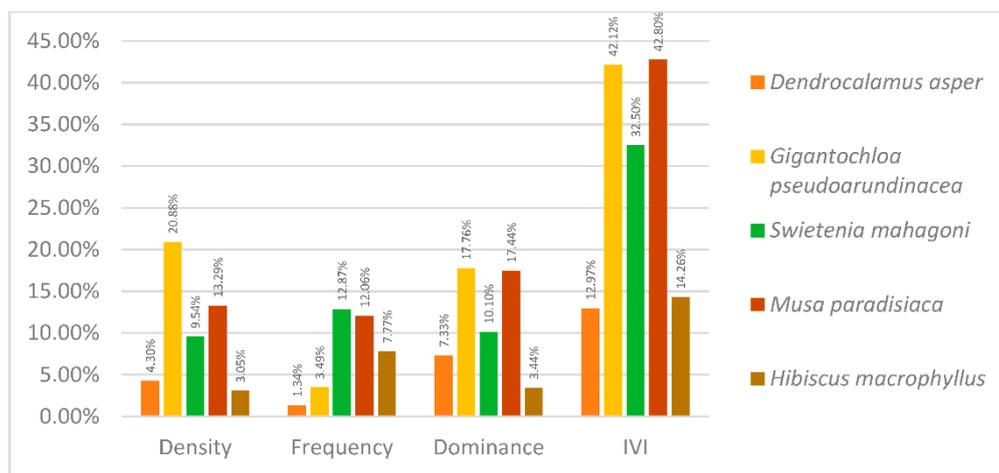


Figure 3. Relative density, relative frequency, relative dominance, and importance value index in the columnar plant category in Sumedang Regency.

According to Figure 4.3, the species *Gigantochloa pseudoarundinacea* had the highest relative density in the category of columnar plants, with a relative density of 20.88%. This species was followed by *Musa paradisiaca* at 13.29%, *Swietenia mahagoni* at 9.54%, *Dendrocalamus asper* at 4.30%, and *Hibiscus macrophyllus* at 3.05%. *Swietenia mahagoni* had the highest relative frequency in the columnar plant category (12.87%), followed by *Musa paradisiaca* (12.06%), *Hibiscus macrophyllus* (7.77%), *Gigantochloa pseudoarundinacea* (3.49%), and *Dendrocalamus asper* (1.34%).

With a relative dominance of 17.76%, *Gigantochloa pseudoarundinacea* had the highest relative dominance in the category of columnar plants, followed by *Musa paradisiaca* (17.44%), *Swietenia mahagoni* (10.10%), *Dendrocalamus asper* (7.33%), and *Hibiscus macrophyllus* (3.44%). With an IVI of 42.80%, *Musa paradisiaca* had the highest importance value index (INP) among the columnar plant species, followed by *Gigantochloa pseudoarundinacea* (42.12), *Swietenia mahagoni* (32.50%), *Hibiscus macrophyllus* (14.26%), and *Dendrocalamus asper* (12.97%). Table 2 contains information on the main flora in each sub-district.

Table 2. Comparison of dominant trees in the columnar plant category by sub-district.

No.	Sub District	Dominant Tree	IVI
1	Tanjungkerta	Pisang (<i>Musa paradisiaca</i>)	82,63%
		Bambu (<i>Bambusa sp.</i>)	27,49%
		Mahoni (<i>Swietenia mahagoni</i>)	23,36%
		Jati (<i>Tectona grandis</i>)	28,12%
		Mangga (<i>Mangifera indica</i>)	17,30%
2	Cisitu	Mahoni (<i>Swietenia mahagoni</i>)	57,67%

		Pisang (<i>Musa paradisiaca</i>)	38,92%
		Awi gombong (<i>Gigantochloa pseudoarundinacea</i>)	37,20%
		Awi tali (<i>Gigantochloa apus</i>)	12,53%
		Kopi (<i>Coffea sp.</i>)	10,38%
3	Darmaraja	Kaliandra merah (<i>Calliandra calothyrsus</i>)	49,81%
		Awi bitung (<i>Dendrocalamus asper</i>)	49,54%
		Haur hejo (<i>Bambusa tuldooides</i>)	28,90%
		Awi gombong (<i>Gigantochloa pseudoarundinacea</i>)	28,02%
		Waregu (<i>Rhapis excelsa</i>)	26,55%
4	Buah Dua	Melinjo (<i>Gnetum gnemon</i>)	49,92%
		Awi gombong (<i>Gigantochloa pseudoarundinacea</i>)	38,62%
		Langkap (<i>Arenga obtusifolia</i>)	36,05%
		Mahoni (<i>Swietenia mahagoni</i>)	28,08%
		Nangsi (<i>Villebrunea rubescens</i>)	25,05%

The banana (*Musa paradisiaca*) species was identified as having the greatest IVI from each sub-district, with an IVI value of 82.63% in the Tanjungkerta sub-district. The banana plant can be found all over Indonesia. Because it can survive in a variety of soil conditions, growing it is relatively simple. Only one fruit is produced by this plant before it dies; however, shoots from its stem will develop into banana offshoots [14]. Bananas are one of the food sources for stingless bees because this plant produces both nectar and pollen, according to a study by [15]. Bananas grow quite easily in a variety of soil types; thus, their availability makes them a major food source for stingless bees. According to [16], bees can use any flowering plant that produces nectar, pollen, or resin as a food source.

Along with bananas, swietenia mahagoni (*Gigantochloa pseudoarundinacea*) and mahogany (*Swietenia mahagoni*) are other dominant species that may be found in practically all sub-districts. Mahogany is a plant that adapts well to its surroundings. It belongs to the class of plants that may grow in a variety of well-draining soil types and do not require a particular type of soil to thrive. As a result, mahogany is widely available around the world. Tetragonula bees consume the pollen and resin produced by the mahogany plant, which also produces seeds. These bees make their bitter honey by combining pollen and resin. Bitter honey does not have the characteristic honey aroma; instead, it smells more like medicine. Since it has less sugar than conventional honey, the bitter flavor is more pronounced. The blossoms of mahogany trees near bee nests are the source of bitter honey [17].

Lowland bamboo species known as gigantochloa (*Gigantochloa pseudoarundinacea*) flourish in tropical and humid regions. In the Sumedang region, this plant is comparatively prevalent in agroforestry. The local population extensively cultivates it for a variety of uses, such as water pipes, traditional musical instruments, and building materials [18,19].

3.1.3. Saplings

In total, 106 sapling species from 33 families were identified using the vegetation analysis. The gigantochloa bamboo (*Gigantochloa pseudoarundinacea*), awi tali bamboo (*Gigantochloa apus*), common bamboo (*Bambusa sp.*), *Bambusa tuldooides*, and red calliandra (*Calliandra calothyrsus*) are the five plant species that make up the majority of the saplings. Figure 4 displays the findings of the vegetation analysis for the sapling category near the stingless bee nests.

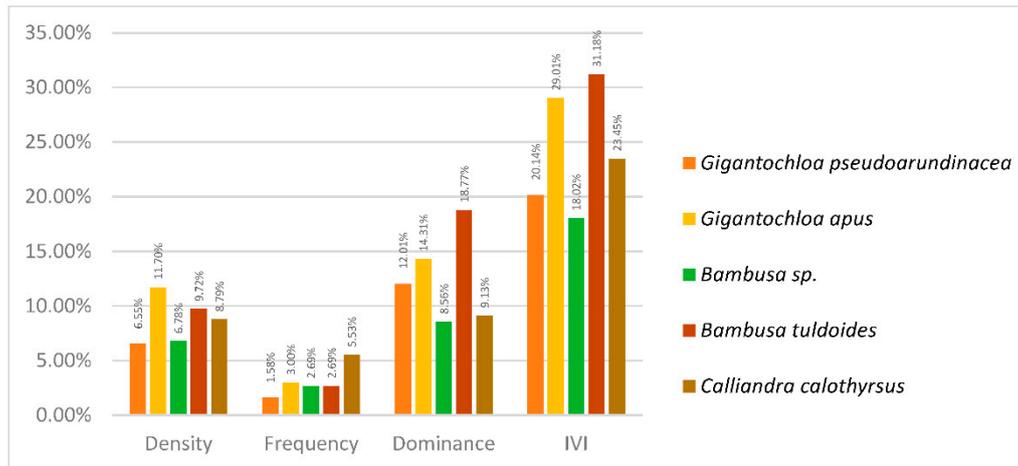


Figure 4. Relative density, relative frequency, relative dominance, and importance value index in the sapling category in Sumedang Regency.

According to the data presented in Figure 4, it is evident that the species exhibiting the highest relative density value within the sapling category is none other than the esteemed *awi tali* bamboo, scientifically known as *Gigantochloa apus*, boasting an impressive value of 11.70%. Following closely behind is *Bambusa tuldooides*, with a respectable relative density value of 9.72%. Notably, the red calliandra, or *Calliandra calothyrsus*, also makes a noteworthy appearance with a relative density value of 8.79%. Additionally, common bamboo, scientifically classified as *Bambusa sp.*, exhibits a relative density value of 6.78%, while gigantochloa bamboo, known as *Gigantochloa pseudoarundinacea*, showcases a relative density value of 6.55%.

The sapling category exhibits a notable relative frequency value, with the red calliandra species (*Calliandra calothyrsus*) taking the lead at an impressive 5.53%. Following closely behind is *awi tali* bamboo (*Gigantochloa apus*) at a respectable 3.00%. Noteworthy contributions are also observed from *Bambusa tuldooides* and common bamboo (*Bambusa sp.*), both exhibiting a relative frequency value of 2.69%. Lastly, gigantochloa bamboo (*Gigantochloa pseudoarundinacea*) makes a modest appearance with a relative frequency value of 1.58%.

The sapling category exhibits the utmost relative dominance value in *Bambusa tuldooides*, with an impressive value of 18.77%. Subsequently, *awi tali* bamboo (*Gigantochloa apus*) follows suit with a respectable value of 14.31%. Gigantochloa bamboo (*Gigantochloa pseudoarundinacea*) demonstrates a noteworthy relative dominance value of 12.01%. Moreover, red calliandra (*Calliandra calothyrsus*) showcases a commendable value of 9.13%. Lastly, common bamboo (*Bambusa sp.*) concludes this list with a noteworthy relative dominance value of 8.56%.

The sapling category exhibits a remarkable distribution of the importance value index (IVI), with *Bambusa tuldooides* taking the lead with an impressive value of 31.18%. Following closely behind is the esteemed *awi tali* bamboo, scientifically known as *Gigantochloa apus*, with a noteworthy IVI of 29.01%. Notably, red calliandra, or *Calliandra calothyrsus*, secures a respectable IVI of 23.45%. Additionally, gigantochloa bamboo, scientifically referred to as *Gigantochloa pseudoarundinacea*, demonstrates a noteworthy presence with an IVI of 20.14%. Lastly, common bamboo, identified as *Bambusa sp.*, exhibits a commendable IVI of 18.02%. A comprehensive compilation of the data pertaining to the dominant plant species within each sub-district is provided in Table 3.

Table 3. Comparison of dominant trees in the sapling category by sub-district.

No.	Sub District	Dominant Tree	IVI
1	Tanjungkerta	Bambu (<i>Bambusa sp.</i>)	38,65%
		Pinang (<i>Areca catechu</i>)	25,03%
		Tisuk (<i>Hibiscus macrophyllus</i>)	23,22%

		Pisang (<i>Musa paradisiaca</i>)	22,67%
		Kopi (<i>Coffea sp.</i>)	16,89%
2	Cisitu	Awi tali (<i>Gigantochloa apus</i>)	48,06%
		Kopi robusta (<i>Coffea robusta</i>)	25,01%
		Haur hejo (<i>Bambusa tuldooides</i>)	22,42%
		Ki sereuh (<i>Piper aduncum L.</i>)	20,81%
		Kopi (<i>Coffea sp.</i>)	19,80%
3	Darmaraja	Haur hejo (<i>Bambusa tuldooides</i>)	72,53%
		Kaliandra merah (<i>Calliandra calothyrsus</i>)	62,66%
		Awi gombong (<i>Gigantochloa pseudoarundinacea</i>)	36,42%
		Ki seueur (<i>Antidesma velotinosum</i>)	22,12%
		Waregu (<i>Rhapis excelsa</i>)	15,86%
4	Buah Dua	Awi tali (<i>Gigantochloa apus</i>)	65,39%
		Bambu (<i>Bambusa sp.</i>)	40,59%
		Rotan (<i>Calamus sp.</i>)	31,05%
		Awi tamiyang (<i>Schizostachyum blumei</i>)	16,61%
		Awi bitung (<i>Dendrocalamus asper</i>)	13,75%

In every sub-district, the *Bambusa tuldooides* species exhibited the most elevated importance value index (IVI). Specifically, this species demonstrated its prominence within the Darmaraja sub-district, boasting an IVI value of 72.53%. *Bambusa tuldooides*, colloquially referred to as "haur hejo," represents a taxonomically classified bamboo species within the esteemed Poaceae botanical family. The indigenous range of this particular species is primarily confined to the vast expanse of China, with additional occurrences documented in various regions of Southeast Asia as well as other countries characterized by tropical and subtropical climates [20]. This particular species of bamboo is commonly utilized for the creation of artisanal handicrafts, showcasing its versatility and cultural significance. Additionally, it is worth noting that the tender shoots of this bamboo variety hold culinary value and can be incorporated into various gastronomic delights [21].

The presence of bamboo from the *Bambusa* genus can be observed in every sub-district, without exception. Bamboo, a botanical entity of considerable interest, manifests as a clumping plant, characterized by the presence of multiple stems that exhibit a gradual growth pattern over time. Bamboo, a remarkably versatile botanical specimen, exhibits a remarkable capacity for acclimatization, demonstrating its ability to flourish in diverse ecological settings encompassing both arid and humid terrains. Furthermore, this resilient plant showcases its adaptability by thriving in both low-lying regions and elevated altitudes [22].

3.1.4. Seedling

Seedlings, the nascent individuals of plants, represent a pivotal stage in the life cycle of various botanical species. Upon careful examination of the outcomes derived from the meticulous analysis of the vegetation, a total of 103 distinct species of seedlings belonging to 38 diverse families have been identified. In the realm of seedlings, it is noteworthy to acknowledge the prevalence of five prominent plant species, namely, *Calliandra calothyrsus*, *Coffea robusta*, *Swietenia mahagoni*, *Musa paradisiaca*, and *Hibiscus macrophyllus*. The findings pertaining to the seedling category vegetation analysis in the vicinity of the stingless bee habitat are illustrated in Figure 5.

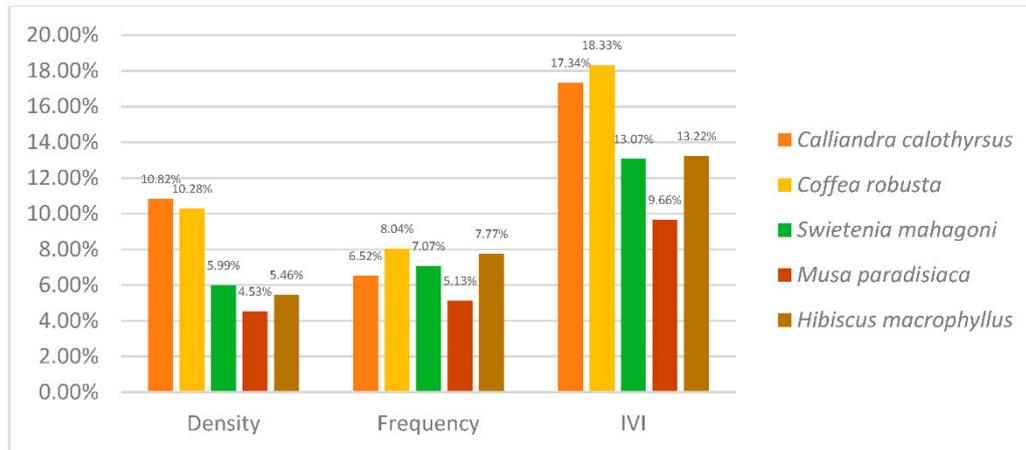


Figure 5. Relative density, relative frequency, relative dominance, and importance value index in the seedling category in Sumedang Regency.

According to the data presented in Figure 5, it is evident that the species *Calliandra calothyrsus* exhibited the highest relative density value within the seedling category, amounting to an impressive 10.82%. Following closely behind, we observe *Coffea robusta* with a relative density of 10.28%. Other notable species include *Swietenia mahagoni* with a relative density of 5.99%, *Hibiscus macrophyllus* with 5.46%, and *Musa paradisiaca* with 4.53%. These findings shed light on the distribution patterns and relative abundance of these species within the seedling category.

The seedling category exhibited a notable distribution of relative frequency values. Remarkably, *Coffea robusta* emerged as the frontrunner with an impressive relative frequency of 8.04%. Following closely behind, *Hibiscus macrophyllus* demonstrated a commendable relative frequency of 7.77%. Equally noteworthy, *Swietenia mahagoni* exhibited a respectable relative frequency of 7.07%. Additionally, *Calliandra calothyrsus* showcased a relative frequency of 6.52%. Lastly, *Musa paradisiaca*, while not reaching the same heights as its counterparts, still displayed a respectable relative frequency of 5.13%.

The seedling category exhibited a remarkable distribution of the importance value index (IVI), with *Coffea robusta* taking the lead with an impressive IVI of 18.33%. Following closely behind is *Calliandra calothyrsus* with a respectable IVI of 17.34%. Notably, *Hibiscus macrophyllus* displayed a commendable IVI of 13.22%, while *Swietenia mahagoni* and *Musa paradisiaca* demonstrated IVIs of 13.07% and 9.66%, respectively.

The data pertaining to the prevailing flora in each sub-district can be readily observed in Table 4. Upon careful examination and analysis of the vegetation data, a total of 103 distinct species of seedlings belonging to 38 diverse families have been identified. In the realm of seedlings, it is noteworthy to mention that there exist five prominent plant species that command our attention: red calliandra (*Calliandra calothyrsus*), Robusta coffee (*Coffea robusta*), mahogany (*Swietenia mahagoni*), banana (*Musa paradisiaca*), and tisuk (*Hibiscus macrophyllus*). The findings pertaining to the seedling category vegetation analysis in the vicinity of the stingless bee habitat are illustrated in Figure 5.

Table 4. Comparison of dominant trees in the prevailing category by sub-district.

No.	Sub District	Dominant Tree	IVI
1	Tanjungkerta	Pisang (<i>Musa paradisiaca</i>)	23,63%
		Tisuk (<i>Hibiscus macrophyllus</i>)	18,67%
		Ki ciat (<i>Ficus septica</i>)	18,45%
		Singkong (<i>Manihot esculenta</i>)	12,97%
		Jambu batu (<i>Syzygium malaccense</i>)	11,10%
2	Cisitu	Kopi robusta (<i>Coffea robusta</i>)	38,98%

		Mahoni (<i>Swietenia mahagoni</i>)	27,47%
		Kaliandra merah (<i>Calliandra calothyrsus</i>)	16,46%
		Tisuk (<i>Hibiscus macrophyllus</i>)	11,25%
		Singkong (<i>Manihot esculenta</i>)	6,63%
3	Darmaraja	Kaliandra merah (<i>Calliandra calothyrsus</i>)	45,05%
		Waregu (<i>Rhapis excelsa</i>)	17,17%
		Kopi robusta (<i>Coffea robusta</i>)	15,84%
		Ki seureuh (<i>Piper aduncum</i> L.)	15,73%
		Kedoya (<i>Dysoxylum amooroides</i>)	14,09%
4	Buah Dua	Mahoni (<i>Swietenia mahagoni</i>)	25,25%
		Rotan (<i>Calamus</i> sp.)	20,17%
		Langkap (<i>Arenga obtusifolia</i>)	19,40%
		Ki seureuh (<i>Piper aduncum</i> L.)	15,22%
		Mara (<i>Macaranga</i> sp.)	14,50%

In every sub-district under investigation, the species that exhibited the most elevated INP (Index of Naturalness and Purity) was *Calliandra calothyrsus*, specifically observed in the Darmaraja sub-district. Remarkably, this particular species demonstrated an IVI value of 45.05%, signifying a substantial level of naturalness and purity within its ecological niche. *Calliandra calothyrsus*, a member of the esteemed Fabaceae family, is a botanical entity that warrants scholarly attention. This particular botanical specimen is renowned for its remarkable capacity for accelerated vegetative development, enabling it to attain vertical dimensions ranging from 2.5 to 3.5 meters. The distribution of this particular species is frequently observed in the geographical region of Southeast Asia, as well as in various other tropical nations [23]. *Calliandra calothyrsus*, a botanical specimen of considerable renown, is widely acknowledged within the scientific community for its remarkable versatility as a plant species. It has garnered significant popularity owing to its inherent capacity for easy cultivation and its remarkable ability to regenerate vigorously subsequent to pruning. Moreover, it exhibits the remarkable ability to bloom incessantly throughout the entire duration of the year, thereby bestowing upon it a profound significance in the realm of honey production [24].

Furthermore, it is worth noting the presence of the esteemed botanical entity known as *Coffea robusta*, a species of considerable significance, known to inhabit the geographical regions encompassing the Cisitua and Darmaraja sub-districts. *Coffea robusta*, a highly esteemed plantation crop, is a member of the illustrious Rubiaceae family. As per the scholarly investigation conducted by [25], it has been observed that *Coffea robusta* exhibits superior growth adaptability in comparison to its counterparts within the realm of coffee species. The cultivation of this particular species is extensively practiced by various communities due to its significant economic worth. It has been observed, as elucidated by [26], that *Coffea robusta* demonstrates a superior level of resistance when confronted with debilitating leaf rust disease in comparison to its counterparts within the coffee species. The existence of bees within coffee plantations engenders a harmonious mutualistic symbiosis, wherein both the bees and coffee plants derive substantial benefits from their interdependence. As per the scholarly work conducted by [27], it has been observed that the symbiotic relationship between bees and coffee plants exhibits a notable augmentation in coffee bean yield, approximately amounting to a 22% increase. Moreover, this harmonious association also yields honey characterized by a sucrose content of 28%.

3.1.5. Understory Plants

The topic of understory plants is indeed a fascinating subject within the realm of biodiversity. According to the findings derived from the vegetation analysis, a total of 82 distinct species belonging to 35 diverse families were successfully identified within the understory plant community. In the realm of the understory plant classification, it is noteworthy to highlight the presence of the five most prominent plant species: *Achyranthes aspera*, *Axonopus compressus*, *Justicia* sp., *Oplismenus* sp., and

Synedrella nodiflora. The findings pertaining to the examination of vegetation within the understory plant classification in the vicinity of the nesting sites of untamed *Tetragonula laeviceps* bees are illustrated in Figure 6.

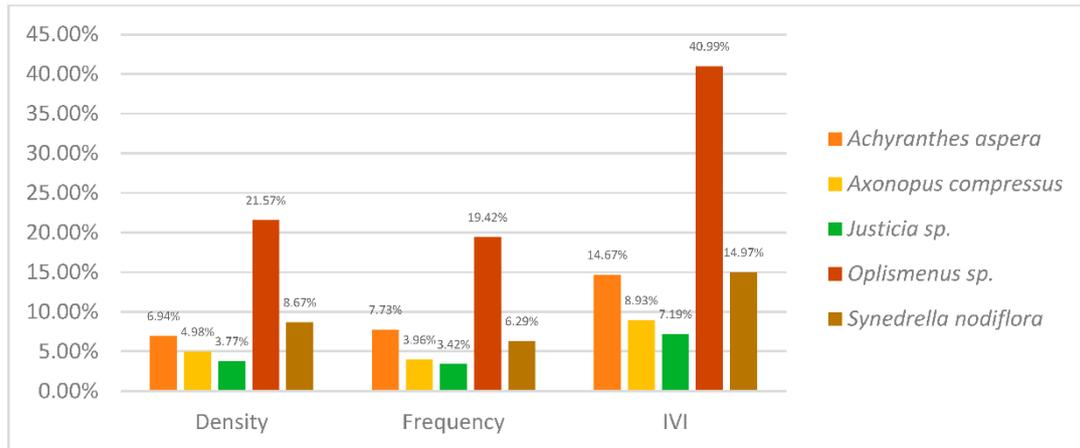


Figure 6. Relative density, relative frequency, relative dominance, and importance value index in the understory plant category in Sumedang Regency.

As per the findings depicted in Figure 6, the species *Oplismenus sp.* exhibited the most substantial relative density within the understory plant category, amounting to an impressive 21.57%. Subsequent to the aforementioned taxon, *Synedrella nodiflora* emerged with a relative density of 8.67%. *Achyranthes aspera*, *Axonopus compressus*, and *Justicia sp.* exhibited relative densities of 6.94%, 4.98%, and 3.77%, respectively.

The most notable observation in the understory plant category pertains to the species *Oplismenus sp.*, which exhibited a relative frequency of 19.42%. Subsequently, we observed *Achyranthes aspera* with a relative frequency of 7.73%, *Synedrella nodiflora* with 6.29%, *Axonopus compressus* with 3.96%, and *Justicia sp.* with 3.42%.

The species *Oplismenus sp.* exhibited the most noteworthy IVI value within the understory plant category, reaching an impressive 40.99%. Following closely behind, we observed *Synedrella nodiflora* with a respectable IVI of 14.97%, *Achyranthes aspera* with a commendable 14.67%, *Axonopus compressus* with a noteworthy 8.93%, and *Justicia sp.* with a modest 7.19%. The comprehensive compilation of data pertaining to the dominant flora within each sub-district is presented in Table 5.

Table 5. Comparison of dominant trees in the understory category by sub-district.

No.	Sub District	Dominant Tree	IVI
1	Tanjungkerta	Jotang kuda (<i>Synedrella nodiflora</i>)	28,63%
		Jarong (<i>Achyranthes aspera</i>)	20,82%
		Rumput pait (<i>Axonopus compressus</i>)	18,44%
		Oplismenus (<i>Oplismenus sp.</i>)	18,34%
		Gandarusa (<i>Justicia sp.</i>)	17,45%
2	Cisitu	Oplismenus (<i>Oplismenus sp.</i>)	43,06%
		Singonium (<i>Syngonium podophyllum</i>)	16,97%
		Jotang kuda (<i>Synedrella nodiflora</i>)	11,97%
		Rumput israel (<i>Asytasia gangetica</i>)	9,21%
		Jarong (<i>Achyranthes aspera</i>)	8,05%
3	Darmaraja	Oplismenus (<i>Oplismenus sp.</i>)	68,80%
		Rumput keranjang (<i>Oplismenus undulatifolius</i>)	42,84%

		Harendong (<i>Clidemia hirta</i>)	10,70%
		Jarong (<i>Achyranthes aspera</i>)	10,47%
		Sembung rambat (<i>Mikania micrantha</i>)	7,74%
4	Buah Dua	Oplismenus (<i>Oplismenus sp.</i>)	64,90%
		Jarong (<i>Achyranthes aspera</i>)	18,88%
		Rumput knop (<i>Hyptis capitata</i>)	12,99%
		Gadung (<i>Dioscorea hispida</i>)	12,49%
		Paku hata (<i>Lygodium sp.</i>)	11,84%

Upon careful examination of the aforementioned table, it becomes apparent that the *Oplismenus* grass species exhibits a widespread distribution across all sub-districts under consideration. Furthermore, it is noteworthy that this particular species attains the highest Index of Natural Presence (IVI) within the confines of the Buah Dua sub-district. *Oplismenus*, scientifically known as *Oplismenus sp.*, represents a botanical specimen that falls within the taxonomic classification of the Poaceae family. Its distribution encompasses diverse geographical regions, including, but not limited to, South Asia, East Asia, Southeast Asia, Australia, and South Africa. This particular botanical specimen exhibits a wide distribution range, primarily observed within the confines of tropical and subtropical regions. As per the scholarly work of [28], it has been observed that *Oplismenus* grass exhibits a remarkable propensity for swift proliferation within forested regions characterized by the presence of arboreal flora, thereby establishing its dominance over other herbaceous species. Hence, this particular species of grass possesses the inherent capability to exert dominance over the designated areas of observation.

5. Conclusions

The subject matter at hand pertains to the remarkable richness of vegetation diversity. The remarkable assemblage of 52 distinct tree species, 77 pole species, 107 sapling species, 103 seedling species, and 82 ground cover (understory plants) species in the immediate vicinity of *Tetragonula laeviceps* bee nests in Sumedang Regency serves as a striking testament to the prodigious and intricate tapestry of plant diversity that thrives in this particular ecological setting. The preservation of biodiversity is of utmost importance in upholding the integrity of ecological systems and providing sustenance for a myriad of fauna species.

The arboreal classification exhibits remarkable prominence in terms of relative density (RD), relative frequency (RF), relative dominance (RD), and importance value index (IVI). The observed phenomenon can be primarily attributed to the remarkable prevalence of the esteemed Aren palm (*Arenga pinnata*) within this particular taxonomic classification. Indeed, the presence of palm trees in the local ecosystem plays a substantial role, thereby contributing significantly to the overall biodiversity. It is worth noting that these palms exhibit a remarkable capacity to influence the atmospheric environment by generating high Ice Nucleating Particle (INP) values, which have been quantified at an impressive 44.56%. This observation underscores the profound significance of these habitats in bolstering the vitality of bee populations and the overall well-being of the ecosystem.

The calculated Shannon Diversity Index (H') values for all vegetation categories surpass the threshold of 3, indicating a considerable magnitude of biodiversity within each respective category. This observation indicates that the ecological milieu surrounding the nests of *Tetragonula laeviceps* bees exhibits a remarkable diversity and robustness, wherein a plethora of plant species harmoniously coexist. The phenomenon of high biodiversity has been widely observed to exhibit a positive correlation with the stability and overall health of ecosystems.

In summary, the vicinity surrounding the nests of *Tetragonula laeviceps* bees in Sumedang Regency exhibits a remarkable array of botanical diversity, wherein the arboreal taxa, particularly the esteemed Aren palm, assume a preeminent position. The remarkable diversity observed in various ecosystems serves as a pivotal factor in fostering a resilient ecological framework, as evidenced by the substantial values obtained from biodiversity indices. The comprehension and preservation of this botanical existence are of utmost importance, not solely for the sustenance of

Tetragonula laeviceps bees, but also for the holistic maintenance of ecological equilibrium within the region.

Funding: This research was funded by Indonesia Ministry of Education and Culture through *Hibah Riset Kemitraan Dasar* (E-Asia Project) and *Penelitian Terapan Unggulan Perguruan Tinggi* (PTUPT), Riset Kompetensi Dosen Unpad, Academic Leadership Grant (ALG) Unpad number XXX" and "The APC was funded by Universitas Padjadjaran".

Institutional Review Board Statement: Not applicable.

Acknowledgments: The authors would say thanks to all research scheme that fully supported this study: Ministry of Education and Culture of Indonesia through *Hibah Riset Penelitian Terapan Unggulan Perguruan Tinggi* (PTUPT) dan *Kemitraan Dasar*; *Hibah Riset Academic Leadership Grant* (ALG) and *Riset Kompetensi Dosen Unpad* from Universitas Padjadjaran. The author would also like to thank several parties who have participated and provided support during the preparation of the results of this study.

Conflicts of Interest: The authors declare no conflict of interest.

References

- Christy, B. Y. (2018). Analisis Hubungan Kekerabatan Beberapa Spesies *Tetragonula* Dengan Penanda Molekuler. Tesis Universitas Andalas. Tersedia [Online] <http://scholar.unand.ac.id/37101/> (Diakses pada Jumat, 09 Desember 2022 pukul 12.30 WIB).
- O'Toole, C. and A. Raw. (1991). *Bees of the World*. Facts on File: London.
- Agussalim, A., Agus, A., Umami, N., & Budisatria, I. G. S. (2017). Variation of Honeybees Forages As Source of Nectar and Pollen Based on Altitude in Yogyakarta. *Buletin Peternakan*, 41(4), 448. <https://doi.org/10.21059/buletinpeternak.v41i4.13593>
- Solihat, R. F. (2022). Analisis Vegetasi Perintis Lokal di Lahan Bekas Tambang Pasir Kecamatan Cimalaka Kabupaten Sumedang. *Jurnal Belantara*, vol. 5(1): 34-44.
- Raihandhany, R., Nugraha, D., & Sidik, R. (2020). Inventarisasi Keanekaragaman Spesies Tumbuhan Bawah Di Kawasan Agrowisata Pangjujungan, Desa Cilembu, Sumedang. *BIOTIKA Jurnal Ilmiah Biologi*, 18(2), 51. <https://doi.org/10.24198/biotika.v18i2.28459>
- Pratama, I, P, N, E., Watiniasih, N, L., Ginantara, I, K. (2018). Perbedaan Ketinggian Tempat Terhadap Jenis Polen Yang Dikoleksi Oleh Lebah Trigona. *Jurnal Biologi Udayana*, vol. 22(1): 42-48.
- Haryadi, N. (2017). Struktur dan Komposisi Vegetasi Pada Kawasan Lindung Air Terjun Telaga Kameloh Kabupaten Gunung Mas. *Ziraa'ah Majalah Ilmiah Pertanian*, vol. 42(2), 137-149.
- Rendra, P. P. R., Sulaksana, N., Alam, B. Y. (2019). Peran Citra Satelit Landsat 8 dalam Identifikasi Tata Guna Lahan di Wilayah Kabupaten Sumedang. *Bulletin of Scientific Contribution: Geology*, vol. 17(2).
- Karmilasanti, Fajri. M. (2020). Struktur dan Komposisi Jenis Vegetasi di Hutan Sekunder: Studi Kasus KHDTK Labanan Provinsi Kalimantan Timur. *Jurnal Penelitian Hutan Tanaman* vol.17(2): 69-85.
- Nurwati, N., Surtinah, Amalia. (2015). Analisis Pemanfaatan Pekarangan Untuk Mendukung Ketahanan Pangan di Kecamatan Rumbai Pesisir Kota Pekanbaru. *Jurnal Ilmiah Pertanian* vol.11(2): 1-8.
- Rozalina. (2019). Profil Kebun Campuran di Desa Karacak Kecamatan Leuwiliang Kabupaten Bogor. *Jurnal Akar* vol.1(1): 72-82.
- Saleh. (2016). Pemanfaatan Tanaman Aren (*Arenga pinnata* Merr.) Sekitar Hutan di Desa Buntupema Kecamatan Curio Kabupaten Enrekang. [SKRIPSI]. Makassar: Universitas Muhammadiyah Makassar.
- Beanal, P., Frans, T. M., & Kainde, R. P. (2021). Hubungan Antara Jenis Pakan Dengan Lebah Madu di Taman Hutan Raya Gunung Tumpa H.V. Worang. *Jurnal Cocos* vol. 13(3).
- Maharani. (2008). Analisis Cabang Usahatani dan Sistem Tataniaga Pisang Tanduk (Studi Kasus : Desa Nanggerang, Kecamatan Cicurug, Kabupaten Sukabumi, Provinsi Jawa Barat). [SKRIPSI]. Bogor: Institut Pertanian Bogor.
- Senoaji, G., Nuryatin, N., Lukman, A. H., Susanti, E. (2022). Pengenalan Budidaya Lebah Trigona di Desa Arga Indah Satu Kabupaten Bengkulu Tengah. *DINAMISIA: Jurnal Pengabdian Kepada Masyarakat* vol.6(4): 855-862.
- Sarwono, B. (2001). *Lebah Madu*. Jakarta: Agro Media Pustaka.
- Pujiarti, R., Amin, A., Ngadianto, A., Septiana, R. M., Purba, B. A. V., Permadi, D. B. (2021). Kualitas Jenis Madu Hutan Suku Baduy Kabupaten Lebak, Provinsi Banten. *Jurnal Ilmu Kehutanan* vol.15(2):123-136.

18. Rumagesan, Q. A. (2019). Analisis Kawasan Boon Pring Terhadap Ketersediaan Air di Hutan Alam Bambu di Desa Sanankerto Kecamatan Turen Kabupaten Malang. Skripsi Universitas Muhammadiyah Malang. Tersedia [Online] <https://eprints.umm.ac.id/55233/> (Diakses pada Kamis, 02 Februari 2023 pukul 14.57 WIB).
19. Irawan, B., Rahayuningsih, S. R., Kusmoro, J. (2006). Keanekaragaman Jenis Bambu di Kabupaten Sumedang Jawa Barat. Sumedang: Universitas Padjajaran.
20. Guerreiro, C. I., Lizarazu, M. A. (2010). Flowering of *Bambusa tuldooides* (Poaceae, Bambusoideae, Bambuseae) in Southern South America. *Darwiniana* 48(1): 25-31.
21. Pertiwi, Y. A. B., Nufus, M., Agustina, A., Rahmadwiati, R., Wicaksono, R. L., Nayasilana, I. N. (2021). Keanekaragaman, Biomassa, dan Cadangan Karbon Bambu di Taman Hutan Raya K.G.P.A.A. Mangkunagoro I. *Jurnal Belantara* vol. 4(2): 140-152
22. Azis, A. (2021). Potensi Pemanfaatan Bambu Tali (*Gigantochloa apus*) Pada Hutan Rakyat di Desa Leu Kecamatan Bolo Kabupaten Bima. [SKRIPSI]. Makassar: Universitas Muhammadiyah Makassar.
23. Wiersum K. F., Rica, I. K. (1992). *Calliandra calothyrsus* Meissn. In L.'t Mannetje dan RM Jones, (Eds). *Plant resources of South-East Asia* vol. 4:68-70.
24. Stewart, J., Mulawarman, J. M. Rosetko., dan M. H. Powell. (2001). *Produksi dan pemanfaatan Calliandra calothyrsus*. Bogor: Pusat Penelitian dan Pengembangan Kehutanan, Departemen Kehutanan.
25. Prambudi, W. (2019). Pengaruh 3 Varietas (BP 436, BP 234, BP 936) dan Dosis Limbah Cair Biogas Terhadap Pertumbuhan Awal Kopi Robusta (*Coffea canephora* Pierre ex Froehner). Skripsi Universitas Muhammadiyah Malang. Tersedia [Online] <https://eprints.umm.ac.id/52567/> (Diakses pada Jumat, 03 Februari 2023 pukul 12.40 WIB).
26. Budiman, H. (2012). *Prospek Tinggi Bertanam Kopi*. Yogyakarta: Pustaka Baru Press.
27. Saepudin, R., Fuah, A. M., Abdullah, L. (2011). Peningkatan Produktivitas Lebah Madu Melalui Penerapan Sistem Integrasi dengan Kebun Kopi. *Jurnal Sain Peternakan Indonesia*, vol.6(2): 115-124.
28. Huh, M. K. (2018). Spatial Distribution Patterns of *Oplismenus undulatifolius* var. *undulatifolius* on Mt. Hanwoo in Korea. *Journal of Life Science* vol. 28(11), 1262-1267.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.