

Agrobiodiversity and resource supply to pollinators in agroforests in the Vale do Ribeira region, São Paulo

*Agrobiodiversidade e oferta de recursos aos polinizadores nas
agroflorestas da região do Vale do Ribeira, São Paulo*

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ABSTRACT

Agroforests are productive systems that can be managed with high species richness and based on practices that favour essential ecological interactions, imitating the functioning of forest ecosystems. To verify the agrobiodiversity managed in agroforests and the supply of floral resources to pollinators, this research was conducted with 20 family farmers who manage agroforests in nine municipalities in the Vale do Ribeira region, São Paulo. Through the guided tour, a great wealth of species and varieties was identified, around 350 in total. In the agroforests visited, the number of managed species varied from 25 to 93, with the best coverage of flowering species being from farmers who are already beekeepers. Among the managed species, there is a high number of native species from the Atlantic Forest Biome and food plants, which reinforces the potential of agroforests for the ethnoconservation of biodiversity and food and nutritional security. Furthermore, approximately 71% of the species are honey-producing, confirming the capacity of agroforests to provide food resources to pollinators. Considering that agroforestry stands out as an important strategy for promoting socio-environmental benefits and adapting to climate change, the results of this study reaffirm its potential in facing challenges and fulfilling commitments linked to sustainable development at a global level.

Keywords: Family farming. Agroforestry systems. Floral resources. Atlantic Forest.

RESUMO

As agroflorestas são sistemas produtivos que podem ser manejados com alta riqueza de espécies e a partir de práticas que favorecem interações ecológicas essenciais, imitando o funcionamento de ecossistemas florestais. Com o objetivo de verificar a agrobiodiversidade manejada nas agroflorestas e a oferta de recursos florais aos polinizadores, esta pesquisa foi conduzida com 20 agricultores(as) familiares que fazem o manejo de agroflorestas em nove municípios da região do Vale do Ribeira, em São Paulo. Por meio da turnê guiada, foi registrada grande riqueza de espécies e variedades, cerca de 350 no total. Nas agroflorestas visitadas, o número de espécies manejadas variou de 25 a 93, sendo as com melhor cobertura de espécies em floração de agricultores(as) que são criadores(as) de abelhas. Entre as espécies manejadas, há um alto número de nativas do bioma Mata Atlântica e de plantas alimentícias, o que reforça o potencial das agroflorestas para a etnoconservação da biodiversidade e segurança alimentar e nutricional. Ademais, aproximadamente 71% das espécies são melíferas, confirmando a capacidade das agroflorestas no fornecimento de recursos alimentares aos polinizadores. Considerando que as agroflorestas se destacam como uma importante estratégia de promoção de benefícios socioambientais e de adaptação às mudanças climáticas, os achados deste estudo reafirmam seu potencial no enfrentamento dos desafios e no cumprimento dos compromissos vinculados ao desenvolvimento sustentável em nível global.

Palavras-chave: Agricultura familiar. Sistemas agroflorestais. Recursos florais. Mata Atlântica.

1 INTRODUCTION

The loss of biodiversity affects ecosystem functioning and their capacity to provide the goods and services necessary to sustain life on the planet (Cardinale *et al.*, 2012). In this context, the decline in pollinator populations has emerged as one of the greatest global concerns in recent decades, as the absence of these agents can impact the production of important agricultural crops, particularly in countries such as Brazil (Imperatriz-Fonseca *et al.*, 2012).

This is because 91 out of the 191 cultivated and wild plant species related to food in Brazil exhibit some degree of dependence on pollination (Wolowski *et al.*, 2019). Globally, 75% of human food, directly or indirectly, depends on plants that are pollinated or benefit from animal pollination, while 40% to 90% of the pollination of natural species in tropical regions is carried out by native stingless bees (Kerr; Carvalho; Nascimento, 1996; Klein *et al.*, 2007; Slaa *et al.*, 2006).

However, pollinator conservation has been threatened by environmentally unsustainable development models, particularly conventional agriculture, which has led to the destruction of natural resource bases and to a growing decline in pollinator populations, especially bees (Cunha; Landeiro, 2012). The main threats to pollinators include habitat loss and fragmentation, habitat degradation (presence of invasive or exotic species, and intensive soil management practices), and pesticide use (Ferreira, 2015).

While land-use changes for agricultural expansion are the main cause of biodiversity loss, biodiversity decline, in turn, affects various ecosystem services essential to agriculture (Soterroni *et al.*, 2024). Large areas of native vegetation and the adoption of pollinator-friendly practices increase both the abundance of bee visits and the diversity of wild pollinators, which in turn improves agricultural productivity through pollination (Campbell *et al.*, 2023; Hipólito; Boscolo; Viana; 2018; Hipólito; Viana; Garibaldi, 2016).

In this context, the ecological intensification of agriculture and the identification of areas with high pollinator availability are useful strategies for territorial management and for the conservation of this fauna (Moreira *et al.*, 2024). Furthermore, knowledge of melliferous flora and available floral resources is essential for the development of beekeeping and meliponiculture. The preparation of floral calendars

also helps identify periods of food abundance and scarcity, facilitating hive management planning, honey production, and interventions in agroecosystems (Salis *et al.*, 2015; Wolf, 2018).

Through cultivation and care, humans have modified landscapes or the characteristics of certain species populations in a process known as domestication, which includes gardens, fields, orchards, agroforests, and homegardens that shelter people, plants, and animals (Clement *et al.*, 2021). Regarding the sustainable use of biodiversity, agroecological agroforestry systems are found in all Brazilian regions, displaying distinct characteristics both in management practices and in species composition, with a significant contribution to the conservation of species threatened with extinction (Felipe *et al.*, 2023).

In agroforestry systems, this diversification of species and crops provides multiple benefits, such as income generation, food sovereignty, environmental restoration, and climate regulation, positioning them as an important alternative to the current socio-environmental collapse by reconciling ecological and economic objectives (Canuto; Urchei; Camargo, 2017). In the Vale do Ribeira region, São Paulo, where this research was conducted and which contains the largest continuous remnant of the Atlantic Forest biome, agroforestry is widely practised among family farmers and traditional communities.

Considering the importance of pollinators as key agents for biodiversity conservation and food sovereignty, the present study aimed to assess the managed agrobiodiversity and the availability of floral resources to pollinators in the agroforestry systems of the Vale do Ribeira region, São Paulo.

2 METHODOLOGIES

2.1 STUDY AREA

The Vale do Ribeira region is located in the southern part of the state of São Paulo, bordering the state of Paraná. It comprises 25 municipalities that are fully or partially included in the Ribeira de Iguape River Basin, within the Ribeira de Iguape and Southern Coast Water Management Unit (UGRHI-11) (Figure 1). The region's climate is humid tropical, classified as humid tropical without a dry season (Af) in 5% of the basin, humid subtropical with a hot summer (Cfa) in 50% of the basin, and humid subtropical with a mild summer (Cfb) in 45%, with an average annual precipitation of 1,400 mm (São Paulo, 2018).

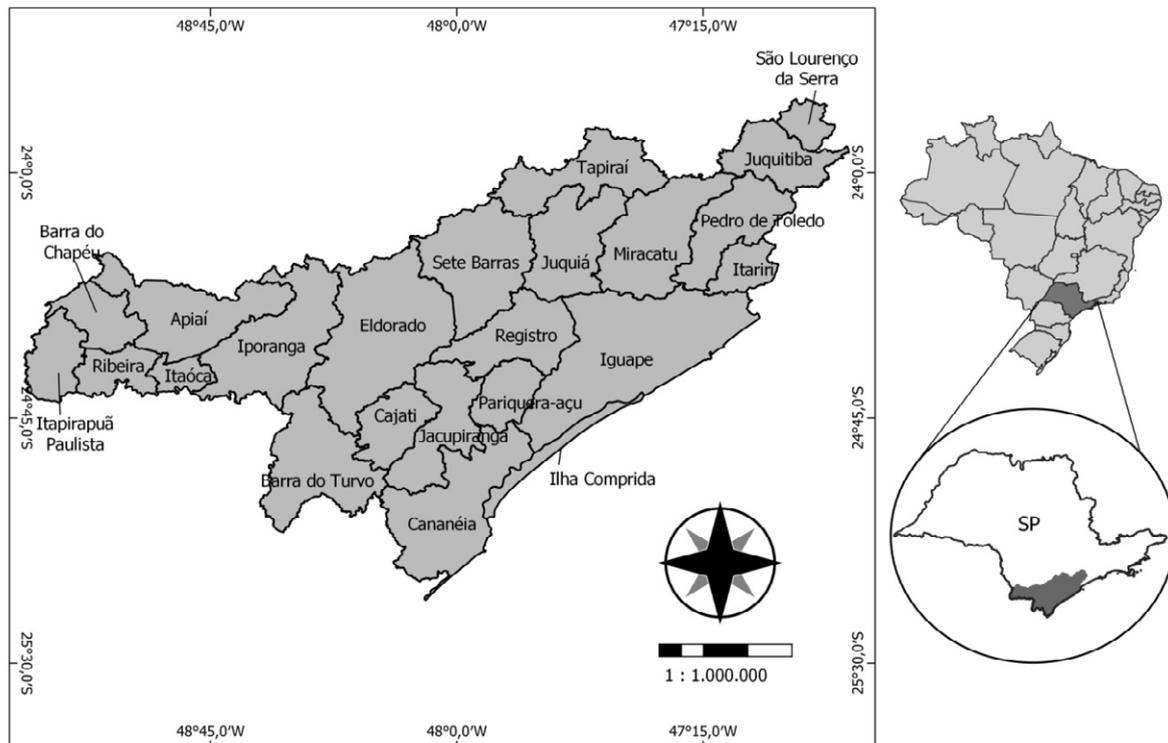


Figure 1 – Location and municipalities of the Vale do Ribeira region, State of São Paulo.

Source: The authors.

The region is part of the Atlantic Forest biome and contains one of its most significant areas, unmatched in the country and of recognised international importance. In 1998, this led Unesco (United Nations Educational, Scientific and Cultural Organisation) to grant the Vale do Ribeira the title of World Historical and Environmental Heritage. Complementing this natural wealth is a great diversity of cultures, including Indigenous, *caiçara*, *quilombola*, and *caipira* traditions, as well as migrant communities such as those from the Brazilian Northeast and descendants of government colonisation programs, including Japanese, French, Swiss, and German settlers, among others (Diegues, 2007).

These populations live daily with the dilemma between development and environmental preservation, since approximately 70% of the region's total area consists of Atlantic Forest remnants, located within Conservation Units (CU), Indigenous and *quilombola* territories, and rural neighbourhoods (Almeida *et al.*, 2017). Furthermore, the Vale do Ribeira region has the highest number of small farmers in the State of São Paulo and is one of the state's administrative regions with the highest levels of social vulnerability (Brazil, 2015; São Paulo, 2019). It is within this territorial context that the farmers participating in the present study are situated and carry out the management of their agroforestry systems.

2.2 RESEARCH METHODOLOGIES

To identify participants with the required profile for the study—farmers who manage agroforestry systems—the snowball sampling method was employed (Goodman, 1961). This non-probabilistic, referral-based approach relied on key informants (community leaders, researchers, and rural extension and technical assistance agents) to recommend participants. Based on these recommendations, contact was made, and a more detailed presentation of the research proposal was provided to interested farmers. Visits were then scheduled for data collection, which took place during 2024.

In accordance with ethical guidelines for research involving human participants, the research project was submitted to and approved by the Human Research Ethics Committee of the Federal University of São Carlos (CEP-UFSCar), Opinion No. 6.866.261, CAAE 76758523.5.0000.5504. Furthermore, the participation of farmers in this study was formalised through the signing of the Informed Consent Form (ICF).

2.2.1 GUIDED TOUR

The guided tour is a field research method that generally requires the participation of a community member skilled in navigating the local vegetation and knowledgeable about the local flora and fauna (Albuquerque *et al.*, 2014). Through the guided tour, the researcher is expected to observe and record characteristics relevant to the description of the visited site, as well as to question the informant on topics of interest to the study, using a voice recorder, camera, and GPS (Silva; Gomes; Albuquerque, 2014).

From this perspective, the guided tour was conducted with the farmers responsible for managing the agroforestry systems (SAFs) in their respective areas. Its objectives were to survey the species that make up these systems and to gather information on species with the potential to provide food resources for pollinators (melliferous plants), when the farmer possessed such knowledge, especially in the case of those engaged in beekeeping or stingless beekeeping.

Following an ethnobotanical approach, which acknowledges the knowledge farmers hold about the plants they manage, species and variety lists were compiled for each agroforestry system. Species identification in the field was carried out with the support of a botanical survey technician, and photographic records were taken for later identification using specialized literature (Carvalho, 2003, 2006, 2008, 2010, 2014; Embrapa, 2025; Flora e Funga do Brasil, 2025; Lorenzi, 1992, 1998, 2009; Magdalena, 2022).

The scientific names, authorship, and classification of species by origin (native, naturalised, and cultivated) and life form (herb, shrub, subshrub, tree, palm tree, dracenoid, liana, scandent, vine, bamboo) followed the standards proposed by the Flora e Funga platform (2025). In addition, information was collected on the different uses of the species (ornamental, medicinal, vegetable, fruit-bearing, timber, service, utensil), as well as on aspects related to pollinators, including melliferous species, plants used for nesting, and each species' degree of pollination dependence (Carvalho, 2003, 2006, 2008, 2010, 2014; Gazzoni, 2022; Lorenzi, 1992, 1998, 2009; Magdalena, 2022; Wolowski *et al.*, 2019).

2.2.2 DEVELOPMENT OF FLORAL RESOURCE CALENDARS

Floral resource calendars allow for the identification of the availability of plant species, their flowering periods, and the resources provided by each plant species (Barateiro; Gazzoni, 2022). In this regard, the creation of such calendars becomes an important tool both for stingless beekeepers and beekeepers in making management decisions for their colonies, and for farmers in planning agricultural activities that depend on pollination (Barateiro; Gazzoni, 2022).

Based on the survey of species present in each agroforestry system, floral resource calendars were developed to show the resources available to pollinators throughout the year. These calendars made it possible to determine the composition of the mellitophilous pasture in each SAF and to identify potential resource gaps. Such information can indicate the need to plant species during periods of resource scarcity, to attract and retain pollinators in the SAF areas.

For the preparation of the calendars, information on the flowering period and pollination dependence of each species, among other data, was obtained from specialized literature (Carvalho, 2003, 2006,

2008, 2010, 2014; Embrapa, 2025; Gazzoni, 2022; Lorenzi, 1992, 1998, 2009; Magdalena, 2022; Wolowski et al., 2019).

3 RESULTS AND DISCUSSION

3.1 PROFILE OF PARTICIPATING FARMERS

In the present study, interviews were conducted with farmers who manage agroforestry systems located in nine municipalities of the Vale do Ribeira region, São Paulo. Of these, five were in the municipality of Sete Barras, four in Barra do Turvo, four in Iguape, two in Cajati, and one in each of the remaining municipalities – Registro, Cananéia, Pariquera-Açu, Eldorado, and Pedro de Toledo.

The profile of the participants consisted of 20 family farmers, 12 men and eight women, aged between 34 and 83 years (Figure 2). Among the male participants, most were between 51 and 75 years old, while the majority of female participants were between 45 and 56 years old, with a median age of 65.5 years (± 12.98) for men and 49.5 years (± 8.84) for women.

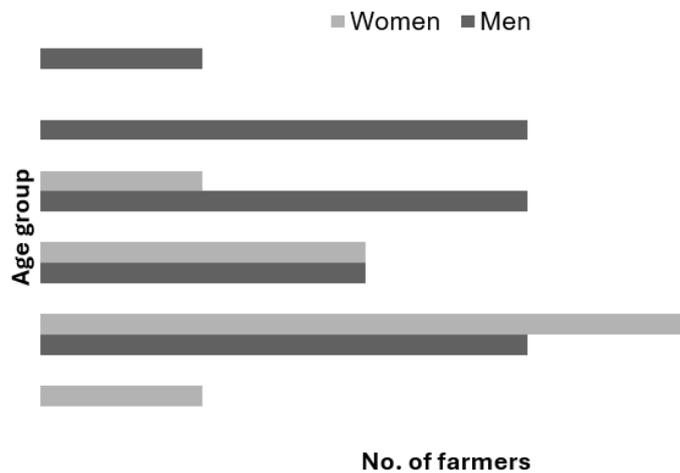


Figure 2 – Distribution of research participants by age group.

Source: The authors.

Regarding the educational level of the interviewed farmers, 40% had attended elementary school, 30% secondary school, 20% higher education, and 10% reported never having attended school. Among those who never attended school and those who did not have access to higher education, only female farmers were represented.

The data on the age of the research participants reveal a low participation of young people in the management of SAFs. In contrast, the data on schooling reflect the vulnerable conditions faced by rural women. Addressing these issues requires specific public policies aimed at ensuring the permanence and social reproduction of rural populations, as well as access to education through models adapted to rural realities.

Dependence on production for household consumption also differs between male and female farmers. While only half of the interviewed men (six) reported relying on their production for food, only one of the eight interviewed women stated that she did not depend on production for her family's diet. Among all farmers who reported depending on their production (13 in total), only one woman stated that production was insufficient for household consumption.

These findings align with the strong connection between women and food sovereignty, as well as food and nutritional security. This is mainly because rural women are generally the primary holders of knowledge about food production and preparation, given their role as those responsible for caring for the family, including its nourishment (Mota; Siliprandi; Pacheco, 2021).

3.2 MANAGED AGROBIODIVERSITY IN THE VISITED AGROFORESTS

The survey conducted through guided tours with farmers in the agroforests recorded a total of 349 species and varieties (Gemim, 2025). Among the botanical families with the greatest number of managed species and varieties are Anacardiaceae (10), Arecaceae (16), Asteraceae (10), Fabaceae (35), Malvaceae (10), Musaceae (11), Myrtaceae (25), Poaceae (10), Rutaceae (19) and Solanaceae (16).

These families include species that are culturally cultivated in the Vale do Ribeira region, such as different varieties of banana (*Musa* sp.), the juçara palm (*Euterpe edulis* Mart.), and native, naturalised, and cultivated fruit trees, notably jabuticaba (*Plinia peruviana* (Poir.) Govaerts), guava (*Psidium guajava* L.), and *Citrus* sp. Table 1 lists the 20 species most frequently found in the visited agroforests.

Table 1 – The 20 species most frequently found in the agroforests visited in the Vale do Ribeira region, São Paulo.

Species	Vernacular name	Frequency
Arecaceae		
<i>Bactris gasipaes</i> Kunth	Pupunha	50%
<i>Euterpe edulis</i> Mart.	Juçara	80%
Cannabaceae		
<i>Carica papaya</i> L.	Mamão, Mamão-formosa, Mamão-papaya	55%
Euphorbiaceae		
<i>Manihot esculenta</i> Crantz	Mandioca	80%
Fabaceae		
<i>Inga</i> sp. var. 1	Ingá	65%
<i>Senna multijuga</i> (Rich.) H.S.Irwin & Barneby	Caquera	65%
Lauraceae		
<i>Persea americana</i> Mill.	Abacate	70%
Melastomataceae		
<i>Pleroma</i> sp., <i>Tibouchina</i> sp.	Jacatirão, Quaresmeira	70%
Musaceae		
<i>Musa</i> sp.	Banana	100%
Myrtaceae		
<i>Campomanesia phaea</i> (O.Berg) Landrum	Cambuci	60%
<i>Eugenia uniflora</i> L.	Pitanga, Pitangueira	55%
<i>Myrciaria glazioviana</i> (Kiaersk.) G.M.Barroso ex Sobral	Cabeludinha	55%
<i>Plinia peruviana</i> (Poir.) Govaerts	Jabuticaba, Jaboticaba	75%
<i>Psidium guajava</i> L.	Goiabeira, Goiaba, Goiaba-tailandesa	90%

Species	Vernacular name	Frequency
Rubiaceae		
<i>Coffea arabica</i> L.	Café	65%
Rutaceae		
<i>Citrus ×limon</i> (L.) Osbeck var. 1	Limão	70%
<i>Citrus reticulata</i> Blanco var. 1	Mexirica, Mexirica-caipira, Tangerina	65%
Sapindaceae		
<i>Litchi chinensis</i> Sonn.	Lichia	80%
Urticaceae		
<i>Cecropia pachystachya</i> Trécul	Embaúba	65%
Zingiberaceae		
<i>Curcuma longa</i> L.	Cúrcuma, Açafração-da-terra, Açafração	65%

Source: The authors.

Among the combinations of species, the most traditional found in the agroforests of the Vale do Ribeira region is that of banana (*Musa* sp.) with juçara palm (*Euterpe edulis*), in which the banana plants provide cover for the initial development of the palm (Figure 3).



Figure 3 – Intercropping of banana (*Musa* sp.) and juçara palm (*Euterpe edulis*), a combination commonly found in the agroforests of the Vale do Ribeira region, São Paulo.

Source: Bruna Schmidt Gemim (2024).

Of the total 349 species and varieties recorded, 159 are native to Brazil (13 of which are native to other biomes but not to the Atlantic Forest biome, in which the Vale do Ribeira region is located), 140 are cultivated, and 50 are naturalised. The high richness of native species managed in these systems demonstrates the potential of agroforests for the ethnoconservation of biodiversity, as well as for the preservation of threatened species such as the juçara palm.

In the Amazon, Campbell *et al.* (2023) found that the productivity of açaí (*Euterpe oleraceae*), measured in tons of fruit per hectare, was nearly five times higher in areas with at least 40% conserved forest compared to areas with 10% forest cover within a one-kilometer radius. Considering that both açaí (*E. oleraceae*) and juçara (*E. edulis*) are highly dependent on pollination, biodiverse agroforests have the potential to attract and maintain wild pollinators, which can contribute to the reproduction and conservation of these important species in their respective biomes.

Regarding the life form of the species found in the visited agroforests, the most representative categories were trees (132 species), herbs (66), shrub/trees (44), shrubs (29), and palm trees (16 species). These data reveal the presence of a large number of tree species in agroforestry systems, which play an important role both in providing food and in offering nesting sites for bees.

According to Menezes *et al.* (2024), including a diversity of native tree species in the planning and enrichment of agroecosystems, as in biodiverse agroforestry systems, is essential for the conservation of Brazil's native bees and for the development of stingless beekeeping, among other benefits. Therefore, for farmers who keep bees, whether native or not, tree planting should be considered as a strategy for maintaining bee populations and producing goods derived from beekeeping.

According to the consulted literature, the vast majority of species listed in the agroforests are melliferous, 258 in total (71%), while 57 are either non-melliferous or have other forms of pollination, and no data were found for the remaining 34 species. However, information on plants that provide shelter for hives remains scarce in the literature. Among the species managed by farmers in the agroforests, 26 are indicated in the literature as being used for bee nesting.

Another important aspect concerns the multiple uses of the species: 103 were classified as fruit-bearing, 82 as vegetables, 61 as timber, 50 as ornamental, 55 as service species, 19 as medicinal, and others for uses such as utensils and religious purposes. Considering only the fruit-bearing and vegetable species, the potential of the visited agroforests for food security becomes evident, as well as their potential for providing alternative income sources through the commercialisation of species with different purposes and uses.

However, the visited agroforests show considerable variation in the richness of managed species, ranging from 25 to 93 species (Figure 4). Of the 20 SAFs visited, 13 have more than 50 species, eight of which are managed by farmers with over 10 years of experience in agroforestry management.

Among the SAFs with less than 10 years of management (11 of the 20 visited), six have fewer than 50 species, and five have more than 50 species, with two of these being the SAFs with the highest number of managed species, totalling 93. Despite having been established more recently, in these two SAFs, the farmers' motivation to "plant diversity" contributed to the cultivation of a large number of species.

Among the visited SAFs, it is evident that management duration may influence the number of species present in the agroforests. This greater richness of managed species in SAFs with more years of management had also been observed by Froufe and Seoane (2011) in agroforestry systems in the Vale do Ribeira region, SP.

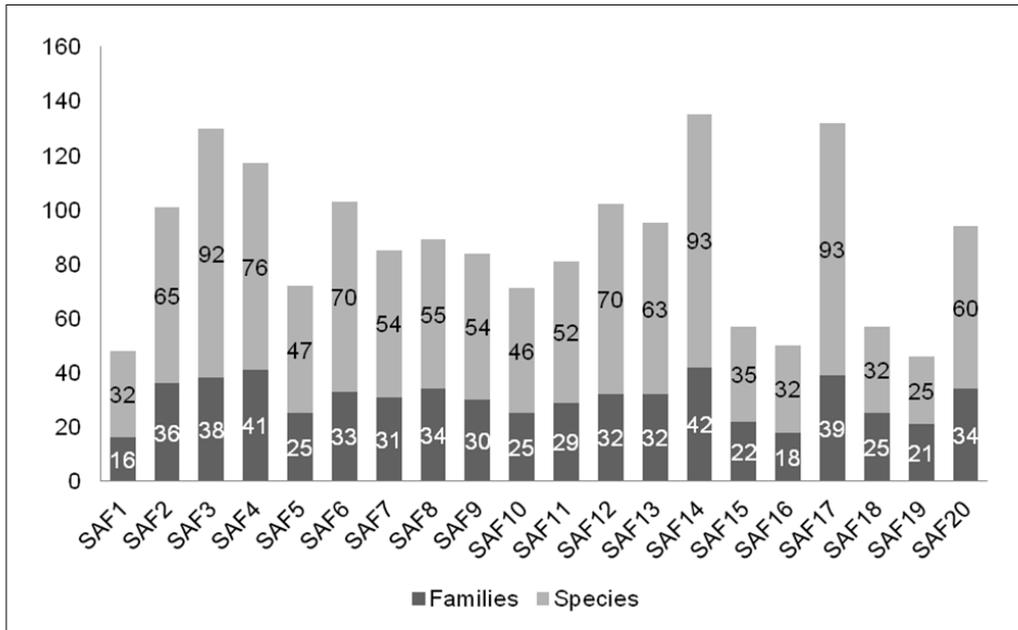


Figure 4 – Number of families and species managed per agroforestry system visited in the Vale do Ribeira region, São Paulo.

Source: The authors.

3.3 AVAILABILITY OF FLORAL RESOURCES FOR POLLINATORS

Based on the data available in the consulted literature, it was possible to identify the flowering periods of melliferous species and to prepare floral resource calendars for each of the visited agroforestry systems. When available, information on the flowering period of species in the state of São Paulo and in the region was included, along with on-site observations, which can serve as a basis and be further adjusted by farmers in their local contexts (Figure 5).



Figure 5 – Flowering species in the agroforestry systems visited in the Vale do Ribeira region, São Paulo. From left to right: araçá (*Psidium cattleianum*), Malay apple (*Syzygium malaccense*), and okra (*Abelmoschus esculentus*).

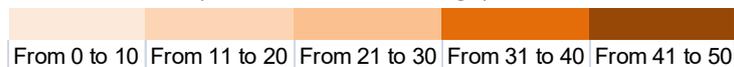
Source: Bruna Schmidt Gemim (2024).

Based on the floral resource calendars, it was possible to identify the periods of greatest abundance and scarcity of resources in each SAF, considering the number of species in bloom each month (Table 2). These data make it possible to identify gaps in the resource calendar of the agroforests and to propose the enhancement of the mellitophilous pasture through the inclusion of additional species.

Table 2 – Floral resource calendars of the visited agroforestry systems, showing the number of flowering species.

SAFs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SAF1	8	4	2	2	3	4	4	9	20	23	22	15
SAF2	15	13	13	10	9	12	13	16	24	22	24	23
SAF3	32	29	28	26	21	29	31	36	42	42	43	39
SAF4	25	21	16	11	15	17	16	21	33	34	36	32
SAF5	18	18	14	9	9	11	11	13	21	23	25	24
SAF6	21	19	18	17	13	19	20	28	32	37	35	28
SAF7	14	13	14	14	13	15	13	15	21	22	24	19
SAF8	21	20	18	14	12	17	14	19	22	21	22	21
SAF9	23	21	22	19	15	18	18	19	23	24	26	22
SAF10	12	10	9	6	7	13	15	16	17	16	17	14
SAF11	12	11	11	8	7	14	12	17	16	19	20	17
SAF12	18	16	19	17	15	19	21	27	31	32	32	23
SAF13	19	18	17	12	13	22	22	26	28	26	27	26
SAF14	44	39	34	27	24	30	33	38	49	45	46	46
SAF15	17	16	15	15	13	16	15	17	20	20	19	19
SAF16	8	5	3	4	4	7	9	10	13	15	14	13
SAF17	26	26	26	25	23	35	34	40	45	40	37	34
SAF18	10	10	11	10	6	9	9	12	14	12	13	12
SAF19	12	12	10	7	5	8	8	8	9	7	10	12
SAF20	29	27	24	19	18	16	19	20	31	31	33	33

Caption: Number of flowering species.



Source: The authors.

Comparing the visited agroforestry systems, SAF1, SAF10, SAF15, SAF16, SAF18, and SAF19 have more months with a lower number of flowering species. In contrast, SAF3, SAF4, SAF6, SAF14, SAF17, and SAF20 have more months with a higher number of flowering species and peaks in resource availability. Overall, the months with the fewest flowering species were April and May, while those with the highest number were September, October, and November autumn and spring, respectively.

Among the SAFs with better flowering species coverage are those managed by farmers who also keep bees, SAF3, SAF4, SAF6, and SAF20, which reinforces the role of farmers in pollinator conservation and the potential of beekeeping and stingless beekeeping in these agroforests for producing bee-derived products. For beekeeping purposes, Camargo *et al.* (2017) state that the planning of SAFs should ensure

a flowering boom, with simultaneous and abundant blooms, to secure food reserves for colonies and generate surpluses for consumption and commercialisation.

In this regard, the SAFs with beekeeping mentioned above can serve as examples for enhancing the mellitophilous pasture in other agroforests. Based on the species found in these SAFs, Box 1 presents a list of species that flower in autumn and winter, aiming to increase the number of flowering species during the most critical periods in the visited agroforests.

Box 1 – List of species flowering between autumn and winter, and annual species, for enhancing mellitophilous pasture in agroforestry systems.

Herb/Liana, scandent, vine	Asteraceae	
	<i>Acmella oleracea</i> (L.) R.K.Jansen	Jambu
	<i>Cosmos sulphureus</i> Cav.	Cosmos
	Brassicaceae	
	<i>Raphanus sativus</i> L.	Nabo-forrageiro
	Cactaceae	
	<i>Pereskia aculeata</i> Mill.	Ora-pro-nóbis
	Convolvulaceae	
	<i>Ipomoea batatas</i> (L.) Lam.	Batata-doce
	Cucurbitaceae	
	<i>Cucurbita maxima</i> Duchesne ex Lam.	Abóbora-moranga
	<i>Cucurbita moschata</i> Duchesne	Abóbora-paulista
	<i>Cucurbita maxima</i> x <i>Cucurbita moschata</i>	Abóbora-cabotiá
	Rosaceae	
	<i>Rubus rosifolius</i> Sm.	Framboesa-do-mato, morango-silvestre
	Solanaceae	
<i>Solanum americanum</i> Mill.	Erva-moura	
<i>Solanum melongena</i> L.	Berinjela	
Tropaeolaceae		
<i>Tropaeolum majus</i> L.	Capuchinha	
Subshrub, Shrub	Asteraceae	
	<i>Solidago chilensis</i> Meyen	Arnica
	<i>Tithonia diversifolia</i> (Hemsl.) A.Gray	Margaridão
	Bixaceae	
	<i>Bixa orellana</i> L.	Urucum
	Ericaceae	
	<i>Gaylussacia brasiliensis</i> (Spreng.) Meisn.	Camarinha
	Euphorbiaceae	
	<i>Ricinus communis</i> L.	Mamona
	Fabaceae	
	<i>Cajanus cajan</i> (L.) Huth	Guandu, feijão-guandu
	<i>Mimosa caesalpiniiifolia</i> Benth.	Sansão-do-campo
Malvaceae		
<i>Abelmoschus esculentus</i> L.	Quiabo	
<i>Dombeya wallichii</i> (Lindl.) Baill.	Astrapeia	
<i>Heliocarpus popayanensis</i> Kunth	Algodoeiro	

Subshrub, Shrub	<i>Hibiscus sabdariffa</i> L.	Vinagreira
	<i>Malvaviscus arboreus</i> Cav.	Hibisco-sapateiro
	Solanaceae	
	<i>Capsicum baccatum</i> var. <i>pendulum</i> (Willd.) Eshbaugh	Pimenta, Pimenta-cambuci, Dedo-de-moça
	<i>Capsicum chinense</i> Jacq.	Pimenta-biquinho
	<i>Capsicum praetermissum</i> Heiser & P.G.Sm.	Pimenta-cumari, Pimenta-cambari
	<i>Cestrum nocturnum</i> L.	Dama-da-noite
	<i>Nicotiana tabacum</i> L.	Fumo
	<i>Solanum aethiopicum</i> L.	Jiló
	<i>Solanum paniculatum</i> L.	Jurubeba
<i>Solanum sessiliflorum</i> Dunal	Maná, manacubio	
Tree	Elaeocarpaceae	
	<i>Elaeocarpus serratus</i> L.	Azeitona-do-ceilão
	Euphorbiaceae	
	<i>Croton urucurana</i> Baill.	Urucurana, Sangra-d'água
	Fabaceae	
	<i>Inga</i> sp. var. 1	Ingá
	<i>Libidibia ferrea</i> (Mart. ex Tul.) L.P.Queiroz	Pau-ferro
	Lauraceae	
	<i>Nectandra grandiflora</i> Nees & Mart	Canela-anhuva, Niúva
	Malpighiaceae	
	<i>Malpighia emarginata</i> DC.	Acerola
	Myrtaceae	
	<i>Campomanesia xanthocarpa</i> (Mart.) O.Berg	Guabiroba
	<i>Eucalyptus</i> sp., <i>Corymbia</i> sp.	Eucalipto
	<i>Myrciaria glazioviana</i> (Kiaersk.) G.M.Barroso ex Sobral	Cabeludinha
	Peraceae	
	<i>Pera glabrata</i> (Schott) Baill.	Tabucuva
	Primulaceae	
	<i>Myrsine coriacea</i> (Sw.) R.Br. ex Roem. & Schult.	Capororoca
	Rhamnaceae	
	<i>Colubrina glandulosa</i> Perkins	Sobrasil
	Rutaceae	
	<i>Citrus reticulata</i> Blanco var. 1	Mexirica
<i>Citrus reticulata</i> Blanco var. 2	Poncã	
<i>Murraya paniculata</i> (L.) Jack	Murta-branca	
Solanaceae		
<i>Solanum betaceum</i> Cav.	Tomarilho	

Source: The authors.

The use of some of these species for feeding bees is quite common among stingless beekeepers and beekeepers, such as *Astrophaea*, cosmos, annatto, castor bean, and ora-pro-nobis (Figure 6). In addition, the use of green manures, such as forage radish and pigeon pea, has proven to be an efficient and recommended technique in apicultural and meliponicultural SAFs, as well as in other models,

serving both as a source of resources for bees and as protection for seedlings in their early stages of development (Camargo *et al.*, 2017).



Figure 6 – Images of cosmos (*Cosmos sulphureus* Cav.) on the left and astrapéia (*Dombeya wallichii* (Lindl.) Baill.) on the right, with a floral visit by the native bee *Scaptotrigona* sp.

Source: Bruna Schmidt Gemim (2024).

Therefore, it is important to keep in mind that SAFs integrated with stingless beekeeping and beekeeping require greater plant diversity, including non-arboreal elements such as green manures and annual crops with blooms attractive to bees. These elements help create a diversified landscape that ensures resource availability in the short and medium term (Camargo *et al.*, 2017). This diversity of components also aids in windbreak, spontaneous plant control, moisture retention, and soil fertilisation, while benefiting different groups of bees by meeting their distinct characteristics and foraging habits (Camargo *et al.*, 2017).

Moreover, the cultivation of annual plants intercropped with other crops, whether or not associated with beekeeping, can attract a rich diversity of pollinators, contributing to family food and financial security. In the case of pumpkin (*Cucurbita* spp.) production, for example, the pollination ecosystem service is essential. According to one of the interviewed farmers, who is also a beekeeper and stingless beekeeper, he harvested about one ton of different pumpkin varieties, which were sold through the PAA – Food Acquisition Program, ensuring both food and income for his family (Figure 7).



Figure 7 – Images of pumpkin (*Cucurbita* spp.) varieties on the right and floral visitation by the native bee *Scaptotrigona* sp. on the left.

Source: Bruna Schmidt Gemim (2024).

The composition of the visited agroforests indicates great potential for integrating beekeeping, given the richness of species flowering at different times of the year. This richness ensures good coverage of food resources for wild pollinators, a particularly relevant aspect since a large portion of the farmers depend on production for household food, and a pollination deficit could place families in a situation of food insecurity.

For the state of São Paulo, Barbosa *et al.* (2020) project a 40% increase in the demand for pollination services, which will require efforts in spatial arrangements that favour pollinators' access to crops and ensure the conditions necessary for their survival. Furthermore, in the face of the climate emergency, it is undeniable that economically vulnerable families, especially those in regions whose economies depend on agriculture, will be the most affected by losses (Soterroni *et al.*, 2024).

In this context, the adoption of pollinator-friendly practices has the potential to create win-win scenarios, benefiting farmers and guiding decision-makers in formulating public policies aimed at biodiversity conservation and restoration, thereby contributing to improved crop yields (Hipólito; Viana; Garibaldi, 2016; Imperatriz-Fonseca; Nunes-Silva, 2010). On this premise, agroforestry systems have been recognised as an important strategy for climate change adaptation, the promotion of food and nutritional security, and an economic alternative aligned with biodiversity conservation and the provision of ecosystem services. They can also be designed to favour the maintenance and creation of pollinators (Camargo *et al.*, 2017; Canuto; Urchei; Camargo, 2017; Nair, 2007; São Paulo, 2021; Schembergue *et al.*, 2017; Schuller *et al.*, 2022). The findings of this study reaffirm this potential, positioning agroforests as a strategic tool in addressing challenges and achieving socio-environmental commitments associated with sustainable development at a global level.

4 FINAL CONSIDERATIONS

The findings of this study highlight the significant role that agroforestry systems in the Vale do Ribeira region can play in biodiversity conservation, pollinator support, and the promotion of food and nutritional security. The richness and diversity of plant species, many of which are melliferous, provide continuous floral resources throughout the year, favouring wild pollinator populations and enhancing agricultural productivity.

Integrating beekeeping and stingless beekeeping into agroforestry management emerges as a promising strategy, not only for increasing the availability of pollination services but also for generating additional sources of income for farming families. Furthermore, the adoption of pollinator-friendly practices within these systems contributes to broader socio-environmental goals, including climate change adaptation, ecosystem restoration, and the sustainable use of natural resources.

Given the projected rise in demand for pollination services and the growing pressures of environmental degradation and climate change, policies and programs that encourage the diversification and ecological intensification of agroforestry systems are crucial. By fostering collaboration among farmers, researchers, and policymakers, it is possible to strengthen these systems as resilient landscapes capable of reconciling production, conservation, and livelihoods, thus reinforcing their strategic importance in achieving sustainable development objectives at local, regional, and global scales.

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