







ARTICLE

Potential of Brazil's native vanilla species: a study on distribution and research gaps

Potencial das espécies nativas de baunilha do Brasil: um estudo sobre distribuição e lacunas de pesquisa

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Abstract: The Orchidaceae family represents 10% of all floral diversity, with approximately 900 genera and 28,000 species, exhibiting a wide range of forms and colors. An important genus of this family is *Vanilla* that contains the chemical compound vanillin, which is globally appreciated and holds high economic value. This genus comprises approximately 110 species, with *Vanilla planifolia* being the most exploited, although other species may have untapped potential for exploration. The aim of this study was to evaluate, analyze, and compile data on native and endemic species of the genus *Vanilla* in Brazil, in order to disseminate information about these species and their potential for exploration. The species prospecting was conducted using the Re flora Program database. After the prospecting process, the main areas of occurrence, type of biome, developmental characteristics, and risk classification of each species were identified. In the second stage of this study, an analysis of existing research was conducted using the Web of Science™ scientific database. A total of 36 native species were found, of which 20 are endemic. *Vanilla* species occurred throughout the country, although there was a higher incidence of these species in the southeastern and northern regions of Brazil. Among the 48 studies found on the Web of Science™ scientific database. There was limited information available on the genus *Vanilla* from Brazil, and only 16 species have published studies. Among the studied species, *Vanilla bahiana* displayed specific characteristics that give it a high potential for large-scale production. There are few studies on native and endemic species of *Vanilla* of Brazil, and most of them are related to species description.

Keywords: bibliometrics, geographic distribution, Orchidaceae, preservation.

Resumo: A família Orchidaceae representa 10% de toda a diversidade floral, com aproximadamente 900 gêneros e 28.000 espécies, exibindo uma ampla variedade de formas e cores. Um importante gênero desta família é *Vanilla*, que contém o composto químico vanilina, amplamente apreciado e de alto valor econômico. Esse gênero compreende aproximadamente 110 espécies, sendo a *Vanilla planifolia* a mais explorada, embora outras espécies possam possuir potencial ainda inexplorado. O objetivo deste estudo foi avaliar, analisar e compilar dados sobre espécies nativas e endêmicas do gênero *Vanilla* no Brasil, a fim de disseminar informações sobre essas espécies e seu potencial de exploração. A prospecção das espécies foi realizada utilizando o banco de dados do Programa Re flora. Após o processo de prospecção, foram identificadas as principais áreas de ocorrência, tipo de bioma, características de desenvolvimento e classificação de risco de cada espécie. Na segunda etapa deste estudo, foi realizada uma análise das pesquisas existentes utilizando o banco de dados científico Web of Science™. Um total de 36 espécies nativas foi encontrado, das quais 20 são endêmicas. As espécies de *Vanilla* ocorreram em todo o país, embora a incidência seja maior nas regiões Sudeste e Norte do Brasil. Havia informações limitadas disponíveis sobre o gênero *Vanilla* no Brasil, e apenas 16 espécies possuem estudos publicados. Entre as espécies estudadas, a *Vanilla bahiana* apresentou características específicas que lhe conferem alto potencial para produção em larga escala. Há poucos estudos sobre espécies nativas e endêmicas de *Vanilla* do Brasil, e a maioria deles está relacionada à descrição das espécies.

Palavras-chave: bibliometria, distribuição geográfica, Orchidaceae, preservação.

Introduction

The Orchidaceae family exhibits remarkable species diversity, encompassing approximately 10% of the global flora, with around 900 genera and 28,000 species, distinguished by their diverse morphological and coloration characteristics. In Brazil alone, there are approximately 2,700 species and 250 genera, distributed across all biomes within the Brazilian territory (Moreira et al., 2024).

One of the most prominent genera within this family is the genus *Vanilla*. This genus contains a commercially valuable secondary metabolite, globally appreciated, known as vanillin, widely recognized in the production of vanilla. Vanillin is a phenolic aldehyde extracted from the pods of the *Vanilla* genus and has been the subject of study for over 60 years. This aromatic organic compound is highly valued and used as a flavoring agent in food, beverages, perfumes, and pharmaceutical products (Xu et al., 2024).

The *Vanilla* genus comprises more than 140 species, with an emphasis not only on *Vanilla planifolia*, which is widely exploited, but also on species such as *V. pompona* and *V. tahitensis* (Oliveira et al., 2022). Nevertheless, there are species within this genus with currently unknown uses and benefits, as well as others with known but yet unexplored

potential (Flores Jiménez et al., 2017). Moreover, several Brazilian vanilla species may be at risk due to human activities encroaching on their natural habitats, and they may face potential harm from the increasing occurrence of extreme weather events, such as heavy rains or droughts (Divakaran et al., 2006). In this context, scientometrics, through the technique of bibliometrics, is crucial for identifying species with commercial potential, endangered species, and, most importantly, for managing germplasm banks (Nogueira et al., 2021).

To facilitate the prospecting of native species in Brazil, the Re flora Program, a government initiative led by the National Council for Scientific and Technological Development (CNPq) in partnership with the Rio de Janeiro Botanical Garden, provides a digital tool for collecting data and images of Brazilian plant and microorganism species. This platform makes access to taxonomic studies more accessible and emphasizes the need for data science research to benefit the conservation of native flora (Re flora, 2020).

In this context, the aim of this study is to gather information on the native and endemic *Vanilla* species in Brazil through scientometrics, with the goal of disseminating knowledge about these plants and their potential for exploration. This data collection is pioneering and significantly

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contributes to the understanding of biodiversity and the conscious preservation of natural resources, allowing local communities to engage in the conservation of these economically promising species.

Materials and Methods

Data collection with Reflora database

The information on the species was obtained from the official Reflora (Flora of Brazil) website, with the official data dated September 2020. For species selection, the available filters "Group," "Family," and "Genus" were used, selecting only the genus *Vanilla* and the native species of Brazil. The information retrieved from the search was manually analyzed and selected to be entered into a spreadsheet, considering only the accepted names and discarding synonyms. Data were collected on the scientific name, life form, substrate, origin, endemism, and geographic distribution.

Drawing the map of the area of occurrence of *Vanilla* species native and endemic native to Brazil

Based on the data obtained from Reflora, a distribution map was created using the geographic information system (GIS) software QGIS[®]. The shapes of the regions and states were obtained from the CodeGeo website. The necessary information to create the maps was manually processed.

Elaboration of the word cloud

The word cloud was created using the software Iramuteq[®], version 0.7 alpha 2, which is frequently used in textual analysis research.

Literature data collection

The Web of Science[™] platform was used to collect literature data. The complete literature on native Vanillas from the last 10 years was used. The search was conducted in February 2024. The documents were imported using the EndNote[®] software. Duplicates and abstracts were removed, and only articles with full text available were analyzed. The final database consisted of 48 articles, which were read in full and analyzed according to the following categories: species, document title, study objective, results, and authors. The software VOSviewer[®], version 1.6.15, was used to create bibliographic networks and visualize the network layouts and clusters. The images were then saved in Portable Network Graphics (PNG) format.

Results

Area of occurrence of *Vanilla* species native and endemic native to Brazil

A total of 36 native species of the genus *Vanilla* (Table 1) were identified in Brazil, of which 55.56% were endemic.

Table 1. List of species identified as native to Brazil based on information available on the Reflora website, 2020. *Life form: H - herb; LFC - liana or fickle or creeper. **Substrate: H - hemiepiphyte; E - earthy. ***CS (Conservation status): NS - not studied; LC - Least Concern; VU - vulnerable; ID - in danger; DD - Data Deficient. **** Federal District - Brasilia, Brazil.

Species	Life form*	Habit**	Endemism	Distribution	Phytogeographical dominance	Type of Vegetation	CS***
1. <i>Vanilla angustipetala</i> Schltr.	LFC	H	No	Northeast: (Bahia) Southeast: (Espírito Santo, São Paulo)	Atlantic Forest	Seasonal Semideciduous Forest, Ombrophilous Forest (= Rainforest)	NS
2. <i>Vanilla appendiculata</i> Rolfe	LFC	H	No	North: (Acre, Amazonas, Pará, Roraima)	Amazon	Campinarana, Igapó Forest, Terra Firme Forest, Palm Forest	NS
3. <i>Vanilla arcuata</i> Pansarin & M.R.Miranda	H	H	Yes	Southeast: (São Paulo)	Atlantic Forest	Restinga	NS
4. <i>Vanilla bahiana</i> Hoehne	LFC	H	Yes	Northeast: (Alagoas, Bahia, Maranhão, Paraíba, Pernambuco, Rio Grande do Norte, Sergipe) Midwest: (Federal District****) Southeast: (Espírito Santo, Minas Gerais, Rio de Janeiro, São Paulo)	Caatinga, Cerrado, Atlantic Forest	Riparian or Gallery Forest, Ombrophilous Forest (= Rainforest), Restinga	NS
5. <i>Vanilla bicolor</i> Lindl.	H	H	No	North (Amazonas, Roraima)	Amazon	Riparian or Gallery Forest, Várzea Forest	NS
6. <i>Vanilla bradei</i> Schltr. ex Mansf.	LFC	H	Yes	Southeast (São Paulo)	Atlantic Forest	Ombrophilous Forest (= Rainforest)	NS
7. <i>Vanilla capixaba</i> Fraga & D. R. Couto	H	H	Yes	Southeast (Espírito Santo)	Atlantic Forest	Seasonal Semideciduous Forest, Rock Outcrop Vegetation	NS
8. <i>Vanilla chamissonis</i> Klotzsch	H	H	No	North (Amazonas) Northeast (Bahia, Pernambuco) Midwest (Federal District, Goiás, Mato Grosso) Southeast (Espírito Santo, Minas Gerais, Rio de Janeiro, São Paulo) South (Paraná, Santa Catarina)	Amazon, Caatinga, Cerrado, Atlantic Forest	Riparian or Gallery Forest, Seasonal Deciduous Forest, Seasonal Semideciduous Forest, Palm Forest, Restinga	LC

Table 1. cont.

9. <i>Vanilla cribbiana</i> Soto Arenas	H	H	No	North (Pará)	Amazon	Igapó Forest	NS
10. <i>Vanilla cristagalli</i> Hoehne	LFC	H	Yes	North (Amazonas)	Amazon	Campinarana	NS
11. <i>Vanilla cristatocallosa</i> Hoehne	LFC	H	Yes	North (Amazonas)	Amazon	Terra Firme Forest	NS
12. <i>Vanilla denticulata</i> Pabst	H	H	Yes	Northeast (Pernambuco)	Atlantic Forest	Seasonal Semideciduous Forest	NS
13. <i>Edwall vanilla dietschiana</i>	H	E	Yes	Southeast (Espírito Santo, São Paulo) South (Santa Catarina)	Atlantic Forest	Ombrophilous Forest (= Rainforest)	VU
14. <i>Vanilla dubia</i> Hoehne	H	H	Yes	Southeast (Espírito Santo, Minas Gerais)	Cerrado, Atlantic Forest	Cerrado (lato sensu), Rock Outcrop Vegetation	ID
15. <i>Vanilla dungsii</i> Pabst	H	H	Yes	Southeast (Rio de Janeiro)	Atlantic Forest	Ombrophilous Forest (= Rainforest)	NS
16. <i>Vanilla edwallii</i> Hoehne	H	H	Yes	Midwest (Federal District, Goiás) Southeast (Espírito Santo, Minas Gerais, Rio de Janeiro, São Paulo) South (Paraná, Rio Grande do Sul, Santa Catarina)	Cerrado, Atlantic Forest	Riparian or Gallery Forest, Seasonal Semideciduous Forest, Ombrophilous Forest (= Rainforest)	LC
17. <i>Vanilla eggersii</i> Rolfe	H	H	No	Midwest (Mato Grosso)	Cerrado	Cerrado (lato sensu)	NS
18. <i>Vanilla ensifolia</i> Rolfe	LFC	H	No	Midwest (Mato Grosso)	Cerrado	Cerrado (lato sensu)	NS
19. <i>Vanilla gardneri</i> Rolfe	LFC	H	Yes	North (Pará) Northeast (Pernambuco, Piauí) Southeast (Minas Gerais, Rio de Janeiro)	Amazon, Atlantic Forest	Várzea Forest, Ombrophilous Forest (= Rainforest)	NS
20. <i>Vanilla labelopapillata</i> A.K. Koch, Fraga, J.U.Santo & Ilk.-Borg.	H	H	Yes	North (Pará)	Amazon	Riparian or Gallery Forest	NS
21. <i>Vanilla lindmaniana</i> Kraenzl.	H	H	Yes	Midwest: (Mato Grosso)	Cerrado	Seasonal Deciduous Forest	NS
22. <i>Vanilla Mexican</i> Mill.	LFC	H	No	North (Acre, Amazonas, Amapá, Pará, Roraima) Northeast (Maranhão) Midwest (Mato Grosso) Southeast (Minas Gerais, Rio de Janeiro)	Amazon, Cerrado, Atlantic Forest	Ombrophilous Forest (= Rainforest), Restinga	NS
23. <i>Vanilla organensis</i> Rolfe	LFC	H	Yes	Southeast (Rio de Janeiro, São Paulo)	Atlantic Forest	Ombrophilous Forest (= Rainforest)	DD
24. <i>Vanilla ovata</i> Rolfe	LFC	H	No	North (Pará, Tocantins)	Amazon	Terra Firme Forest, Seasonal Semideciduous Forest	NS

Table 1. cont.

25. <i>Vanilla palmarum</i> (Salzm. Ex Lindl.) Lindl.	H	H	No	North (Acre, Amazonas, Amapá, Pará, Roraima, Tocantins) Northeast (Alagoas, Bahia, Maranhão, Paraíba, Pernambuco, Piauí, Sergipe) Midwest (Goiás, Mato Grosso do Sul, Mato Grosso)	Amazon, Caatinga, Cerrado, Atlantic Forest	Caatinga (stricto sensu), Campinarana, Cerrado (lato sensu), Riparian or Gallery Forest, Seasonal Semideciduous Forest, Palm Forest, Restinga, Amazonian Savanna	NS
26. <i>Vanilla paludosa</i> Pansarin, J.M. Aguiar & A.C. Ferreira	H	H	Yes	Southeast (São Paulo)	Cerrado	Riparian or Gallery Forest	NS
27. <i>Vanilla parvifolia</i> Barb. Rodr.	LFC	H	Yes	Southeast (Rio de Janeiro, São Paulo) South (Paraná)	Atlantic Forest	Ombrophilous Forest (= Rainforest)	NS
28. <i>Vanilla paulista</i> Fraga & Pansarin	H	H	Yes	Southeast (São Paulo)	Atlantic Forest	Seasonal Semideciduous Forest	NS
29. <i>Vanilla penicillata</i> Garay & Dunsterv.	H	H	No	North (Amazonas)	Amazon	Terra Firme Forest, Amazonian Savanna	NS
30. <i>Vanilla pompona</i> Schiede	H	H	No	North (Amazonas, Amapá, Pará, Rondônia, Tocantins) Northeast (Maranhão, Paraíba, Pernambuco) Midwest (Goiás, Mato Grosso) Southeast (Minas Gerais)	Amazon, Cerrado	Anthropic Area, Campinarana, Cerrado (lato sensu), Terra Firme Forest, Seasonal Semideciduous Forest, Palm Forest, Rock Outcrop Vegetation	NS
31. <i>Vanilla ribeiroi</i> Hoehne	LFC	H	Yes	Midwest (Mato Grosso)	Cerrado	Riparian or Gallery Forest	NS
32. <i>Vanilla schwackeana</i> Hoehne	LFC	H	Yes	Northeast (Pernambuco) Southeast (Minas Gerais)	Cerrado	Cerrado (lato sensu), Restinga	NS
33. <i>Vanilla sprucei</i> Rolfe	H	H	No	North (Amazonas)	Amazon	Riparian or Gallery Forest	NS
34. <i>Vanilla trigonocarpa</i> Hoehne	LFC	H	No	North (Amazonas, Pará)	Amazon	Terra Firme Forest	NS
35. <i>Vanilla uncinata</i> Huber ex Hoehne	LFC	H	No	North (Amazonas, Pará)	Amazon	Terra Firme Forest	NS
36. <i>Vanilla verrucosa</i> Hauman	H	H	No	South (Rio Grande do Sul)	Atlantic Forest	Ombrophilous Forest (= Rainforest)	NS

The cultivation and/or identification of this orchid genus is expanding throughout Brazil. The Southeast region of Brazil has the highest concentration of species, with 18 native plants, including 14 endemic plants (77.8%). The North region has 17 native species, of which four are

endemic. The South region has the fewest species, with six native plants, of which three are endemic. The Northeast region has nine native species, including four endemic ones, and the Central-West region has 10 species, of which four are endemic (Fig. 1).

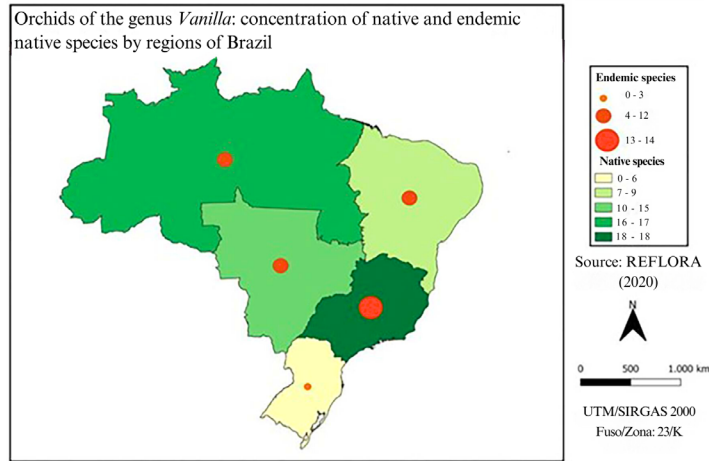


Fig. 1. Distribution map of *Vanilla* genus species for native and endemic species in Brazil.

From the word cloud, we can observe that the Atlantic Forest, Amazon, and Cerrado are the biomes with the highest occurrence of species; furthermore, many species occur in more than one biome.

The Atlantic Forest has the highest concentration of endemic species (45%), totaling 13 species, nine of which are found only within this phylogeographic domain. These species are *V. arcuata*, *V. bradei*, *V. capixaba*, *V. denticulata*, *V. dietschiana*, *V. dungsii*, *V. organensis*, *V. parvifolia*, and *V. paulista*. Considering that the vast majority of native species are hemiepiphytic, it is important to highlight that the only native terrestrial species (*V. dietschiana*) is endemic, occurring exclusively in the ombrophilous forests of the Atlantic Forest.

The phylogeographic domain of the Amazon has four endemic species (15%): *V. gardneri*, *V. cristagalli*, *V. cristatocallosa*, and *V. labelopapillata*. In total, 30.6% of Brazilian *Vanilla* species are found in this biome (Fig. 2). The phytophysiognomies to which these species belong include Riparian Forest, Terra Firme Forest, Campinarana, Floodplain Forest, and Ombrophilous Forest.

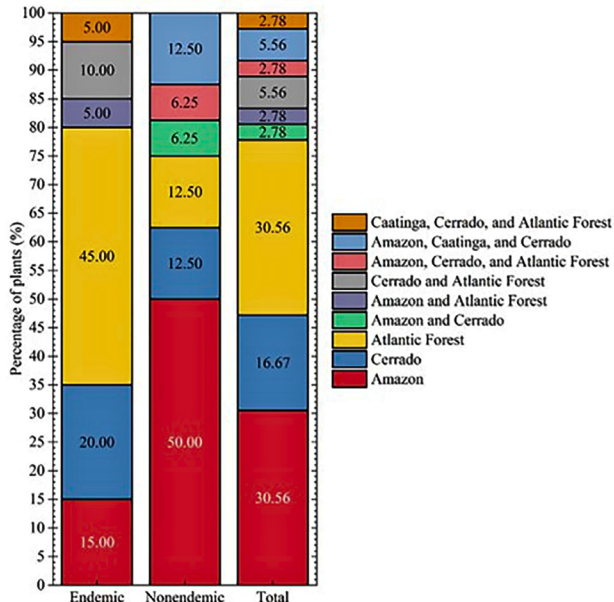


Fig. 2. Classification of the occurrence of native and endemic species by biome

In the Cerrado, seven species (16.67%) are found, two of which are exclusive (*V. schwackeana* and *V. paludosa*). The only species found in the Caatinga is *V. phaeantha* (synonym *V. bahiana*), which is also found in the Cerrado and the Atlantic Forest. The Caatinga is the phylogeographic domain with the lowest species presence among those observed (Fig. 2).

The species found throughout the Amazon, Caatinga, and Cerrado represent 5.6% of the total species and 12.5% of the non-endemic ones. Only one species, *V. dubia*, is found in the Caatinga, Cerrado, and Atlantic Forest domains, representing 2.78% of the total and is considered endemic (Fig. 2).

The classification of the species found in relation to their environmental risks is shown in Fig. 3. Currently, for 80.0% of the plants, there is insufficient data for classification or they have not been evaluated. The species *V. dietschiana* is considered vulnerable (2.78%) and the species *V. dubia* is classified as endangered. Both are endemic. Two species (5.56%) are considered of least concern regarding environmental risk, *V. chamissonis* and *V. edwallii*.

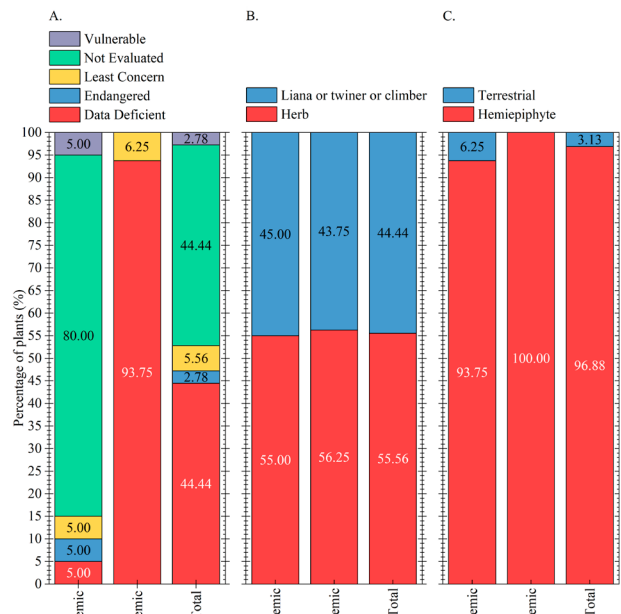


Fig. 3. Classification of environmental risk (A) and life form of native *Vanilla* species in Brazil (B and C).

Regarding life form, the majority of species are classified as herbaceous (55.6%), representing 56.3% of the non-endemic species. The other species are classified as lianas/vines/climbers, accounting for 44.44% of the total species, 43.75% of the non-endemic species, and 45.00% of the endemic species. The vast majority of identified species are considered hemiepiphytic (96.9%). Among the endemic species, 93.8% are hemiepiphytic, with only one classified as terrestrial (Fig. 3). Hemiepiphytic species can begin their life cycle as epiphytes, extending their roots toward the ground, or as terrestrial species that later grow toward the tree canopies.

Literature review

Among the 48 studies found on the Web of Science™ platform (<https://rpubs.com/arthuraocc/vanillas>), an average of 23% of the articles addressed endemic species, 63% addressed non-endemic species, while 13% of the articles covered both. Additionally, only one article describing a new *Vanilla* species found in Brazil was identified. Among the studied species, *Vanilla pompona* had the highest occurrence, being the subject of 67% of the articles found.

A network visualization of keywords generated by the VOSviewer® software, illustrating the interconnections and groupings among various

topics or terms related to *Vanilla* research, is shown in Fig. 4A. The keywords were divided into different clusters, reflecting interconnected research areas. The green cluster represents a network highlighting *Vanilla planifolia*, with associated terms such as identification, hybridization, and genetic diversity. The red cluster, on the other hand, is related to diversity and the impact of factors such as climate change and plant growth. The blue cluster focuses on the evolution of Orchidaceae and its subfamilies, with an emphasis on the Neotropics and reproductive biology. The presence of smaller clusters, such as the orange one related to the term vanillin, indicates different branches of research connected to the study of chemical substances present in vanilla.

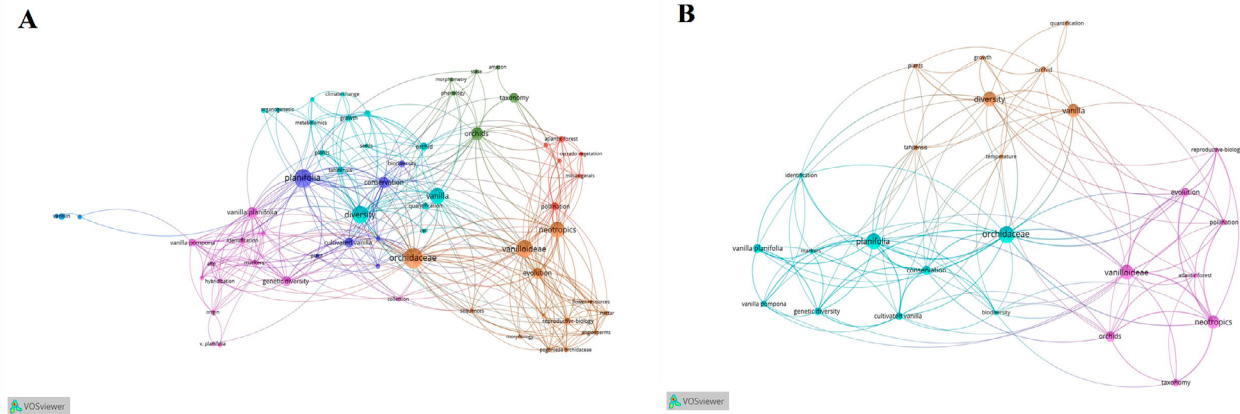


Fig. 4. (A) Connections among keywords used in studies published on the Web of Science platform; (B) Connections among keywords, emphasizing the term *Orchidaceae*, as utilized in works published on the Web of Science platform.

Delving deeper into the interaction network centered around the keyword *Orchidaceae* (Fig. 4B), the highlighted clusters include topics such as *planifolia*, diversity, and Neotropics. The red cluster, which includes *planifolia*, is related to aspects of identification, genetic diversity, and species conservation of *Vanilla*. The blue cluster focuses on diversity, addressing themes such as growth and quantification. The green cluster encompasses the Neotropics, evolution, and pollination, suggesting connections with the reproductive biology of *Vanilla* and other orchids.

It is observed that the number of publications on *Vanilla* increases over the years, with a sharp peak in 2023, which shows 14 publications, the highest value recorded in Fig. 5. Between 2004 and 2010, the number of publications is relatively low and consistent, with few works per year. From 2010 onwards, there is a gradual increase, with fluctuations in the following years. Periods such as 2012, 2014, 2017, and 2021 show considerable increases, which may suggest heightened interest and academic output during these times.

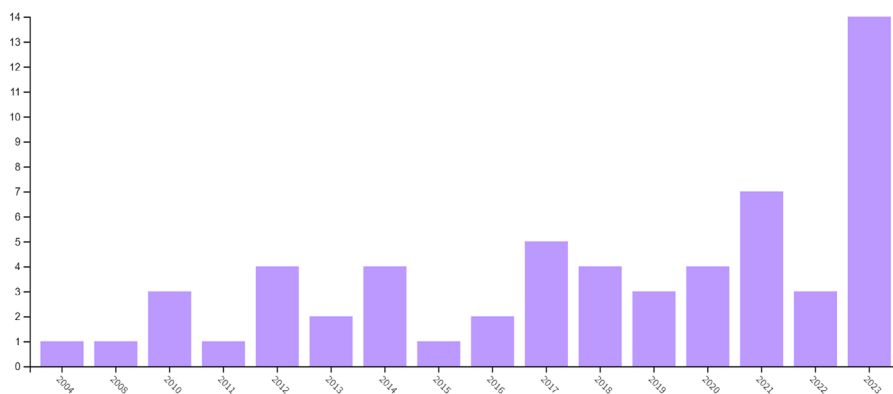


Fig. 5. Number of publications per year on *Vanilla*.

A tree map chart, where the predominant field of publications on *Vanilla*, with 31 publications, is Plant Sciences, highlighting the centrality of plant sciences in the analyzed research, is shown in Fig. 6. Fields such as Agronomy (5 publications), Biochemistry/Molecular Biology (5 publications), Ecology (4 publications), Food Science Technology (4 publications), and Applied Chemistry (4 publications) are also

significant, suggesting that research on *Vanilla* involves a multidisciplinary approach, ranging from food science to molecular biology. Other fields such as Genetics and Heredity (3 publications), Biodiversity Conservation (3 publications), and Cell Biology (2 publications) complement the picture, revealing the breadth of disciplines that intersect to investigate aspects related to plant biodiversity, conservation, and genetics.



Fig. 6. Fields of publication on *Vanilla*.

The author network generated displays the collaboration between different researchers in the field of *Vanilla* studies. The authors are grouped into clusters based on the intensity of their collaborations (Fig. 7). One of the most prominent clusters is the green cluster, led by researcher Pansarin, who played a central role in the articles listed in Table 2. Other significant clusters include the blue cluster, centered around researcher

Grisoni, with multiple collaborations involving names such as Verpoorte and Lubinsky, and the yellow cluster, where Besse appears with relevant collaborations. There are also smaller clusters, such as the red one, with Watteyn and Karremans, and the brown cluster, where Warner and Jimenez are connected.

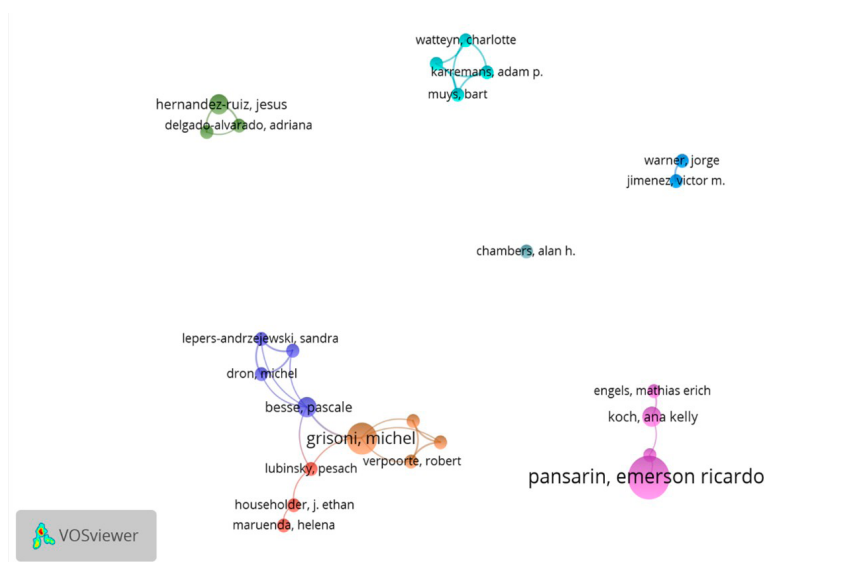


Fig. 7. Connections between authors publishing on *Vanilla* on the Web of Science platform.

Discussion

Area of occurrence of *Vanilla* species native and endemic native to Brazil

As observed from the collected data, *Vanilla* species are present in all phytogeographic domains of the Brazilian territory, with notable endemism in the Amazon, Atlantic Forest, and Cerrado regions. The Amazon is characterized by a hot climate with constant rainfall, while the Atlantic Forest experiences a warm and humid climate. Several *Vanilla* species occur in warm and humid environments, with relative humidity exceeding 80%, average temperatures ranging from 22 to 32 °C, and minimum temperatures above 10 °C. These plants require an average annual precipitation of 1200 to 2500 mm, with two to three months of water deficit to stimulate flowering, conditions that can be found in various areas of the intertropical belt (Baquero-Peña and Guerrero-Beltrán, 2017).

Studies on commercial *Vanilla* species indicate that temperatures above 33 °C, combined with precipitation deficits, compromise critical stages of development, such as flowering and fruiting. Additionally, prolonged periods of excessive rainfall also hinder the development of these plants (Ifrikhar et al., 2023). These data highlight the risks that climate change poses to the *Vanilla* community, affecting water regimes and temperature patterns in the areas where these plants occur. The

Brazilian Cerrado, with its high temperatures and low precipitation, provides a favorable environment for species more tolerant to water scarcity and heat, which gives these plants remarkable adaptive traits. This biome, recognized as the most biodiverse savanna in the world, is also one of the main global biodiversity hotspots for conservation (Klink and Machado, 2005).

Additionally, *Vanilla* species play important ecological roles due to their diverse growth forms within the ecosystem. The different life forms, such as herbs, vines, lianas, and hemiepiphytes, interact with other plants and animals, with the predominance of hemiepiphytic forms suggesting specific adaptations to distinct ecological niches (Lima & Moreira, 2022).

Literature review

In the last five years, research on the genus *Vanilla* has advanced significantly, revealing new perspectives on the ecology, genetics, biochemistry, and conservation of these species. Although the number of studies on *Vanilla* in Brazil is still limited, growing scientific interest has focused mainly on species such as *Vanilla bahiana*, *Vanilla bicolor*, *Vanilla capixaba*, and *Vanilla pompona*. These studies address evolutionary and ecological aspects as well as potential industrial applications, highlighting the complexity and potential of these species.

Genetic diversity is a central theme in recent research. Rasoamanalina et al. (2023) analyzed the genetic structure of germplasm collections of *V. pompona*, revealing a wide genetic diversity that can be explored for the development of more robust varieties adapted to different cultivation systems. Silva et al. (2023) investigated the chemical diversity and sensory potential of *V. bahiana*, *V. capixaba*, and *V. pompona*, highlighting the importance of this diversity for the commercial exploitation of these species. This knowledge is crucial for conservation strategies and genetic improvement, as environmental pressures and climate change directly impact the survival of native species.

A remarkable advancement is the identification of pollination strategies in *V. bahiana* and *V. pompona*, which use “food deception” tactics to attract pollinators without offering substantial rewards. This behavior maximizes pollination with reduced energy costs (Pansarin, 2022; Watteyn et al., 2022). These evolutionary adaptations are particularly relevant in environments where pollinator diversity directly influences the reproduction and distribution of these species. Additionally, Pansarin (2023) explores non-specific pollen transfer and double reward production in *V. pompona*, suggesting that this flexibility in the plant-pollinator interaction may contribute to the high genetic variability observed in natural *Vanilla* populations in Brazil.

In addition to pollination, the bioactive properties of *Vanilla* species have attracted considerable interest. Volatile compounds in *V. bahiana* and *V. capixaba* show potential for use in the cosmetics and fragrance industries (Silva et al., 2023). In *V. pompona*, bioactive compounds exhibit therapeutic applications for skin aging, expanding the use of this species beyond essence production (Wang et al., 2023). The industrial exploration of vanilla also benefits from advancements in biotechnology. The *in vitro* regeneration of *V. pompona* suggests that tissue culture can accelerate the development of new varieties, making production more efficient and sustainable (Warner et al., 2023). This approach is essential in Brazil, where environmental conditions demand adapted and resilient varieties.

In the context of genetic improvement, the development of specific molecular markers has proven essential for selecting hybrids with desirable characteristics. Li et al. (2021) developed markers for *V. bahiana* and *V. pompona*, aiming to optimize the propagation of varieties with greater resistance to pathogens and better flower quality. This advancement is crucial for genetic improvement and the sustainability of *Vanilla* production in Brazil, where fungal diseases present a significant challenge. Barreda-Castillo et al. (2023) delved into this topic by investigating the impact of temperature on the infectivity of *Fusarium oxysporum* in hybrids of *V. planifolia* and *V. pompona*, emphasizing the importance of understanding the ideal environmental conditions for cultivation. Moreover, studies on morphological and physiological responses to water stress in *V. pompona* hybrids (Barreda-Castillo et al., 2023) contribute to the development of varieties more adapted to climate change, a critical aspect for the sustainability of production.

On a global scale, the increasing number of publications on *Vanilla* reflects growing interest in topics such as conservation, genetics, and the impact of climate change. The peak in 2023 coincides with advancements in molecular and ecological technologies, as well as the recognition of the economic and biological value of vanilla for the food and pharmaceutical industries (Xu et al., 2024).

Research areas are multidisciplinary, encompassing Plant Sciences, Agronomy, Biochemistry/Molecular Biology, and Ecology. The predominance of Plant Sciences underscores the centrality of this field in *Vanilla* research, while studies in Genetics and Biodiversity Conservation indicate concerns about genetic preservation and species sustainability. Industrial interest is highlighted by research in Food Science and Applied Chemistry, focusing on vanillin production (Bautista-Aguilar et al., 2021).

Conclusions

This study identified a total of 36 native species, 20 of which are endemic. The highest concentration of species is found in regions with the phytogeographic domains of the Atlantic Forest, Amazon, and Cerrado. *V. dubia* was the only species evaluated as threatened, but some species lack sufficient information to issue a statement regarding their conservation status. Only 16 species have had published studies, highlighting the lack of research on the genus *Vanilla* in Brazil. Despite the advances of the last five years, most studies on endemic species have focused

on plant descriptions. The potential of native *Vanilla* species remains underexplored, and continued research is essential to capitalize on the economic and biological opportunities these species offer.

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Author Contribution

MCN: Conceptualization, Investigation, Data Curation, Writing - Original Draft. **GNT:** Methodology, Formal analysis, Data Curation, Writing - Original Draft. **JFOC:** Methodology, Formal analysis, Data Curation. **AAO:** Methodology, Formal analysis, Data Curation. **ARCN:** Formal analysis, Investigation, Data Curation, Writing - Review & Editing, Visualization. **MVR:** Conceptualization, Investigation, Resources, Writing - Original Draft, Visualization, Supervision, Project administration, Funding acquisition.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability Statement

Data will be made available upon request to the authors.

Declaration of generative AI and AI-assisted technologies in the writing process

The authors declare that the use of AI and AI-assisted technologies was not applied in the writing process.

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