Review of the state of knowledge of the flora of Vaupés (Colombia)

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ABSTRACT

The department of Vaupés, located in the Amazon region of Colombia, covers approximately 65.268 km2, representing 5.7% of the country's territory. The department hosts a rich floristic diversity that plays a crucial role in the dynamics of local ecosystems. This richness gains even greater importance due to the ethnobotanical use by ancestral communities over time. Despite the increase in literature production on the flora of Vaupés in recent decades, there is a lack of an updated review specifically focused on existing bibliography related to the department's flora. This work aims to conduct a comprehensive review up to 2023 of the knowledge production in the department related to flora,using analyses of various indicators. Different databases such as Scopus, Scielo, WoS, academic search engines like Google Scholar, and repositories were used for the review. Two inclusion criteria were applied to the documents: 1) The documents had to focus on municipalities or localities within the department as the study area, and 2) The research had to be related to flora. Graphs and tables were employed for analyses to identify patterns and trends. In total, 92 publications related to the flora of Vaupés were identified, reflecting a significant increase compared to previous studies. Most publications were concentrated in the municipality of Mitú, primarily led by Richard Evans Schultes, who stood out as the main author with 49 publications.While the research article stood out as the most used form of publication, another significant source was gray literature, primarily derived from undergraduate and postgraduate theses. Ethnobotany and taxonomy emerged as dominant areas of research, encompassing 39% and 34% of the publications, respectively, reflecting the importance given to traditional knowledge and accurate species identification in the region. Temporal analysis revealed publication peaks between 1974-1984 and 2004-2014. The concentration of publications by some authors, especially Schultes, emphasizes the need for diversification in research perspectives. It is crucial to encourage new researchers and interdisciplinary collaboration to enrich research in Vaupés. Finally, addressing knowledge gaps in less-explored areas such as ecology, palynology, phytogeography, and plant physiology is essential for a holistic understanding of the department's ecosystem.

Keywords: Bibliometric Analysis, Neotropical Biodiversity, Publications, Vaupés.

1. INTRODUCTION

Vaupés is a Colombian department located in the Amazon region. This department has nearly 65,268 km2 and represents 5.7% of Colombian territory. It shares borders to the north with Guaviare and Guainía, to the east with Brazil, to the south with Amazonas, and to the west with Amazonas, Caquetá, and Guaviare [1]. Within its territorial distribution, there are three municipalities: Mitú (the capital), Taraira, and Carurú, as well as three departmental townships: Papunaua, Pacoa, and Yavaraté [2,3] Additionally, it hosts two areas of great importance for conservation: the Nukak Natural Reserve and the Yaigojé Apaporis National Natural Park. It is worth noting that approximately 76.85% of the population residing in Vaupés belongs to indigenous peoples [2].

Vaupés hosts a broad floristic diversity that plays a crucial role in the dynamics of local ecosystems. This botanical richness is of particular importance due to the ethnobotanical use by the ancestral peoples present in the territory [4,5,6].

To achieve proper conservation and management of the flora in this territory, it is essential to have comprehensive knowledge based on various studies and disciplines. However, having these studies alone is not sufficient; it is equally vital to be aware of their existence and maintain a record of them. In this context, literature reviews play a crucial role by serving as a source to consolidate existing knowledge and promote interest in the biodiversity of the territory. Additionally, they are a powerful tool for building communication bridges between diverse disciplines [7,8] and for identifying gaps in the existing knowledge on a specific topic.

Over the past few decades, there has been a significant increase in bibliographic production related to the flora of Vaupés [4,8,9,10,11,12]. However, research in the department has not undergone a proper process of analysis and systematization. The synthesis and systematic analysis of this scattered knowledge is essential to assess the current state of scientific knowledge.

The purpose of this work is to conduct a literature review with an analysis of the state of knowledge of the flora of Vaupés. Through this review, the aim is to address the following research questions: (I) What is the current level of scientific knowledge about the flora of Vaupés based on bibliographic production over time? (II) What are the most studied topics related to the flora of Vaupés? (III) Which authors have significantly contributed to the study of the flora of Vaupés? (IV) What are the most representative municipalities in terms of scientific production in the Vaupés department?(V) Are there significant gaps in the scientific literature that require further research in this field?

The significance of this review lies in its ability to consolidate and update the current knowledge about the flora of Vaupés, identify research areas focused on the flora, and provide valuable information for decision-making related to the conservation and sustainable development of the department.

2. METHODOLOGY

2.1 LITERATURE SEARCH PROCEDURE

To conduct the present study, a systematic review was carried out across various databases (Scopus, Scielo and Web of Science), repositories of Colombian universities and public institutions, and the Colombian Network of Scientific Information from the Ministry of Science, Technology, and Innovation. An academic search engine (Google Scholar) was also utilized. Furthermore, a co-authorship review was performed to examine the literature cited within the consulted texts. Search equations were employed for databases and the academic search engine, while keywords and thematic filtering options were used for repositories (Table 1).

Two inclusion criteria were applied for document selection. Firstly, it was required that the documents addressed municipalities or localities located within the department of Vaupés. Secondly, publications were expected to include research related to the subject of flora.

Table 1. Information sources with their search equation or keywords.

Information source	Search equation
Scopus	TITLE-ABS-KEY ("Medicinal plants" OR "floristic inventory" OR "floristic composition" OR "Ethnobotany" OR "inventory" OR "Indigenous medicine" OR "Forest ecology" OR "Forest" OR "Phytogeography" OR "Ecology" OR "Genetic" OR "Floristic structure" OR "conservation" OR "Genetic diversity" OR "Taxonomy" OR "Plant Physiology" OR "Diversity and Floristic Composition" OR "Epiphytic" OR "Lianas") AND TITLE-ABS-KEY ("Vaupés" OR "Mitú" OR "Río Cuduyarí" OR "Río Kuduyarí" OR "Raudal de Jirijirimo" OR "Raudal Yayacopí" OR "Río Papurí" OR "Taraíra" OR "Río Piraparaná" OR "Yavaraté" OR "Javaraté") AND NOT TITLE-ABS-KEY ("Language" OR "Bird" OR "Fish" OR "Odonata" OR "Ants" OR "Catfish" OR "Hymenoptera" OR "Diptera" OR "Araneae" OR "Coleoptera" OR "Anura") AND NOT SUBJAREA("PSYC" OR "SOCI") AND AUTH ("RE Schultes")
Scielo	((Vaupés) AND (medicinal plants) OR ("floristic inventory") OR ("floristic composition") OR (ethnobotany) OR (inventory) OR (Indigenous medicine) OR ("Forest ecology") OR (Forest) OR (Phytogeography) OR (Ecology) OR (Genetic) OR (Floristic structure) OR (Conservation) OR ("Genetic diversity") OR (Taxonomy) OR ("Plant Physiology") OR ("Diversity and Floristic Composition") OR ("Epiphytic") OR ("Lianas")) AND NOT "Fishes" OR "Peces" AND NOT "Mariposas" OR "Lepidoptera"
Web of Science (WOS)	TS=(Vaupés OR "Mitú" OR "Río Cuduyarí" OR "Río Kuduyarí" OR "Raudal de Jirijirimo" OR "Raudal Yayacopí" OR "Río Papurí" OR "Taraíra" OR "Río Piraparaná" OR "Yavaraté" OR "Javaraté") AND TS=("Medicinal plants" OR "floristic inventory" OR "floristic composition" OR "Ethnobotany" OR "inventory" OR "Indigenous medicine" OR "Forest ecology" OR "Forest" OR "Phytogeography" OR "Ecology" OR "Genetic" OR "Floristic structure" OR "conservation" OR "Genetic diversity" OR "Taxonomy" OR "Plant Physiology" OR "Diversity and Floristic Composition" OR "Epiphytic" OR "Lianas") AND WC=(Plant Sciences)
Repositorys	In the search engine, the word 'Vaupés' was added followed by the theme 'Biology'

Google Scholar	("Vaupés" OR "Mitú" OR "Río Cuduyarí" OR "Río Kuduyarí" OR "Raudal de Jirijirimo" OR "Raudal Yayacopí" OR "Río Papurí" OR "Taraíra" OR "Río Piraparaná" OR "Yavaraté" OR "Javaraté") AND "RE Schultes" AND ("Medicinal plants" OR "floristic inventory" OR "floristic composition" OR "Ethnobotany" OR "inventory" OR "Indigenous medicine" OR "Forest ecology" OR "Forest" OR "Phytogeography" OR "Ecology" OR "Genetic" OR "Floristic structure" OR "conservation" OR "Genetic diversity" OR "Taxonomy" OR "Plant Physiology" OR "Diversity and Floristic Composition")

2.2 Compilation of Information

An Excel database was created containing 11 information items: (1) Title, (2) Reference, (3) Study exclusively for Vaupés, (4) Municipality, (5) Year of publication, (6) Type of publication, (7) Main author, (8) Theme, (9) Information source, (10) Availability of visualization, and (11) Keywords.

2.3 Analysis of Information

A comprehensive analysis of the gathered information was conducted to provide a detailed overview of publications related to the flora of the department. Various types of charts and tables were employed for this purpose.

To identify literature production, eight class intervals were defined, each spanning 10 years, except for the last one, which covers only 9 years (Table 2). The first interval, labeled 1944-1954, includes articles published during that period. In subsequent intervals, such as 1954 to 1964, it is important to clarify that articles from the initial year are excluded, and the count begins from the following year, maintaining this convention for the other intervals. This allowed for the identification of trends and temporal patterns in knowledge production related to the flora of the department.

The number of publications per municipality was analyzed, allowing for the identification of the most active municipalities in terms of botanical research. The primary author who made significant contributions to the flora of the department was also analyzed. Publication types were classified to determine the most frequently used ones, and the most studied topics were identified to visualize the predominant area of interest in the research. Furthermore, an investigation into the used information source was conducted, allowing for the observation of the main data sources and determining which one was most commonly employed to find literature related to the department. A keyword frequency analysis was performed to identify the most-used keywords in the publications. Finally, the number of publications exclusively focused on the department was determined, providing insight into the percentage of exclusive production for Vaupés.

3. Resultsand Discussion

For the present study, a total of 92 studies were identified, whose scope covered the department of Vaupés, with their research areas focusing on the flora of the area.The first publication identified in the systematic review was the work titled 'Plantae Colombianae VIII,'

written by Richards Evans Schultes in 1944 [13]. Schultes is also the primary author who has made the greatest contribution to the knowledge of the Vaupés flora, with a total of 49 publications (Table 3). The most prominent research area in the study was ethnobotany, comprising 41% of the publications, followed by taxonomy with 34% (Figure 4). This indicates the value placed on ancestral knowledge of the territory and the importance of determining the species present. Most studies were conducted for the municipalities of Mitú and Pacoa (Figure 1).

3.1 Publications Across the Years

In total, 52 years of knowledge production were found for the Vaupés department from the year 1944 to 2023, although for this last year, there could be a bias due to studies that might be under review or pending publication. Two intervals with the highest publication of studies were identified, namely between 1974-1984 and 2004-2014, with 15 and 16 publications, respectively. The interval with the lowest production was between 1984-1994, with a total of 7 publications (Table 2).

In the study by Infante & Rangel in 2018, fewer than 50 publications were reported for the department of Vaupés, considering data up to the year 2015 [14]. The present study shows a significant increase, with a total of 92 publications, representing an increase of 42 publications. For the period from 2014 to 2023, there was a production of 12 publications, half of which exclusively focus on the department, addressing topics in ethnobotany, with one also covering phytochemistry. When specifically analyzing publications solely centered on Vaupés, it is observed that 28% of them, i.e., 26 publications, focused exclusively on this department, while the remaining 72% include Vaupés but also address other departments.

Table 2. Interval classes in years of scientific production for the department of Vaupés.

Interval (years)	Number of publications
1944 - 1954	11
1954 - 1964	13
1964 - 1974	8
1974 - 1984	15
1984 - 1994	7
1994 - 2004	10
2004 - 2014	16
2014 - 2023	12
Total	**92**

Scientific studies have primarily focused on the municipality of Mitú, followed by Pacoa. The relevance of Pacoa is attributed to research conducted by Richard Shultes in the areas of Raudal de Yayacopi and Jirijirimo, as well as in the rivers Piraparaná, Cananarí, and Pacoa. On the other hand, Carurú appears as the municipality with fewer associated publications (Figura 1). No studies related to flora were found in the departmental township of Papunaua. The category of information classified as 'NA' refers to cases where the lack of specification of the municipality or locality in the documents, or the lack of access to them for a thorough review, as in the case of technical reports and articles that only had an abstract, determined the impossibility of obtaining this data.

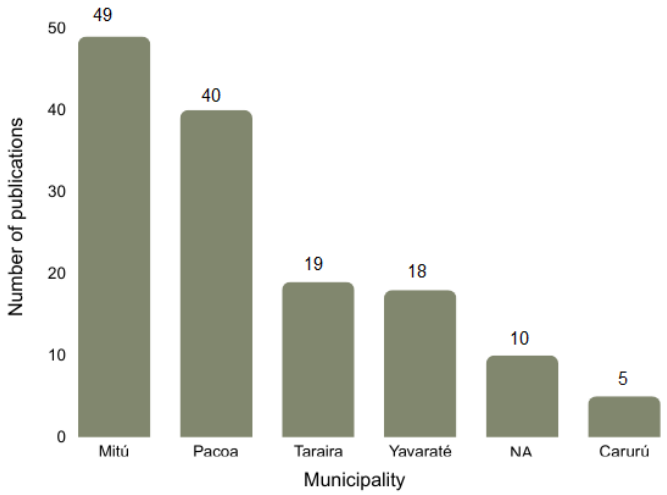

Fig. 1. Number of publications by municipality

In the research of the Vaupés department, a total of 38 main authors were identified, whose contributions are reflected in a total of 92 publications. Standing out among them is Richard Evans Schultes (Table 3), who made a significant contribution not only to the department but also to the Amazon region. Specifically for Vaupés, he contributed to 53% of the publications, highlighting the importance of his work overthe past twelve years in the region [15]. Additionally, four other main authors were identified, who have made significant contributions, albeit to a lesser extent, with percentages ranging from 2% to 4%. Their works focus on the themes of Ethnobotany, Taxonomy, and Floristics.

The concentration of scientific production among a limited number of authors could be influencing the diversity of perspectives and approaches in the research of the department. While the contribution made by the most prominent authors has been of great importance, it is essential to examine how this predominance may affect the breadth of topics addressed and the representativeness of various disciplines in the production of knowledge about flora (Figure4).

Tabla3. Main Authors

Main Author	Number of Publications	Percentage
Schultes, R.E.	49	53%
Cárdenas López, D.	3	4%
Clavijo, L.	3	3%
Aymard C, G.A.	2	2%
Beltrán Zapata, G.D.	2	2%
Remaining authors	33	36%
Total	**92**	**100%**

The research article stands out as the most used publication type to disseminate various studies, encompassing 82% of the publications. However, it is important to note that 13% corresponded to grey literature, primarily derived from undergraduate and postgraduate

theses (Figure 2). Furthermore, it is noteworthy that 92% of this grey literature was exclusive to the department, emphasizing the importance of considering this information that is sometimes overlooked. Another format within grey literature was the technical report, characterized by being more challenging to access but potentially containing relevant information [16].The publication types of a 'book' and 'book chapter' represent 2% and 3%, respectively.Although these percentages are comparatively low compared to research articles, they should not be underestimated, as these formats can provide valuable perspectives and more extensive contextualization of certain topics.

The concentration of publications in certain information sources reveals a noticeable pattern in the distribution of scientific production in the department of Vaupés. Google Scholar stands out as the predominant source, contributing a total of 54 publications. This predominance could be attributed to its accessibility, global reach, and ability to integrate various disciplines. Scopus follows in importance with 15 publications, followed by cited sources, which are publications found referenced and cited in other publications, contributing a total of 12 (Figure 3). The preference for Google Scholar could be attributable to its user-friendly interface and efficient search algorithms, facilitating the location of relevant studies. The significant difference in the number of publications between Google Scholar and other sources could also be due to the indexing and visibility policies of these platforms. Scopus, Web of Science, and other referenced databases may have stricter inclusion criteria, which could limit the number of studies from the department of Vaupés that are admitted to their indexes. On the other hand, the more robust presence on Google Scholar could suggest greater inclusivity and accessibility for researchers from various institutions, thereby fostering widespread dissemination of research.

In Colombia, there is an initiative that promotes Open Science through the Colombian Network of Scientific Information, created by the Ministry of Science, Technology, and Innovation [17]. However, only one publication was found on this platform (Figure 3). It is considered necessary to implement improvements, especially in an advanced search system that allows the use of search equations, thereby facilitating the location of documentation in the various repositories of universities or institutions in the country.

Additionally, the most frequently used keywords in the publications were identified, which include: Vaupés, Colombia, Plants, Amazonia, Amazon, Flora, Taxonomy, Diversity, Vascular, Indigenous, and Guayana (Figure 5).

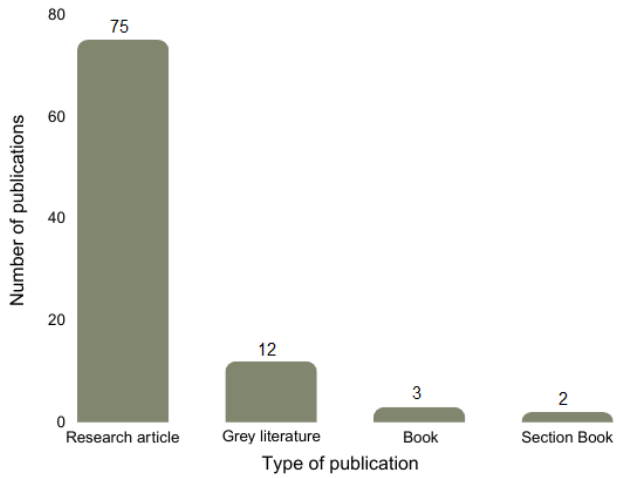

Fig. 2. Type of Publication

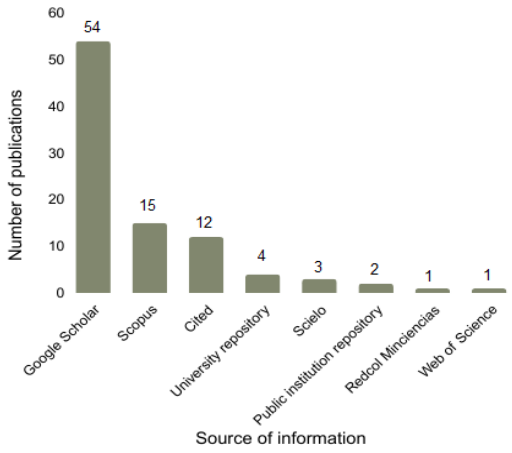

Fig. 3. Information sources used for literature search

Analyzing the research areas reveals a clear concentration of publications in two specific fields: ethnobotany, representing 41%, and taxonomy, contributing 34% of the publications. These results suggest a strong emphasis on studying interactions between local communities and flora, as well as the classification and description of species in the context of the department of Vaupés. This focus could be influenced by the rich biological and cultural diversity of the region, emphasizing the importance of understanding the relationships between the local population and their natural environment, as well as the need for accurate taxonomic classification [4,5,6,8,9,18,19,20,21,22].

However, it is crucial to highlight the areas with less representation in the publications. Ecology, genetic diversity, plant physiology, phytogeography, phytochemistry, and palynology, each with a percentage ranging from 1% to 7%, receive proportionally less attention. These areas, while contributing more modestly, should not go unnoticed as they can offer valuable insights into understanding specific aspects of the Vaupés ecosystem that may have been underestimated.

The concentration of studies in specific areas could create certain gaps in the understanding of ecological processes, patterns of genetic diversity, and physiological processes of plants in the region. Future research could benefit from exploring these underrepresented areas, thereby expanding the holistic understanding of the Vaupés ecosystem.

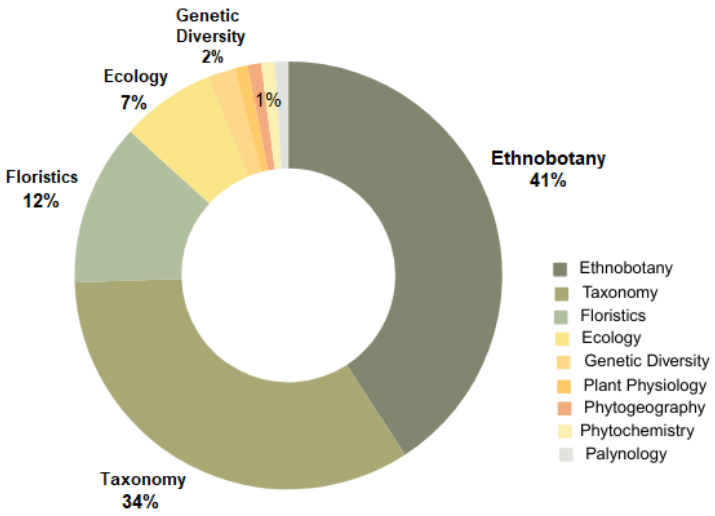

Fig. 4. Areas of interest studied in the publications

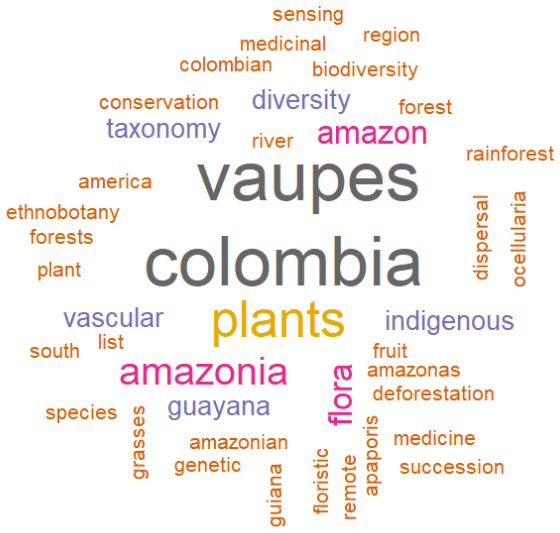

Fig. 5. Most used keywords in the publications

4. Conclusion

-It is essential to encourage the involvement of new researchers and interdisciplinary collaboration to enrich research in the department of Vaupés.

- It is crucial to address knowledge gaps resulting from limited participation in certain research areas. This approach could broaden perspectives and delve into less-explored aspects, leading to a more comprehensive understanding of the ecosystem in the Vaupés department.

- A significant dominance in the areas of ethnobotany and taxonomy is evident in the research of the department. This focus reflects the importance given to traditional knowledge and precise identification of species in the region, highlighting the rich biological and cultural diversity of Vaupés.

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