Arecaceae in Brazil: A Critical Synthesis of Taxonomic, Ecological, and Ethnobotanical Research and Implications for Conservation

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Abstract

The family Arecaceae Bercht. & J. Presl (palms) comprises one of the most diverse and functionally relevant groups of tropical angiosperms, playing a central role in forest structure and in socioecological systems across Brazil. This article presents a documentary and bibliographic review aimed at synthesizing the current state of knowledge on Arecaceae in Brazil and identifying patterns, gaps, and biases in scientific production. Literature searches were conducted in national and international databases, with taxonomic validation based on the official Flora e Funga do Brasil database. The analyzed studies were organized into four thematic axes: (i) taxonomy and biogeography; (ii) population ecology and biotic interactions; (iii) ethnobotany and sustainable use; and (iv) technological innovations and conservation genetics. The review indicates that Brazil harbors a high diversity of palms, distributed across all phytogeographic domains, with marked concentrations of research effort in taxonomic and floristic studies, which account for over 45% of the publications. In contrast, fewer than 20% of studies address population ecology using robust demographic data. Ethnobotanical research represents 25–30% of the literature but rarely incorporates quantitative assessments of sustainability, while technological and genetic approaches comprise less than 15% of studies and still face limitations related to field validation and practical application. Overall, the consolidation of knowledge on Arecaceae in Brazil requires stronger integration between classical botanical approaches and emerging tools to support evidence-based strategies for conservation and sustainable management.

Keywords: Palms; Conservation biology; Integrative review; Research biases; Sustainable management.

1. Introduction

The family Arecaceae Bercht. & J. Presl represents one of the most emblematic and ecologically influential lineages of tropical angiosperms, playing a central role in the structure, functioning, and resilience of forest ecosystems, particularly in the Neotropics (Raj et al., 2022). As a major evolutionary branch of monocotyledons, palms combine high morphological diversity, wide ecological amplitude, and strong biotic interactions, making them key components of tropical biodiversity and ecosystem processes (Dransfield et al., 2008; Baker & Dransfield, 2016).

Globally, Arecaceae are predominantly distributed in tropical and subtropical regions, where they occupy a wide range of habitats and life forms, from emergent canopy species to understory palms, climbing taxa, and species adapted to flooded, coastal, or seasonally dry environments (Jaganathan, 2021). This ecological versatility reflects a long evolutionary history marked by diversification across contrasting climatic, edaphic, and hydrological conditions (Dransfield et al., 2008; Baker & Dransfield, 2016).

Brazil stands out as one of the main centers of palm diversity worldwide. Palms occur across all Brazilian phytogeographic domains, including the Amazon, Atlantic Forest, Cerrado, Caatinga, and coastal ecosystems, contributing significantly to forest structure and landscape heterogeneity. Their presence across such contrasting environments highlights the high adaptive capacity of the family and underscores its relevance for understanding patterns of tropical plant diversity and biogeography (JBRJ, 2025).

From an ecological perspective, palms often act as structural and functional keystone components in tropical forests (Lueder et al., 2022). Numerous studies have demonstrated their importance in shaping forest architecture, influencing light availability, and supporting food webs through the production of fruits and other resources consumed by a wide range of vertebrate and invertebrate species (Terborgh, 1986; Kahn & de Granville, 1992). These interactions link palms directly to processes such as seed dispersal, nutrient cycling, biomass accumulation, and forest regeneration, reinforcing their ecological significance beyond their taxonomic richness alone.

In addition to their ecological importance, Arecaceae possess profound socio-economic and cultural relevance. Many species support traditional livelihoods, non-timber forest product chains, and regional agroextractive economies, particularly in Amazonian, riverine, and Indigenous contexts. Uses include food, construction materials, fibers, oils, medicinal products, and handicrafts, placing palms at the interface between biodiversity conservation and human well-being (Santana & Jardim, 2005; Sousa et al., 2021). More recently, palms have gained prominence in discussions on bioeconomy, sustainable development, and climate-resilient livelihoods.

Despite this prominence, scientific knowledge on Arecaceae in Brazil remains unevenly distributed. Research efforts have historically concentrated on specific regions, taxa, and disciplinary approaches, resulting in marked geographic, taxonomic, and thematic biases. Floristic inventories and taxonomic revisions have advanced considerably over recent decades, providing a relatively stable framework for species recognition and nomenclature (Dransfield et al., 2008; Baker & Dransfield, 2016). However, other dimensions of palm biology, such as long-term population dynamics, functional ecology, and integrated assessments of human use and ecological sustainability, remain comparatively underexplored (Cerqueira et al. 2024; Cosmo et al. 2024).

Geographic asymmetries are particularly evident, with a disproportionate concentration of studies conducted near major research centers and in more accessible portions of the Amazon and Atlantic Forest, while extensive areas of the Cerrado, Caatinga, and interbiome ecotones remain poorly sampled (Elias et al., 2018). Similarly, research tends to focus on a limited number of economically or ecologically prominent genera, potentially obscuring patterns associated with less conspicuous but functionally important taxa.

In parallel, the last two decades have witnessed rapid advances in technological tools applied to palm research, including remote sensing, spatial modeling, molecular genetics, and automated classification approaches. These innovations have expanded analytical scales and opened new avenues for biodiversity assessment and conservation planning. Nonetheless, their effective integration with classical botanical, ecological, and ethnobotanical knowledge remains a challenge, particularly with regard to field validation, taxonomic accuracy, and applicability to management and policy (Pirie et al., 2016; Muscarella et al., 2020; Costa et al., 2023).

A critical and integrative synthesis of the scientific literature on Arecaceae in Brazil is timely and necessary. By systematically examining patterns, gaps, and biases across taxonomic, ecological, ethnobotanical, and technological dimensions, such a synthesis can contribute to more balanced research agendas and support evidence-based strategies for the conservation and sustainable use of Brazilian palms. Accordingly, this article presents a documentary and bibliographic review aimed at consolidating current knowledge on Arecaceae in Brazil and identifying priorities for future research and conservation action.

2. Review Methodology

2.1. Methodological approach

This study consists of a critical and integrative documentary and bibliographic review aimed at systematizing the scientific production on the family Arecaceae in Brazil and identifying knowledge gaps relevant to the taxonomy, ecology, and conservation of the group. The methodology was structured to ensure transparency, traceability, and reproducibility—fundamental principles in biodiversity-oriented reviews, where heterogeneity of sources and approaches requires careful disclosure of biases and analytical criteria (Pullin & Stewart, 2006; Snyder, 2019). Although not a systematic review *stricto sensu*, the study adopted procedures inspired by consolidated protocols for integrative syntheses, particularly regarding explicit definition of search strategies, eligibility criteria, and thematic organization of the analyzed studies.

2.2. Search strategy and data sources

Bibliographic searches were conducted exhaustively between January and March 2024 in national and international databases, including Web of Science, Scopus, SciELO, and Google Scholar. To ensure taxonomic consistency and up-to-date nomenclature, the official Flora e Funga do Brasil database, maintained by the Rio de Janeiro Botanical Garden, was used as the primary reference (JBRJ, 2025).

Additionally, the CAPES Theses and Dissertations Catalog was consulted to incorporate academic output from Brazilian graduate programs, particularly relevant for historically under-sampled biomes or species with restricted distributions. The use of multiple sources aimed to reduce publication bias and broaden the representativeness of national scientific production, including regional journals and qualified grey literature (Grant & Booth, 2009).

Descriptors were applied in Portuguese and English and combined using Boolean operators (“AND”, “OR”), including the terms: Arecaceae, Palmae, palms, Brazil, taxonomy, floristics, ecology, demography, ethnobotany, conservation, remote sensing, and conservation genetics. Search strategies were adapted to the specificities of each database to maximize retrieval of studies on underrepresented genera and emerging methodological approaches.

2.3. Temporal scope and eligibility criteria

The temporal scope covered publications from 1990 to 2024, corresponding to the consolidation of modern systematic botany in Brazil and the progressive incorporation of ecological, demographic, and technological approaches in palm studies (Galeano et al., 1995; Cosmo et al., 2024). Included materials comprised peer-reviewed journal articles, scientific book chapters, and taxonomic reference works. Theses and dissertations were considered only when they presented novel primary data, especially related to under-sampled biomes (e.g., Caatinga and Cerrado) or species listed in threat categories. Studies conducted outside Brazilian territory, incidental citations without data analysis, non-critical reviews, and technical reports lacking external evaluation were excluded, prioritizing methodological robustness and evidence reliability (Pickering & Byrne, 2014).

2.4. Thematic organization and critical analysis

Selected studies were organized into four thematic axes, defined by analytical recurrence in the literature: (i) Taxonomy and Biogeography; (ii) Population Ecology and Interactions; (iii) Ethnobotany and Sustainable Use; (iv) Technological Innovations and Genetics (Figure 1). This categorization enabled assessment of how scientific effort is distributed among different subfields of botany and ecology, as well as identification of thematic and geographic imbalances in national research output (Baker & Dransfield, 2016). The analysis adopted a critical perspective, moving beyond descriptive compilation. Aspects such as sample representativeness, adequacy of methodological designs, validity of ecological inferences, and degree of integration between empirical data and conceptual models were examined. This approach is essential to evaluate whether the knowledge produced effectively supports public policies, conservation strategies, and action plans for threatened species (Pirie et al., 2016; Muscarella et al., 2020).

Figure 1. Thematic organization and critical analysis of the scientific literature on Arecaceae: Conceptual framework illustrating the four main thematic axes used to organize the reviewed studies—(i) Taxonomy and Biogeography, (ii) Population Ecology and Interactions, (iii) Ethnobotany and Sustainable Use, and (iv) Technological Innovations and Conservation Genetics—and the key criteria applied in the critical assessment, including sample representativeness, methodological adequacy, validity of ecological inferences, and integration between empirical data and analytical models.

2.5. Limitations of the review

It is acknowledged that institutional and regional heterogeneity in Brazilian botanical research imposes limitations on bibliographic coverage, as a substantial portion of scientific production remains in non-indexed institutional repositories. Moreover, the taxonomic dynamics of the family Arecaceae, characterized by frequent nomenclatural revisions, may introduce inconsistencies in historical series, requiring continuous updating of synonyms and taxonomic concepts (Dransfield et al., 2008). Nevertheless, the methodological strategy adopted provides a solid basis for identifying patterns, gaps, and biases in research on Arecaceae in Brazil, integrating global and national sources and reflecting both the academic state of the art and the practical challenges of botanical conservation.

3. Results and Discussion

3.1. Taxonomy and Biogeography of Arecaceae in Brazil

The analyzed literature demonstrates that taxonomy and biogeography constitute the most consolidated and historically structured axis of research on Arecaceae in Brazil. Floristic inventories, taxonomic revisions, and official databases have made it possible to establish a relatively stable overview of the family's diversity in the national territory. According to the Flora e Funga do Brasil database (JBRJ, 2025), Arecaceae are currently represented by 96 genera and 416 accepted species in Brazil, of which 144 are endemic, confirming the country as one of the world's main centers of diversity for the group (Table 1).

This taxonomic richness is distributed across all Brazilian phytogeographic domains, with the highest concentrations of species occurring in the Amazon, the Cerrado, and the Atlantic Forest. The broad spatial distribution of palms reflects their high ecological plasticity and adaptive capacity to different climatic, edaphic, and hydrological regimes, including dense ombrophilous forests, seasonally flooded areas, savannas, coastal restingas, and human-altered environments.

Despite this comprehensive panorama, critical analysis of the scientific production reveals a persistent spatial bias. Collection effort and publication output are concentrated mainly in regions with greater density of research institutions and logistical infrastructure, especially in southeastern Brazil and in more accessible areas of the Legal Amazon. As a result, extensive areas of the Cerrado, Caatinga, and in ecotones between phytogeographic domains remain under-sampled, limiting more refined biogeographic inferences and the identification of priority areas for conservation (Elias et al., 2018).

From a taxonomic perspective, large-stature genera with high economic or ecological value—such as *Attalea*, *Euterpe*, *Syagrus*, and *Astrocaryum*—dominate floristic records and systematic revisions. In contrast, understory taxa, clumping palms, or genera with more restricted distributions—such as *Geonoma*, *Bactris*, and *Allagoptera*—remain relatively under-represented in the literature, despite their structural and functional importance in forest ecosystems. This asymmetry compromises comparative diversity analyses and may distort the understanding of the family's actual patterns of distribution and endemism in Brazil. Table 1 summarizes the genera of Arecaceae recorded in Brazil, based on consolidated data from the Flora e Funga do Brasil database (JBRJ, 2025), highlighting the high generic diversity and taxonomic heterogeneity of the group within the national territory.

Table 1. Genera of Arecaceae recorded in Brazil

Letter	Genera
A	*Acanthophoenix* H.Wendl., *Acoelorraphe* H.Wendl., *Acrocomia* Mart.. *Adonidia* Becc., *Aiphanes* Willd.. *Allagoptera* Nees, *Ammandra* O.F.Cook, *Aphandra* Barfod, *Archontophoenix* H.Wendl. & Drude, Areca L., *Arenga* Labill., *Astrocaryum* G.Mey., *Attalea* Kunth.
B	*Bactris* Jacq. ex Scop., Barcella (Trail) Trail ex Drude, *Bentinckia* Berry ex Roxb., *Bismarckia* Hildebrandt & H.Wendl., *Borassus* L., *Brahea* Mart. ex Endl., *Butia* (Becc.) Becc.
C	*Calamus* L., *Calyptrocalyx* Blume, *Calyptrogyne* H.Wendl., *Calyptronoma* Griseb., *Carpentaria* Becc., *Caryota* L., *Ceroxylon* Bonpl. ex DC., *Chamaedorea* Willd., *Chamaerops* L., *Chelyocarpus* Dammer, *Coccothrinax* Sarg., *Cocos* L., *Copernicia* Mart. ex Endl., *Corypha* L., *Cryosophila* Blume, *Cyrtostachys* Blume
D–F	*Deckenia* H.Wendl. ex Seem., *Desmoncus* Mart., *Dictyocaryum* H.Wendl., *Dictyosperma* H.Wendl. & Drude, *Drymophloeus* Zipp., *Dypsis* Noronha ex Mart., Elaeis Jacq., Euterpe Mart.
G–J	*Gaussia* H.Wendl., *Geonoma* Willd., *Heterospathe* Scheff., *Howea* Becc., *Hyophorbe* Gaertn., *Hyospathe* Mart., *Iguanura* Blume, *Iriartea* Ruiz & Pav., *Iriartella* H.Wendl., *Itaya* H.E.Moore, *Jubaea* Kunth
L–M	*Latania* Comm. ex Juss., *Leopoldinia* Mart., *Lepidocaryum* Mart., *Leucothrinax* C.Lewis & Zona, *Licuala* Wurmb, *Livistona* R.Br., *Lodoicea* Comm. ex DC., *Manicaria* Gaertn., *Mauritia* L.f., Mauritiella Burret, *Metroxylon* Rottb.

O–P	*Oenocarpus* Mart., *Oncosperma* Blume, P*hoenicophorium* H.Wendl., *Phoenix* L., *Pholidostachys* H.Wendl. ex Hook.f., *Phytelephas* Ruiz & Pav., *Pinanga* Blume, *Prestoea* Hook.f., *Pritchardia* Seem. & H.Wendl. ex H.Wendl., *Pseudophoenix* H.Wendl. ex Sarg., *Ptychosperma* Labill.
R–S	Raphia P.Beauv., Ravenea C.D.Bouché, Rhapis L.f. ex Aiton, Roystonea O.F.Cook, Sabal Adans., Serenoa Benth. & Hook.f., Socratea H.Karst., Syagrus Mart., Synechanthus H.Wendl.
T–W	*Thrinax* L.f. ex Sw., *Trachycarpus* H.Wendl., *Trithrinax* Mart., *Veitchia* H.Wendl., *Verschaffeltia* H.Wendl., *Wallichia* Roxb., *Washingtonia* H.Wendl., *Wendlandiella* Dammer, *Wettinia* Poepp. ex Endl., *Wodyetia* A.K.Irvine
Híbrido	×*Butyagrus*

Source: Adapted from the Flora e Funga do Brasil database (JBRJ, 2025).

3.2. Population Ecology and Biotic Interactions

From an ecological perspective, Arecaceae rank among the most influential components of the structure and functioning of tropical forests, acting both in the canopy and in the understory. Studies conducted in Neotropical forests indicate that palms may account for between 10% and 25% of the total density of woody individuals in certain forest types, particularly in floodplains, seasonally flooded forests, and savanna–forest ecotones, highlighting their structural and functional importance (Terborgh, 1986; Kahn & de Granville, 1992).

From a trophic standpoint, palms play a disproportionately important role relative to their species richness. Ecological reviews indicate that between 40% and 60% of terrestrial and arboreal frugivorous vertebrate species in Amazonian forests consume *Arecaceae* fruits at least seasonally, with even higher values during periods of scarcity of other resources (Figure 1) (Terborgh, 1986; Ferreira et al., 2023). In some systems, palm fruits may account for more than 50% of the available fruit biomass during the dry season, characterizing the group as a key element for the stability of food webs.

Despite this relevance, the results of this review indicate a critical shortage of long-term demographic studies. It is estimated that fewer than 20% of ecological studies published on Arecaceae in Brazil incorporate complete demographic analyses (recruitment, growth, and mortality), whereas most are based on punctual surveys or time series shorter than five years, which are insufficient for long-lived species with life cycles spanning several decades (Cerqueira et al., 2024).

In addition, a significant taxonomic bias is evident in the ecological literature. Approximately 60–70% of the population and biotic interaction studies focus on a restricted number of large-stature genera with high economic value, such as *Euterpe*, *Attalea*, and *Mauritia*. In contrast, predominantly understory genera such as *Geonoma*, *Bactris*, and *Allagoptera* represent less than 15% of the available ecological analyses, despite their high species richness and broad geographic distribution (Muscarella et al., 2020; Cosmo et al., 2024).

This asymmetry has direct implications for the predictive capacity of ecological models. Reproductive strategies, growth rates, and dependence on dispersers vary substantially between emergent palms and understory species, rendering family-level extrapolations of ecological patterns inappropriate. Recent studies demonstrate that understory species may exhibit recruitment rates up to 40% lower than those of arborescent palms in fragmented environments, increasing their vulnerability to habitat loss and disperser depletion (Muscarella et al., 2020)

Another underexplored aspect concerns the diversity of biotic interactions. Although frugivory accounts for most of the research effort, fewer than 10% of studies address interactions with pollinators, herbivores, pathogens, or soil microorganisms. This gap limits an integrated understanding of the processes regulating Arecaceae population dynamics, particularly under scenarios of climate change and reorganization of ecological networks.

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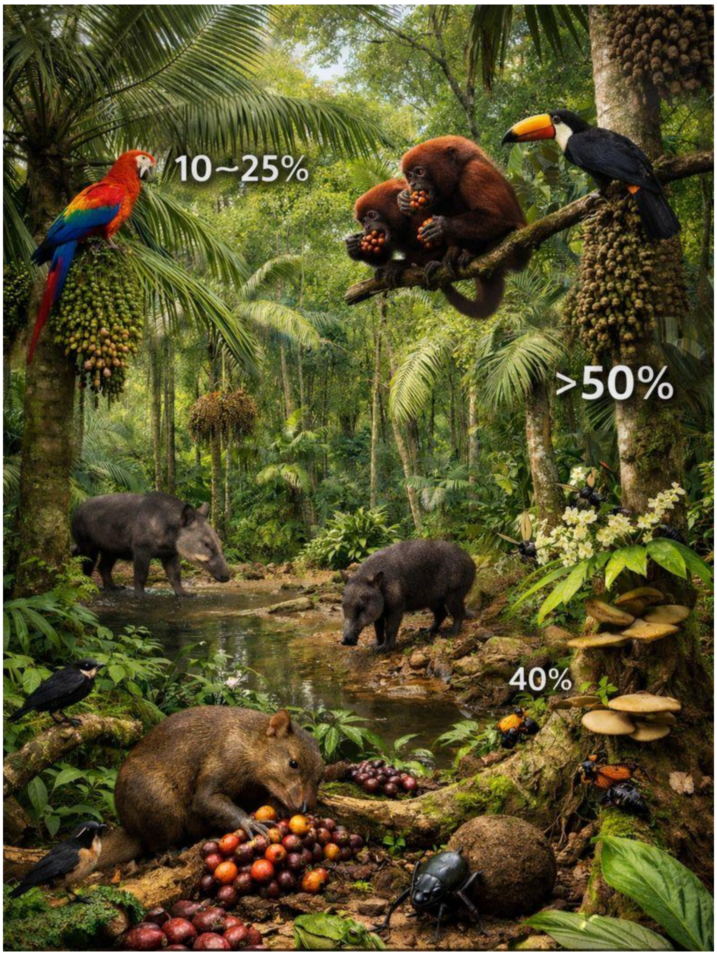

Figure 1. Structural and trophic importance of Arecaceae in Neotropical forests: Arecaceae palms contribute substantially to forest structure and food-web stability, accounting for 10–25% of woody plant density in some forest types and providing seasonal fruits consumed by 40–60% of frugivorous vertebrates, with peak relevance during periods of resource scarcity.

In summary, although palms are widely recognized as keystone species in tropical ecosystems, the Brazilian literature remains strongly concentrated thematically and taxonomically. Advancing knowledge in this field requires the expansion of long-term demographic studies, the inclusion of functionally distinct species, and the integrated quantification of biotic interactions, thereby strengthening realistic assessments of Arecaceae population persistence and their contribution to maintaining the ecological integrity of Brazilian biomes.

3.3. Ethnobotany and Sustainable Use

Ethnobotany constitutes one of the most consolidated and diverse fields of research on Arecaceae in Brazil, particularly in the Amazon, where palms occupy a central position in traditional sociocultural and productive systems. Regional reviews indicate that between 60% and 80% of the palm species recorded in Amazonian communities have at least one documented use, encompassing food, construction, traditional medicine, handicrafts, household utensils, and income generation (Figure 2) (Sousa et al., 2021; Gaio Junior & Ribas, 2023).

Genera such as *Mauritia*, *Oenocarpus*, *Attalea*, *Astrocaryum*, and *Euterpe* account for most ethnobotanical citations, representing approximately 70% of the traditional use records compiled in the Brazilian literature (Figure 2). These genera support local and regional value chains associated with the extraction of fruits, fibers, leaves, oils, and starches, and are frequently classified as "multiple-use" resources in riverside, extractivist, and Indigenous communities (Sousa et al., 2021).

Despite this descriptive richness, a critical analysis of the literature reveals a significant methodological asymmetry. It is estimated that more than 65% of ethnobotanical studies on Arecaceae in Brazil (Figure 2) are predominantly qualitative, focusing on the documentation of uses, cultural categories, and relative importance of species, without incorporating ecological or demographic metrics that would allow assessment of exploitation sustainability (Gaio Junior & Ribas, 2023). Only 10–15% of the studies integrate information on harvesting intensity, extraction frequency, or natural regeneration of the exploited populations.

This gap is particularly relevant for widely used species. Isolated studies indicate that intensive extraction of fruits or leaves may reduce recruitment by up to 30–50% in local palm populations when management practices are not adopted, especially in fragmented environments or under market pressure (Souza et al., 2018). Nevertheless, such evidence remains scattered and is rarely incorporated systematically into ethnobotanical analyses.

Another critical issue concerns the integration of traditional knowledge with formal management strategies. Although more than 80% of ethnobotanical studies explicitly acknowledge the value of local knowledge, fewer than 20% propose or evaluate participatory management models based on the co-production of knowledge between communities and researchers. This disconnect limits the translation of ethnobotanical knowledge into public policies, non-timber forest management plans, or sustainable-use certification schemes.

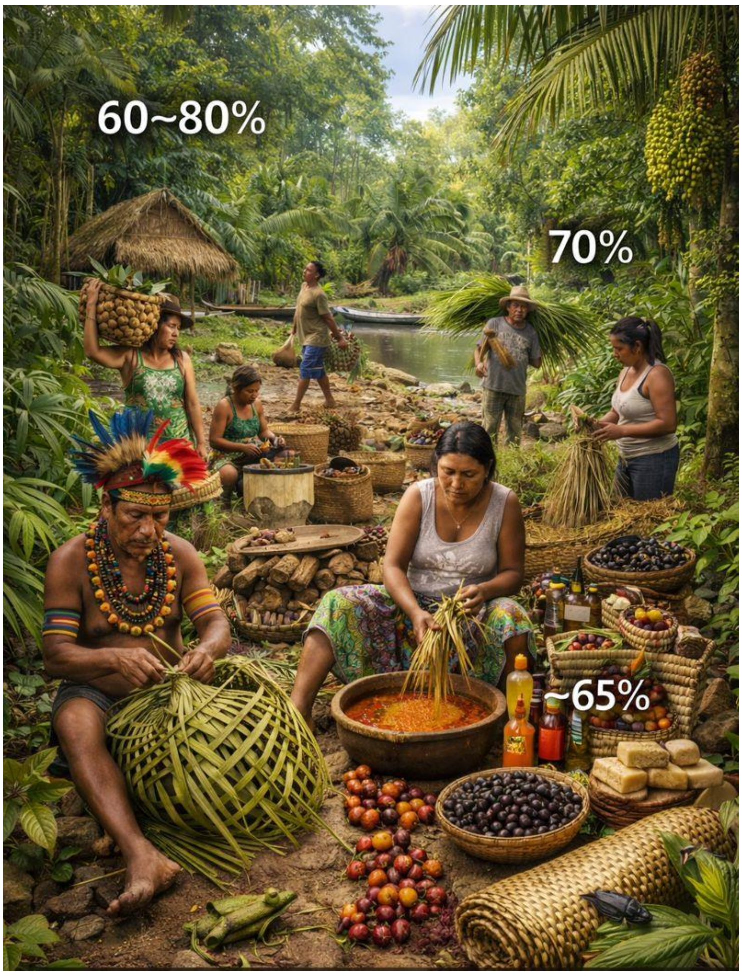

Figure 2. Ethnobotanical importance and sustainable use of Arecaceae in the Amazon: Traditional Amazonian communities rely extensively on palm species (Arecaceae) for food, construction materials, handicrafts, medicinal products, and income generation. Approximately 60–80% of palm species recorded in Amazonian communities present at least one documented use, with genera such as *Mauritia*, *Oenocarpus*, *Attalea*, *Astrocaryum*, and *Euterpe* accounting for nearly 70% of ethnobotanical records. Despite their

socioecological relevance, most ethnobotanical studies remain predominantly qualitative, highlighting the need for integrating traditional knowledge with ecological and demographic assessments to support sustainable management.

In the context of the emerging bioeconomy, this methodological fragmentation represents a strategic bottleneck. The consolidation of sustainable value chains associated with Brazilian palms requires that traditional use be assessed in light of ecological evidence, avoiding both uncritical romanticization and generalized criminalization of extractivist practices. The literature indicates that the integration of ethnobotany, population ecology, and forest economics remains incipient in Brazil, constituting one of the main scientific gaps for the development of socially just and ecologically viable bioeconomy models based on Arecaceae.

3.4. Technological Innovations and Conservation Genetics

Over the last two decades there has been a significant expansion in the use of technological tools in research on Arecaceae in Brazil, following global trends in botany and applied ecology. Estimates based on bibliometric reviews indicate that 35–45% of studies published after 2010 incorporate some form of advanced technology, including remote sensing, spatial modeling, genetic analyses, and, more recently, machine-learning algorithms for taxonomic identification and structural estimations (Costa et al., 2023).

Remote sensing—particularly through high-resolution imagery, LiDAR, and drone-based data—has been mainly employed to map the distribution of arborescent palms and to estimate biomass. However, the literature indicates that about 60% of these applications focus on a limited number of dominant genera, such as *Mauritia*, *Attalea*, and *Euterpe*, once again reflecting a taxonomic bias (Figure 3). Understory species, slender-stemmed palms, or clumping growth forms remain underdetected, with omission rates exceeding 40% in dense forests, thereby compromising the accuracy of population estimates (Gaio Junior & Ribas, 2023).

In the field of artificial intelligence and automated detection, comparative studies show that classification algorithms based solely on morphological or spectral patterns achieve average accuracy rates of 70–85% for large palms, but performance drops to below 60% when applied to morphologically similar species or hyperdiverse environments such as central Amazonia. These errors may lead to substantial over- or underestimation of population density and carbon stocks, particularly when systematic field validation is lacking (Costa et al., 2023).

Conservation genetics represents another expanding technological axis. Approximately 20–25% of recent studies on Arecaceae in Brazil employ molecular markers to assess genetic diversity, population structure, and gene flow, with notable advances in species of economic and conservation interest. These studies demonstrate that fragmented populations may exhibit reductions of up to 30–50% in genetic diversity compared to continuous populations, indicating potential risks of genetic erosion over medium and long time scales (Muscarella et al., 2020).

Despite these advances, the practical application of conservation genetics remains limited. Fewer than 15% of the reviewed studies on palm genetics establish direct links with management plans, restoration initiatives, or public policies, partly due to high analytical costs, legal restrictions related to access to genetic heritage and benefit-sharing, and limited coordination among researchers, managers, and local communities. Furthermore, the rapid taxonomic dynamics of the group impose additional challenges, as nomenclatural inconsistencies may compromise comparability among genetic and ecological studies (Dransfield et al., 2008).

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Figure 3. Overview of technological approaches applied to Arecaceae research in Brazil, including remote sensing, machine learning, and conservation genetics, highlighting current advances and limitations.

Overall, the literature converges on the view that technological innovations should be understood as complementary (rather than substitutive) tools to field-based taxonomic, ecological, and ethnobotanical research. The effectiveness of these approaches depends directly on the quality of botanical identifications, sampling representativeness, and integration between empirical data and analytical models. Thus, advancing research on Arecaceae in Brazil requires not only technological sophistication but also the strengthening of classical botanical foundations, ensuring that innovation effectively contributes to evidence-based conservation.

4. Conclusions

This bibliographic review demonstrates that the family Arecaceae occupies a central position in the Brazilian flora, both in terms of taxonomic diversity and ecological, socioeconomic, and cultural relevance. Data consolidated from the Flora e Funga do Brasil database confirm Brazil as one of the world's main centers of diversity for the family, with wide distribution across all phytogeographic domains and high levels of endemism, particularly in the Amazon, Cerrado, and Atlantic Forest phytogeographic domains.

The critical analysis of the literature reveals, however, that scientific knowledge on Arecaceae in Brazil has advanced unevenly. While taxonomy and biogeography are supported by relatively consolidated foundations based on floristic inventories and systematic revisions, significant gaps persist in long-term demographic studies, comparative functional ecology, and integrated assessments of human-use impacts on natural populations. The predominance of research focused on a limited number of economically important genera and on regions with greater scientific infrastructure constrains a comprehensive understanding of the ecological and evolutionary patterns of the family.

In the field of ethnobotany, the literature highlights the deep integration between palms and traditional livelihoods, especially in Amazonia. Nevertheless, the recurrent disconnect between ethnobotanical records and quantitative ecological data hampers the development of evidence-based sustainable management strategies. The sustainability of traditional palm use necessarily depends on the articulation among local knowledge, population ecology, and participatory governance.

Technological innovations and advances in conservation genetics have greatly expanded analytical possibilities, but they still face challenges related to validation, standardization, and practical application. This review indicates that such tools should be incorporated in a manner complementary to classical botanical and field-based ecological approaches, avoiding overgeneralization and interpretations detached from ecological and social realities.

In summary, strengthening research on Arecaceae in Brazil requires overcoming geographic and thematic asymmetries, expanding long-term studies, and effectively integrating taxonomy, ecology, ethnobotany, and emerging technologies. By systematizing patterns, gaps, and biases in the scientific literature, this article contributes to the formulation of more balanced research agendas and provides a foundation for public policies aimed at the conservation and sustainable use of Brazilian palms.

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