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Publication status: This preprint has been published elsewhere.
DOI of the published preprint: https://doi.org/10.1590/1677-941X-ABB-2026-0026

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https://doi.org/10.1590/SciELOPreprints.19049

Submitted on: 2026-11-25
Posted on: 2026-11-27 (version 1)
(YYYY-MM-DD)

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ACTA BOTANICA BRASILICA

Sociedade Botânica do Brasil
ISSN: 1677-941X
acta.botanica.org.br

A Global Overview of Euphorbiaceae *sensu lato* in the 21st Century: Taxonomic, Nomenclatural, and Geographical Synthesis

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Abstract

Euphorbiaceae *sensu lato* is a broad taxonomic concept encompassing seven families (Centroplacaceae, Euphorbiaceae *sensu stricto*, Pandaceae, Peraceae, Phyllanthaceae, Picrodendraceae, and Putranjivaceae). These families were historically treated within a broader concept of Euphorbiaceae but are now recognized as distinct lineages based on molecular and morphological evidence. Our survey, based on plant databases, reveals that 2,877 names were published for Euphorbiaceae *s.l.* in the 21st century. These publications spanned various ranks, with the vast majority being at the species and

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infraspecific levels. Of these names, 1,236 were published as new species or infraspecific taxa. Most of these new taxa were described from tropical regions, especially Brazil, Madagascar, India, Mexico, and Australia. In addition, megadiverse genera such as *Euphorbia*, *Croton*, and *Phyllanthus* contributed significantly to these expressive numbers. Advances in phylogenetic studies and increased botanical exploration have driven this taxonomic scenario. Many taxonomic changes also reflect efforts to align classification with evolutionary relationships, emphasizing monophyletic groupings. Euphorbiaceae *s.l.* provides a clear example of how modern systematics are aligning taxonomic classifications with evolutionary relationships, while also revealing how much of the planet's plant diversity remains unknown.

Keywords: New species; Nomenclature; Phylogenetic Systematics; Plant Distribution; Plant Taxonomy

Introduction

Euphorbiaceae *sensu lato* (*s.l.*) is an informal term currently used to refer to a group of plant families included within Euphorbiaceae until the early 2000s but now recognized as independent families (APG, 2016). This was a result of an intensification of molecular studies on Euphorbiaceae *s.l.* between 1998 and 2000, revealing the non-monophyletic nature of the family as it was delimited. As phylogenetic understanding progressed, the evolutionary relationships among the segregated clades and Euphorbiaceae *sensu stricto* (*s.s.*) became clearer, leading to the formal recognition of several clades as distinct families.

These segregations were widely supported by both morphological and molecular data (Corner, 1976; Webster, 1987; Meeuse, 1990; APG, 1998; 2003; Savolainen *et al.*, 2000; Chase *et al.*, 2002; Wurdack *et al.*, 2004; 2005; Davis & Wurdack, 2004; Davis *et al.*, 2005; Hoogland & Reveal, 2005; Wurdack & Davis, 2009), and have had important nomenclatural implications, requiring the updating of names, combinations, and taxonomic concepts, and directly impacting floristic databases, herbaria, and biodiversity inventories on a global scale.

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In this current scenario, the seven families composing Euphorbiaceae *s.l.* account for approximately 325 genera and 9,500 species: Pandaceae (3 genera / 17 species), Peraceae (5/106), Phyllanthaceae (59/2,330), Picrodendraceae (25/96), Putranjivaceae (2/221), Centroplacaceae (2/9), and Euphorbiaceae *s.s.* (229/6,745) (APG, 2016; POWO, 2025). Most of these families are widely distributed across the globe, except Pandaceae and Centroplacaceae, which have more restricted distributions, mainly in Africa and Southeast Asia (POWO, 2025). Due to its high species richness and broad geographic range, Euphorbiaceae *s.l.* is commonly found across a wide variety of vegetation types, including tropical rainforests, seasonally dry forests, arid zones, natural grasslands, wetlands, and rocky outcrops (Webster, 2014; POWO, 2025).

Although recent robust phylogenetic data recover all these families within the megadiverse Malpighiales (Xi *et al.*, 2012; APG, 2016; Zuntini *et al*., 2024), they also confirm the non-monophyletic nature of the group. Xi *et al.* (2012) recovered most of these families (Euphorbiaceae *s.s.*, Peraceae, Phyllanthaceae, and Picrodendraceae) within the euphorbioid clade, together with Linaceae and Ixonanthaceae, whereas Pandaceae was placed in the parietal clade. More recently, Zuntini *et al.* (2024) recovered a topology in which Euphorbiaceae *s.s.* and Peraceae, no longer separated by Rafflesiaceae, form an early-diverging lineage within Malpighiales. Their results also corroborated the close relationship between Phyllanthaceae and Picrodendraceae, consistent with the phyllanthoid subclade recovered by Xi *et al.* (2012), while Centroplacaceae, Pandaceae, and Putranjivaceae were more closely associated with the parietal clade identified by Xi *et al.* (2012), which also includes families such as Salicaceae and Violaceae. In light of these phylogenomic findings, the APG V (2026) classification included Peraceae within Euphorbiaceae *s.s.*, thereby expanding the circumscription of the family compared with the APG IV (2016) system. Even after the segregation of several clades, Euphorbiaceae *s.s.* remains one of the most species-rich angiosperm families globally, comprising around 6,745 species with a cosmopolitan distribution (Webster, 2014; APG, 2016). This remarkable diversity is largely driven by megadiverse genera such as *Euphorbia* L. (2,055 spp.), *Croton* L. (1,124 spp.), and *Acalypha* L. (429 spp.) (POWO, 2025). Megadiverse genera in Euphorbiaceae have long benefited from adopting more inclusive delimitation, but recent changes in *Phyllanthus* L., another megadiverse genus among the segregated families with over 1,000 spp.,

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seem to go in the opposite direction, generating nomenclatural instability and difficulties in identifying clear morphological characters to diagnose its segregates (Muñoz-Rodríguez *et al.*, 2023).

These megadiverse genera encompass a wide spectrum of life forms, ecological strategies, and morpho-anatomical characteristics and occupy a broad range of habitats across tropical, subtropical, and temperate regions. Such environmental heterogeneity generates numerous ecological niches, which in turn promote the evolution of new species adapted to local conditions (Echeverría-Londoño *et al.*, 2020). Many tropical and subtropical areas still contain remote or difficult-to-access regions that have only recently been systematically explored by botanists, resulting in the frequent discovery of new taxa (Fernandez-Hilario *et al.*, 2024).

Globally, Australia, Brazil, China, and New Guinea stand out as major contributors to the description of new plant species, with BRIC nations in particular investing significantly in building taxonomic capacity (Zhang *et al.*, 2014). Most of these discoveries are concentrated in the world's biodiversity hotspots (Joppa *et al.*, 2011), and many taxa are described retrospectively from herbarium collections during taxonomic revisions (Gross, 2011; Joppa *et al.*, 2011). Notably, most newly described species across different organism groups in recent decades exhibit narrow endemism, and a large proportion of them are already included under some category of conservation threat (Liu *et al.*, 2022; Antonelli *et al.*, 2023).

In this study, we seek to analyze and discuss the advances and challenges of the taxonomy of Euphorbiaceae *s.l.* in the 21st century, considering recent nomenclatural changes and patterns of geographic distribution on a global scale, in light of modern phylogenetic approaches and systematic revisions.

Material and Methods

For this study, we define Euphorbiaceae *s.l.* as an informal, non-monophyletic group comprising Centroplacaceae, Euphorbiaceae *s.s.*, Pandaceae, Peraceae, Phyllanthaceae, Picrodendraceae, and Putranjivaceae. This broad circumscription was adopted to ensure consistency and comparability when analyzing taxonomic data

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published over a period during which changes in the recognition and delimitation of these families were proposed. Although the recently published APG V classification (2026) included Peraceae within Euphorbiaceae *s.s.*, we retained the broader circumscription throughout our analyses to maintain consistency with the taxonomic framework adopted for the study period (2000–2024).

All names published within Euphorbiaceae *s.l.* in the 21st century were compiled from the International Plant Names Index (IPNI, 2024) database (Supplementary material I). We first analyzed all taxonomic novelties published in Euphorbiaceae *s.l.* between 2000 and 2024, encompassing all taxonomic ranks (from family to form), as well as the different nomenclatural statuses (new taxon, new status, new name, and new combination). The definition of new taxon (*taxon novum – tax. nov*.), new status (*status novus – stat. nov*.), new name (*nomen novum – nom. nov*.), and new combination (*combinatio nova – comb. nov*.) follows the most recent International Code of Nomenclature for algae, fungi, and plants (ICN, Madrid Code) (Turland *et al.*, 2025).

After compiling the published taxa in Euphorbiaceae *s.l.*, we defined the major geographic regions (macroregions) of the world and mapped the new taxa described in the 21st century. Seven geographic macroregions were defined for this mapping: Asia, Central and North America (including the Caribbean), Continental Africa, Europe, Madagascar, Oceania, and South America. Madagascar was treated as a separate region from Continental Africa to highlight its significant contribution to the description of new taxa. Despite its relatively small geographic size, Madagascar represents one of the most floristically diverse regions. The entire territory of Russia was included within the Asian macroregion; however, this had no impact on the results, as no new taxa were described from the western portion of the country, which is typically considered part of Europe.

In mapping the new specific and infraspecific taxa, we highlighted the countries and macroregions with the highest number of new taxa described. For this geographic analysis, we considered only taxonomic units at the species and infraspecific levels (subspecies, variety, and form). Artificial hybrids published as new taxa were not included in the geographic mapping, as they do not represent taxa that originated naturally in the wild.

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When a taxon was described as occurring in more than one country or macroregion, it was counted in all geographic units where it was recorded. For example, *Euphorbia collenetteae* Al-Zahrani & El-Karemy was described as occurring in both Africa (Sudan and Eritrea) and Asia (Saudi Arabia) (Al-Zahrani & El-Karemy, 2007). Similarly, *Croton maranonensis* Riina & Martín-Muñoz was described from both Peru and Ecuador (Martín-Muñoz *et al.*, 2024).

Certain names, although validly published, are illegitimate under the ICN. For example, *Euphorbia occulta* Halford & W.K.Harris is a later homonym of *Euphorbia occulta* Klotzsch and is therefore illegitimate. We retained the nomenclatural status indicated in the IPNI database. For geographic quantification purposes, we used only names formally described as "new taxa", rather than accepted names when those were published as "nomen novum". In the aforementioned case, we included *Euphorbia occulta* Halford & W.K.Harris (the later homonym), rather than *Euphorbia operta* Halford & W.K.Harris, which is the accepted replacement name. This methodological approach was adopted because a new name does not represent the description of a new taxon and therefore does not reflect an original taxonomic discovery. Consequently, for quantifying and mapping newly described taxa, we included later homonyms, as they were originally published as new taxa, despite being illegitimate. Nevertheless, this standardization does not affect the quantitative data, but we emphasize that accepted names should always be verified using up-to-date databases, specialized literature and nomenclatural types, since we retained the original names as downloaded from the data sources.

Results and Discussion

A total of 2,877 taxon names were published within Euphorbiaceae *s.l.* during the 21st century, across multiple taxonomic ranks (Fig. 1A). Among the newly described taxa, 1,236 correspond to units at the species and infraspecific levels (subspecies, variety, and form) (Fig. 1B), whereas only 148 correspond to new taxa described at ranks above the species, such as new genera, subgenera, sections, or series. More than half of all names published within Euphorbiaceae *s.l.* during the 21st century (1,493; 52%) correspond to new combinations, new status, or new names, while 1,384 (48%) represent the description of new taxa (Fig. 2).

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Considering all taxonomic names published in Euphorbiaceae *s.l.* during the 21st century, the majority belonged to Euphorbiaceae *s.s.* (1,677), followed by Phyllanthaceae (1,156), Putranjivaceae (24), Picrodendraceae (15), Peraceae (3), and Centroplacaceae (2) (Fig. 3A). All families included in Euphorbiaceae *s.l.* in this study, except for Pandaceae, had names published in the 21st century across various taxonomic ranks. Species richness within these families is strongly correlated with the number of names published, with Euphorbiaceae *s.s.* being the most diverse, followed by Phyllanthaceae.

Centroplacaceae was the only family newly described based on the tribe Centroplaceae described by Radcliffe-Smith (2001) within the subfamily Phyllanthoideae (currently Phyllanthaceae). Later, Hoogland & Reveal (2005) elevated this tribe to family rank, formally describing Centroplacaceae and including only the genus *Centroplacus* Pierre. The other segregated families received previously published names, which had nomenclatural priority under the ICN. Wurdack & Davis (2009) proposed the transfer of the genus *Bhesa* Buch.-Ham. ex Arn. into Centroplacaceae, where it remains circumscribed today, along with *Centroplacus* (POWO, 2025).

Within Euphorbiaceae *s.s.*, Cheilosoideae was given subfamily status by Wurdack *et al.* (2005), based on the elevation of the tribe Cheiloseae, which had previously been treated as part of Acalyphoideae by Webster (1994) and Radcliffe-Smith (2001), to reflect its relationship as sister to the remaining subfamilies. Balakrishnan & Chakrabarty (2007) proposed another subfamily in the treatment of Euphorbiaceae for the flora of India, Hippomanoideae, but this was not widely accepted by specialists around the world. Currently, Cheilosoideae remains recognized as a subfamily within Euphorbiaceae *s.s.*, whereas Hippomanoideae is not accepted in the APG (2016) classification.

A considerable number of new names for suprageneric taxa within the Phyllanthaceae were published in the classification by Webster (2014), as this was largely based on a manuscript written before his death in 2005 and therefore reflects an earlier framework in which Phyllanthaceae (Phyllanthoideae), Peraceae (Peroideae), and Picrodendraceae (Oldfieldioideae) were still treated as subfamilies within Euphorbiaceae, *i.e.*, it still follows the concept of Euphorbiaceae *s.l.*, as molecular studies (Wurdack *et al.*, 2005; Wurdack & Davis, 2009) and taxonomic revisions (Ralimanana &

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Hoffmann, 2011) that have reshaped the group's systematics were still in production when Webster passed away.

Regarding tribal and subtribal levels, most new names were recorded within Euphorbiaceae *s.s.* (17/20) as expected, and most of them correspond to new taxa. These are the result of advances in the systematics of these families based on molecular data, although more data are still needed to support and reevaluate several infrafamilial groups within Euphorbiaceae *s.s.* and Phyllanthaceae. An exemplary case is that of two recently described tribes, Caperonieae and Ditaxeae, which were established in 2023 based on an integrative study combining molecular and morphological data focused on clades within the subfamily Acalyphoideae of Euphorbiaceae *s.s.* (Külkamp *et al.*, 2023).

A total of 25 new genera were described in Euphorbiaceae *s.l.* during the 21st century. Of these, 22 were proposed as new taxa and three as new status derived from previously recognized sections (Fig. 1A, B). Eight of these genera were described within Phyllanthaceae and 17 within Euphorbiaceae *s.s.* (Supplementary material I).

At the subgenus rank, 27 names were published, of which only three correspond to new taxa, and the remainder were published as new combinations or changes in status. Most of these names were assigned to Phyllanthaceae (21), with six attributed to Euphorbiaceae *s.s.* (Supplementary material I). A significant portion of the subgenus names proposed within Phyllanthaceae is the result of the comprehensive taxonomic revision conducted by Bouman *et al.* (2022).

Of the 81 sections published in Euphorbiaceae *s.l.* in the 21st century, 55 were new taxa, 15 were status changes, and 11 were new combinations (Supplementary material I). These were distributed between Euphorbiaceae *s.s.* (62) and Phyllanthaceae (19).

Most of the sections were described in megadiverse genera containing hundreds of species, such as *Euphorbia* (33), *Croton* (19), and *Phyllanthus* (10) (Supplementary material I). The use of section ranks in these megadiverse genera aims to improve classification efficiency in taxonomically complex groups and to facilitate the study of evolutionary and morphological relationships.

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A similar pattern was observed for subsections: of the 46 proposed, 31 were described as new taxa, and 15 were published as new combinations or new status. In this analysis, new combinations and new status were not considered separately, as some taxa were simultaneously assigned a new status and a new combination within the same taxonomic proposal (see Fig. 2 and Supplementary material I). As with sections, all 46 subsections were proposed in species-rich genera, particularly *Euphorbia* (24), *Croton* (13), *Phyllanthus* (5), and *Jatropha* L. (4) (Supplementary material I).

A total of 22 names were proposed at the series rank in the 21st century, all within Euphorbiaceae *s.s*. The majority of these were assigned to the genus *Euphorbia* (21) and a single one to the genus *Cnidoscolus* Pohl.

Overall, the patterns observed indicate contrasting trends across taxonomic ranks in Euphorbiaceae *s.l.* While new generic names largely reflect the discovery and recognition of previously unknown lineages (e.g., *Bahiana* J.F.Carrión, *Brasiliocroton* P.E.Berry & Cordeiro, *Chicomendes* W.Cordeiro & M.F.Sales, *Karima* Cheek & Riina), most names proposed at the subgenus, section, and subsection levels represent nomenclatural rearrangements or redefinitions of pre-existing groups. This trend is particularly evident in Phyllanthaceae, where a substantial proportion of subgenus names resulted from the comprehensive taxonomic revision by Bouman *et al.* (2022). At the sectional and subsectional ranks, the proliferation of names is especially pronounced in megadiverse genera, where these categories have been extensively employed to improve classificatory resolution and to facilitate the interpretation of evolutionary patterns within large and complex lineages.

With the advancement of molecular studies in recent decades, the understanding of evolutionary relationships among taxa has undergone substantial improvement (Wurdack *et al.*, 2009). This progress has enabled significant refinements in classification systems across multiple taxonomic levels. A deeper comprehension of evolutionary history, coupled with the adoption of criteria favoring monophyletic groups, has led to the description of taxa at various hierarchical ranks, with Euphorbiaceae serving as a notable example of this trend (Wurdack *et al.*, 2004, 2005; Wurdack & Davis, 2009). The incorporation of molecular data and the application of phylogenetic tools have played a crucial role in enhancing and stabilizing taxonomic

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classifications by providing a more robust and objective foundation for establishing phylogenetic relationships among organisms (APG V, 2026).

A clear illustration of this molecular-driven reclassification is provided by the megadiverse genus *Phyllanthus*, which has been shown to be polyphyletic in recent phylogenetic analyses and was recently reclassified in relation to other taxa within the tribe Phyllantheae (Bouman *et al.*, 2022). This taxonomic revision led to the proposal of hundreds of names, primarily through new combinations. Of the 2,877 names published in Euphorbiaceae *s.l.* during the 21st century, 621 (21.6%) originated from this extensive taxonomic revision by Bouman *et al.* (2022), accounting for 54% of all names published in Phyllanthaceae during the same period (Supplementary material I).

Species and infraspecific taxa

As expected, names proposed at the species and infraspecific ranks represented most taxonomic publications in Euphorbiaceae *s.l.* during the 21st century, totaling 2,651 names and accounting for 92% of all published names in this group of families. Among these, 2,217 (83.6%) were described at the species rank, including three nothospecies, whereas 434 (16.4%) were published at infraspecific ranks, comprising 310 varieties, 113 subspecies, and 11 forms (Supplementary material I).

Although Phyllanthaceae accounts for approximately 40% of all names published in Euphorbiaceae *s.l.* in the 21st century (Fig. 3A), mostly due to the combinations proposed by Bouman *et al.* (2022), its relative contribution to new taxa is relatively lower (195 – 15.8%), when compared to Euphorbiaceae *s.s.* (1,007 – 81.5%), with only 34 new taxa published in the remaining families of the group (Fig. 3B).

From a geographical perspective, most new taxa were concentrated in tropical regions of the world (Fig. 4). Although this is an expected scenario given the higher diversity of the group in tropical and subtropical regions (Radcliffe-Smith, 2001; Webster, 2014), it also indicates that much diversity remains to be discovered in these regions.

The ongoing exploration of previously under-surveyed areas has proven to be an important source of new taxa, mainly in megadiverse and widely distributed genera, such as *Euphorbia*, *Croton*, *Phyllanthus*, and *Acalypha*. These genera exhibit high

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diversity across a range of environments, from tropical rainforests in Central and South America, Southeast Asia, and Africa (including Madagascar) to seasonally dry regions in Africa, Australia, and both North and South America (Webster, 2014; POWO, 2025).

South America registered the highest number of newly described species and infraspecific taxa in Euphorbiaceae *s.l.* during the 21st century, with 321 taxa, followed closely by Madagascar with 271 (Fig. 4A). Madagascar is notably smaller than the other macroregions outlined in Fig. 4, representing only 3.3% of the area of South America for example. This stark contrast highlights the exceptional plant diversity of the island and underscores the extent to which its flora remains understudied, as evidenced by the large number of recently described taxa.

Madagascar's isolation from continental Africa approximately 160 million years ago initiated the evolution of unique lineages and a high rate of endemism (Antonelli *et al.*, 2022). It is currently estimated that 80–85% of Madagascar's flora is endemic, making it one of the world's most important plant biodiversity hotspots (Droissart *et al.*, 2023). Recent years have seen an increase in plant species descriptions from the island, driven by intensified botanical exploration and research. Key institutions such as the Royal Botanic Gardens, Kew, the Real Jardín Botánico in Madrid, the Missouri Botanical Garden, and the Muséum National d'Histoire Naturelle in Paris have been actively involved in significant projects throughout the country (Madagascar Catalogue, 2025).

Asia was another major macroregion for the description of new taxa, with a total of 236 taxa (Fig. 4). Most of these were recorded from Indonesia and Malaysia, as well as from mainland Asia, particularly India (Fig. 4B). Indonesia alone harbors an exceptionally rich vascular flora, with 30,466 native vascular plant taxa recorded in a recent national checklist (Sun *et al.*, 2024). This region has proven to be particularly important for the discovery of new plant species in various groups throughout the 21st century, as demonstrated by numerous recent studies (Girmansyah, 2016; Atmaja & Tirta, 2019; Rahayu & Rodda, 2019; Henderson & Rustiami, 2019; Hughes *et al.*, 2020; Rodda & Rahayu, 2020; Utteridge & Rustiami, 2022).

The high number of newly described taxa recorded for Oceania is primarily attributed to taxa described from Australia, particularly in the state of Queensland, located in the northeastern part of the country (Supplementary material I). Previous

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studies have also reported greater plant diversity in the coastal regions of Australia, with Queensland standing out as one of the main centers of plant diversity in the country (Mokany *et al.*, 2022).

Central and North America also exhibited a significant number of newly described taxa in the 21st century, with most of these records originating from Mexico (Fig. 4). Previous studies have highlighted Mexico as a region with high diversity of Euphorbiaceae *s.s.*, particularly associated with seasonally dry habitats, including both dry forests and open ecosystems such as deserts (Villaseñor, 2016). Euphorbiaceae *s.s.* is the fifth most diverse plant family in Mexico, with over 700 species recorded, while Phyllanthaceae has only 49 species (Villaseñor, 2016). This explains the higher proportion of new taxa described within Euphorbiaceae *s.s.* compared to the other segregated families in Mexico (Supplementary material I). The substantial number of new taxa described in Mexico is mainly attributed to the most diverse genera found in seasonally dry habitats, such as *Bernardia* Houst. ex Mill., *Cnidoscolus*, *Croton*, *Euphorbia*, and *Jatropha* (Supplementary material I).

When considering the countries with the highest number of newly described taxa in Euphorbiaceae *s.l.* during the 21st century, Brazil holds a prominent global position with 222 new taxa recorded, ranking second only to Madagascar, which accounts for 271 new taxa (Fig. 4). This result is expected, as several factors contribute to these high numbers, including the country's remarkable species richness in Euphorbiaceae *s.s.* (996 species – Silva *et al.*, 2020), its vast geographic area, the great diversity of ecosystems (Flora e Funga do Brasil, 2025), and the notable increase in taxonomic studies over the past decades not only on the megadiverse *Euphorbia, Croton* and *Acalypha*, but also on other diverse genera, such as *Cnidoscolus* and *Manihot* Mill.

Other countries such as Australia, Mexico, and India also stand out as important centers of diversity, jointly contributing 255 new taxa. Together, the five countries with the highest number of newly described taxa represent 60.5% of all discoveries in Euphorbiaceae *s.l.* in the 21st century (Supplementary material I), underscoring their key role in recent taxonomic advances for the group.

Zhang *et al.* (2014) had already identified Brazil and Australia as among the countries with the highest number of newly described taxa. Another pattern highlighted

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in this study and previously noted by Joppa *et al.* (2011) is the high concentration of taxonomic discoveries in the world's biodiversity hotspots. In this context, Brazil and Madagascar stand out for containing regions designated as biodiversity hotspots and for exhibiting a remarkable number of newly described taxa in Euphorbiaceae *s.l*. In addition to these two countries, Southeast Asia and the tropical Andes are also recognized hotspot areas that have revealed a substantial number of new taxa within Euphorbiaceae *s.l*. (Supplementary material I).

Megadiverse genera contributed most of the new taxa

The megadiverse genera within Euphorbiaceae *s.l.* are the main contributors to the high number of newly described taxa in the 21st century (Fig. 5). The two largest genera in the family, *Croton* and *Euphorbia*, account for approximately half (606 taxa – 49%) of all new species and infraspecific taxa described in Euphorbiaceae *s.l.* during this period (Fig. 5). In addition to these, other rich genera also stand out for the number of newly described taxa, such as *Phyllanthus* (86), *Manihot* (55), *Cnidoscolus* (46), and *Acalypha* (39).

Euphorbia and *Croton* largely account for the high number of new taxa described in Brazil and Mexico. In these countries, other diverse genera such as *Acalypha*, *Cnidoscolus*, *Manihot*, *Jatropha*, and *Phyllanthus* also played major roles. Similarly, *Acalypha*, *Croton*, and *Euphorbia* are highly diverse in Madagascar, accounting for 237 new taxa, which represents 87% of the new taxa described in the country.

In Oceania, the megadiverse genera *Croton* and *Euphorbia*, along with *Macaranga* Thouars, accounted for the highest number of newly described taxa, totaling 75 species (37% of the region's total). While such widespread, species-rich genera contribute substantially to new species, notable increases have also occurred in geographically restricted and relatively species-poor genera. Striking examples include *Bertya* Planch. (28 spp.), *Beyeria* Miq. (25 spp.), and *Ricinocarpos* Desf. (29 spp.) (POWO, 2025), which had 12, 14, and 13 new species described, respectively, during the 21st century (Supplementary material I). These newly described species account for approximately 43%, 56%, and 45% of the currently accepted species in each genus, respectively, highlighting the substantial contribution of recent taxonomic research documenting species diversity in these groups.

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This notable rise is largely due to taxonomic revisions conducted by Halford & Henderson (2002; 2007; 2008). These findings highlight the fundamental importance of taxonomic research for biodiversity knowledge. Nonetheless, despite its crucial role, taxonomy has increasingly been treated as basic science and has lost prominence in recent years (Engel *et al.*, 2021), both in terms of publication priority in scientific journals and research funding support.

This pattern, in which the most diverse genera tend to have the highest number of newly described taxa, is also evident at the family level. Euphorbiaceae *s.s.*, being more diverse than the other families analyzed in this study, accounts for the majority (81.4%) of new taxa described in the 21st century.

Several factors help explain this trend among megadiverse genera: (1) they attract more taxonomic attention, with a greater number of specialists working on them, leading to increased research activity and funding; (2) they often have broad geographic distributions, allowing them to occupy a wide range of ecological niches; (3) land occupation and botanical collecting have intensified and expanded access to previously unexplored areas; and (4) advances in integrative taxonomy (molecular, chemical, and anatomical approaches) have shed light on complex infrageneric groupings, which are especially common in species-rich genera.

This prominence is particularly notable in regions where the family is highly diverse, such as Australia, Brazil, India, Indonesia, Madagascar, and Mexico (Fig. 4; Supplementary material I). These findings reinforce the correlation between pre-existing taxonomic richness and the number of newly described taxa, highlighting the importance of regional biodiversity and the intensity of taxonomic research efforts in driving species discovery.

Nomenclatural changes in Euphorbiaceae *s.l.*: Implications of phylogenetic systematics

Hennig's (1966) clade-based classification was fundamental to the development of phylogenetic systematics, which gained prominence in Botany from the 1990s onward with the publication of the first Angiosperm Phylogeny Group classification (APG, 1998). With the advancement of molecular tools, numerous taxa have been

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reclassified according to recovered phylogenetic topologies to apply the principles of cladistic classification, which is based on monophyletic taxa (APG, 2016).

In line with these principles and following the rules established by the International Code of Nomenclature for algae, fungi, and plants (Turland *et al.*, 2025), many names have undergone changes across different taxonomic ranks. One of the families most profoundly affected by these systematic advances is Euphorbiaceae *s.l.*, a large and morphologically diverse group traditionally encompassing a broad assemblage of genera. Molecular phylogenetic studies employing DNA sequence data from all three genomes have revealed that Euphorbiaceae *s.l.* is not monophyletic (Wurdack *et al.*, 2004; 2005; Wurdack & Davis, 2009). In addition to the new classifications proposed at the family rank, several studies proposing infrageneric classifications have been published (e.g., Riina *et al*., 2010; van Ee *et al*., 2011; Yang *et al*., 2012). These changes include new combinations, new status, new names, and the description of new taxa, often in response to the recognition of polyphyletic or paraphyletic groups. It is worth noting, however, that not all nomenclatural changes are directly linked to phylogenetic analyses, although phylogenetic results remain the main driver today.

While these nomenclatural changes are essential to aligning taxonomy with evolutionary history, they are not without consequence. Scientific names serve as a critical interface across multiple biological disciplines, including ecology, pharmacology, agriculture, conservation biology, education, and others (Bennett & Balick, 2014). Consequently, changes to these names can have wide-ranging consequences. For instance, medicinal studies that referenced outdated names may become disconnected from more recent botanical literature (Bennett & Balick, 2014). Similarly, biological collections, floristic databases, herbarium records, and educational materials often require extensive revisions following taxonomic reclassifications, requiring substantial time, effort, and financial resources (Garnett *et al.*, 2022).

Despite the challenges, nomenclatural changes in Euphorbiaceae *s.l.* exemplify how advances in molecular systematics have reshaped our understanding of evolutionary relationships and how these insights have been incorporated in the search for a more stable and standardized taxonomic framework. The reclassification of taxa

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based on well-supported phylogenies not only improves the evolutionary coherence of classification systems but also provides a stronger foundation for comparative studies, biodiversity assessments, and future taxonomic research.

Author's Contributions

JK conceived and designed the study, collected and analyzed the data, and wrote the manuscript. JCRM and OLMS reviewed the manuscript, and contributed to data interpretation and discussions.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability Statement

All data supporting the findings of this study are available within the article and its supplementary data.

AI Usage Statement

Artificial intelligence (ChatGPT) was used to assist with the grammatical review of the text.

Funding Information

To the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), the main Brazilian agency for the promotion of science and technology, for the scholarship awarded to JCRM (process no. 150361/2025-4) and support to OLMS (process no. 442162/2020-0), both linked to the Program for Supporting Research Projects for Training and Capacity Building in Biological Taxonomy (PROTAX). OLMS also thanks the Universidade de São Paulo through the "Programa de Apoio a Novos Docentes" (PAND 22.1.09345.01.2) and the "Fundação de Amparo à Pesquisa do Estado de São Paulo" (FAPESP 2021/08545-2 and 2022/12597-0).

Supplementary Material

The following online material is available for this article:

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Supplementary material I: Names published in Euphorbiaceae *sensu lato* in the 21st century.

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Figure Captions

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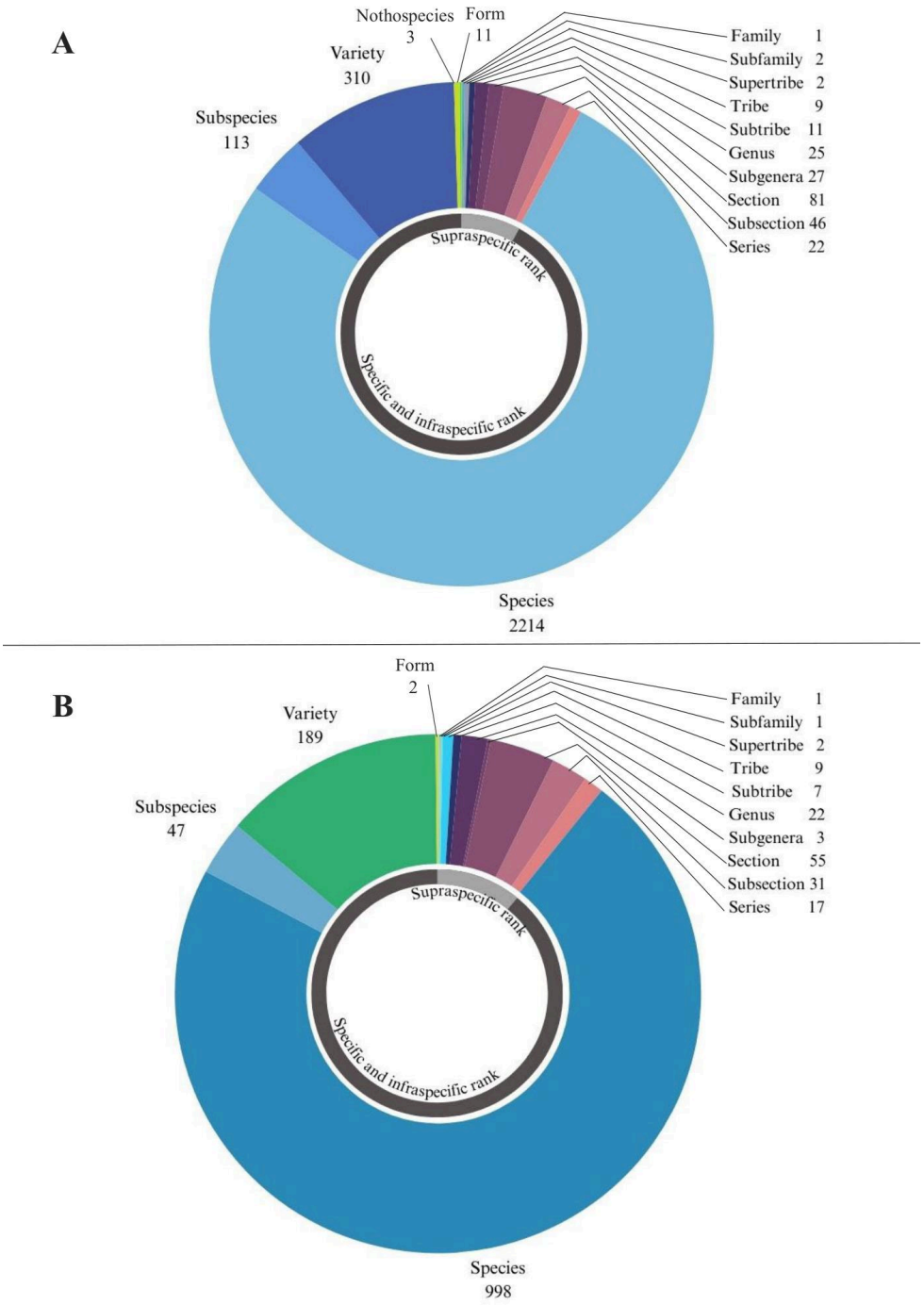


Figure 1 A. Number of taxa per rank proposed in Euphorbiaceae *s.l.* considering all nomenclatural statuses (new taxon, new status, new name, and new combination) in the 21st century. **B.** Number of taxa per rank proposed in Euphorbiaceae *s.l.* considering only new taxa published in the 21st century.

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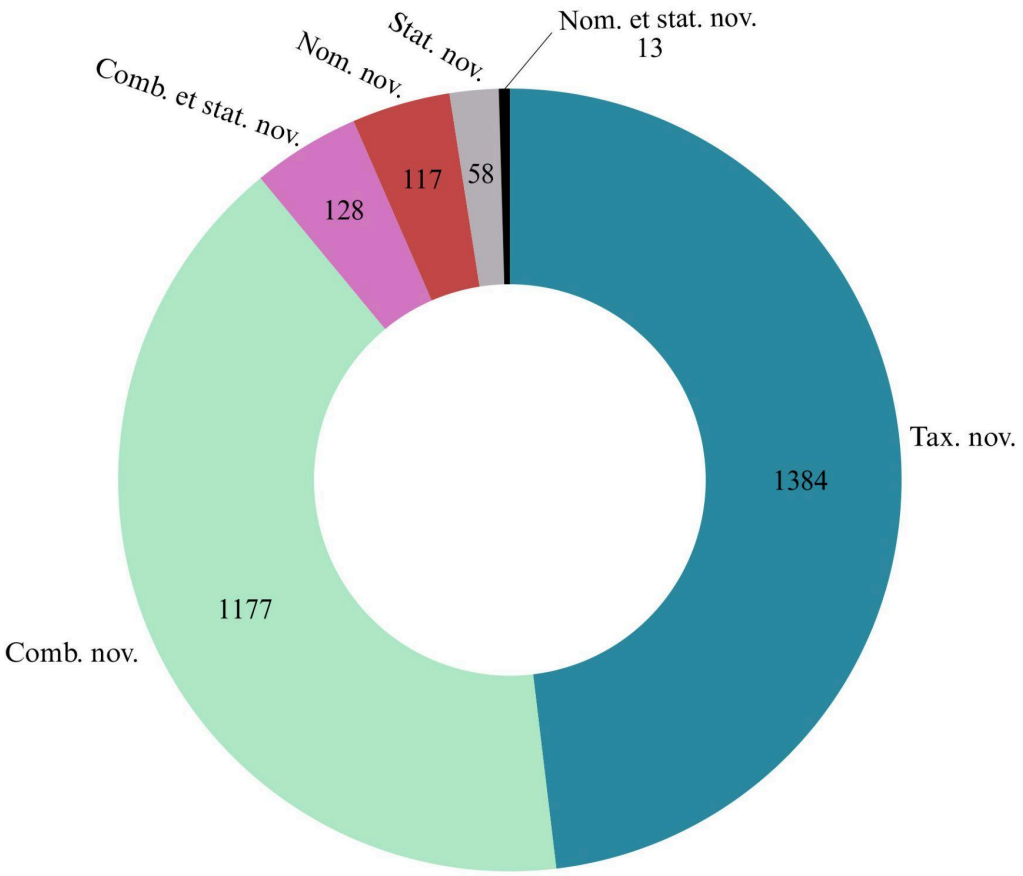


Figure 2. Number of taxa proposed in Euphorbiaceae *s.l.* in the 21st century considering all nomenclatural statuses. *Tax. nov.* (new taxon), *stat. nov.* (new status), *nom. nov.* (new name), and *comb. nov.* (new combination).

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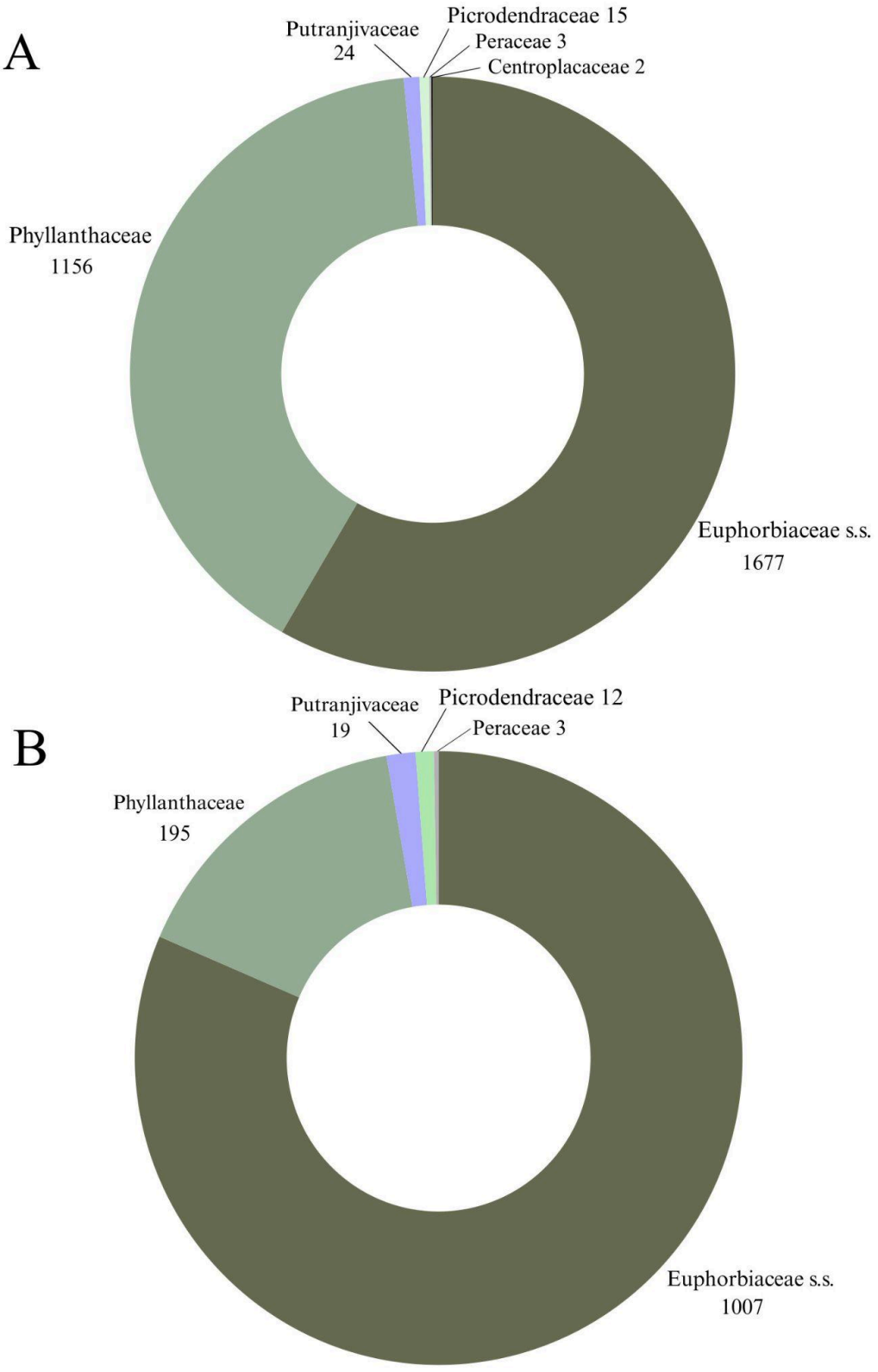


Figure 3 A. Number of taxa proposed by family in Euphorbiaceae *s.l.* considering all nomenclatural statuses in the 21st century. **B.** Number of taxa proposed by family in Euphorbiaceae *s.l.* considering only new taxa in the specific and infraspecific rank in 21st century.

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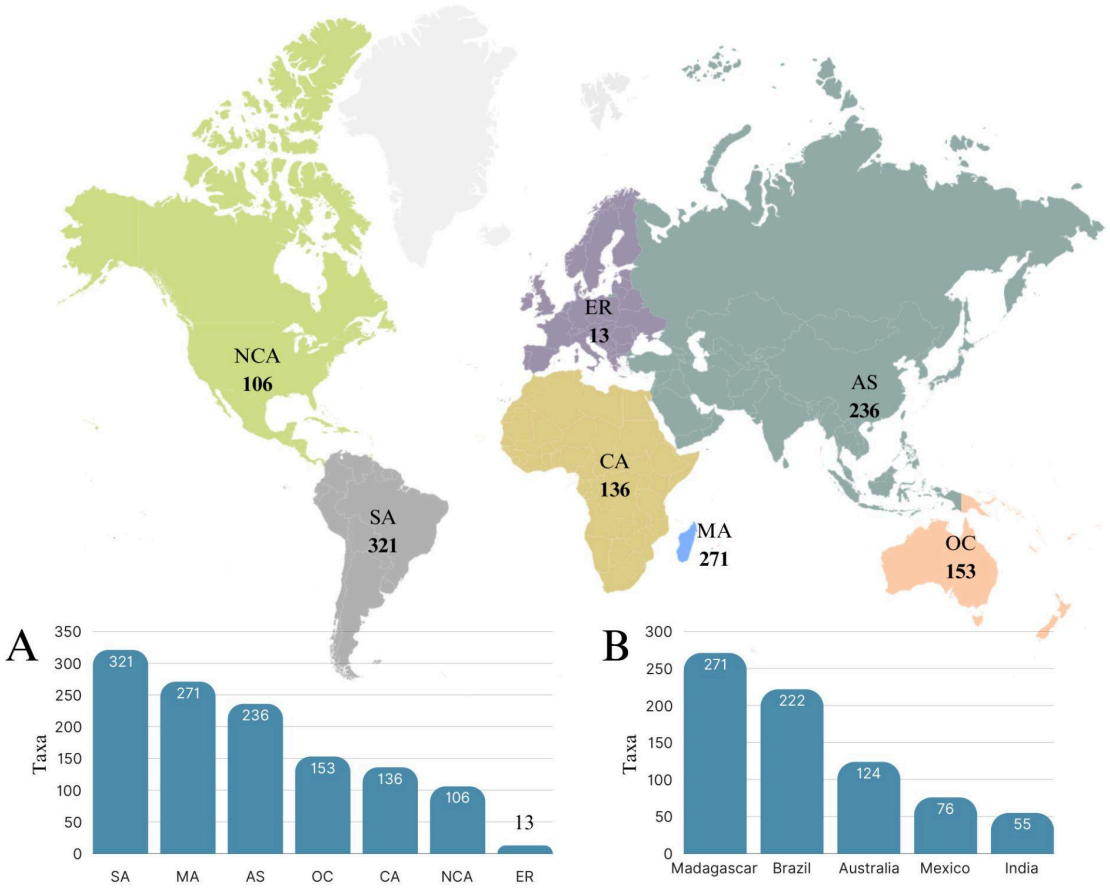


Figure 4. Distribution map of the new taxa in the specific and infraspecific rank of Euphorbiaceae *s.l.* published in the 21st century. **A.** New taxa per macroregion. SA – South America, NCA – Central and North America, CA – Continental Africa, MA – Madagascar, ER – Europe, AS – Asia, OC – Oceania. **B.** Countries with the highest number of new taxa described at specific and infraspecific ranks in Euphorbiaceae *s.l.* in the 21st century.

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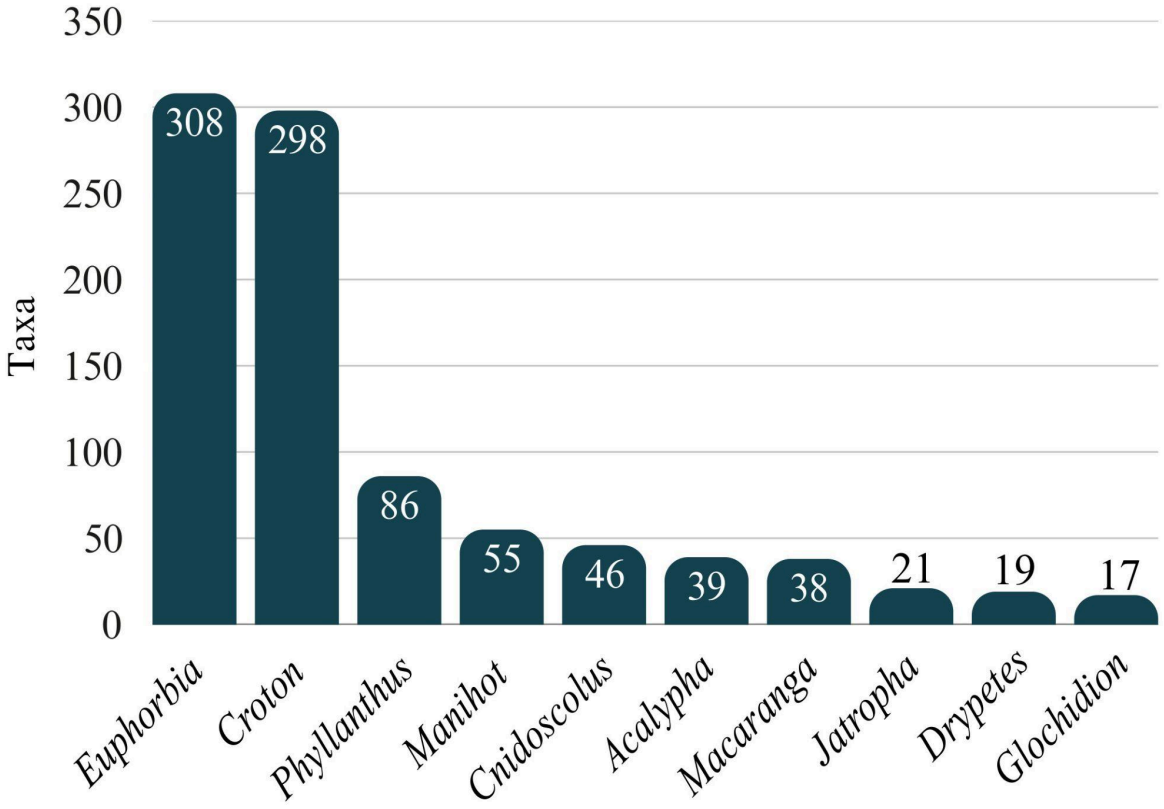


Figure 5. Genera with the highest number of new taxa described in Euphorbiaceae *s.l.* in the 21st century.

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