# Spatial and temporal distribution of knowledge on *Ritchiea capparoides* (Andrews) Britten

Aubin Befrude Sessomissou Adjakidjè, Sedami Igor Armand Yevide, Gbodja Houéhanou François Gbesso, Essenam Esdora Christine Dansou, Carolle Avocevou-Ayisso, and Adandé Belarmain Fandohan

**Correspondence**

**Aubin Befrude Sessomissou Adjakidjè[1], Sedami Igor Armand Yevide[2]*, Gbodja Houéhanou François Gbesso[1]*, Essenam Esdora Christine Dansou[2], Carolle Avocevou-Ayisso[2], and Adandé Belarmain Fandohan[2]**

[1]Horticultural Research and Green Space Management Unit, Plant, Horticultural and Forestry Sciences Laboratory, School of Horticulture and Green Space Management, National University of Agriculture, P.O. Box 43, Ketou, Benin.
[2]Forestry and BioResources Conservation Research Unit, Plant, Horticultural and Forestry Sciences Laboratory, School of Tropical Forestry, National University of Agriculture, P.O. Box 43, Ketou, Benin.

*Corresponding Author: yias01@yahoo.fr; fr.gbesso@gmail.com

**Ethnobotany Research and Applications 29:39 (2024)** - http://dx.doi.org/10.32859/era.29.39.1-18
Manuscript received: 16/06/2024 – Revised manuscript received: 07/09/2024 - Published: 08/09/2024

## Review

## Abstract

*Background*: *Ritchiea capparoides* is a fast-growing ornamental climbing shrub native to Africa, classified under the Capparaceae family. Despite its importance, it is commonly associated with genera *Maerua* and *Crateva*. This bibliometric analysis assesses the spatial and temporal distribution of scientific knowledge concerning these genera, utilizing major academic databases.

*Methods*: Scientific literature was retrieved from Scopus and Web of Science, accessed indirectly via the Research4Life platform. A total of 410 publications from 1941 to the first quarter of 2024 were processed and analyzed using tools such as Microsoft Excel 2020, ArcMap, Ghephi, and R Studio with the Bibliometrix package and Biblioshiny.

*Results*: The analysis showed that these genera have been the subject of 391 articles, accounting for 95.37% of all publications, predominantly in English, and have been cited 8,316 times. This equates to an average of 21 citations per publication and approximately one citation every five years. The Journal of Ethnopharmacology emerged as the most productive outlet, whereas the Journal of Medicinal Plants Research had the highest impact based on citation metrics. Collaboration analysis revealed that, of the total, 363 publications involved 1,381 authors in collaborative efforts, though 6.6% of studies were conducted without any collaboration between authors, institutions, or countries. Only 29.4% of the publications featured international collaborations, with the most significant networks centered around Ethiopia, India, and South Africa.

*Conclusions*: This study highlights the rich knowledge and collaborative importance in advancing research on *Ritchiea capparoides*, *Maerua*, and *Crateva*.

*Keywords*: *Ritchiea capparoides, Bibliometric analysis, Medicinal plants, Collaboration networks*

## Background

Plant genetic resources are one of the foundations of life in human societies on earth. Medicinal and/or food plants represent a component of plant genetic resources and are largely depleted by humans' activities (Kambale *et al.* 2016). According to Akabassi *et al.* (2021), more than 80% of the local African population is dependent on herbal medicines as their first means of care and 50% of drug prescriptions come from chemical molecules derived from plants. As a result of these services to humanity, plants constitute a potential reservoir of uses that must be protected and enhanced. Many medicinal species are threatened with extinction despite their importance. Of the 53,000 to 72,000 species of medicinal plants recorded worldwide, 15,000 are threatened with extinction (IUCN 2019; Akabassi *et al.* 2021), and the most threatened are those with a restricted geographical distribution and whose roots, seeds, and fruits are used in traditionnal medicine (Nzuki 2016). Among the latter are *Ritchiea capparoides* (Andrews) Britten, an important species in the African pharmacopoeia.

*Ritchiea capparoides*, is an ornamental climbing shrub of the Capparaceae family, consisting of two varieties, *Ritchiea capparoides* (Andrews) Britten var. *capparoides* (four-petaled flower) and *Ritchiea capparoides* var. *longipedicellata* (Gilg) DeWolf (eight or more petaled flower) (Burkill, 1985). Native to Africa, *R. capparoides* is restricted to the Sudanian, Zambezian, and sometimes Guineo-Congolian zones. It is widespread from Senegal to Kenya, extending southwards to northern Zambia, Angola, and Mozambique (Adjanohoun *et al.* 1989; Lemmens 2013).

It is a climbing fast-growing heliophilous diploid species with a chromosomal formula of 2n=20 (Timberlake *et al.* 2011; Yongo *et al.* 2011), capable of reaching 6 m in height (DeWolf 1961; Elffers *et al.* 1964; Adjanohoun *et al.* 1989; Neuwinger 2000; Akoègninou *et al.* 2006). It consists of alternate leaves with 3 to 5 leaflets and a petiole of 1.5 to 7 cm long. The leaflets are elliptic to obovate or lanceolate, cuneate, and often asymmetric at the base. It is coriaceous, glabrous has entire margins pinnately veined with 4 to 7 pairs of lateral veins, and has an umbelliform terminal or axillary inflorescence, which sometimes bears up to 30 flowers (Akoègninou *et al.* 2006). *R. capparoides* consists of bisexual flowers with a greenish-white to yellowish-white color. The flower pedicel can reach 8 cm long with free sepals, elliptic to lanceolate, 1.5 to 3 cm long (Adjanohoun *et al.* 1989; Lykke et Goudiaby 1999; Akoègninou *et al.* 2006). It is composed of 4 to 8 oblong-linear petals with numerous white filament stamens. The fruits of the species are cylindrical capsuled, resembling a berry of 4 to 8 cm × 2.5 to 4 cm in size, containing numerous seeds that are approximately 1 cm long, slightly compressed, and trigonal in shape. *R. capparoides* has many synonyms including *Ritchiea thouretiae* Gilg & Gilg-Ben.*, Ritchiea bussei* Gilg*, Ritchiea ealaensis* De Wild.*, Ritchiea engleriana* Buscal. & Muschl.*, Ritchiea fragariodora* Gilg*, Ritchiea pynaertii* De Wild.*, Ritchiea immersa* De Wild.*, Ritchiea insculpta* Gilg & Gilg-Ben.*, Ritchiea laurentii* De Wild.*, Ritchiea leucantha* Gilg & Gilg-Ben.*, Ritchiea longipedicellata* Gilg*, Crateva capparoides* Andrews*, Crateva fragrans* Sims*, Crateva moschata* Banks ex Sims*, Ritchiea insignis* (Pax) Gilg*, Maerua insignis* Pax (Akoègninou *et al.* 2006) expending three genera (*Ritchiea*, *Crateva*, and *Maerua*) in the plant family of Capparaceae.

*R. capparoides* is an important species in African pharmacopoeia. In southwestern Nigeria, the decoction of its leaves and roots is widely used for treating infectious and malarial diseases (Ajaiyeoba and Okogun 1996). Anowi *et al.* (2013) reported the antiplasmodial and antimicrobial activities of this plant extracts. The roots and leaves are used externally for snakebites and to treat Guinea worm infections. In Gambia, roots and branches are used to treat patients with trypanosomiasis (Ajaiyeoba and Okogun 1994). The roots have also been indicated to possess aphrodisiac properties (Adjanohoun *et al.* 1989). *R. capparoides* is also highly sought after for treating and combating intestinal worms, gonorrhea, stomach ailments, rheumatism, ophthalmia, conjunctivitis, swellings, and coughs (Burkill 1985; Ajaiyeoba and Okogun 1994; Neuwinger 2000). However, the recognized medicinal value of the species constitutes a considerable threat to its conservation and sustainable management as it continues to be exploited in the wild (Anowi *et al.* 2013). Though classified as Least of Concern on the IUCN Red List (https://www.iucnredlist.org) based on an assessment conducted in 2018, given the use of its organs in traditional medicines, it is important to assess the current knowledge on the species, which involves evaluating the scientific importance attributed to the different genera to which its synonyms belong and the species itself. In this framework, the present work aims at conducting a bibliometric analysis on *R. capparoides* and the genera to which its synonyms belong, to answer the following questions: i) what are the spatial and temporal distribution of knowledge on *Ritchiea*, *Crateva*, and *Maerua* in general and on *R. capparoides* specifically?, ii) what are the network of collaboration between authors involved in publications and their countries?, iii) What are the knowledge gaps on *Ritchiea*, *Crateva*, and *Maerua* in general and *R. capparoides* specifically in terms of conservation and domestication?

## Materials and Methods

### Data collection

Bibliometric analysis, depending on its goal, is carried out using various database collections or repositories that provide access to scientific productions and/or citation indexes. Web of Science and Scopus are two giant core database collections mainly used to collect the necessary scientific productions to conduct a bibliometric analysis (Guerrero-Moreno and Oliveira-Junior 2024). They have been used to retrieve and process literature data for countless bibliometric analyses on various topics expanding from different research areas to single and/or group of species (Liu et al., 2011; Zeng et al., 2014; Yevide *et al.* 2016; Duan *et al.* 2020; Saggiomo *et al.* 2020; Tourinho *et al.* 2020). Contrary to these databases that are well known, directly accessed, and widely used for this purpose, there is Research4Life less used due to a lack of knowledge about its existence and its potential to access numerous databases including Web of Science (Clarivate) and Scopus, the paid-access platform usually difficult of direct access from developing countries. Research4Life is an initiative which is a public-private partnership comprising of research institutions and UN agencies. The goal of Research4Life is to provide affordable access to scholarly, professional, and research information in least developing countries. It is the collective name for five programs *viz*. Research in Health (Hinari), Research in Agriculture (AGORA), Research in the Environment (OARE), Research for Development and Innovation (ARDI), and Research for Global Justice (GOALI) that provide developing countries with free or low-cost access to up to 81,000 leading journals and books in the fields of health, agriculture, environment, and applied sciences. Research4Life allows also access to Web of Science and Scopus databases *via* its platform.

Given the multitude of synonyms of *R. capparoides* expanding three genera: *Ritchiea*, *Maerua*, and *Crateva* (Akoègninou *et al.* 2006), these genera were used as keywords to locate and retrieve scientific productions that have these keywords in their title, keywords and abstract from Scopus and Web of Science databases indirectly accessed *via* Research4Life platform. The search was conducted in the first half of March 2024 by selecting no specific domain areas to ensure the obtention of a larger volume of records, guaranteeing the sample's representativeness to gain a global perspective. In addition, a few publications on *R. capparoides* and its synonyms were collected from Google Scholar by focusing the search of these keywords in the title of the article without any additional filter.

**Data cleansing and compiling**

The search performed *via* the Researcch4Life platform yielded 330 records from Scopus and 192 records from Wed of Science totaling 522 documents of various types. Given similarities of journals shared by these two database collections, the two results were merged and the resulting file was scrutinized automatically using various text strings in Microsoft Excel 2020 and manually to remove duplicates and irrelevant documents. At the end of this process, over 522 documents were obtained, 114 documents were removed and the remaining 408 plus 2 documents from Google Scholar were used for trend analysis. As in most bibliometric analyses, it is common to exclude all document types different from articles and reviews because they usually are not peer-reviewed and evaluated in their full length (Garza-Reyes 2015; De Oliveira *et al.* 2019), only 391 publications formed by 374 articles and 17 reviews were considered for further analysis.

**Data analysis**

The temporal evolution of publications and their total citations over time was computed, and Microsoft Office Excel 2020 was used to produce the graph. For the total citation, the maximum value from the two databases from which publications were retrieved was used.

Based on the affiliation of the authors, the authors' country information was extracted and used to determine the contribution of countries worldwide in publications on the three searched genera. Only publications having affiliation information provided were considered and ArcGIS version 10.4 was used with the world geopolitical boundaries of countries layer retrieved from the geospatial data portal of the Food and Agriculture Organization of the United Nations (FAO, geospatial information for sustainable food systems) to produce the map of the spatial distribution and access the spatial pattern of the publications.

Content analyses were conducted using Microsoft Excel 2020 and Bibliometrix (Version 4.1.4) with Biblioshiny (https://www.bibliometrix.org/home/index.php/layout/biblioshiny), which is an open-source tool based on R used for comprehensive analysis and mapping of scientific literature (Aria and Cuccurullo 2017). The choice of Bibliometrix package with built-in Biblioshiny for content is associated with its extensibility in the RStudio programming language. Furthermore, the open-source nature ensures regular updates and continuous support from a community of users and developers, making these tools relevant and functional over time (Aria and Cuccurullo 2017). Additionally, their availability for free contrasts with other applications that may be expensive or require subscriptions to access comparable functionalities (Guler *et al.* 2016). The extensive documentation and learning resources available for these tools facilitate their adoption and effective use, providing researchers with a solid foundation for conducting meaningful and accurate bibliometric analyses, as well as enabling information mapping using simple and complex graphics (Aria and Cuccurullo 2017).

Social network analysis was conducted to understand research networks and clusters using Gephi version 0.9 software. Ghephi was chosen given its flexibility to analyze the collaboration network with ease by moving gradually in degree of complexity and the quality of the graphics it provides. For the social network analysis, we created authors' countries and authors' networks to investigate the level of collaboration between countries, especially amongst African countries and overseas partners, as well as between leading authors. In this analysis, nodes represent authors or countries and edges represent publications on which two authors or countries have collaborated. The strength of the network (edge) relates to the number of publications the two have co-published. As is common in other bibliometric analyses, research published by authors from England, North Ireland, Scotland, and Wales were labeled as documents from the United Kingdom (Liu *et al.* 2011; Yevide *et al.* 2016).

The number of authors, affiliations, and countries were generated from the collected data to investigate collaboration between authors' affiliations, authors' countries, and number of authors on the publication.

## Results

**Temporal evolution of scientific productions on the genera *Ritchiea, Maerua, and Crateva***

The information gathered through Scopus and Web of Science search engines *via* the Research4Life platform, based on the used keywords, resulted in retaining 408 documents in addition to 2 from Google scholars. The first publication on *Ritchiea*, *Maerua*, and *Crateva* dated back to 1941, in the form of an article focusing on the structure and functioning of *Capparis zeylanica* and related genera's cells (Raghavan and Venkatasubban 1941).

From 1941 to the first quarter of 2024, a total number of 410 scientific productions including 391 articles were produced and cited 8,316 times. The average citation was about 21 per publication and about one citation per publication every 5 years. The temporal evolution of scientific production on these genera revealed three major evolutionary trends: marginal, progressive, and exponential with a decline from 1941 to 1991, 1992 to 2019, and 2020 to 2024 respectively (Figure 1). The period from 1941 to 1991 showed marginal evolution, with only 11 documents (2.7%), all articles, published over 50 years, with long intervals, from 0 to 14 years or an average of about 5 years between two consecutive publications. The longest period of absence of publications was from 1941 to 1976. Among these 11 documents, only one, published in French in the "*Bulletin de la Société Botanique de France*" in 1956 on the genus *Maerua* of the Capparaceae family of Madagascar (Hadj-Moustapha 1956), was not cited at all. The 10 remaining were cited 1 to 36 times totaling 110 citations with an average of 11 citations per publication over the 50 years or 1 citation per publication every 5 years. Between 1992 and 2019, the number of publications exhibited a progressive evolution, marked by 262 articles (63.9%) in addition to 12 other (2.9%) scientific productions. The number of publications evolved from 2 (0.5%) per year in 1992, to 21 (5.1%) in 2018 with an average of 9 publications per year in that period. The total citation was the highest with a noticeable peak of 750 citations in 2017. The average citation per publication was 28 with about 1 citation per publication per year. From 2020, and beyond, an exponential increase was observed in scientific productions on the genera *Ritchiea*, *Maerua*, and *Crateva* with 125 publications, of which 94% were articles in the year beginning that period. Two peaks of scientific production the first in 2020 with 38 documents and the second in 2022 with 33 documents. The total number of citations in this period was 628, and the highest number of citations was recorded for 2020, with 296 citations. This period was also marked by greater yearly production of about 2 publications different from articles. However, the number of citations per publication per year was similar to the one from 1941 to 1991.

Over the 83 years of scientific productions on the three genera belonging to the Capparaceae family, 39 years, all in the marginal production period, recorded zero publication as well as zero citation. Among the 410 publications, only 09 were found addressing specifically research on *R. capparoides* and its synonyms and were cited 70 times.

**Spatial distribution of publications on the genera *Ritchiea*, *Maerua*, and *Crateva***

The geographic contribution of publications varies from 0 to 87 per country (Figure 2). India stands out as the country with the highest number of publications, 87 in total representing 15.79% of articles published on the genera *Ritchiea*, *Maerua*, and *Crateva*. Following India, other countries such as South Africa, Nigeria, Saudi Arabia, Ethiopia, Kenya, and the United States, have produced 21 to 30 publications each totaling together 148 publications (26.86%) including 103 from the African countries in the list. The countries with the lowest production are more distributed in Asia and Africa than on the other continents. Almost half of the countries in Africa contributed to the knowledge production of the studied genera and as a continent produced 194 publications representing 35.21% of the total number of publications followed by Asia (190 publications) and Europe (103 publications). America and Oceania were the continents with the lowest production (Figure

3). In Africa, the Western, Eastern, and Southern regions were the most productive while the Southern in Asia and the Western in Europe had slightly more than half of the scientific production of the continent. Worldwide, about 20 countries recorded only one publication including in Africa Cape Verde in the Western, Djibouti, and Rwanda in the Eastern, Algeria, and Tunisia in the Northern, and Botswana in the Southern.

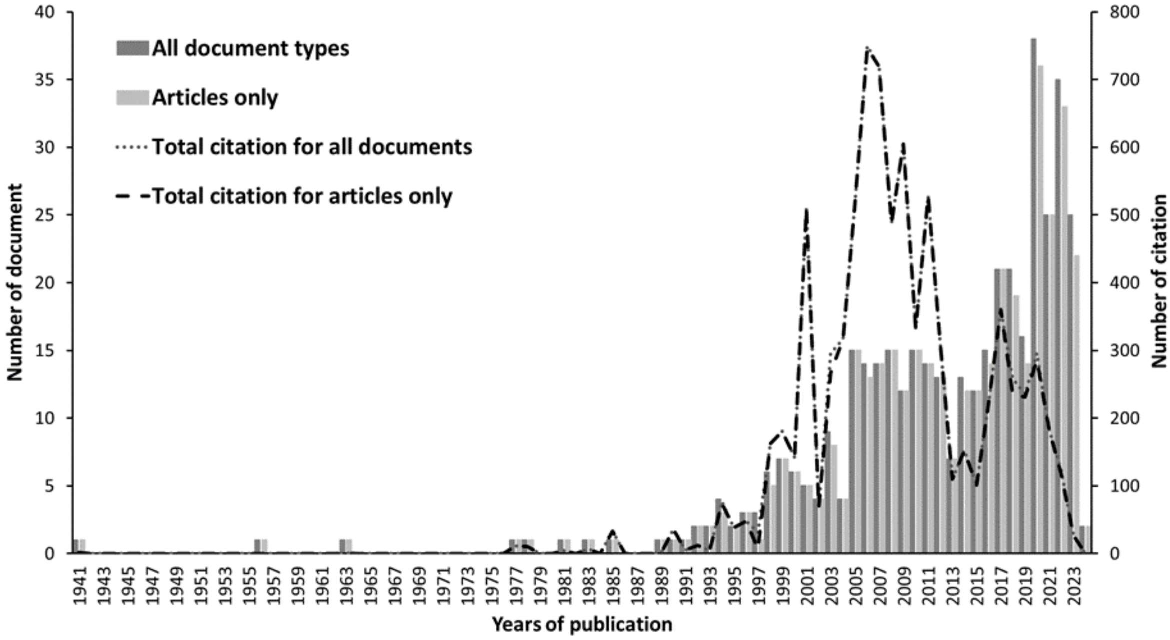


Figure 1. Trend of total number of publications and number of citations for research on *Ritchiea*, *Maerua*, and *Crateva*

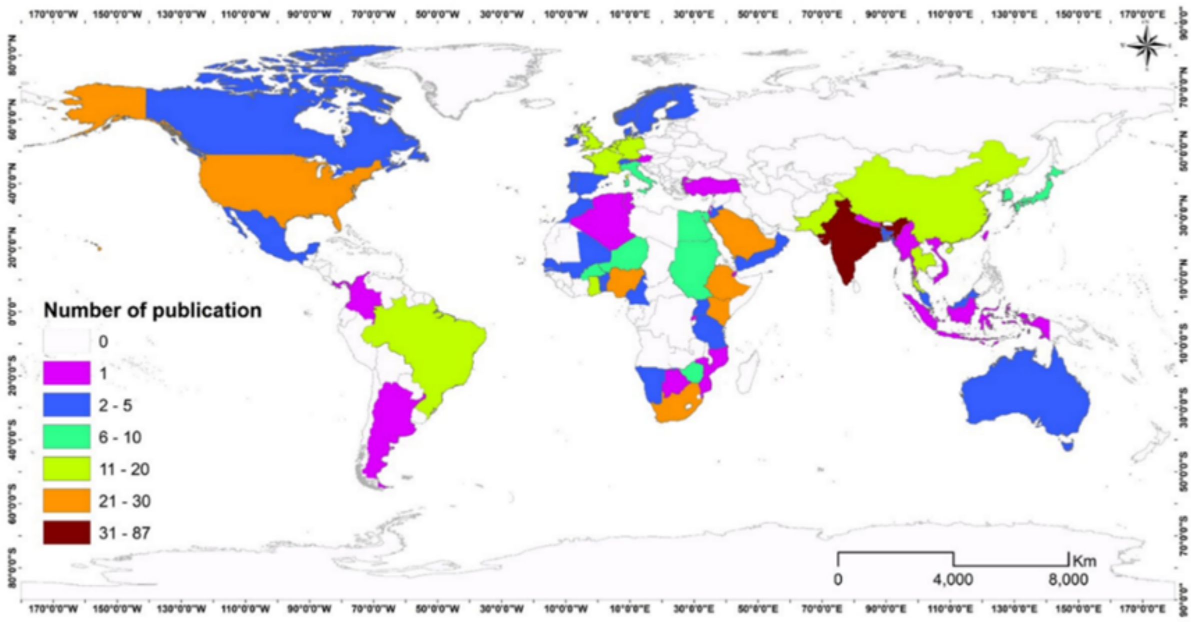


Figure 2. Global geographical distribution of publications on *Ritchiea*, *Maerua*, and *Crateva* based on authors' countries

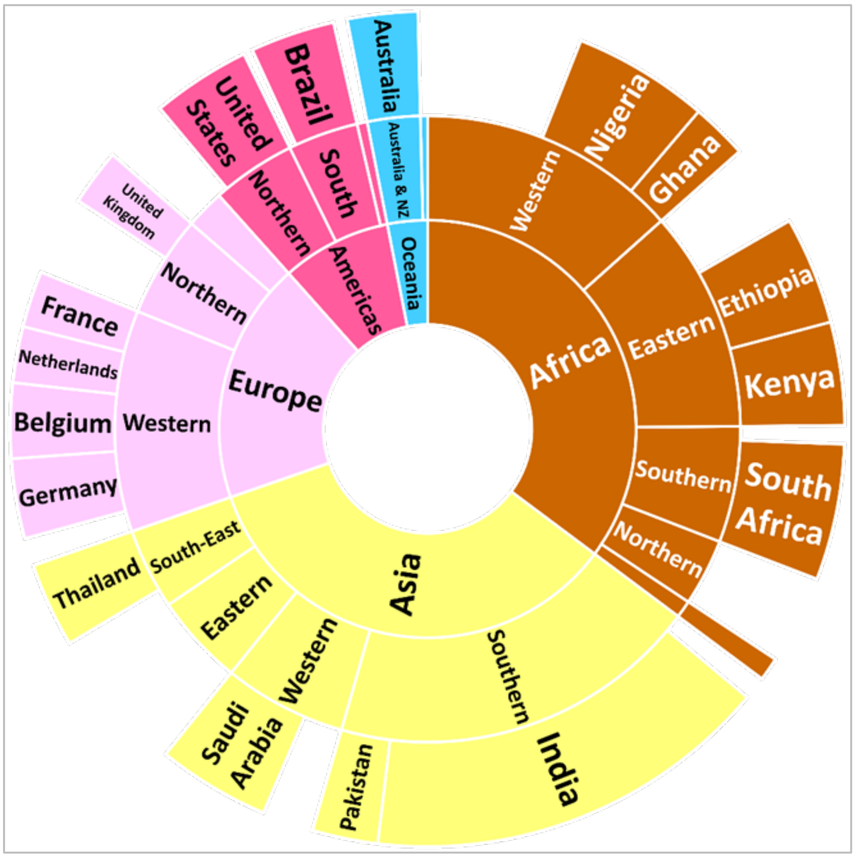


Figure 3. Contribution of continents, regions, and countries in publications on *Ritchiea*, *Maerua*, and *Crateva*

**The most productive and influential journals**

Articles and reviews published on the studied genera encompass 266 journals or sources out of which, 34 journals have published 2 publications, 213 have published a single publication, and 19 journals have published more than 2 publications. Among the latter, the *Journal of Ethnopharmacology* has the highest number of publications (34) with an impact factor of 5.4, followed by *Livestock Research for Rural Development*, *Journal of Applied Pharmaceutical Science*, *Evidence-based Complementary and Alternative Medicine*, and *Journal of Arid Environments*, which have produced 12, 7, 6, and 5 publications respectively (Table 1). Four (4) other journals have each produced 4 publications, among which the journal with the highest impact factor, *Phytotherapy Research* (7.2) is found. The remaining 9 journals have published 3 publications each. Regarding the impact of the most active journals, even though having the highest impact factor, the published publications in *Phytotherapy Research* were cited 121 times representing 30.25 citations per publication, which is less than half of what *Fitoterapia* recorded (78 citations per publication) despite having only 3 publications and an impact factor of 3.4 as well as the most productive journal, the *Journal of Ethnopharmacology* (77.71 citations per publication) with an impact factor of 5.4. Above all these journals in the most active sources list, the *Journal of Medicinal Plants Research*, *OECOLOGIA*, *BMC Complementary and Alternative Medicine*, *Letters in Applied Microbiology*, and *Plant Foods for Human Nutrition* have the highest impact in terms of the number of citations per publication which were 148, 144, 143, 125, and 123 citations per publication respectively, despite having only one publication published between 1998 and 2011. The publications from these journals addressed medicinal plants used by traditional healers in Sudan, the anticancer, antimicrobial, and antioxidant potentials of medicinal plants in Yemen, as well as the antimicrobial activity of plants from Argentina, and the nutrient content of edible leaves of wild plants from Niger. *Veterinary Parasitology*, also absent from the most active sources list, has 136 citations per publication with two published articles in 2006 and 2017 on the use of plants for controlling gastrointestinal helminths in livestock with emphasis on small ruminants and the *in vitro* anthelmintic properties of browse plant species against *Haemonchus contortus* (Rudophi, 1803) Cobb, 1898 using polyphenol content and composition.

Table 1. List of the most active sources

| Sources | Number of publications | Percentage of publication | Total citations | Percentage TC | TC/P | Impact factors |
|---|---|---|---|---|---|---|
| *Journal of Ethnopharmacology* | 34 | 8.70 | 2642 | 32.17 | 77.71 | 5.4 |
| *Livestock Research for Rural Development* | 12 | 3.07 | 49 | 0.60 | 4.08 | |
| *Journal of Applied Pharmaceutical Science* | 7 | 1.79 | 70 | 0.85 | 10.00 | |
| *Evidence-based Complementary and Alternative Medicine* | 6 | 1.53 | 93 | 1.13 | 15.50 | |
| *Journal of Arid Environments* | 5 | 1.28 | 77 | 0.94 | 15.40 | 2.7 |
| *Phytotherapy Research* | 4 | 1.02 | 121 | 1.47 | 30.25 | 7.2 |
| *Journal of Herbal Medicine* | 4 | 1.02 | 66 | 0.80 | 16.50 | 2.3 |
| *Rodriguesia* | 4 | 1.02 | 19 | 0.23 | 4.75 | |
| *International Journal of Research in Pharmaceutical Sciences* | 4 | 1.02 | 2 | 0.02 | 0.50 | |
| *Fitoterapia* | 3 | 0.77 | 234 | 2.85 | 78.00 | 3.4 |
| *South African Journal of Botany* | 3 | 0.77 | 147 | 1.79 | 49.00 | 3.1 |
| *Journal of Food Composition and Analysis* | 3 | 0.77 | 58 | 0.71 | 19.33 | 4.3 |
| *African Journal of Ecology* | 3 | 0.77 | 47 | 0.57 | 15.67 | 1 |
| *Planta medica* | 3 | 0.77 | 41 | 0.50 | 13.67 | 2.7 |
| *Journal of Genetic Engineering and Biotechnology* | 3 | 0.77 | 40 | 0.49 | 13.33 | |
| *Plants* | 3 | 0.77 | 32 | 0.39 | 10.67 | |
| *Journal of Herbs, Spices and Medicinal Plants* | 3 | 0.77 | 14 | 0.17 | 4.67 | |
| *International Journal of Biological and Chemical Sciences* | 3 | 0.77 | 9 | 0.11 | 3.00 | |
| *Nordic Journal of Botany* | 3 | 0.77 | 2 | 0.02 | 0.67 | 0.9 |

**Collaboration between authors, authors' countries, and institutions**

Since the first publication on the studied genera was published in 1941 to the first quarter of 2024, and apart from the 28 single authors' publications, there have been 1,381 authors involved in the 363 collaborative published publications. Regardless of the number of publications two or more authors have published together, they have established a total number of 4004 edges in a network formed by about 246 isolated smaller networks (Figure 4a). To investigate the strength of collaboration between authors, all the edges formed by one collaborative publication were removed leading to a remaining 261 edges (Figure 4b). After removing the isolated nodes that represent authors having only a single publication tie between themselves and/or others, a total of 261 edges existed between 158 authors in a network formed by 35 isolated smaller networks (Figure 4c). Similarly, two publications ties were removed leading to 84 edges in 14 smaller networks (Figure 4d). The final collaboration network between authors having at least three publications together was formed by 56 authors with Nadeem M, Khan S, Shaikhaldein HO, Salih AM, Al-quraniny F, Tarroum M, and Alansi S having the biggest and strongest collaborative network. There were 5 smaller networks showing collaborations between a pair of authors (Figure 4e).

Regarding collaboration between authors' countries, 276 publications (70.59%) were published by 48 single authors' countries with India (72), Nigeria (20), Thailand (16), Brazil (15), Kenya (15), South Africa (14), Saudi Arabia (13), and Pakistan (10) having the highest number of single authors' countries publications. The network resulting from remaining publications with authors from at least two different countries reveals the presence of 62 countries and 142 edges, regardless of the number of publications produced together. France and the United States were at the center of the biggest but not the strongest authors' countries networks with 15 countries each but sharing Ethiopia, Cameroon, South Africa, Germany, Brazil, and Australia. The relatively biggest and strongest networks had at their center Ethiopia with a strong collaboration between Netherlands and Belgium, India with a strong collaboration between Saudi Arabia and South Korea, and South Africa with a strong collaboration between Belgium and Cameroon. When reduced to a network with authors' countries with at least two collaborative publications, only 32 countries and 33 edges remained with 3 separated smaller networks including one with two countries that were Japan and Kenya (Figure 5).

To investigate intranational or international collaboration between authors, a table presenting the number of authors, authors' affiliations, and authors' countries was produced and reveals that there was more collaboration between institutions within the same country than institutions between different countries. In total, only 6.6% of publications were done without collaboration between neither authors, institutions, and countries (Table 2).

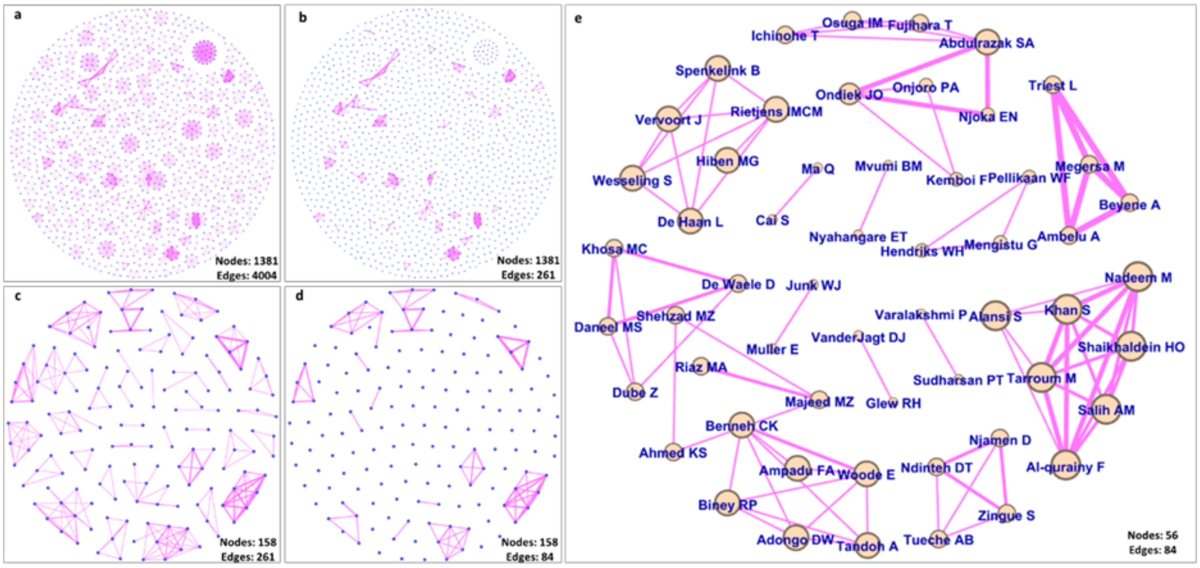


Figure 4. Social networks of collaboration between authors regardless of the number of publications published together (a), with only one publication edge removed (b), with a minimum of two publications published together (c), with two publications edges removed (d), and with a minimum of three publications published together (e)

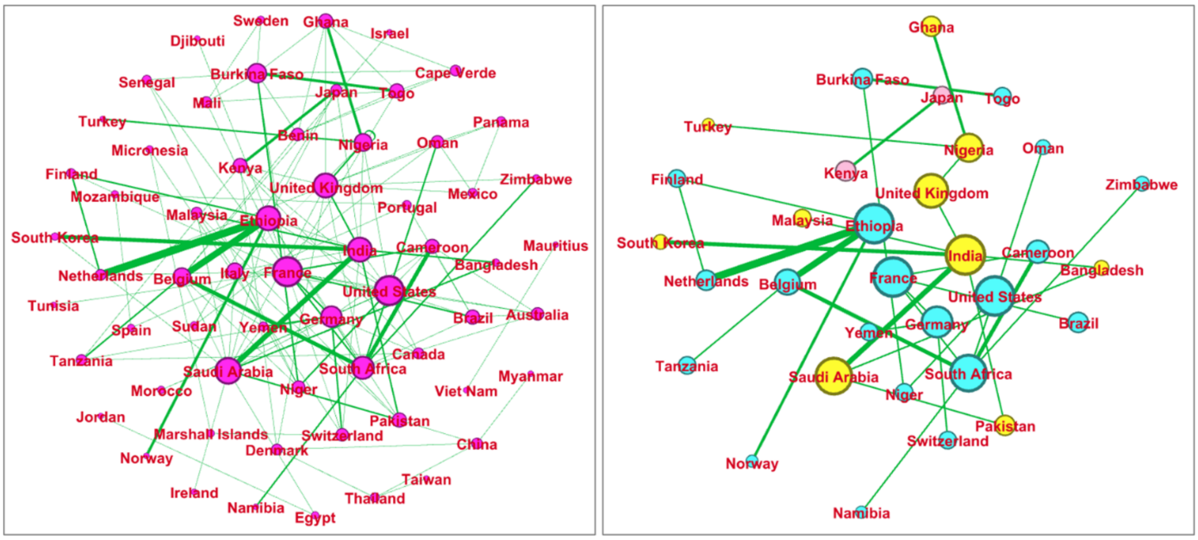


Figure 5. Social networks of collaboration between authors' countries regardless of the number of publications published together (left), with a minimum of two publications published together (right)

Table 2. Collaboration between authors' institutions

| | | Number of authors | | | Total |
|---|---|---|---|---|---|
| | | One | Two | > two | |
| **One Country** | One institution | 26; (6.6%) | 30; (7.7%) | 65; (16.6%) | 121; (30.9%) |
| | Two institutions | | 19; (4.9%) | 57; (14.6%) | 76; (19.4%) |
| | > two institutions | | 2; (0.5%) | 78; (19.9%) | 80; (20.5%) |
| | **Sub total** | 26; (6.6%) | 51; (13%) | 200; (51.2%) | 277; (70.8%) |

| | | | | | |
|---|---|---|---|---|---|
| **Two countries** | Two institutions | 2; (0.5%) | 9; (2.3%) | 22; (5.6%) | 33; (8.4%) |
| | > two institutions | | 1; (0.3%) | 56; (14.3%) | 57; (14.6%) |
| | **Sub total** | 2; (0.5%) | 10; (2.6%) | 78; (19.9%) | 90; (23%) |
| **> two countries** | > two institutions | | | 24; (6.1%) | 24; (6.1%) |
| | **Sub total** | | | 24; (6.1%) | 24; (6.1%) |
| **Total** | | 28; (7.2%) | 61; (15.6%) | 302; (77.2%) | 391; (100%) |

**Publication languages and content analysis outcome**

Based on the language information provided in the retrieved publications, almost 96% of the publications were published in English followed by French and Portuguese. Spanish and Turkish recorded only one publication each. However, even though the lowest publication was done in Spanish and Turkish, in terms of impact, their total citation per publication was higher compared to the papers published in French while the number of citations per publication per year was almost the same. Papers published in English and Portuguese had the highest impact (Table 3).

Table 3. Language of publication and their impacts

| Languages | Number of publications | Percentage (%) | Total citations | Total citations per publication | Total citations per publication per year |
|---|---|---|---|---|---|
| **English** | 375 | 95.91 | 8118 | 21.65 | 2.04 |
| **French** | 9 | 2.30 | 25 | 2.78 | 0.31 |
| **Portuguese** | 5 | 1.28 | 57 | 11.40 | 0.84 |
| **Spanish** | 1 | 0.26 | 7 | 7.00 | 0.29 |
| **Turkish** | 1 | 0.26 | 6 | 6.00 | 0.26 |
| **Total** | 391 | 100.00 | 8213 | 21.01 | 1.98 |

The word cloud generated from the publications' titles and abstracts to identify the meaningful group of words revealed that most of the research carried out on the studied genera was investigating the medicinal potential of species belonging to *Ritchiea*, *Maerua*, and *Crateva*. However, these investigations focused more on plant species like *Maerua angolensis* DC., *Crateva adansonii* DC., *Maerua crassifolia* Forssk. and *Maerua oblongifolia* (Forssk.) A.Rich. and very little on *Ritchiea capparoides* and its synonyms. To investigate the medicinal potential of these species, the aqueous, and/or ethanolic extracts of their organs such as leaves, roots, and stem bark were produced and even tested *in vitro* and/or *in vivo* against several ailments identified during ethnobotanical studies (Figure 6).

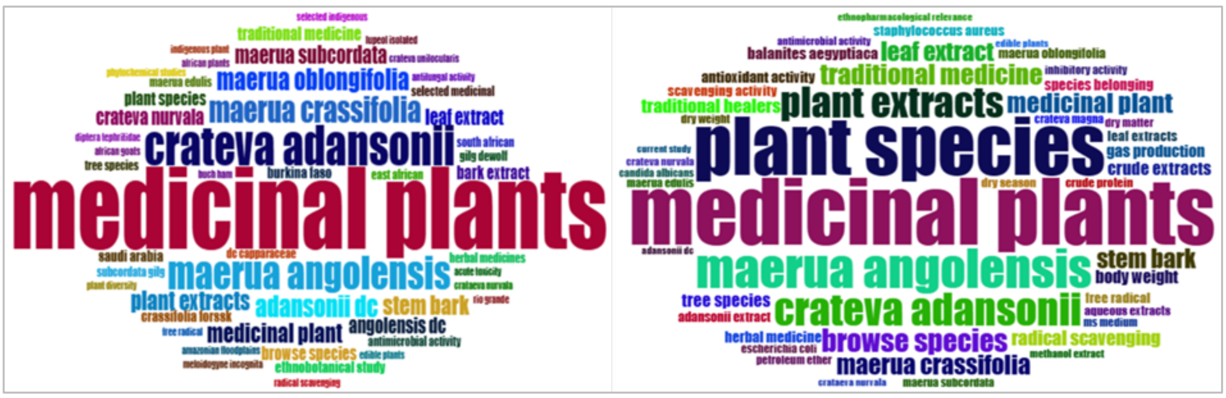


Figure 6. Wordcloud outcome of the 50 meaningful groups of words from the publications' titles (left), and publications' abstracts (right)

**Uses of plants belonging to genera *Ritchiea*, *Maerua*, and *Crateva***

The genus *Maerua* encompasses approximately 60 species found on the African continent (Abreu *et al.* 2014), while the genus *Ritchiea* comprises around 30 to 40 different species, mainly distributed across tropical and subtropical Africa. Similarly, the genus *Crateva* includes about 15 species of trees or shrubs distributed in tropical and subtropical regions of Asia, Africa, and Australia. Species belonging to these genera possess potent medicinal potential proved by the amount of research on these species' medicinal uses including traditional and modern. In addition, they are also used for water purification, pest control, and food.

***Traditional and modern medicinal uses***

Traditional medical practices reveal a diversified use of different species of *Maerua*. Ethnobotany has highlighted the multifunctional use of *Maerua triphylla* A. Rich among the Maasai and Kikuyu communities in Kenya, where the fruit, leaf, root, trunk bark, and even twig decoction are employed as aphrodisiacs, antidotes against poisoning, treatment for rheumatism, boils, cancer, respiratory problems, snakebites, headaches, and gastrointestinal disorders (Wangusi *et al.* 2021; Maroyi 2020c). Similarly, *Maerua oblongifolia* (Forssk.) A.Rich has been recognized as an aphrodisiac (Koteswara and Seetharami 2018), while the stem bark of *Maerua angolensis* DC. is traditionally used for managing epilepsy (Benneh et al., 2018). Sudanese ethnobotanical data indicate that *Maerua pseudopetalosa* (Glig & Glig-Ben.) DeWolf is used in combination to treat various conditions such as bites from venomous animals, urinary disorders, blood, and gynecological disorders (Issa *et al.* 2018; Maroyi 2020b). Additionally, *Maerua siamensis* (Kurz) Pax is employed in traditional Thai medicine to alleviate pain and inflammation (Nukulkit *et al.* 2022), while *Maerua crassifolia* Forssk is widely used in the Sahel to treat various ailments such as headaches, fever, and skin infections (Maroyi 2020a). In East Africa, the tuber of *M. subcordata* (Gilg.) DeWolf is used by the Kunama people to treat malaria, seasonal coughs, and various ailments, while its leaves are used for wound healing, pain and infection relief, diabetes treatment, and even as a laxative (Hiben *et al.* 2019). Furthermore, *Crateva religiosa* G. Forst. is employed in traditional veterinary medicine in Benin to combat bacterial infections in *Thryonomys swinderianus* (Temmick, 1827).

Laboratory research on *Maerua triphylla* A. Rich. root extracts, traditionally used in Kenya, has revealed the presence of phytochemical compounds such as cardiac glycosides, flavonoids, alkaloids, and phenols, imparting analgesic and anti-inflammatory properties to *M. triphylla*, suggesting its usefulness in pain and inflammation relief (Wangusi *et al.* 2021). Extracts of *Maerua subcordata* (Gilg) DeWolf have shown potential in modulating inflammatory processes (Hiben *et al.* 2020; Gebrelibanos *et al.* 2019). While *Maerua angolensis* extract has been tested for its anticonvulsant potential, proving its efficacy through the ether/petroleum ether fraction, as well as exhibiting antidiabetic activity with a low risk of hypoglycemia and body weight loss (Benneh *et al.* 2017; Benneh *et al.* 2018; Adigwe *et al.* 2024). Additionally, root extracts of *Maerua oblongifolia* have also demonstrated anticonvulsant properties in laboratory (Sundara and Saravanan *et al.* 2016), while root extracts of *Maerua decumbens* (Brongn.) DeWolf showed significant antihyperglycemic effects in diabetic rats (Kiptisia *et al.* 2020). Furthermore, leaf extracts of *Maerua juncea, Maerua apetala* (Spreng.) M. Jacobs, and *Maerua schinzii* Pax exhibited antibacterial, antifungal, anti-HIV, and cytotoxic activities (Maroyi 2020e). In the same vein, ethanol extracts of *Crateva adansonii* DC and *Maerua siamensis* showed anti-inflammatory and anti-malarial properties (Theanphong and Somwong, 2022). However, *Maerua arenaria* (DC.) Hook. F. &Thomson has been identified as an allergen in patients with asthma, allergic rhinitis, and eczema (Mehta *et al.* 2018), while *M. edulis* could be a potential source of lead compounds with anticancer and antidiabetic activities (Sithole and Mukanganyama 2017; Amoo *et al.* 2022). Moreover, *Maerua nuda* Scott Elliot is a plant appreciated by bats (Génin and Rambeloarivony 2018), and *Maerua crassifolia* is recommended for grazing to increase vitamin A content in cow's milk and is also appreciated by bees for honey production (Jacks *et al.* 1999; Sajwani *et al.* 2007). Leaf and bark extracts of *Crateva nurvala* and *Crateva tapia* have demonstrated a protective effect against renal ischemia/reperfusion, whereas *Crateva unilocularis* Buch.-Hah., in combination with other species, showed potential antioxidant and anti-obesity activity (Choucry *et al.* 2018; Poudel *et al.* 2011). Moreover, *Crateva magna* (Lour.) DC. extract has shown antidiabetic activities and potent cobra venom neutralizing ability (Das *et al.* 2010; Kumarapppan *et al.* 2011). Also, *Crateva adansonii* is involved in the treatment of COVID-19 according to some studies (Houeze *et al.* 2023).

Within *Ritchiea* genus, leaves and bark of *Ritchiea capparoides* have been identified as having anticancer properties (Olaleye *et al.* 2024). Extracts of its leaves, stem bark, and roots have demonstrated *in vitro* antifungal activity against several strains of fungi (Ajaiyeoba *et al.* 1998). The methanolic extract of its roots has also been evaluated for *in vitro* anthelmintic activity against tapeworms, earthworms, and nematodes, showing more pronounced activity against tapeworms and less effect on nematodes, although the activity was inferior to that of the reference compound piperazine citrate (Ajaiyeoba and Okogun 1996). Additionally, a study isolated and identified the leavo-isomer of stachydrine in the leaves of *Ritchiea capparoides* demonstrating its antimicrobial activity against *Escherichia coli* and *Staphylococcus aureus*, as well as its antiplasmodial activity against malaria, thereby supporting the traditional uses of the leaves of this plant in ethnomedicine (Taiwo *et al.* 2013).

***Water Purification***

Research has demonstrated that tubers of *Maerua subcordata*, in combination with seeds of *Moringa stenopetala* (Baker f.) Cufod., used as plant-based coagulants, successfully eliminated 99.9% of turbidity and microbial load from Ethiopian surface waters, rivaling chlorine treatments (Megersa *et al.* 2016; Megersa *et al.* 2017; Megersa *et al.* 2019). Similarly, in 2023, other studies revealed that *Maerua subcordata* root powder was effective up to 68% in removing fluoride ions from well water, thereby contributing to reducing the prevalence of dental fluorosis and bone mineralization deficiency in Kenya. Local communities living in rural regions of Kenya also utilize *Maerua decumbens* roots for water purification. This capability was tested and approved in a study optimizing wastewater treatment from the paint industry using the bio-coagulant from *Maerua decumbens*, which demonstrated high removal of various pollutants under specific conditions (Maghanga *et al.* 2024).

***Pest Control***

The bushman's cabbage, also known as *Maerua edulis*, exhibits significant insecticidal activity against the cowpea weevil *Callosobruchus maculatus* (Fabricius, 1775), suggesting its potential as an ecological alternative to synthetic pesticides. Extracts of *M. edulis* have also been observed to inhibit beetle egg-laying activity, thus enhancing their utility in combating crop pests. It has therefore been used in Zimbabwe to control ticks in cattle (Nyahangare *et al.* 2017). Additionally, powders of stems, leaves, and bulbs of *Maerua angolensis* have shown nematicidal activity against *Meloidogyne incognita* (Kofoid & White, 1919), a nematode affecting greenhouse tomato roots, sometimes rivaling with a standard chemical nematicide (Khosa *et al.* 2019). In Pakistan, *Maerua arenaria* is used to control the invasion of termites. Compounds extracted from leaves and branches of *Maerua siamensis* have demonstrated strong larvicidal efficacy against *Aedes aegypti* larvae, the vector of yellow fever, suggesting their potential as alternative larvicidal agents to chemical insecticides. The study on the sensitivity of *Meloidogyne incognita* to extracts of *Maerua angolensis* and *Tabernaemontana elegans* Stapf, revealed inhibition of *M. incognita* juvenile hatching (Khosa *et al.* 2020). Furthermore, maximum mortality of domestic mosquito larvae (*Culex quinquefasciatus*) was observed with *Maerua arenaria* extracts. Finally, extracts of *Crateva magna* have been identified as effective against pathogens associated with cabbage leaf spot disease, *Alternaria brassicicola* (Schwein.) Wiltshire (Jantasorn *et al.* 2017).

***Alimentary Use***

*Maerua edulis* and *M. pseudopetalosa* are collected from the wild for their edible fruits (Maroyi 2020d). As food, these fruits are consumed both in times of food scarcity and abundance, while the tuber is used as food in times of famine (Hiben *et al.* 2019). Similarly, *Maerua angolensis* can be used in the dry season as a supplement to enhance animal nutrition in arid and semi-arid areas (Kemboi *et al.* 2021). Additionally, *Maerua crassifolia* is highly recommended for grazing purposes to increase the vitamin A content and thus, the value of cow milk (Jacks *et al.* 1999). This species is also highly favored by bees for honey production (Sajwani *et al.* 2007).

***Conservation and Domestication of Species from the Genera Ritchiea, Maerua, and Crateva***

On the basis of assessments conducted by IUCN (https://www.iucnredlist.org), data on the studied genera exits for about 50 species including 7 Endangered (*Ritchiea quarrei*, *Maerua boranensis*, *Maerua acuminata*, *Maerua robynsii*, *Maerua schliebenii*, *Maerua homblei*, and *Maerua descampsii*), 3 Vulnerable (*Ritchiea macrantha*, *Maerua calantha*, and *Maerua mungaii*), 1 Near Threatened (*Maerua kaessneri*), and 1 Critically Endangered (*Ritchiea afzelii*). About 24% of the reported species belonging to these genera are listed on the IUCN red list as species of conservation concern. However, though not on the IUCN red list, in Saudi Arabia, a study analyzing the vegetation of Wadi Al-Jufair reveals that it harbors *Maerua crassifolia*, a regionally endangered tree (Alatar *et al.* 2012). Between 2020 and 2021, vegetation surveys conducted in the southern region of Saudi Arabia led to the discovery of five new plant taxa, including another species of the genus *Maerua*, namely *Maerua angolensis DC. subsp. angolensis* (Capparaceae) (Al-Khulaidi *et al.* 2023). Subsequently, an effective in vitro micropropagation protocol for *Maerua crassifolia*, a threatened tree species, was developed in Saudi Arabia. The best results were achieved with MS medium containing 7.5 µM 6-benzylaminopurine (BAP) and 1.0 µM 1-naphthaleneacetic acid (NAA) for shoot formation, and MS medium with 1.0 µM indole-3-butyric acid (IBA) for root formation. Ninety percent of rooted plantlets were successfully acclimatized, demonstrating a cost-effective and efficient protocol for propagating *M. crassifolia* (Alatar *et al.* 2023). The application of silver nanoparticles (AgNPs) from *Ochradenus arabicus* Chaudhary, Hillc. & A.G.Mill. leaves at specific concentrations enhances shoot regeneration, growth, and physiological properties of in vitro-cultured *Maerua oblongifolia* (Shaikhaldein *et al.* 2020).

## Discussion

The species belonging to the genera *Ritchiea*, *Maerua*, and *Crateva* began to truly appear in literature in the late 1940s. Temporal analysis of scientific productions on the genera *Ritchiea*, Maerua, and *Crateva* shows that between 1941 and 1991, scientific publications were rare. However, the early publications on the genera to which *R. capparoides* belong, commenced with the description and functioning of plant species' cells followed by studies on the identification, extraction, and characterization of some key chemical compounds from *Crateva nurvala* and *Ritchiea longipedicillata* roots extracts in addition to experiment on the effect of extracts on lab rats having certain conditions. This shows that the medicinal potential of the studied species was well-known before the first research on them. It would have been expected that initial studies on species belonging to the studied genera would have been more on the ethnobotanical field before evolving toward the extraction of active compounds existing in these plants' organs and their testing to heal some conditions. In the 20th century, phytotherapy was not universally recognized as scientific knowledge. For instance, in Germany, phytotherapy was legally recognized on January 1, 1978, as scientific knowledge (Clément 2005). Between 1992 and 2019, there was a progressive increase in the number of publications, due to the discovery of phytochemistry and the isolation of active principles. Thus, scientists began to take a greater interest in medicinal plants. Species of the genera *Ritchiea*, *Maerua*, and *Crateva* were mainly used in traditional medicine (Benneh *et al.* 2018), water purification (Megersa *et al.* 2016), ethnoveterinary (Ajaiyeoba and Okogun 1998) by populations. In 2002, the World Health Organization (WHO) confirmed its commitment to traditional medicines and the need to improve accessibility for the poorest segments of the population (Dejouhanet 2009). Therefore, these species involved in traditional medicine were more studied to understand more and better their functioning and chemical composition. There has been an exponential increase of publications in 2020 followed by a slow decrease to 2024. The medicinal value of species from the studied genera exposed some of them to extinction threats, which could justify the recent increase in scientific interest to explore possibilities for sustainable management, domestication, conservation, and reproduction of these species. For example, *Maerua crassifolia* is an endangered species in Saudi Arabia (Alatar *et al.* 2012), and precautions have begun to be taken for the reproduction of these species in response to this threat (Shaikhaldein *et al.* 2020; Alatar *et al.* 2023). The global geographic distribution of countries that have published on the genera *Ritchiea*, *Maerua*, and *Crateva* revealed that only India has produced more documents on these genera. This could be explained by the fact that India is one of the natural habitats of two of the genera, *Crateva* and *Maerua* (Figure 7). India is among the countries rich in traditional medicinal practices that are recognized worldwide, such as Unani and Siddha traditional medicines, yoga, and naturopathy (Abraham *et al.* 2005). It is also noted that the majority of *Maerua* species are used in Indian medicine (Joshi *et al.* 2022). However, in terms of continental output, with few exceptions, Asia, particularly its southern region where India is located, ranks behind Africa. Africa took the lead, with the western, eastern, and southern regions being the most productive. This can be attributed to the fact that the three studied genera (*Ritchiea*, *Maerua*, and *Crateva*) are naturally distributed in Africa and are almost absent in the northern region, whereas Asia harbors only two genera (*Maerua* and *Crateva*). The *Journal of Ethnopharmacology* is a well-known scientific journal in the field of ethnopharmacology, which publishes research on the traditional uses of medicinal plants by different cultures (Polat *et al.* 2013). Since the studied genera are essentially composed of medicinal plants, it was normal that the highest number of publications was in this journal. Collaboration networks revealed that Ethiopia has the strongest collaboration links with two specific countries, Belgium and the Netherlands, despite having a considerable number of collaborations with other countries. It should be noted that Ethiopia is a developing country, with government initiatives to stimulate economic development and attract investments, such as research funding. The interest in medicinal plants persisted in Belgium, whether in the context of alternative medicine, pharmaceutical research, or the consumption of natural products, as it has a strong collaboration with South Africa. Both countries, being African, constitute a natural habitat for the studied genera. The word cloud generated from the titles and abstracts of publications to identify the meaningful group of words revealed that most of the research conducted on the studied genera focused on the medicinal potential of species belonging to *Ritchiea, Maeru*a, and *Crateva*. This is certainly because the studied species of the genera *Ritchiea, Maerua*, and *Crateva* are primarily composed of medicinal plants (Olaleye *et al.* 2024; Choucry *et al.* 2018; Maroyi 2020c). To explore the medicinal potential of these species, aqueous and/or ethanolic extracts of their organs such as leaves, roots, and stem bark were produced and even tested in vitro and/or in vivo against several ailments identified during ethnobotanical studies. Yet, very little research has been conducted on *Ritchiea capparoides* and its synonyms, which is certainly due to its distribution limited to Africa only (Figure 7) and its level of recognition at the continental level.

Until now, no research question has yet addressed the origin of *R. capparoides* while it is essential to resolve the uncertainty about the origin and distribution of the genus *Ritchiea* through phylogenetic studies. This will make it possible to determine the bottlenecks causing the isolation of certain populations of the species. Studies of the importance of *R. capparoides* according to distribution areas and socio-cultural groups will make it possible to determine the impact of the collection and exploitation of organs on the viability of the species. Currently, existing work on these questions is quite general (Adjanohoun *et al.* 1989) and not specific to the species. Research questions relating to the effect of climate and habitat on the morphological characteristics of the species across its distribution areas are almost non-existent in Africa and outside. Yet, these questions are essential in determining and identifying the ecology-suitable areas for the growth and development of the species. Furthermore, this constitutes an important point for the development of a good conservation and sustainable management strategy. Germination of *R. capparoides'* seeds has not yet been the subject of study. The evaluation of ecophenotypic variations and germination ability of the species' seeds are necessary for good conservation programs. Concerning the chemical and antimicrobial properties of *R. capparoides*, existing works come essentially from Nigeria whereas it is important to extend to the other species distribution areas to identify the impact of climate on the effectiveness of these properties. In addition, this work linked to phylogenetic studies will make it possible to identify the gene pools of the species with the best chemical and antimicrobial properties for a good valorization program.

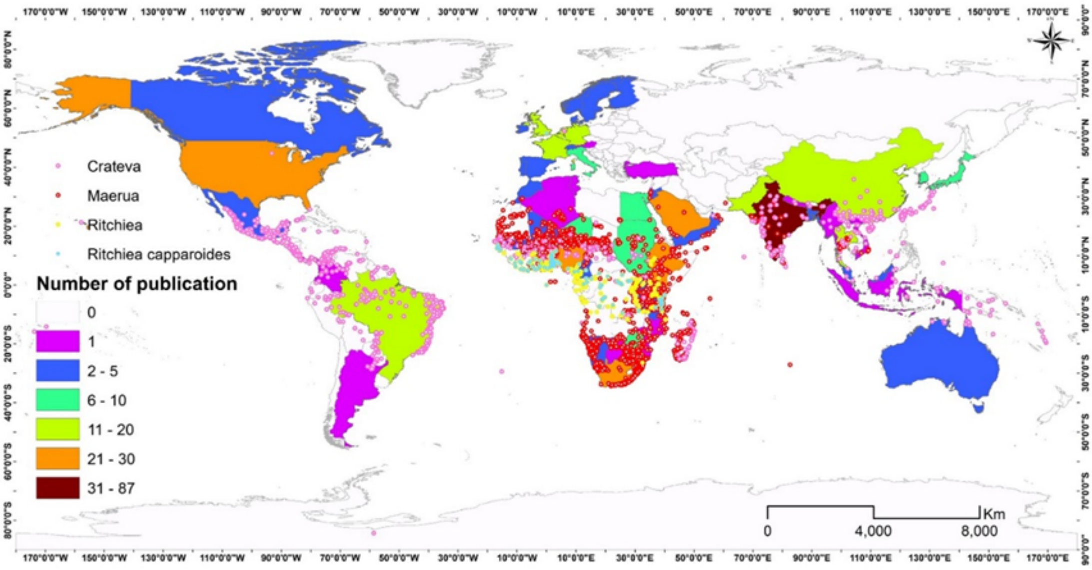


Figure 7. Global geographical distribution of publications on *Ritchiea*, *Maerua*, and *Crateva* based on authors' countries overlaid with the distribution of occurrences points from GBIF of the studied genera and *R. capparoides*

## Conclusion

The bibliometric analysis conducted on *Ritchiea capparoides* Britten and the genera to which its synonyms belong has revealed that, scientific productions dated back to 1941 with a marginal evolution over the first fifty years. The highest number of publications occurred after 2020. However, starting from 1941 to the first quarter of 2024, the total number of publications is estimated at 410 including 391 articles representing 95.37% mainly published in English and cited 8,316 times with an average of 21 citations per publication and about one citation per publication every 5 years. The most productive source list has on top the *Journal of Ethnopharmacology*. The *Journal of Medicinal Plants Research* had the highest impact in terms of the number of citations per publication even though absent from the most productive journals. In terms of collaboration, 1,381 authors were involved in the 363 collaborative published publications regardless of the number of publications done together. Although 6.6% of publications were done without collaboration between neither authors, institutions, and countries, only 29.4% were done by authors from at least two different countries with the biggest and strongest networks having at their centers Ethiopia, India, and South Africa. Species belonging to the studied genera have potent medicinal potential proved by multiple publications addressing their medicinal uses in addition to their usage in water purification, pest control, and food. However, regarding the available knowledge on these genera and especially on *R. capparoides*, several research questions regarding the origin of the species through phylogenetic studies, the effect of climate change on its distribution, as well as the species domestication through the mastering of its germination growth and development are essential and need to be investigated to enhance and expand the existing knowledge.

## Declarations

**List of abbreviations:** R.: *Ritchiea* ; WoS: Web of Science ; R4L: Research4Life, MS Excel: Microsoft Excel ; ArcMap: ArcMap GIS Software ; Ghephi: Gephi Network Analysis Software ; FAO: Food and Agriculture Organization ; WHO: World Health Organization ; UN: United Nations ; AGORA: Access to Global Online Research in Agriculture ; OARE: Online Access to

Research in the Environment ; ARDI: Access to Research for Development and Innovation ; GOALI: Global Online Access to Legal Information ; BAP: Benzylaminopurine ; NAA: Naphthaleneacetic Acid ; IBA: Indole-3-Butyric Acid ; AgNPs: Silver Nanoparticles

**Ethics approval:** Ethics statement was not needed for the review.

**Consent for publication:** Authors agreed the content and publication**.**

**Funding:** Non-funded review**.**

**Conflict of Interest:** Authors declare no conflict of interest.

**Availability of data and materials:** The data included in this review are collected from the literature available online and are available for any requests.

**Author's Contributions:** ABSA: Methodology, Data curation, Formal analysis, Writing – original draft. SIAY: Conceptualization, Methodology, Data curation, Formal analysis, Software, Visualization, Writing – original draft, Writing – review & editing. GHFG: Conceptualization, Resources, Data curation, Supervision, Writing – review & editing. EECD: Data curation, Formal analysis, Writing – original draft. CAA: Writing – review & editing. ABF: Conceptualization, Writing – review & editing.

## Acknowledgements

The authors express their sincere gratitude to the reviewers for their invaluable insights and thorough evaluations of this manuscript.

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