INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 25, No. 6, p. 31-50, 2024

RESEARCH PAPER OPEN ACCESS

Scientific Contributions and Gaps in *Hura crepitans* L. Research: A Comprehensive Bibliometric Analysis of Publications From 1909 to 2024

Sedami Igor Armand Yevide[1], Sidoine Kolaolé Yebadokpo[1], Gbodja Houéhanou François Gbesso[*2]

[1]*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*

[2]*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*

Key words: Bibliometric analysis, *Hura crepitans*, International collaboration, Knowledge gaps, Benin

http://dx.doi.org/10.12692/ijb/25.6.31-50 Article published on December 04, 2024

Abstract

Hura crepitans, is a species endemic to tropical parts of North and South America, including the Amazon rainforest. It is well-known for its unusual traits, which have important ecological and ethnobotanical applications. Bibliometric analysis was performed using data from Web of Science, Scopus, Research4Life, PubMed, and Google Scholar in May 2024 with "Hura crepitans", "Hura brasiliensis", "Hura senegalensis", and "Hura strepens" as keywords. A total of 453 publications were collected, and after eliminating duplicates and irrelevant publications, 194 scientific production all articles were used for the analysis. The temporal evolution of publications and their total citations over time was computed, and content analyses were performed using Microsoft Excel 2019 and Bibliometrix with Biblioshiny. ArcGIS version 10.4 was used to produce the spatial distribution map and access the spatial pattern of publications. Social network analysis was conducted to understand research networks and clusters using Gephi version 0.9. The results showed a relatively low publication trend during the early decades, with sporadic publications appearing every few years. A significant increase in publications has occurred since 2000. English productions account for 88.14%, with 3,870 citations, averaging 22.63 citations per publication. Forest Ecology and Management emerged as the most productive source, followed by the Journal of Ethnopharmacology. Knowledge gap analysis revealed the need for research to investigate *Hura crepitans* toxicity, secure production methods, and ecological connections outside its native location like other African nations in which it has been introduced for deeply mastering the species' multiple advantages in medicine, industry, agriculture, and other fields.

* **Corresponding Author:** Gbodja Houéhanou François Gbesso ✉ fr.gbesso@gmail.com

Introduction

Understanding ecological dynamics, biodiversity protection, and possible applications in various industries, including agriculture, medicine, and environmental management, requires a knowledge of plant species. Therefore, plant species from earth's natural ecosystems are suitable candidates for scientists to be particularly interested in. Among them, *Hura crepitans,* commonly known as sandbox tree, possumwood, monkey no-climb in English, and Portuguese as assacu, (Tupi: asaku), and jabillo is a remarkable evergreen tree from the Euphorbiaceae family (Esonu *et al*., 2014; Issac *et al*., 2023). It is endemic to tropical parts of North and South America, including the Amazon rainforest (Sidohounde *et al*., 2019). *Hura crepitans* is well-known for its unusual traits, which have important ecological and ethnobotanical applications. It has several synonyms, including *Hura brasiliensis*, *Hura senegalensis*, *Hura strepens*, and different varieties of *Hura crepitans*. In the wild, it can reach 40 m in height with a stem and main branches densely spiny. The bark is generally grey with black, conical spines (Ajani *et al*., 2019). Its stipules are lanceolate or ovate-lanceolate 10 to 15 mm long and 2 to 3 mm thick. The leaf has a broadly ovate blade of 5 to 29 cm in length and 5 to 17 cm in width attached to a 4 to 20 cm long petiole. The leaf blade is papery, abaxially pilose along the midrib, and elevated on both surfaces, with 10 to 16 lateral veins on each side (Owojuyigbe *et al*., 2020). It has a cordate base and caudate-acuminate apex. The margins are more or less shallowly dentate-serrate. The male flowers are ovoid-conical inflorescence, mostly dark red. The female flower is often solitary, with a cup-shaped calyx terminating in a thick apical disc of 1 cm in diameter and 5 to 20 radiating lobes of 5 to 10 mm. The fruiting pedicel is pendent to 6 cm, holding an oblate fruit of 3 to 5 × 8 to 9 cm in diameter, concave at its apex and base, and longitudinally grooved, becoming reddish brown. It contains brownish and smooth seeds 5 to 8 mm thick and 15 to 20 mm in diameter. Perhaps the most unusual feature is the fruit capsule, which, when ripe, explodes with a rattling sound, distributing its seeds thus the name crepitans, which means "rattling" (Esonu *et al*., 2014). This extraordinary plant has enormous application potential, necessitating additional research into its chemical composition, ecological roles, and possible uses in medicine, agriculture, and biofuel production (Issac *et al*., 2023). *Hura crepitans* have unique phytochemical properties that scientists are fascinated by because of their prospective applications in industry and health. Several studies have highlighted its potential for phytochemical screening, nutraceutical potential, and anti-inflammatory effects (Avoseh *et al*., 2018; Ajani *et al*., 2019). Despite the increased amount of research, there are still many uncertainties concerning this species, particularly its many applications and ecological services in Africa (Owojuyigbe *et al*., 2020; Issac *et al*., 2023). Furthermore, little is known about this species in Benin. The only notable studies undertaken in Benin have focused on converting seed oil into biodiesel (Sidohounde *et al*., 2019).

Bibliometric or bibliometric analysis is a quantitative analysis method that uses mathematical and statistical tools to measure the interrelationships and impacts of publications within a given area of research or on a given subject. It provides a global overview of many academic studies. It is also used to efficiently identify influential studies, authors, journals, organizations, and countries over time and established and emerging research areas (van Eck and Waltman, 2010). Bibliometric analysis has been applied in various disciplines to scale up research performance and assess trends in scientific publications, including authorship, thematic areas, geographical origins, and citation counts (Pritchard, 1969). This approach has also been used to analyze scientific production's spatial and temporal distribution on a group of species or a single species from both the animal and plant kingdoms (Bertin *et al*., 2018; Duan *et al*., 2020; Saggiomo *et al*., 2020). This approach has also been useful in conducting meta-analyses and systematic reviews, particularly for human health and environmental conservation

(Abrahamse and Steg, 2013). Bibliometric analysis is a powerful approach to uncovering and summarizing the existing knowledge on a particular topic and shedding light on the existing gaps for further research endeavors. Although bibliometric analysis has been applied to various species, to our knowledge, it has not yet been applied to *Hura crepitans* to bridge knowledge gaps and expand our understanding of the species' potential, the research areas, and the research aspects worth investigating. Understanding the current level of research on this species is critical for improving our knowledge on this subject and ensuring that future studies are informed and strategically focused (Ajani *et al.*, 2019; Owojuyigbe *et al.*, 2020). In the current work, bibliometric analysis was used to access the spatial and temporal distribution of knowledge on *Hura creptitans* to provide light on the species' research environment by identifying prior scientific endeavors as well as the major gaps that remain to be filled. This study aims to answer the following questions: i) What are the spatial and temporal distributions of knowledge on *Hura crepitans*? ii) How was collaborative research conducted on *Hura crepitans*? iii) What and who are the leading actors in the investigations of *Hura crepitans*? iv) What are the most and least covered aspects of research on *Hura crepitans* worldwide?

Materials and methods

Data collection

Bibliometric analysis mainly uses various platforms or repositories that provide access to scientific productions and/or citation indices. Web of Science and Scopus are the key scientific production databases retrieved from and used to conduct bibliometric analyses. Contrary to these well-known and widely used databases, some others, including Research4Life, PubMed, and Google Scholar, are less used due to various reasons extending from lack of knowledge about their existence to the questionable quality of the scientific productions available on them. 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 also allows access to Web of Science and Scopus databases via its platform. PubMed is a free resource for searching and retrieving biomedical and life sciences literature. It was developed and maintained by the National Center for Biotechnology Information (NCBI) at the U.S.

National Library of Medicine (NLM), located at the National Institutes of Health (NIH). PubMed database contains more than 36 million citations and abstracts. Google Scholar is a free access web search engine that provides an easy and simple way to broadly search for scholarly literature from many disciplines and sources. By using a web crawler, Google Scholar can find about 100 million scholarly documents written in English on the Web. However, it has been criticized for including predatory journals.

To carry out the current bibliometric analysis and to ensure consideration of almost the comprehensive scientific productions available on *Hura crepitans*, scientific productions were gathered from Scopus, Web of Science, Research4life, PubMed, and Google Scholar in May 2024 using the following keywords "*Hura crepitans*", "*Hura brasiliensis*", "*Hura senegalensis*", and "*Hura strepens*". Given the structure of the various platforms, the keywords were searched in the publication title, keywords, and abstract on Web of Science, Scopus and Research4life. On PubMed, the same keywords were searched in publications' titles and abstracts, while on Google Scholar, they were searched in publications' titles only and by checking the box exclude citations.

Data cleaning and merging

The search performed yielded 159 records from Scopus, 125 from Web of Science, 30 from PubMed, and 115 from Research4Life, leading to 431 documents that were supplemented by 22 additional documents from Google Scholar, totaling 453 documents of various types. These scientific productions collected from these various platforms were scrutinized separately to remove duplicated entries, theses, and reports within the database when they exist. Given the questionable quality of some scientific productions from Google Scholar, all the scientific productions in published predatory journals were removed after checking the journal's name on beallslist.net. After this first removal of duplicates and elimination of scientific productions published in predatory journals, the data from the selected platforms were merged and a second removal of duplicates between platforms was conducted. The data from Web of Science and Scopus were prioritized during this process.

This means that when an entry exists in Web of Science and Scopus, the one from Web of Science is kept while the one from Scopus is removed while keeping its citations count information from Scopus. Similarly, when a duplicated entry exists in Scopus, the one from Scopus is kept, and others are removed. The prioritization of the platform continues from Research4Life to PubMed and Google Scholar. Since information on scientific production from Research4Life, PubMed, and Google Scholar lacks some information that is present in data from Web of Science and Scopus, such publications were individually downloaded and used to complement their missing information in the merged database. Since citation counts are provided by both Scopus and Web of Science, the maximum value of citations from the two platforms was used. 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). Over the 453 documents obtained, 259 documents were removed, and the remaining 194 publications, all articles, were considered for further analysis.

Data analysis

The temporal evolution of publications and their total citations over time was computed, and Microsoft Office Excel 2019 was used to produce the graph and table. The maximum value from the two databases from which publications were retrieved was used for the total citation.

Based on the authors' affiliation, the authors' country information was extracted and used to determine the contribution of countries worldwide in publications on the searched species. 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 performed using Microsoft Excel 2019 and Bibliometrix (Version 4.1.4) with Biblioshiny, which is an open-source application based on R used for extensive analysis and mapping of scientific literature. The choice of the Bibliometrix package with built-in Biblioshiny for material is related to its extensibility in the RStudio programming language. Furthermore, the open-source nature provides frequent updates and constant support from a community of users and developers, keeping these tools relevant and viable over time (Aria and Cuccurullo, 2017). Additionally, its availability is free compared with other programs that may be pricey or require memberships to access comparable capacity (Güler, 2023). The extensive documentation and learning resources available for these tools facilitate their adoption and effective use, providing researchers with a solid basis for conducting meaningful and accurate bibliometric analyses and enabling information mapping using simple and complex illustrations (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 the 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).

Results

Publication types, citation patterns, and language distribution

The publication trend for *Hura crepitans* shows that the number of publications was relatively low during the early decades (1909-1999), with sporadic publications appearing every few years (Fig. 1). From 2000 to 2012, there was a noticeable increase in research activity, with the number of publications rising consistently and peaking at various points, particularly in the late 2000s and early 2010s. From 2013 onward, there has been a significant and sustained increase in the number of publications, indicating a growing interest and continued research focus on *Hura crepitans* in recent years.

Table 1. Publication language and their impacts.

Languages	Number of publications	Percentage (%)	Total citation	Total citations per publication	Total citations per publication per year
English	171	88.14	3870	22.63	1.51
French	7	3.61	8	1.14	0.03
German	3	1.55	6	2.00	0.06
Portuguese	5	2.58	22	4.40	0.48
Spanish	8	4.12	28	3.50	0.38
Total	194	100	3934	20.28	1.36

The first publication on *Hura crepitans* focuses on isolating a substance known as a haemagglutinating constituent, crepitine (Richet, 1909). This substance is profoundly studied through experiences made by Jaffe and Seidl from 1943 to 1969, who isolated and characterized the substance named Hurain extract from the sap of *Hura crepitans*.

The citation trend for research on *Hura crepitans* shows fluctuations over the years, with notable peaks at certain periods (Fig. 1). Early citations (before 1975) were sporadic and low, reflecting the limited number of publications during that time and also the weak impact of research on the topic. From 1975 onwards, visible peaks in citations indicate periods of increased academic interest and impact. The most significant rise in citations appears around the late 1990s to early 2000s, coinciding with the increased number of publications. There was a notable citation dip after this peak, but a subsequent rise occurred from 2010 onward, reflecting a renewed and growing interest in *Hura crepitans*.

In the analysis of 194 publications on *Hura crepitans*, English emerged as the most productive language, constituting 88.14% of the total publications (Table 1). These English-language publications received a substantial number of citations, totaling 3,870, with an average of 22.63 citations per publication and an annual citation rate of 1.51. The second most used language was Spanish, which, unlike English, has an average impact close to Portuguese, though this latter recorded fewer publications. In contrast, while French was among the top three most used languages, comprising 3.61% of the total publications, it had the lowest impact in terms of citations.

Table 2. Source of publication on *Hura crepitans*.

Sources	Number of publications	Percentage (%)	Citations	TC/P	Average TC/P/Y	Impact factor 2023
forest ecology and management	10	5.15	484	48.40	2.52	3.7
journal of ethnopharmacology	8	4.12	393	49.13	4.12	5.4
acta amazonica	5	2.58	19	3.80	0.42	0.8
electronic journal of environmental, agricultural and food chemistry	3	1.55	48	16.00	1.08	6.1
renewable energy	3	1.55	69	23.00	4.35	8.7
revista arvore	3	1.55	2	0.67	0.05	0.5
biochemical journal	2	1.03	326	163.00	3.98	4.1
Biotropica	2	1.03	124	62.00	2.55	2.1
comptes rendus hebdomadaires des seances de l'academie des sciences serie d	2	1.03	1	0.50	0.01	
foods and raw materials	2	1.03	2	1.00	0.20	2.0
international journal of ambient energy	2	1.03	7	3.50	0.44	3.63
journal of food agriculture & environment	2	1.03	5	2.50	0.16	
leather and footwear journal	2	1.03	4	2.00	0.40	0.21
petroleum and coal	2	1.03	4	2.00	0.29	5.6
revista cubana de plantas medicinales	2	1.03	3	1.50	0.09	
trees-structure and function	2	1.03	70	35.00	2.19	2.3
freshwater biology	1	0.52	263	263.00	11.43	2.7
cancer surveys	1	0.52	177	177.00	4.21	5.2
ecohydrology	1	0.52	152	152.00	16.89	2.6
canadian journal of forest research	1	0.52	139	139.00	6.62	2.2
antiviral research	1	0.52	136	136.00	6.48	7.6
landscape and urban planning	1	0.52	130	130.00	9.29	9.1
biomass conversion and biorefinery	1	0.52	6	6.00	6.00	4
veterinary parasitology	1	0.52	69	69.00	5.75	2.6
agricultural and forest meteorology	1	0.52	71	71.00	5.07	6.2
food and chemical toxicology	1	0.52	29	29.00	4.83	4.3
evidence-based complementary and alternative medicine	1	0.52	24	24.00	4.80	2.0
pharmaceutics	1	0.52	19	19.00	4.75	5.4
journal of the north american benthological society	1	0.52	82	82.00	4.56	2.35
biodiversity and conservation	1	0.52	72	72.00	4.24	3.4
bioenergy research	1	0.52	20	20.00	3.33	3.6
febs letters	1	0.52	93	93.00	3.32	3.5
environmental research	1	0.52	53	53.00	3.31	8.3
hydrobiologia	1	0.52	3	3.00	3.00	2.6

Most Active and Influential Sources

Among all the source publishing research on *Hura crepitans, Forest Ecology, and Management* was the most active, with 10 publications (5.15% of the total) and 484 citations, averaging 48.40 citations per publication and a yearly average of 2.52 (Table 2). The *Journal of Ethnopharmacology* followed closely with 8 articles (4.12%) and 393 citations, averaging 49.13 citations per publication and a remarkable yearly rate of 4.12. In addition to important sources are *Acta Amazonica*, with 5 publications and 19 citations (3.80 citations per publication, 0.42 per year), and the *Electronic Journal of Environmental, Agricultural and Food Chemistry*, which had 3 publications and 48 citations, averaging 16 citations per publication and 1.08 yearly. *Renewable Energy* also lit up through 3 publications and 69 citations (23 citations per publication, 4.35 per year). Several journals, despite offering few papers, have significant citation impacts. For instance, the *Biochemical Journal* has two articles that had a total of 326 citations, an average of a remarkable 163 citations per publication, and 3.98 annually. Similarly, *Biotropica* has two articles with 124 citations, an average of 62 citations per publication and 2.55 yearly. *Freshwater Biology* and *Cancer Surveys* each had one publication but had significant citation counts of 263 and 177, respectively, showing their main impact in the area. The collective impact of these publications is substantial, with 3934 citations. Each publication receives approximately 20.28 citations, indicating active scholarly engagement. The average annual citation rate per publication is 1.36.

Authors and their countries

The spatial distribution of knowledge using the total number of publications per country on *Hura crepitans* indicates 36 countries that contributed. Among them, only 8 were from Africa (Fig. 2). Based on the global geographical distribution, the research on this species is significantly concentrated in certain countries like Nigeria, which records a high number of publications between 25 and 91, followed by Brazil (17-24) and the United States (10 -16). The countries which have recorded the lowest (01) number of publications are Benin, Niger, Ethiopia and India.

The contribution of continents, regions, and countries in publications *on Hura crepitans* depicted that Western Africa, particularly Nigeria, dominates the diagram, indicating that this region contributes most significantly to research on *Hura crepitans* (Fig. 3). Following this, South America, with countries like Brazil, Peru, Venezuela, and Colombia, forms the second category of major contributors to research on *Hura crepitans*. Conversely, South Asia, specifically India, is shown as the region contributing the least.

To analyze the collaboration between authors, only 178 publications, representing 91.75%, were considered, and the remaining 8.25% were single authors' publications and therefore irrelevant for collaboration analysis. The collaborative publications were done by 683 authors with 1956 edges regardless of the number of publications that two authors did together, depicting a dense network of connections among authors and resulting in about 109 smaller networks (Fig. 4a). However, when one publication edge is removed (Fig. 4b), the network becomes significantly sparser, with only 123 edges among the same 683 nodes. This indicates that many collaborations were based on a single publication. When isolated nodes are eliminated from the collaboration network, leaving only authors with a minimum of two publications published together (Fig. 4c), only 75 nodes remain with 123 edges established in 18 clusters, including 5 clusters of collaboration between two authors. The largest and strongest cluster is centered on Trinel M. and formed by authors like Roumy V., Ruiz L., Samaillie J., Rivière C., Sahpaz S., Bordage S., Dubuisson J., Hennebelle T., Le Lamer AC., Jullian V., Jacquemin D., Crossay E., Rolland C., Mejia K., Cabanillas BJ., Racaud-Sultan C., Fabre N., Owojuyigbe O.S., Larbie C., Firempong C.K., Komlaga G., and Emikpe B.O. Strong collaboration existed among the two authors' clusters between Ajiwe V.I.E. and Ogbu I.M.

Based on information on authors' countries available on 193 publications, only 43 publications resulted in collaboration between countries and were used to access collaborations between authors' countries. The initial network, regardless of the number of publications, revealed 38 edges between the 28 countries, placing at the center of the network United States with strong collaboration between Nigeria, South Africa, and Costa Rica even though the strongest collaboration was established between Peru and France (Fig. 5a). By investigating the network centered on the United States (Fig. 5b) and the network centered on Nigeria (Fig. 5c), it was revealed that the network centered on Nigeria had a greater number of collaborative countries (09) than the one centered on the United States (08 countries). After countries with one edge were isolated and removed to focus on countries with at least two collaborative publications (Fig. 5d), only 14 countries remained with 11 edges. The largest and strongest network was centered around Nigeria, and it had the strongest collaboration with the United States and South Africa.

Publications' content analysis outcomes

The content analysis of publications on *Hura crepitans* was done utilizing the word clouds and the thematic maps built from publications' titles and abstracts, as well as an in-depth study of publications to point out key discoveries. While generating the word cloud, to avoid being misled by the search terms, *Hura crepitans* was eliminated from the word cloud output to focus on pertinent collections of words different from the main keyword. This enables visual representations of commonly occurring words to be shown.

Word clouds and thematic maps results

The content analysis *via* the thematic map offered a comprehensive view of thematic trends in *Hura crepitans* research and potential future fields of investigation by organizing the meaningful terms into four distinct areas: niche themes, motor themes, emerging or declining themes, and basic themes (Fig. 6).

By exploring these variables together, we acquire helpful data. The title word cloud shows phrases like "seed oil", "crepitans seed", "sandbox Hura", "tree species", and "chemical composition", indicating a broad interest in seed-related characteristics and the tree species.

This correlates with the large number of "seed oils" and "sandbox seed" in the driving themes of the thematic map, suggesting main studies focused on the seed composition of this plant species.

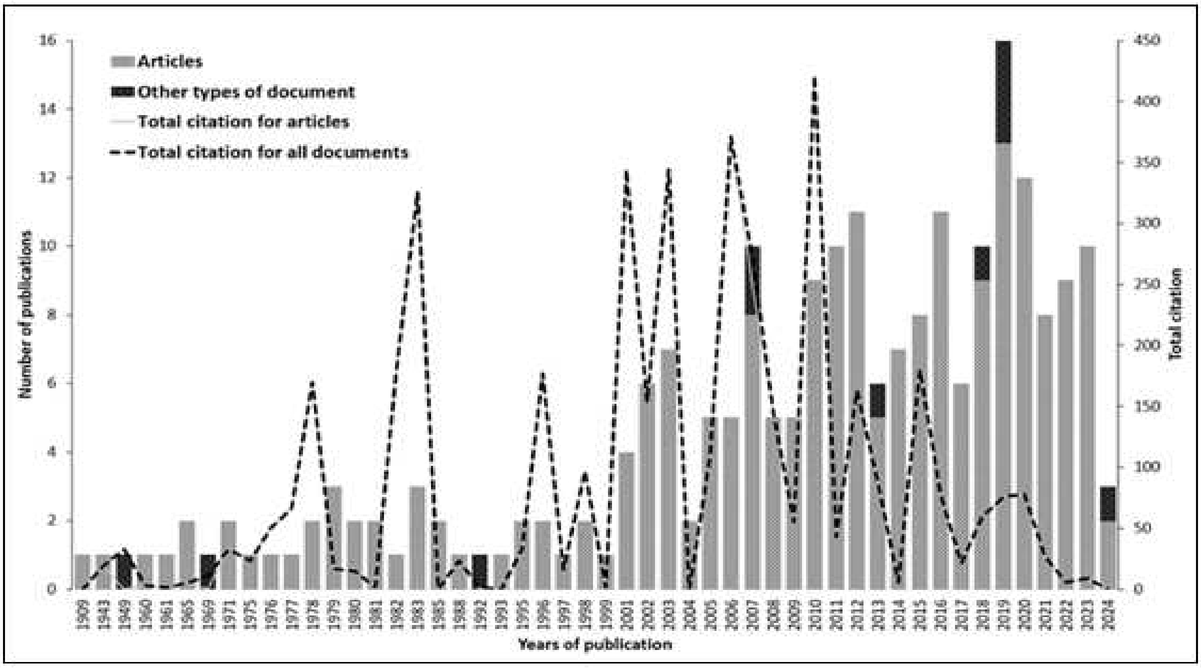

Fig. 1. Total number of publications and citations for research on *Hura crepitans*.

The abstracts word cloud gets more, showing words like "medicinal plants"; fatty acid", "tree species". It is associated well with the motor topics and signifies a focus on *Hura crepitans* ' potential for biofuel production (also suggested by "biodiesel production" in rising topics), "soil water", "Leaf bag". In addition, terms like "antimicrobial activity" indicate towards growing interest in researching *Hura crepitans* for medical use. Finally, the presence of "tree species" in both word clouds, positioned as essential topics, shows a well-established focus on understand *Hura crepitans* in its ecological context.

Exploring the Potential Benefits of Hura crepitans: A Synthesis of Research Findings

Research on *Hura crepitans* has focused predominantly on the species seeds, as revealed in the word cloud and the thematic maps. *Hura crepitans'* seed and leaf extracts exhibited antimicrobial activity against various insects including *Plasmodium falciparum* parasite (Fernández-Calienes *et al.*, 2011; Okeniyi *et al.*, 2018). The biosynthesis of silver nanoparticles using aqueous extracts from *Hura crepitans* seeds further highlighted its potential in medical applications due to the antimicrobial activity exhibited by the synthesized nanoparticles (Jonathan *et al.*, 2018). Additionally, the seed oils of the species exhibit promising nutraceutical potential, containing essential minerals like magnesium, potassium, iron, and zinc while being free from harmful heavy metals such as nickel (Ajani *et al.*, 2019). These phytochemicals contribute to its utility in various industrial applications, particularly in the food and pharmaceutical sectors. It was found that *Hura crepitans'* seed oil (HCSO) supplementation in rats reduced pro-inflammatory cytokine expression, suggesting anti-inflammatory properties (Jonathan *et al.*, 2018). The presence of lectin, a protein in the seeds, with mitogenic activity (ability to stimulate cell division), specifically in human T lymphocytes, has been highlighted (Ajala *et al.*, 2023).

This lectin showed potency even at low concentrations and became more active with purification, suggesting potential applications in research or medicine. Leaf extracts' in vitro antioxidant activity was reported, highlighting the potential for countering oxidative damage (Kitadi *et al.*, 2024). However, authors observed potential anemia risks with long-term use of *Hura crepitans'* leaf extract in rats, emphasizing the need for further safety studies (Iannacone *et al.*, 2014). More recently, the mineral composition of *Hura crepitans'* leaves, bark, and seeds was analyzed (Kitadi *et al.*, 2024). Authors found that these organs contain minerals like iron, zinc, magnesium, and selenium, potentially beneficial for people with sickle cell disease (Kitadi *et al.*, 2024). While some toxicity of this plant species is acknowledged (Iannacone *et al.*, 2014; Ezeh *et al.*, 2021; Ningrum *et al.*, 2024). *Hura crepitans'* extracts from various plant parts exhibit promising antimicrobial activity against large specimens of pathogens. Proper extraction techniques were important to manage *Hura crepitans*' known toxicity while harnessing its potential for therapeutic applications (Velazquez-González *et al.*, 2022). Authors examined how fermentation time affects the nutritional and chemical composition of ogiri, a condiment made from *Hura crepitans'* seeds (Ahaotu *et al.*, 2020). The study revealed significant changes during fermentation, with decreased carbohydrates, protein, and fiber content, while moisture content increased (Ahaotu *et al.*, 2020). Terpenoids were found throughout the process, while steroids were minimal. Overall, the study demonstrated the suitability of *Hura crepitans'* seeds for ogiri production, with fermentation influencing the final nutritional profile (Ahaotu *et al.*, 2020).

As it is useful for humans' health and food, researchers have also reported the importance of *Hura crepitans'* seeds for animals. Indeed, the effectiveness of the species' seeds against coccidiosis in lambs has been investigated, and the findings indicated that *Hura crepitans* Seed Oil (HCSO) exhibits anticoccidial properties, potentially offering a viable and natural alternative to conventional anticoccidial therapies for livestock (Velazquez-González *et al.*, 2022). The potential of *Hura crepitans'* seed meal (HCSM) as a feed supplement for sheep has been assessed, and analysis revealed a crude protein content of 251.1 g/kg and a dry matter content of 931.7 g/kg in HCSM (Velazquez-González *et al.*, 2022).

The study also showed promising digestibility, with the highest dry matter degradability (DMD) observed within the first 3 hours of incubation, showing a change rate of 41%. Additionally, *Hura crepitans'* seed meal provided essential amino acids, including glutamic acid (16.9%), arginine (13.0%), and aspartic acid (9.7%).

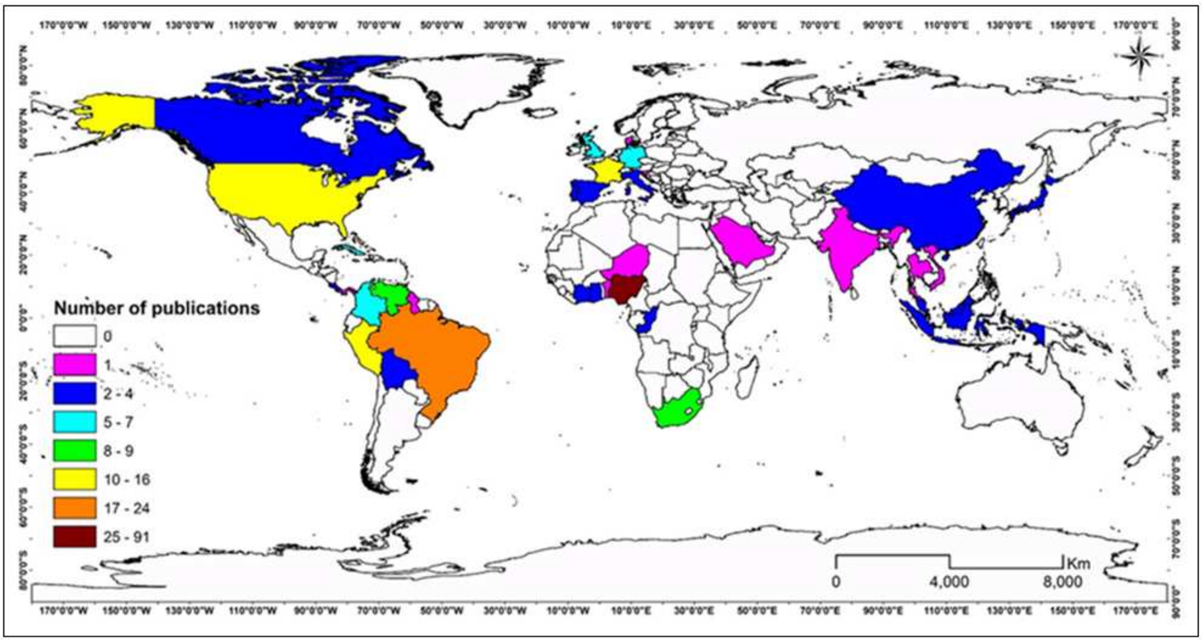

Fig. 2. Global geographical distribution of publications on *Hura crepitans* based on authors' countries.

These findings suggest that HCSM could be a valuable source of nutrients for ruminant animals, with a gradual energy utilization reaching a maximum of 14.6% after 72 hours post-incubation (Escalera-Valente *et al.*, 2022).

These studies highlight the significant ethnopharmacological and medicinal potential of *Hura crepitans*' organs for both humans and animals. Additionally, research on biodiesel production from the seeds of *Hura crepitans* shows promise. The oil extracted from the seeds has been successfully converted into biodiesel through transesterification (Otoikhian *et al.*, 2016; Sidohounde *et al.*, 2019; Escalera-Valente *et al.*, 2022), indicating favorable fuel properties and potential as a sustainable feedstock. Moreover, the development of recyclable catalysts from seed pods for biodiesel production has been investigated (Ogbu *et al.*, 2018). This method offers a sustainable and cost-effective solution by utilizing waste products and achieving high catalytic activity (up to 94.81% ester conversion) with good reusability. A neural network model was developed to predict oil yield during solvent-based extraction from *Hura crepitans* seeds (Ajala *et al.*, 2023). The potential of *Hura crepitans* seed oil (HCSO) as a sustainable raw material for waterborne alkyd resins has also been explored. Research suggests that HCSO and other plant-based oils could be a viable alternative to petroleum-derived materials in various industrial applications (Issac *et al.*, 2023). Additionally, waste sandbox shells as a green catalyst for biodiesel production has been examined, promoting resource efficiency (Yeung *et al.*, 2018).

In the cosmetics industry, the use of *Hura crepitans* seed oil (HCSO) in developing emollient creams was studied (Saraiva *et al.*, 2019). They extracted HCSO *via* solvent extraction and characterized it using standard methods. The researchers prepared aluminum and magnesium soaps from palm kernel oil sodium soap through the precipitation method to serve as thickeners and emulsifiers in the cream formulation, alongside shea butter and an aqueous extract of turmeric, demonstrating HCSO's potential for cosmetic applications.

In the pulp and paper industry, the suitability of *Hura crepitans* leaves as an alternative raw material was investigated. The analysis revealed favorable properties, including high lignin and cellulose content, low solubility in sodium hydroxide solution, and appropriate fiber lengths for papermaking, suggesting that *Hura crepitans* leaves have the potential for sustainable pulp and paper production (Isaac *et al.*, 2022).

Discussion

Despite multiple advantages related to sandbox trees, research on this species from 1909 to 2024 remains limited, particularly in the wood industry or ethnobotany fields. Integrating ethnopharmacology studies with bibliometric analyses could provide a more comprehensive understanding of the plant's historical uses and research trends. For example, studies such as those by Ritter *et al.* (2015) and Yeung *et al.* (2018) highlighted the importance of ethnopharmacological knowledge in understanding the full scope of *Hura crepitans*' applications.

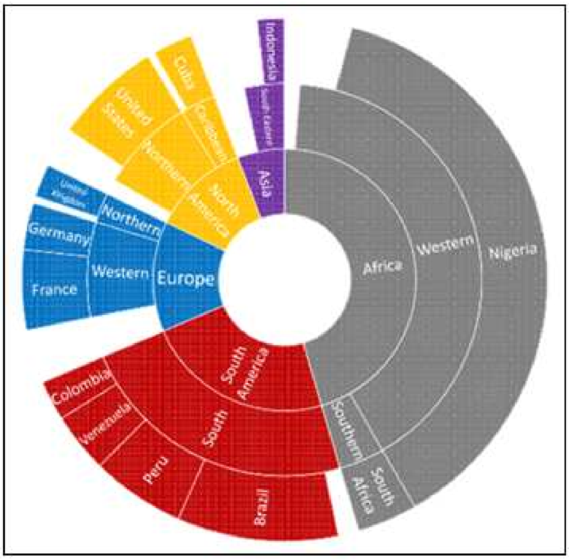

Fig. 3. Contribution of continents, regions, and countries in publications on *Hura crepitans*.

While a noticeable increase in *Hura crepitans* research is observed post-2000, potentially driven by growing interest in its pharmacological applications, this surge requires a nuanced interpretation. While ecological and pharmacological potentials are contributing factors in botanical research trends (Saraiva *et al.*, 2019), it might overlook other important influences. For instance, the increased accessibility of digital databases and online publishing platforms in the late 20th and early 21st centuries could have played a role in the observed trend. Furthermore, attributing research peaks solely to scientific breakthroughs or policy shifts (Moyer *et al.*, 2017), neglects the potential impact of evolving societal interests and funding priorities. A more comprehensive analysis should consider the influence of funding trends, technological advancements, and evolving research priorities within specific disciplines. For example, the rise of interdisciplinary fields like ethnopharmacology (Jorim *et al.*, 2012; Ningthoujam *et al.*, 2012; Leonti and Casu, 2013) could be a significant driver of increased research on traditionally used plants like *Hura crepitans*.

The significance of English in *Hura crepitans* publications highlights a crucial concern in scientific communication: the language obstacle. Despite English emerging as the universal language of science, this gives rise to inherent accessibility obstacles for researchers in non-English speaking areas (Fleury and Heredia, 2023). This prevalence is underscored in studies by some authors which point out the dominant impact of English in scientific publishing, particularly in disciplines such as computer science (Cheriguene *et al.*, 2020).

This linguistic bias not only limits the dissemination of knowledge but can also hinder the participation and recognition of researchers from diverse linguistic backgrounds (Ramírez-Castañeda, 2020). This is particularly relevant for *Hura crepitans'* research, where valuable traditional knowledge held within local communities might not be readily accessible in English-language publications.

Furthermore, as suggested, promoting multilingualism in scientific communication, such as providing translations of abstracts or key findings, could significantly broaden the reach and impact of research, fostering greater inclusivity and knowledge exchange. This is particularly crucial for research on species like *Hura crepitans,* which has significant cultural and ecological importance in various regions worldwide. Key journals such as Forest Ecology and Management and the Journal of Ethnopharmacology have been major channels for disseminating research on *Hura crepitans*. However, a geographical analysis reveals that research efforts are heavily concentrated in regions like Nigeria and Brazil. This focus aligns with the plant's introduction to Nigeria and the prevalence of traditional ethnomedical knowledge in these areas.

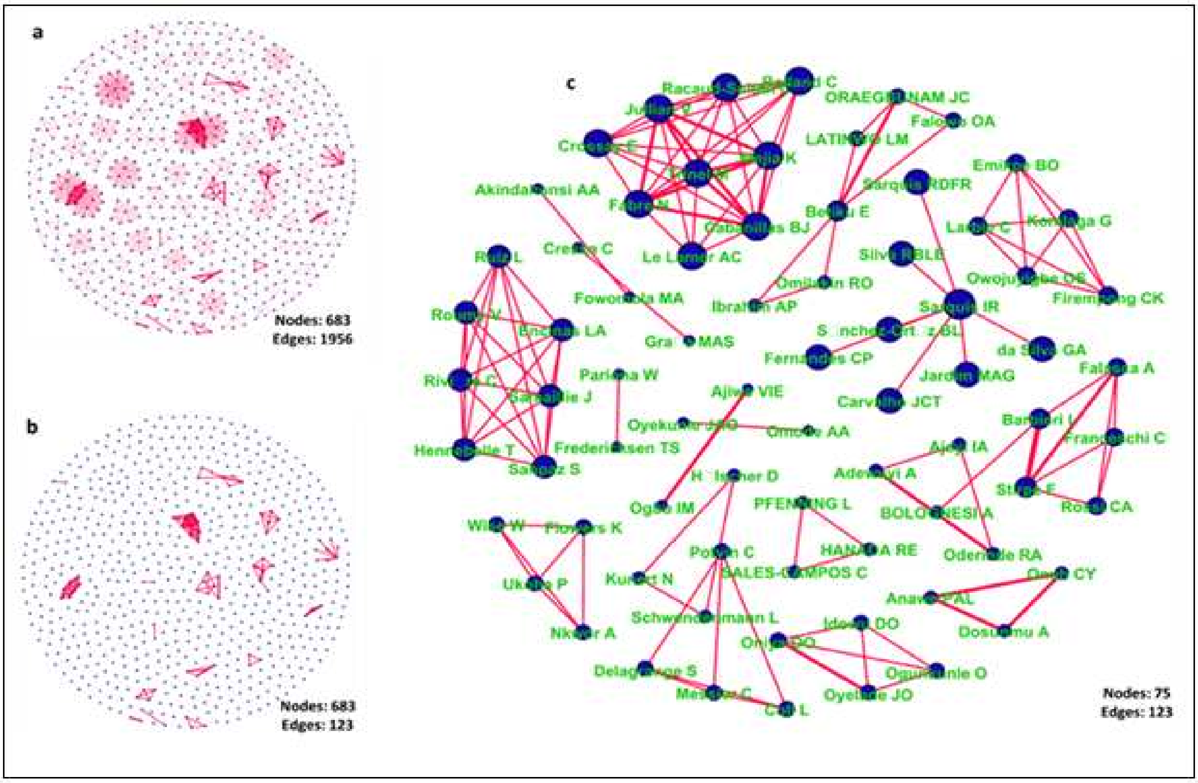

Fig. 4. Social networks of collaboration between authors regardless of the number of publications published together (a), with only one publication edge removed (b), with a minimum of two publications published together (c).

This regional emphasis, while important, risks overlooking the potential diversity of *Hura crepitans* across its entire range and the valuable insights that can be gained from local knowledge. For instance, the diverse traditional uses and economic value of *Ricinodendron heudelotii* in Benin demonstrate the importance of local knowledge in understanding plant resources (Akpovo *et al.*, 2023) highlights the diverse traditional uses and economic value of *Ricinodendron heudelotii* in Benin, demonstrating the importance of local knowledge in understanding plant resources. Similar specific researches explore the potential of *Hura crepitans'* seed oil for biodiesel production in Benin, showcasing the need to investigate region-specific applications (Montcho, 2016; Sidohounde *et al.*, 2019). Furthermore, research (Dicko *et al.*, 2019) emphasizes the influence of ethnic groups on the utilization and knowledge of plant species like *Lophira lanceolata* in Benin. This underscores the importance of considering socio-cultural factors when studying the distribution and use of *Hura crepitans* across its range. A broader geographical perspective in *Hura crepitan's* research, particularly within understudied African regions, will not only enhance our understanding of its biology and ecology but also contribute to more effective and context-specific conservation and resource management strategies.

The collaborative analysis between the author and between countries reveals a centralized structure, with the United States and Nigeria emerging as key collaborative hubs, showing the importance of these countries in advancing research on this species. Research on *Hura crepitans* is still in its early stages, particularly when compared to other regions like Africa, where research on Gum Arabic has been more extensive (Honorio Coronado *et al.*, 2023). Further, the ethnobotanical survey on medicinal plants in Nigeria's Ughelli North Local Government Area highlights the traditional use of *Hura crepitans* for various ailments (Treasure *et al.*, 2020), suggesting its potential in the realm of traditional medicine (Oraegbunam *et al.*, 2020). While pharmacological and botanical studies provide a crucial foundation for understanding *Hura crepitans,* they represent only a fraction of its potential significance. A comprehensive understanding of the plant's cultural importance and traditional uses is essential.

Documenting and preserving this ethnobotanical knowledge is crucial for cultural heritage and its potential to reveal novel applications in medicine, agriculture, and other fields (Leonti and Casu, 2013). Failing to do so risks the loss of invaluable knowledge accumulated over generations. For instance, a study on medicinal plants used for malaria treatment in Benin (Yetein *et al.*, 2013) highlights the importance of local knowledge in uncovering potential therapeutic applications.

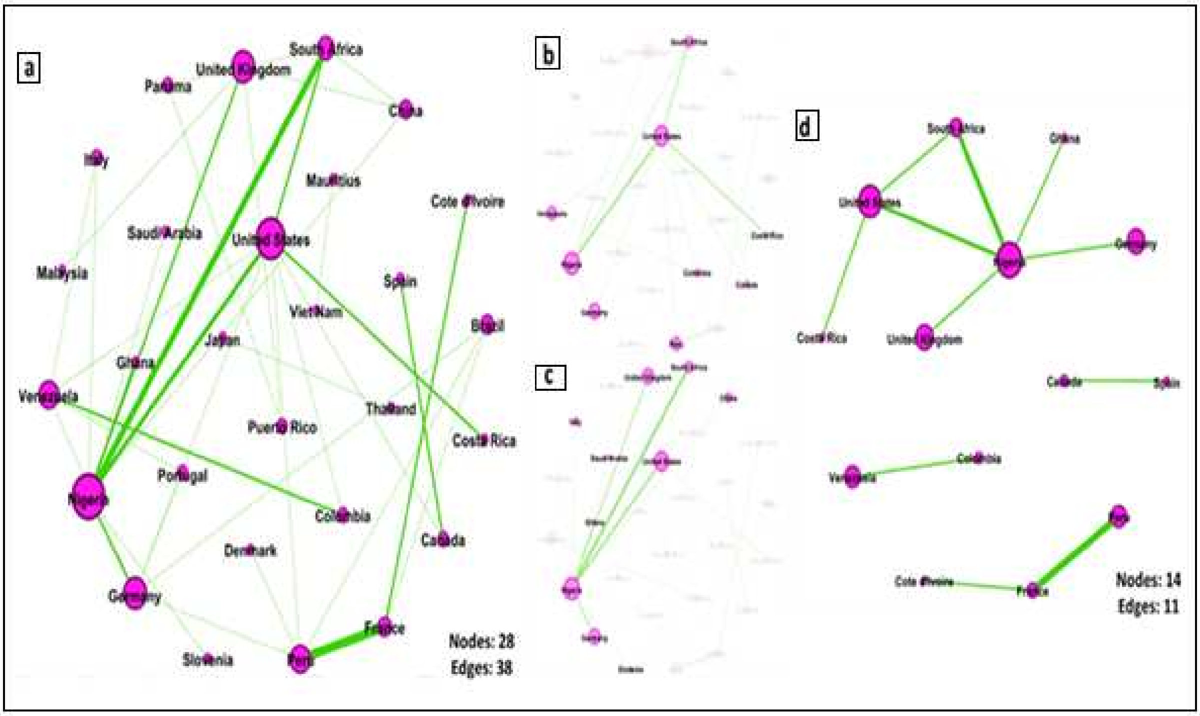

Fig. 5. Social networks of collaboration between authors' countries regardless of the number of publications published together (a), with only the United States at the center (b), with only Nigeria at the center (c), and with a minimum of two publications published.

The thematic diversity, spanning from bioactive compounds to agricultural applications, suggests a multidisciplinary approach that could benefit from increased international collaboration and knowledge exchange, particularly with underrepresented regions. While recent research on *Hura crepitans* highlights several emerging thematic areas, spatial analysis reveals potential divergences between the plant's native range and the distribution of research efforts. For instance, Nigeria emerges as a leading contributor to the *Hura crepitans* literature in terms of the number of publications, despite the species potentially being non-native to the region, but in the center and south American regions where the distribution of species is concentrated. Expanding research efforts to regions where *Hura crepitans* are non-native, such as West Africa and Asia, could yield valuable insights into its adaptability and potential applications in new ecological contexts. This aligns with the increasing emphasis on place-based knowledge for sustainable development (Ontong and Le Grange, 2014). However, as the Convention on Biological Diversity emphasized, such expansion necessitates careful consideration of the risks associated with introducing species outside their native ranges (IPBES, 2023). Rigorous risk assessment and adherence to ethical guidelines are paramount to prevent unintended ecological consequences. While the existing research on *Hura crepitans* provides a base for understanding its potential, a closer examination reveals significant knowledge gaps and opportunities for future research. Current studies predominantly focused on the plant's phytochemistry and bioactivity, exploring its potential applications in medicine and sustainable industries. For instance, investigations into *Hura crepitans*' secondary metabolites have revealed promising antioxidant and antimicrobial properties, particularly in its leaves, seeds, and bark. Furthermore, researchers have begun exploring its potential for sustainable applications, such as biodiesel production from its seed oil and its use in pulp and paper production. However, other crucial research areas remain underexplored. Despite its reported toxicity, comprehensive safety assessments of *Hura crepitans* are limited, hindering its responsible utilization. Further investigation into its toxicological profile is crucial to ensure safe handling and application. The wood production potential of *Hura crepitans* has been explored, but findings suggest limitations for commercial timber production due to insufficient regeneration (Stephen *et al.*, 1995).

This highlights the need for research into sustainable cultivation practices and conservation strategies to ensure the long-term availability of *Hura crepitans* as a valuable resource. This highlights the need for research into sustainable cultivation practices and conservation strategies to ensure the long-term availability of *Hura crepitans* as a valuable resource.

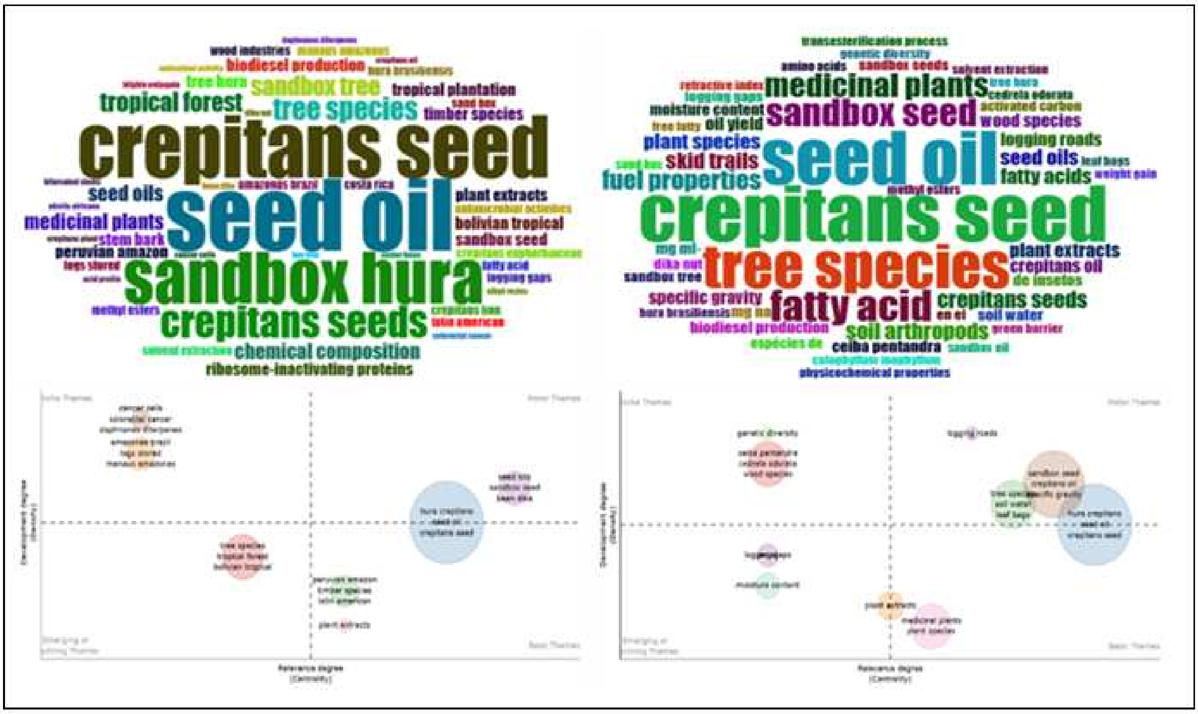

Fig. 6. Word cloud outcome of the 50 meaningful groups of words from the publications' titles (up left), publications' abstracts (upright), and their respective thematic map.

Beyond its practical applications, understanding *Hura crepitans*' ecological role requires further investigation. While studies have shed light on its unique seed dispersal mechanisms and pollination strategies (Tobias *et al.*, 2019; Ribera *et al.*, 2020), broader ecological research remains limited, particularly regarding its interactions with other species and its role in ecosystem dynamics. The potential of *Hura crepitans* seed shells in water treatment through activated carbon production has been highlighted (Nsi *et al.*, 2016), emphasizing the value of exploring diverse applications.

A comparative approach, contrasting *Hura crepitans* with related Euphorbiaceae species, could provide valuable insights into its unique characteristics and potential. This approach could encompass various aspects, from phytochemical profiles and bioactivities to ecological interactions and evolutionary adaptations.

Research on *Hura crepitans* is progressing; however, a strategic shift in focus is needed to address critical knowledge gaps. Prioritizing research on its toxicology, sustainable cultivation, ecological interactions, and comparative analysis will provide a more comprehensive understanding of this fascinating and potentially valuable species. This aligns with the principles of academic publishing, which encourages a balanced and comprehensive exploration of research topics to advance scientific knowledge effectively (Habib *et al.*, 2014).

Conclusion

Hura crepitans, also called sandbox trees, have been of increasing scientific attention in recent years due to the increased understanding of environmental difficulties and traditional medical values for such species. Although most studies are written in English, future studies should involve multiple languages to improve scientific knowledge. *Hura crepitans* is native to the American continent; this species is not studied there alone.

In Western Africa, notably Nigeria, when species is introduced, it can be noticed that this is one of its key research fields, showing that it has gotten strongly integrated into local activities and ecosystems. South America is second among the world's top countries contributing to research on *Hura crepitans*. This suggests that apart from being naturally prevalent in particular places and having a presence in corresponding traditional medical applications, the same case cannot be affirmed for other plants located elsewhere internationally since their local medicinal use could vary per plant species. Despite the diversity of publications found on this species, additional research is necessary to appreciate its potential fully. It is vital to conduct extensive toxicological investigations, sustainable farming practices, and ecological interactions beyond the natural habitat of this plant to ensure its safe usage in possible applications. In addition, it would be good to examine how adaptable this species is, its ecological connection, and its uses in other African countries into which it has been introduced.

Author contributions

Yevide SIA: Conceptualization, Methodology, Data curation, Formal analysis, Software, Visualization, Writing – original draft, Writing – review & editing. **Yebadokpo SK:** Methodology, Data curation, Formal analysis, Writing – original draft. **Gbesso GHF**: Conceptualization, Resources, Data curation, Supervision, Writing – review & editing. All authors finalized the format and commented on the manuscript. All authors read and approved the final manuscript.

Declarations

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

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

Funding: Non-funded review**.**

Competing interests: The authors declare that they have no competing interests.

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

References

Abrahamse W, Steg L. 2013. Social influence approaches to encourage resource conservation: A meta-analysis. Global Environmental Change **23(6),** 1773-1785.
https://doi.org/10.1016/j.gloenvcha.2013.07.029

Ahaotu NN, Echeta CK, Bede NE, Awuchi CG, Anosike CL, Ibeabuchi CJ, Ojukwu M. 2020. Study on the nutritional and chemical composition of" Ogiri" condiment made from sandbox seed (Hura crepitans) as affected by fermentation time. GSC Biological and Pharmaceutical Sciences **11(2),** 105-113.
https://doi.org/10.30574/gscbps.2020.11.2.0115

Ajala OO, Oyelade JO, Oke EO, Oniya OO, Adeoye BK. 2023. A nonlinear autoregressive exogenous neural network (NARX-NN) model for the prediction of solvent-based oil extraction from Hura crepitans seeds. Chemical Product and Process Modeling **18(4),** 647-55. http://dx.doi.org/10.1515/cppm-2022-0032

Ajani OO, Owoeye TF, Owolabi FE, Akinlabu KD, Audu, OY. 2019. Phytochemical screening and nutraceutical potential of sandbox tree (Hura crepitans L.) seed oil. Foods and Raw Materials **7(1),** 143-150. http://doi.org/10.21603/2308-4057-2019-1-143-150

Akpovo AH, Honfo SH, Fandohan AB. 2023. Geographical distribution, abundance and population structure of Ricinodendron heudelotii (Baill.) Pierre ex. Heckel, a culturally important species in Benin Republic. South African Journal of Botany **157,** 231-242. https://doi.org/10.1016/j.sajb.2023.03.062

Aria M, Cuccurullo C. 2017. bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of Informetrics **11(4),** 959-75. https://doi.org/10.1016/j.joi.2017.08.007

Avoseh ON, Ogunbajo LO, Ogunwande IA, Ogundajo AL, Lawal OA. 2018. Anti-inflammatory Activity of Hexane and Ethyl Acetate Extracts of Hura crepitans L. European Journal of Medicinal Plants **24(1),** 1-6. http://dx.doi.org/10.9734/EJMP/2018/41439

Bertin S, Luigi M, Parrella G, Giorgini M, Davino S, Tomassoli L. 2018. Survey of the distribution of Bemisia tabaci (Hemiptera: Aleyrodidae) in Lazio region (Central Italy): a threat for the northward expansion of Tomato leaf curl New Delhi virus (Begomovirus: Geminiviridae) infection. Phytoparasitica **46,** 171-182. https://doi.org/10.1007/s12600-018-0649-7

Cheriguene A, Tayeb K, Abdelaziz KC. 2020. Writing for Journal Publications: A Case Study of Eight Computer Scientists in Algeria. Arab World English Journal Special Issue on CALL **6,** 102-113. https://dx.doi.org/10.24093/awej/call6.7

de Oliveira OJ, da Silva FF, Juliani F, Barbosa LCFM, Nunhes TV. 2019. Bibliometric method for mapping the state-of-the-art and identifying research gaps and trends in literature: An essential instrument to support the development of scientific projects. IntechOpen. http://dx.doi.org/10.5772/intechopen.85856

Dicko A, Natta AK, Biaou HSS, Akossou A. 2019. Assessing morphological traits variation and fruit production of Lophira lanceolata (Ochnaceae) in Benin. American Journal of Plant Sciences **10(6),** 1048-1060. http://dx.doi.org/10.4236/ajps.2019.106076

Duan G, Bai Ye, Ye D, Lin T, Peng P, Liu M, Bai S. 2020. Bibliometric evaluation of the status of Picea research and research hotspots: comparison of China to other countries. Journal of Forestry Research **31(4),** 1103-1114. https://doi.org/10.1007/s11676-018-0861-9

Escalera-Valente F, Loya-Olguín JL, Martínez-González S, Carmona-Gasca CA, Bautista-Rosales PU, Gutiérrez-Leyva R. 2022. Evaluation of nutritional and ruminal degradability potential of sandbox (Hura crepitans L.) seeds in stabled Blackbelly sheep. Revista Brasileira de Zootecnia **51,** e20220012. http://dx.doi.org/10.37496/rbz5120220012

Esonu B, Ozeudu E, Emenalom O, Nnaji C, Onyeikegbulem, I K. 2014. Nutritional Value of Sandbox (Hura Crepitans) Seed Meal for Broiler Finisher Birds. Journal of Natural Sciences Research **4(23),** 95-99.

Ezeh GC, Udeh NE, Ozioko CA, Onoja SO, Eze RE, Omeh YN, Ezeja MI, Anaga AO. 2021. Acute and sub-acute toxicity profile of methanol extract of Hura crepitans leaf on Wistar rats. Notulae Scientia Biologicae **13(2),** 10939. https://doi.org/10.15835/nsb13210939

Fernández-Calienes VA, Mendiola MJ, Acuña RD, Caballero LY, Scull LR, Gutiérrez GY. 2011. Actividad antimalárica y citotoxicidad de extractos hidroalcohólicos de seis especies de plantas usadas en la medicina tradicional cubana. Revista Cubana de Medicina Tropical **63(1),** 52-57.

Fleury HJ, Heredia A. 2023. The Language Barrier as Part of Editorial Policies on Diversity and Inclusion. Revista Brasileira de Psicodrama **30**(12), https://doi.org/10.1590/psicodrama.v30.606_IN

Garza-Reyes, JA. 2015. Lean and green–a systematic review of the state of the art literature. Journal of Cleaner Production **102(1),** 18-29. https://doi.org/10.1016/j.jclepro.2015.04.064

Güler G. 2023. A Bibliometric Analysis on Dimensionality Studies of Psychological Constructs Used in Education and Psychology. International Innovative Education Researcher (IEdRes) 3.

Habib M, Maryam H, Pathik BB. 2014. Research methodology-contemporary practices: Guidelines for academic researchers. Cambridge Scholars Publishing, UK.

Honorio CEN, Schulz C, Martín BM, del Águila PJ, del Aguila VM, Dávila CN, Córdova OCJ, García MG, Ríos PMA, Cole LES, Charpentier UE, Valdivia AS, Vargas BV, Delgado AD, Paima RR, Marín RW, Isla RGM, Dávila TW, Baker TR, Reed MS, Roucoux KH. 2023. Los humedales y turberas en los territorios indígenas urarinas : usos, manejo y carbono almacenado . in M Martín Brañas , E Fabiano & D Del Castillo Torres (eds) , Donde habitan los neba : naturaleza, cultura e impactos ambientales en los territorios del pueblo Urarina . Instituto de Investigaciones de la Amazonía Peruana , Iquitos, 57-87 p.

Iannacone JA, Ayala H, Alvariño L, Paredes EC, Villegas W, Alomia J, Santos S, Nolazco N, Cruces L. 2014. Riesgo ecotoxicológico acuático y terrestre del bioplaguicida catahua, Hura crepitans (Euphorbiaceae). Revista de toxicología **30,** 50-62.

Roy HE, Pauchard A, Stoett P, Renard TT, Bacher S, Galil BS, Hulme PE, Ikeda T, Sankaran KV, McGeoch MA, Meyerson LA, Nuñez MA, Ordonez A, Rahlao SJ, Schwindt E, Seebens H, Sheppard AW, Vandvik V. 2023. Summary for Policymakers of the Thematic Assessment Report on Invasive Alien Species and their Control of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.7430692

Isaac IO, Willie IE, Idio NS. 2023. Preparation and physicochemical characterization of emulsion alkyd resins from cottonseed, Hura crepitans L. seed and palm kernel oils. International Journal of Frontline Research in Chemistry and Pharmacy **2(01),** 005-13. https://doi.org/10.56355/ijfrcp.2023.2.1.0052

Isaac IO, Willie IE, Thompson QS. 2022. Studies on the utilization of Hura crepitans seed oil, aqueous extract of Curcuma longa L., aluminium, and magnesium metallic soaps in the preparation of emollient cream. Researchers Journal of Science and Technology **2(3),** 18-27.

Jonathan J, Oluwafemi O, Ronke O, Samuel O, Jesse O. 2018. Hura crepitans seed mediated biosynthesis of silver nanoparticles, characterization and its antimicrobial activity against microorganism. Journal of Bionanoscience **12(5),** 614-620. http://dx.doi.org/10.1166/jbns.2018.1569

Jorim RY, Korape S, Legu W, Koch M, Barrows LR, Matainaho TK, Rai PP. 2012. An ethnobotanical survey of medicinal plants used in the eastern highlands of Papua New Guinea. Journal of Ethnobiology and Ethnomedicine **8,** 47. https://doi.org/10.1186/1746-4269-8-47

Kitadi JM, Inkoto CL, Kwilu J, Lengbiye EM, Tshibangu DST, Tshilanda DD, Ngbolua KN, Mbala BM, Schmitz B, Mpiana PT. 2024. Evaluation of mineral content of plants used in the management of sickle cell disease. Orapuh Journal **5(2),** e1116. https://dx.doi.org/10.4314/orapj.v5i2.16

Leonti M, Casu L. 2013. Traditional medicines and globalization: current and future perspectives in ethnopharmacology. Frontiers in Pharmacology **4**, 92. https://doi.org/10.3389/fphar.2013.00092

Liu X, Zhang L, Hong S. 2011. Global biodiversity research during 1900–2009: a bibliometric analysis. Biodiversity and Conservation **20,** 807-826. https://doi.org/10.1007/s10531-010-9981-z

Montcho PS. 2016. Production et caractérisation du biodiesel éthylique à partir de l'huile végétale non conventionnelle de Hura crepitans du Bénin. Université d'Abomey-Calavi, Laboratoire d'Etude et de Recherche en Chimie Appliquée (LERCA). 70 p.

Moyer R, Ikert K, Long K, Marsh J. 2017. The value of preoperative exercise and education for patients undergoing total hip and knee arthroplasty: a systematic review and meta-analysis. JBJS Reviews **5**(12), e2. https://doi.org/10.2106/JBJS.RVW.17.00015

Ningrum LW, Rahadiantoro A, Helmanto H, Rahmadana M, Aryanti NA, Ramadhan R. 2024. Tree health assessment and risk management of Hura crepitans L. in Purwodadi botanical garden. AIP Conference Proceedings. 21 February 2024; 3001 **(1),** 080053. https://doi.org/10.1063/5.0186200

Ningthoujam SS, Talukdar AD, Potsangbam KS, Choudhury MD. 2012. Challenges in developing medicinal plant databases for sharing ethnopharmacological knowledge. Journal of Ethnopharmacology **141(1),** 9-32. https://doi.org/10.1016/j.jep.2012.02.042

Nsi E, Akpakpan A, Ukpong EJ, Akpabio U. 2016. Preparation and characterization of activated carbon from Hura Crepitans Linn seed shells. The International Journal of Engineering and Science **5(9),** 38-41.

Ogbu IM, Ajiwe VIE, Okoli CP. 2018. Performance Evaluation of Carbon-based Heterogeneous Acid Catalyst Derived From Hura crepitans Seed Pod for Esterification of High FFA Vegetable Oil. BioEnergy Research **11,** 772-783. https://doi.org/10.1007/s12155-018-9938-8

Okeniyi JO, Popoola API, Okeniyi ET, Owoeye TF, Deborah KA. 2018. Performance of Hura Crepitans Mediated Ag-Nanoparticle Material on the Inhibition of Microbes Inducing Microbiologically-Influenced-Corrosion. Paper presented at the CORROSION 2018, Phoenix, Arizona, USA.

Ontong K, Le Grange L. 2014. The role of place-based education in developing sustainability as a frame of mind. Southern African Journal of Environmental Education **30,** 27-38.

Oraegbunam JC, Oladipo B, Falowo OA, Betiku E. 2020. Clean sandbox (Hura crepitans) oil methyl esters synthesis: A kinetic and thermodynamic study through pH monitoring approach. Renewable energy **160,** 526-537. https://doi.org/10.1016/j.renene.2020.06.124

Otoikhian SK, Aluyor EO, Audu TOK. 2016. Two-Steps Transesterification of Hura Crepitans Seed Oil using Polymer Based Catalyst. Walailak Journal of Science and Technology **13(11),** 931-937.

Owojuyigbe OS, Firempong CK, Larbie C, Komlaga G, Emikpe BO. 2020. Hepatoprotective potential of Hura crepitans L.: A review of ethnomedical, phytochemical and pharmacological studies. Journal of Complementary and Alternative Medical Research **9(2),** 1-10. http://dx.doi.org/10.9734/jocamr/2020/v9i230136

Pritchard RD. 1969. Equity theory: A review and critique. Organizational Behavior and Human Performance **4(2),** 176-211. https://doi.org/10.1016/0030-5073(69)90005-1

Ramírez-Castañeda V. 2020. Disadvantages in preparing and publishing scientific papers caused by the dominance of the English language in science: The case of Colombian researchers in biological sciences. PloS one **15(9),** e0238372. https://doi.org/10.1371/journal.pone.0238372

Ribera J, Desai A, Whitaker DL. 2020. Putting a new spin on the flight of jabillo seeds. Integrative and Comparative Biology **60(4),** 919-924. https://doi.org/10.1093/icb/icaa117

Richet C. 1909. Etudes sur la crépitine Toxine de Hura crepitans : Annales de l'Institut Pasteur.

Ritter MR, da Silva TC, de Lima AE, Albuquerque UP. 2015. Bibliometric analysis of ethnobotanical research in Brazil (1988-2013). Acta Botanica Brasilica **29(1),** 113-119. https://doi.org/10.1590/0102-33062014abb3524

Saggiomo L, Esattore B, Picone F. 2020. What are we talking about? Sika deer (Cervus nippon): A bibliometric network analysis. Ecological Informatics. **60,** 101146, https://doi.org/10.1016/j.ecoinf.2020.101146

Saraiva M, Vieira P, O'garra, A. 2019. Biology and therapeutic potential of interleukin-10. Journal of Experimental Medicine **217(1),** e20190418. https://doi.org/10.1084/jem.20190418

Sidohounde A, Nonviho G, Bothon FTD, Montcho PS, Dossa CPA., Tchiakpe L, Sohounhloue D. 2019. Biodiesel synthesis by ethanolysis of Hura crepitans seed oil unfit for consumption in Benin. American Journal of Physical Chemistry **8,** 50-57.

Stephen PH, Robin BF. 1995. Demography and harvest potential of Latin American timber species: data from a large, permanent plot in Panama. Journal of Tropical Forest Science **7(4),** 599–622. Retrieved from https://jtfs.frim.gov.my/jtfs/article/view/1856

Tobias LM, Cordeiro I, Demarco D. 2019. Floral development in Hura crepitans (Euphorbiaceae): a bat-pollinated species with multicarpellate gynoecium. Brazilian Journal of Botany **42,** 509-519. https://doi.org/10.1007/s40415-019-00543-0

Treasure IO, Adjene JO, Odigie MO. 2020. Ethnobotanical survey of medicinal plants in Ughelli North Local Government Area of Delta State. Journal of Medicine: Study and Research **3,** 014. http://dx.doi.org/10.24966/MSR-5657/100014

Van Eck NJ, Waltman L. 2010**.** Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics **84,** 523-538. https://doi.org/10.1007/s11192-009-0146-3

Velazquez-González MY, Loya-Olguin JL, Valdes-Garcia YS, Martinez-Gonzalez S, Avila-Ramos F, Escalera-Valente F, Gonzalez-Montaña JR. 2022. Hura crepitans Seeds for Control of Eimeria spp. in Lambs as an Alternative to Conventional Therapies. Veterinary Sciences **9(9),** 488. https://doi.org/10.3390/vetsci9090488

Yetein MH, Houessou LG, Lougbégnon TO, Teka O, Tente B. 2013. Ethnobotanical study of medicinal plants used for the treatment of malaria in plateau of Allada, Benin (West Africa). Journal of Ethnopharmacology **146(1),** 154-163. https://doi.org/10.1016/j.jep.2012.12.022

Yeung YT, Aziz F, Guerrero-Castilla A, Arguelles S. 2018. Signaling pathways in inflammation and anti-inflammatory therapies. Current Pharmaceutical Design **24(14),** 1449-1484. http://dx.doi.org/10.2174/1381612824666180327165604

Yevide ASI, Wu B, Khan AS, Zeng Y, Liu J. 2016. Bibliometric analysis of ecosystem monitoring-related research in Africa: implications for ecological stewardship and scientific collaboration. International Journal of Sustainable Development & World Ecology **23(5),** 412-422. https://doi.org/10.1080/13504509.2015.1129998