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Overview and trends in forensic palynology based on a scientometric study in the PubMed database

Panorama e tendências em palinologia forense a partir de um estudo cienciométrico na base de dados PubMed

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Abstract

Pollen grains found on human bodies, objects, and in the environment can correlate and reveal potential forensic significance. Understanding the evolution of production and scientific information in this field contributes to the real-world application of evidence gathered through research. This study analyzes scientific literature on forensic palynology indexed in the PubMed database to outline a scientometric overview of the area. Bibliometric indicators from the retrieved publications were systematically organized and analyzed descriptively. Simple textual statistics, word clouds, and similarity analyses were applied to the corpus generated from the abstracts of the studies using IRaMuTeQ. The search yielded 73 publications, published between 1997 and May 2022. The most frequently cited terms were *pollen* (n = 261) and *forensic* (n = 144). Research in this field expanded from 2006 onward, with a notable contribution from P. Wiltshire, who authored 11 papers, and from the journals Forensic Science International (n = 19), Journal of Forensic Sciences (n = 16), and Science & Justice (n = 8). Forensic palynology research is expanding and can support professional practice in the criminal field.

Resumo

Grãos de pólen em corpos humanos, objetos e no ambiente podem ser correlacionados e revelar um potencial criminalístico. Compreender a evolução da produção e informação científica na área contribui para a aplicação no mundo real das evidências reunidas pela pesquisa. Este trabalho analisa estudos científicos sobre palinologia forense indexados na base de dados PubMEd, a fim de delinear um panorama cienciométrico da área. Indicadores bibliométricos das publicações recuperadas foram sistematizados e analisados descritivamente. Análises de estatística textual simples, nuvem de palavras e similitude foram empregadas no corpus gerado com os resumos dos trabalhos, por meio do IRaMuTeQ. A busca recuperou 73 trabalhos, publicados entre 1997 e maio/2022. As palavras mais citadas foram pollen (n = 261) e forensic (n = 144). Os estudos ampliaram-se a partir de 2006, com destaque para P. Wiltshire, autora de 11 trabalhos, e para os jornais Forensic Science International (n = 19), Journal of Forensic Sciences (n = 16), e Science & Justice (n = 8). A pesquisa em palinologia forense está em expansão e pode subsidiar a prática profissional na área criminal.

Introduction

Forensic palynology involves the use of palynomorphs in civil and criminal investigations (Bryant; Mildenhall, 1998). Palynomorphs are distinguished by their acid-resistant organic walls, including any microscopic structure that withstands exposure to hydrochloric acid (HCl), hydrofluoric acid (HF), nitrogen hydroxide oxide (H_2NO_3), and other similarly corrosive substances (Jansonius; McGregor, 1996). As a result, palynomorphs form an artificial phylogenetic group because they are categorized based on the chemical preparation method, which removes carbonate and silicate fragments and concentrates organic matter. This group encompasses dinoflagellates, foraminifera, calcareous nanofossils, radiolarians, diatoms, ostracods, chitinozoans, spores, and pollen grains (Traverse, 2007). Despite forensic palynology's potential within criminal investigations, only a limited number of studies have been conducted to compile, analyze, and discuss the body of evidence generated, in order to enhance real-world professional practice.

Pollen grains are particularly valuable in forensic palynology due to their outer organic wall (exine), which grants them durability and allows for preservation against potential degradation both during and after deposition (Fritzsche, 1837). Additionally, pollen grains exhibit significant mobility (López Sáez et al., 2003), readily adhere to various surfaces (Bauermann et al., 2002), and can be dispersed by pollen rain (López Sáez et al., 2003).

Pollen rain refers to the movement of masses of pollen grains deposited in various environments, primarily influenced by wind direction and intensity (Bauermann et al., 2002). Once the grains are deposited, the local pollen spectrum can be determined, which can be correlated with the biome of the sample's origin and with potential human activities occurring in that area. Thus, human bodies become pollen traps, as pollen grains dispersed in the atmosphere get retained along with airborne particles during routine respiratory activity (Mercuri, 2015; Wiltshire; Black, 2006). In criminal investigations, analyzing palynomorphs obtained from nasal washes, alongside inorganic components of dust and soil, provides valid evidence of events, including the circumstances leading to a victim's death (Wiltshire; Black, 2006). This is because pollen is only released during a plant's flowering period, and the presence of grains in the nasopharyngeal tract can indicate the seasonal period of a particular plant species at the time of death (Szibor et al., 1998). Consequently, pollen grains can establish connections between individuals and locations, whether inhaled or found in contact with hair or other parts of the body (Mercuri, 2015).

Beyond the human body, pollen grains also possess forensic potential in traces and artifacts, spanning from historically classic cases like the studies on the Shroud of Turin (Blessmann, 2010) to more recent cases, such as identifying national and international drug trafficking routes (Said, 2022) or providing evidence in sexual assault cases (Horrocks; Walsh, 1999), among others (Coyle, 2004).

Therefore, correlating pollen grains found on objects or human bodies with those present in the environment underscores the relevance of palynological studies for forensic investigations. An updated overview of scientific research in this field can demonstrate the effectiveness of forensic palynology in various contexts, gathering the best evidence from these investigations, including useful protocols for professional practice. Furthermore, studies on the scientific output in this field (such as literature review, bibliometric or scientometric analyses, etc.) can highlight which research questions remain unresolved and thus guide future scientific investigations.

Fields like scientometrics focus on measuring scientific and technological progress across various disciplines, relying on quantitative assessments and comparative analyses of scientific activity, productivity, and advancement (Silva; Bianchi, 2001). Researchers applying scientometrics use bibliometric data or indicators to quantify the effort, behavior, and societal impact of the sciences (Silva; Bianchi, 2001), employing metrics such as impact factor (IF), h-index, and CiteScore, among others.

In this context, the present study aimed to review the forensic palynology publications available in the PubMed database, conducting a scientometric analysis of these studies to provide an overview of scientific production in the field.

Methods

Database

PubMed, developed and maintained by the National Center for Biotechnology Information at the U.S. National Library of Medicine, part of the National Institutes of Health, was selected for this study. Since its launch in 1996, PubMed has provided free online access to over 34 million citations and abstracts, with daily updates to its data. Full-text articles are typically available via links to the publisher's site or through PubMed Central (PubMed, 2024). We selected this database because of its breadth of content and the availability of access for our research group.

Using PubMed-indexed journals, we filtered publications relevant to forensic palynology by applying the boolean operator AND to narrow the search to specific descriptors. The basic search used the term "forensic palynology," while the advanced search included combinations such as "crime AND palynology," "crime AND pollen," "criminality AND pollen," and "forensic AND pollen." All searches were conducted in three languages (Spanish, English, and Portuguese) with results open to all publication types and years available in the database (1997–May 2022), without additional filters.

Screening Based on PubMed Searches

We reviewed the titles and abstracts of all retrieved studies to assess their relevance to this research. The search for "forensic palynology" yielded a total of 44 studies, from which three were excluded after reading the abstracts due to their lack of relevance, i.e., the articles dealt only superficially with forensic palynology.. In contrast, searches for this descriptor in other languages did not retrieve any studies. Searching "crime AND palynology" resulted in 20 studies that duplicated those from the previous search, while searches using these terms in Spanish and Portuguese retrieved only one duplicate article.

Next, an advanced search using "crime AND pollen" retrieved 41 studies. Of these, eight were excluded for being unrelated to the research topic, and 19 were discarded as duplicates, leaving 14 studies for inclusion. Searches using these terms in other languages resulted in studies that were not relevant to this research. The search for "criminality AND pollen" returned no results. However, searches for these terms in English and Spanish retrieved 27 studies, of which 22 were duplicates, two were out of scope, and three were included in the review.

Searches for "pollen AND forensic" in Portuguese and Spanish yielded no studies. Conversely, using the descriptors "pollen AND forensic" in English retrieved 121 studies. Of these, 59 were duplicates, and 48 were irrelevant to the research aim, leaving 14 studies for inclusion. In total, the searches mentioned across PubMed resulted in 73 studies included in the scientometric analysis.

The data were organized into a spreadsheet for analysis, categorized by the following variables: study title, journal, year of publication, author names, number of authors, article citations within the database, keywords, and the number of keywords.

Using IRAMuTeQ

We compiled a single corpus of abstracts from all studies using LibreOffice for analysis via the IRAMuTeQ software (Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires), a free program developed under open-source principles and licensed under GNU GPL (v2) (Camargo; Justo, 2013). The software operates within the R statistical environment and uses Python (https://www.python.org/). In IRAMuTeQ, the corpus represents the entire textual dataset created by the researcher, while a text is an individual unit within the corpus. In this study, each abstract is treated as a text, and metadata or command lines separate one text from another. The text segment (TS) corresponds to text fragments, which the software processes based on word context (Camargo; Justo, 2013).

For corpus preparation, we used three variables, identified by specific characters, corresponding to the year of publication, journal, and citation count (Table 1). The corpus was processed using the standard 40-character TS mode, as all texts exceeded three lines and were thus classified as long responses. IRAMuTeQ generated textual statistics, a word cloud, and a similarity analysis.

Table 1 – Codes for variables used in the IRAMuTeQ corpus.

Variable_Year	Code
1990–2000	*a_01*
2001–2010	*a_02*
2011–2022	*a_03*
Prior to 1990	*a_04*
Variable_Citation	**Code**
0–3 citations	*cit_01*
4–7 citations	*cit_02*
8–11 citations	*cit_03*
12–15 citations	*cit_04*
16 or more citations	*cit_05*
Variable_Journal	**Code**
Forensic science journals	*per_01*
Health/medical journals	*per_02*
Molecular biology journals	*per_03*
Botany journals	*per_04*
General biology journals	*per_05*

Textual statistics or lexicographical analyses convert texts into textual segments (TS), count the number of words, measure average frequency and hapax legomena, identify active and supplementary forms, and lemmatize terms. This process transforms the lexemes (the set of morphological inflections) of a word into its common base, also known as "reduced forms." Consequently, word clouds visually represent only the frequency of terms in an easily understandable format; the larger the word, the more frequent it is within the corpus (Camargo; Justo, 2018).

Similarity analysis, based on graph theory (Flament, 1981), allows researchers to identify the structure of the corpus representation through co-occurrences and the connectivity between words. Moreover, it recognizes the proximity of segments based on categorical variables (Ratinaud; Marchand, 2012). A graph consists of a set of vertices and edges, where the vertices represent lexical forms, and the edges indicate when and how often one lexical form co-occurs with another within text segments. Initially, each edge connects two vertices, representing their similarity. To establish this correspondence, the software generates a table that highlights the degree of similarity between vertices and applies a maximum spanning tree technique. The vertices connect via edges based on the table's results, eliminating the edge with the lowest similarity value when a triangle of three vertices and three edges, or any closed cycle, appears. This process continues until all closed cycles are eliminated, and the maximum spanning tree is reached.

To enhance similarity analysis, a cutoff point was calculated (2 * number of occurrences / number of forms), which accounts for the significance of the words. This step is necessary because graphs display all analyzed words, resulting in an overloaded and hard-to-interpret tree. The cutoff point thus indicates the minimum frequency a term must reach to be included in the tree. For this analysis, a frequency threshold of 11 was set.

Findings and Discussion

From the 73 studies analyzed (Table 1), eight had no full-text available at the time of the research, so only accessible abstracts were used. Most studies (n = 71) were published in English, with just two originally in Mandarin (Sevillano; Aznart, 2018; Chan et al., 2020), but were translated into English here to standardize writing and analysis. Notably, 24 studies had no internal citations in the PubMed database. Only five works were cited more than nine times, while most publications (n = 44) received between one and eight citations (m = 3.05; SD = 5.79; var = 33.47) (Figure 1, Table 2).

Figure 1. Number of citations per number of articles with focus on forensic science in PubMed.

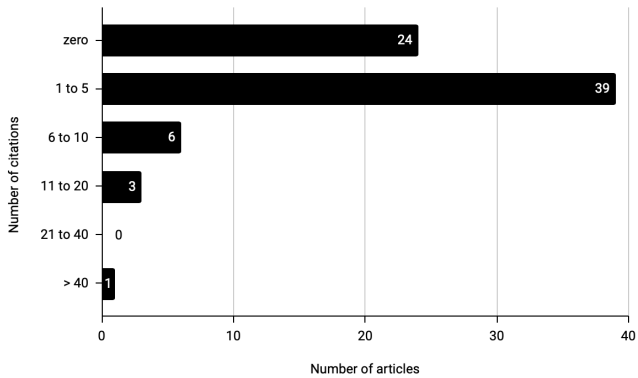
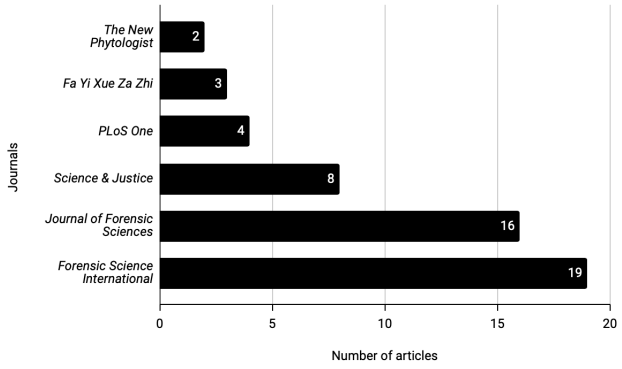


Table 2 – List of studies (n = 73) in forensic science included in the scientometric analysis, retrieved from the PubMed database.

Main Author	Year of Publication	Abbreviated Journal Title	Number of	Number of Cita-	Number of
Alotaibi SS	2020	Saudi J Biol Sci	7	1	5
Arguelles P	2015	Anat Rec	3	4	3
Bağcıoğlu M	2015	PLoS One	3	16	-
Bell KL	2016	Forensic Sci Int Genet	5	18	6
Bell KL	2016	Genome	7	42	6
Bisbing RE	2006	Forensic Sci Rev	2	1	27
Brown AG	2002	J Forensic Sci	3	2	-
Brown AG	2006	Forensic Sci Int	1	4	5
Bryant VM	2006	Forensic Sci Int	2	5	3
Bull PA	2006	J Forensic Sci	3	0	4
Carvalho Á	2013	Forensic Sci Int	7	0	6
Chalfin A	2019	J Health Econ	3	0	5
Chan T	2020	J Forensic Sci	6	1	5
Charlier P	2014	Cardiovasc Pathol	14	1	4
Charlier P	2016	Med Sci Law	10	2	10
Chen YX	2020	Fa Yi Xue Za Zhi	2	0	5
Coyle HM	2001	Croata Med J	4	8	10
Donaldson MP	2010	J Forensic Sci	2	0	7
Donders TH	2014	PLoS ONE	6	3	-
Dunker S	2021	New Phytol	7	6	6
Ezegbogu MO	2021	Sci Justice	1	0	5
Gonçalves AB	2016	PLoS One	7	9	-
Guedes A	2011	Sci Justice	7	1	4
Guo H	2022	J Forensic Sci	8	0	7
Hawksworth DL	2016	Forensic Sci Int	3	0	3
Horrocks M	2001	J Forensic Sci	2	0	-
Horrocks M	2004	J Forensic Sci	1	2	-
Hunt CO	2020	Rev Palaeobot Palynol	2	0	6
Hunter P	2006	EMBO Rep	1	1	-
Kenđel A	2020	Front Plant Sci	2	8	8
Kim KS	2010	J R Soc Interface	4	6	6
Lancia M	2013	J Forensic Sci	6	1	6
Laurence AR	2019	Forensic Sci Int	2	1	6
Liu MY	2019	Fa Yi Xue Za Zhi	5	0	6
Lombardi G	1999	J Forensic Sci	1	0	-
Mathewes RW	2006	Forensic Sci Int	1	1	4
Mildenhall DC	2004	J Forensic Sci	1	1	-
Mildenhall DC	2006	Forensic Sci Int	1	2	7
Mildenhall DC	2006	Forensic Sci Int	1	5	5
Mildenhall DC	2006	Forensic Sci Int	3	5	6
Montali E	2006	Forensic Sci Int	4	4	5
Morgan RM	2006	Forensic Sci Int	4	0	6
Morgan RM	2010	Sci Justice	4	3	7
Morgan RM	2013	Sci Justice	3	3	6
Morgan RM	2014	Sci Justice	4	1	6
Morgan RM	2014	Sci Justice	4	2	6
Novey HS	1997	Am Rev Respir Dis	2	0	-
Piotrowska-Weryszko K	2017	Arch Med Sadowej Kryminol	3	1	5
Punyasena SW	2012	New Phytol	4	11	-
Rawlins BG	2006	J Forensic Sci	7	3	7
Reinhard KJ	2018	J Forensic Sci	3	0	7
Riding JB	2021	Forensic Sci Int	1	0	6
Schield C	2016	Sci Justice	6	2	6
Seidemann RM	2009	J Forensic Sci	3	0	7
Sevillano V	2018	PLoS One	2	8	-
Szibor R	1998	Nature	5	4	-
Tello-Mijares S	2016	Comput Math Methods Med	2	4	-
Uitdehaag SCA	2021	Sci Justice	5	0	8
Walsh KAJ	2008	J Forensic Sci	2	3	4
Wang Z	2021	Food Addit Contam Part A Chem Anal Control Expo Risk Assess	4	3	6
Warny S	2013	Science	1	1	-
Warny S	2020	Forensic Sci Int	4	0	6
Webb JC	2018	Forensic Sci Int	4	3	6
Williams S	2014	J Forensic Sci	4	0	7
Wiltshire PEJ	2006	Forensic Sci Int	1	2	6
Wiltshire PEJ	2006	Forensic Sci Int	1	0	8
Wiltshire PEJ	2006	Forensic Sci Int	2	1	5
Wiltshire PEJ	2014	Forensic Sci Int	4	0	6
Wiltshire PEJ	2015	Forensic Sci Int	4	4	6
Wiltshire PEJ	2015	J Forensic Sci	3	0	9
Wiltshire PEJ	2015	J Forensic Leg Med	3	2	6
Wiltshire PEJ	2016	Fungal Biol	1	1	6
Zhang D-Y	2007	Fa Yi Xue Za Zhi	2	0	–
		Average	3.59	3.05	6.30
		Standard Deviation	2.41	5.79	3.15
		Variation	5.80	33.47	9.89

Among the 27 scientific journals where the reviewed studies were published, only six accounted for more than one publication (Figure 2). Forensic Science International led with the highest number of publications (n = 19), followed by the Journal of Forensic Sciences (n = 16) and Science & Justice (n = 8) in third place. All these journals focus on forensic science and hold recognition within the scientific community, with impact factors (IF) in 2023 of 2.2, 1.6, and 1.9, respectively, according to the Journal Citation Reports (JCR – Clarivate Analytics). The JCR impact factor indicates the average number of citations an article receives in a given journal, calculated by dividing the number of citations received by the articles published in that journal during the two years preceding the evaluation by the total number of articles published by the journal in the current year (Marziale; Mendes, 2002). The articles retrieved from PubMed were published from 1997 to the year of the study (May 2022), with notable peaks in 2006 and 2016, which had 15 and eight listed publications, respectively (Figure 3). Overall, the average number of publications per year equaled 3.17 articles (SD = 3.31; var = 10.97), showing a significant increase and consistency starting in 2013 (m = 4.20; SD = 2.25; var = 5.07) (Table 2).

Figure 2. Listing of the six journals with the highest number of publications with focus on forensic science. indexed in PubMed



Forensic expertise operates within a multidisciplinary framework, addressing problems through interdisciplinary and multisectoral approaches (Fachone; Velho, 2007). This context influences the authorship of the studies. Most studies (n = 59) involved collaboration among up to 14 authors (m = 2.41; sd = 3.05; var = 5.80) (Table 2). Only 14 studies had a single author, while one study included 14 co-authors (Charlier et al., 2014). The three authors with the highest publication counts in this review are: Patricia E. J. Wiltshire, a visiting professor for Geography and Environmental Science at the University of Southampton (n = 11 publications, with 8 as the primary author and 3 as co-author), Ruth M. Morgan, professor of Crime and Forensic Science at University College London (n = 6), and Peter A. Bull, who was an associate professor in Physical Geography, fellow and tutor at Hertford College, University of Oxford (n = 4).

Regarding keywords, 24 of the 73 studies used six descriptors; the others employed between three and 27 (m = 6.30; sd = 3.15; var = 9.89) (Table 2). The term "pollen" appeared as a keyword in 37 publications, either alone or accompanied by adjacent terms such as "pollen analysis," "pollen calendar," "pollen content," and "pollen wall." Excluding "pollen," the most frequently used descriptors were "forensic" (n = 38), "palynology" (n = 34), and "science" (n = 15). Other keywords appeared with a frequency of seven or fewer. This situation is illustrated in the word cloud created from the review (Figure 4).

After analyzing the bibliographic indicators organized in the spreadsheet, we explored the content of the abstracts using IRAMuTeQ software. The textual corpus divided into 415 text segments, with each segment created from every 40 characters. Consequently, the total number of included word occurrences reached 14,958. The total number of word forms amounted to 2,619, alongside 1,326 hapax legomena, which are words that appeared only once. The textual statistics, which constituted the first analysis performed in IRAMuTeQ, solely present the frequency behavior of the words, along with their respective grammatical classes. The software generates a Zipf diagram that illustrates the distribution of word frequencies in the corpus by rank (the order of word occurrence) (Figure 5).

Figure 3. Number of publications with focus on forensic science per year in PubMed. Source: Authors, using the web application Word Cloud Generator, available at https://www.jasondavies.com/wordcloud/. Accessed on May 28, 2024.

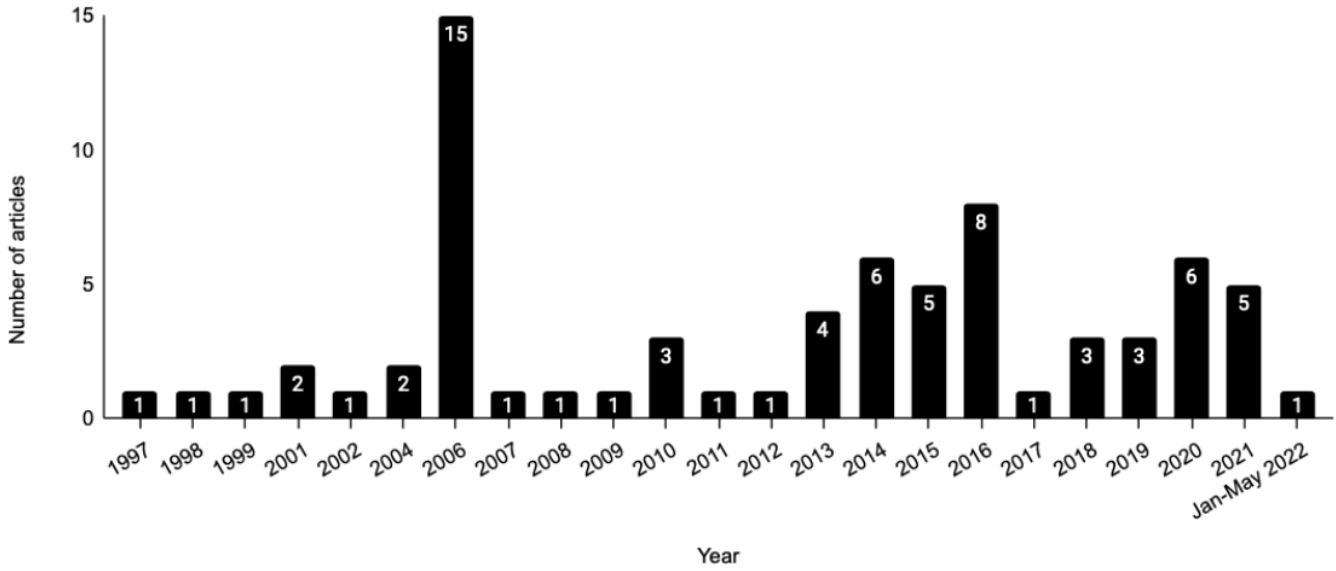
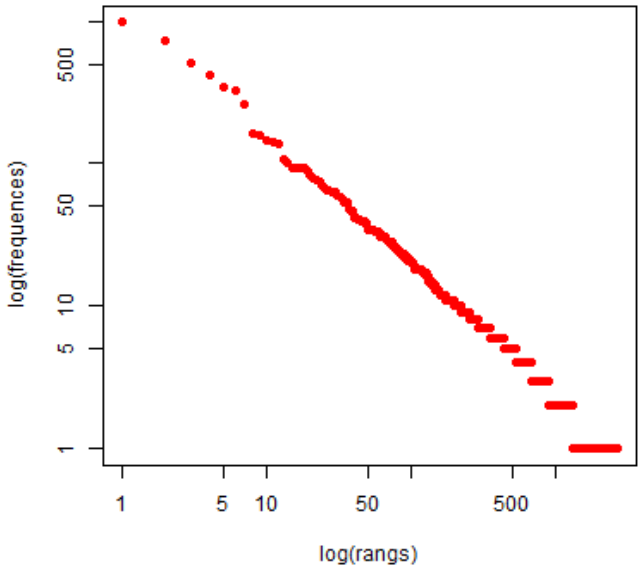


Figure 4. Word cloud generated from keywords of the publications on forensic science in PubMed.

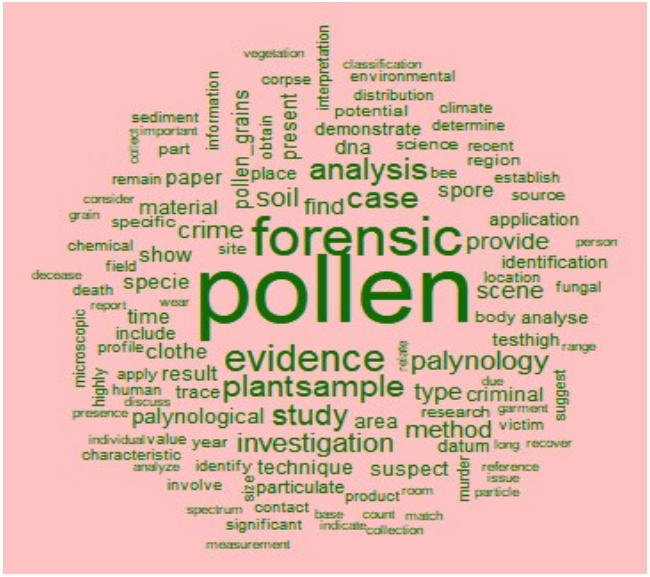
Figure 5. Zipf diagram.



The statistics indicate that the most frequently cited word was "pollen" (n = 261), followed by "forensic" (n = 144), demonstrating that the bibliographic material indeed focuses on the research theme. The word cloud of active forms (Figure 6) further confirms this, as the most prominent terms were "pollen" and "forensic." Following these, the terms "analysis," "case," "evidence," "location," "plant," "sample," and "study" garnered more emphasis than the other words in the textual corpus. Other words that gained visibility in the cloud, with occurrences exceeding 30, included: "palynology," "investigation," "soil," "method," "crime," "provide," "type," "scene," "find," "present," "pollen grains," "spore," "palynological," "show," "result," "clothe," "species," "criminal," "technique," and "area." In this analytical tool, only active forms (verbs, adjectives, nouns, and unclassified words) were utilized since complementary forms did not yield a relevant analysis in the research.

The occurrence of words in the word cloud highlights the focus of the research papers, as the lexical repertoire of a specific topic requires unique terms from the field. In this sense, one can observe that some of the most frequently analyzed words are common in forensic literature, which typically examines or reports on a specific case. Terms such as case, crime, criminal, and scene often appear more

Figure 6. Word cloud generated from active forms in the abstracts of the publications on forensic science in PubMed.



frequently when the study addresses a crime scene, usually in association with more general terms like area and location. Therefore, we infer that most of the works center on forensic case studies.

For the similarity analysis, the software generated a graphic depicting the occurrence of terms, illustrating that larger word sizes indicate greater importance in the discourse (more citations), while thicker lines connecting the words suggest stronger relationships between them (Figure 7). The figure 6 shows two larger communities that are strongly connected by the thickest lines in the tree: one emphasizing the term pollen and the other highlighting forensic. From the pollen community (on the right), it is possible to correlate the most significant words and evaluate the emergence of several smaller communities derived from this one. The same principle applies to the forensic community; however, it includes only two underlying communities.

Considering the forensic and pollen cores, we find that the combination of words with certain similarities can create subcategories. The first community, forensic, unfolds into an area we term investigation, aimed at addressing criminal situations. This subcategory includes terms such as case, field, investigation, material, reference, report, and science. Publications within this grouping exemplify how forensic palynology is called upon to address questions arising from legal demands. The article by Hawksworth et al. (2016) illustrates this scenario, presenting co-occurrences of terms from this category while describing ten case study examples in which rarely reported or unusual spores proved crucial in criminal investigations (Hawksworth et al., 2016).

Within the forensic community, two categories emerge from the broader context. The first contains terms such as criminal, identify, involve, murder, and significant, while the second includes descriptors like evidence (a key co-occurrence term), collection, interpretation, provide, trace, and value. The lexicographic set of both communities suggests an investigative perspective. Familiarity with the textual corpus reveals that these terms indicate the resolution of specific facts based on palynological traces, emphasizing the application of palynomorphs in forensic contexts.

In the second community, labeled as pollen, the lexical forms indicate that the co-occurrence of this term aligns more closely with a set of words related to methodology, such as method, technique, and sample, as well as more general descriptors like body, characteristic, classification, count, distribution, identification, microscopic, potential, scene, size, specific, study, and test. Together, these terms refer to the study of pollen grains within the context being examined, that is, in relation to the location, objects, and samples involved.

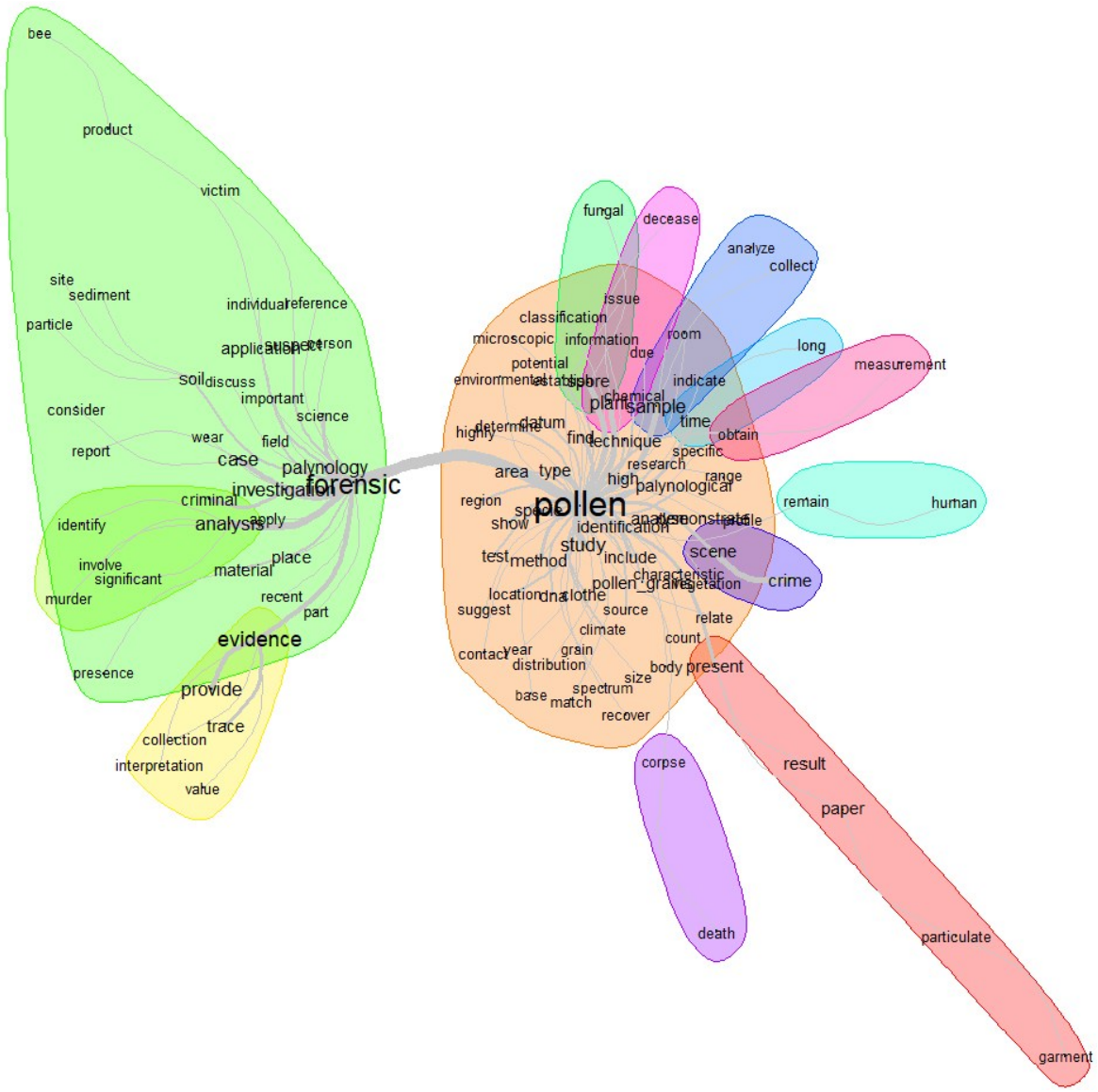
Unlike the forensic group, which contains two subcategories, the pollen group includes nine subcommunities. The first group, marked in green, at the 12 AM position, presents the following terms: fungal, classification, information, establish, and spore. The second group, highlighted in pink and positioned to the right of Group 1 in a clockwise direction, comprises the lexical forms: decease, issue, due, plant, and chemical. Subsequently, from the third to the ninth group, in a clockwise direction, the gathered forms are as follows: Group 3 (analyze, collect, room, indicate, and sample); Group 4 (time and long); Group 5 (obtain and measurement); Group 6 (remain and human); Group 7 (scene and crime); Group 8 (present, result, paper, particulate, and garment); and Group 9 (corpse and death).

Among the mentioned subcommunities, Group 7 exhibits the greatest similarity with the pollen community, as they connect in the tree with the thickest branch. Consequently, we observe that the terms in Group 7 co-occur with the term pollen in 20 abstracts of research papers. Among the 20 abstracts corresponding to Group 7, which encompass all forms of co-occurrence, 15 were published in forensic journals; three in general biology journals; one in a molecular biology journal; and one in a health/medicine journal. Group 9 presents semantically similar terms to Group 7, with this set represented in three abstracts from the text corpus, all published in forensic journals, and two of these are also included in Group 7. Therefore, the proximity of the narratives from the subcommunities within the pollen community likely relates to the same studies.

Conclusion

Forensic palynology represents an area of growing legal interest, necessitating continuous updates in the relevant knowledge base. This study identified 73 publications on the topic within the PubMed database, showing a more consistent quantitative evolution starting

Figure 7. Similarity analysis on forensic palynology from articles retrieved from PubMed.



from 2013. The scientometric analysis also revealed a collaborative profile within the field, indicated by an average number of authors per publication exceeding three, as well as a diversification across 27 journals that highlight the generated scientific output.

By enabling analyses that integrate both quantitative and qualitative levels, IRAMuTeQ provided a rapid overview of the arguments present in the abstracts of the studies reviewed in this work, delivering succinct information about a large dataset. The studies in forensic palynology generally focus on research and reports of real cases, reinforcing the applicability of the informational content they gather in real contexts.

Thus, the data presented here outline the landscape of research in forensic palynology based on the PubMed database. While limiting the search to a single database may be recognized as a constraint of the study, it also opens avenues for future investigations in other databases, such as Scopus and Web of Science, to broaden the scientometric and informational panorama surrounding research in forensic palynology. Consequently, the forensic professional field can benefit from scientific insights on how forensic palynology can contribute to various investigative fronts in the real world.

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Authorship Contributions

Conceptualization: ASS, JSN. Data curation: ASS. Formal Analysis: ASS. Investigation: ASS. Methodology: ASS, JSN. Project administration: ASS. Resources: ASS. Software: ASS. Supervision: JSN. Validation: ASS, JSN. Visualization: ASS, JSN. Writing – original draft: ASS. Writing – review & editing: JSN.

Conflict of Interest

The authors declare that there are no conflicts of interest to report.

Data Availability

The complete set of data analyzed during the current study are presented in the body of the manuscript.

Ethical Compliance

We, the authors, declare that we used the ChatGPT chatbot, a generative Artificial Intelligence developed by OpenAI using neural networks, solely to translate a preliminary version of this manuscript from Brazilian Portuguese to American English. We carefully reviewed the final version submitted to the journal and take full responsibility for the content presented herein.

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