Mapping the Calliphoridae Evidence Base for Post-Mortem Interval (PMI) Estimation: A Bibliometric Study

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Abstract: Research on post-mortem insects became increasingly significant in forensic science, particularly in determining the post-mortem interval (PMI). Within forensic entomology, the family Calliphoridae has emerged as a reliable taxon due to its consistent developmental patterns. Bibliometric analysis provides a systematic approach to evaluating scientific output, identifying global trends, and mapping collaborative networks in this field. This study presented a comprehensive bibliometric analysis of 625 publications indexed in Scopus up to 2025, comprising 624 journal articles and one book, with a specific focus on Calliphoridae and PMI estimation. The results revealed a significant growth in publications in recent years, with the United States (122), Brazil (62), and China (60) emerging as the most productive countries. Leading journals contributing to this field include Forensic Science International (134), Journal of Medical Entomology (89), and Journal of Forensic Sciences (80). Dominant keywords such as "forensic entomology," "postmortem interval," "Calliphoridae," "Diptera," and "larva" reflected the research focus on species identification, larval development, and forensic applications. Collaboration analysis highlighted strong international networks, with key contributions from institutions such as Goethe-Universität Frankfurt am Main (Germany) and Soochow University (China). The disciplinary distribution showed Medicine (506) as the leading field, followed by Agricultural and Biological Sciences (152), and Biochemistry, Genetics, and Molecular Biology (109). Overall, these findings provided a comprehensive mapping of the development of forensic entomology research, and indicated a trend toward integrating molecular approaches, insect growth analysis, and practical applications in forensic investigations.

1 INTRODUCTION

Forensic entomology has become an indispensable discipline in modern forensic science, bridging the natural sciences with criminal investigation. This field applies the biological study of arthropods, particularly insects to legal contexts, especially in determining the post-mortem interval (PMI), or the time elapsed since death. Among the numerous insect taxa associated with decomposing remains, the family *Calliphoridae* (commonly known as blow flies) has emerged as one of the most significant groups for PMI estimation due to their predictable developmental cycles and early colonization behavior (Sukontason et al., 2022).

Blow flies are typically the first insects to arrive at a decomposing body, laying eggs on natural body openings or wounds shortly after death. The growth and development of their immature stages (egg, larva,

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pupa) are highly influenced by temperature and environmental conditions. Consequently, the species composition and developmental rate of *Calliphoridae* provide critical clues for reconstructing the time since death. These features have made them the cornerstone of entomological evidence in forensic casework around the world (Marchiori, 2022).

Over time, the role of *Calliphoridae* in forensic investigations has evolved from purely descriptive species identification to the integration of experimental, ecological, and molecular approaches. Early works focused on life cycle documentation, while contemporary research now explores thermal summation models, DNA barcoding, microbial interactions, and environmental factors that influence colonization dynamics. This reflects a paradigm shift toward a more quantitative, standardized, and interdisciplinary form of forensic entomology (Szpila et al., 2024).

Despite the rapid expansion of literature in this domain, there remains a lack of comprehensive bibliometric mapping that evaluates how this body of research has developed globally. Bibliometric studies are essential for identifying publication trends, key contributors, collaboration networks, and emerging research themes. Such mapping not only highlights the scientific growth of a discipline but also guides future directions by revealing underexplored areas and potential international partnerships (Kiraz and Özdemir, 2021) .

Therefore, the present study applies a bibliometric framework to systematically assess research on *Calliphoridae* related to PMI estimation. Specifically, it aims to identify the evolution of scientific output, leading countries and journals, thematic research patterns, and collaborative structures. By examining over six hundred publications indexed in the Scopus database, this study provides a quantitative foundation for understanding how *Calliphoridae* have shaped and continue to advance forensic entomology globally (Wiraagni et al., 2024).

2 METHODS

This study adopted a bibliometric approach to analyze the global research landscape on *Calliphoridae* and their role in post-mortem interval (PMI) estimation within forensic entomology. Bibliometric analysis is a quantitative method that enables the evaluation of publication trends, research productivity, and intellectual structures within a scientific field (Lazarides et al., 2025). It allows for the identification of influential authors, leading institutions, and thematic evolutions over time, providing a comprehensive overview of how knowledge develops across disciplines.

All bibliographic data were retrieved from the Scopus database, chosen for its wide coverage of peer-reviewed scientific publications and detailed citation metadata. Scopus was considered suitable for this purpose because it encompasses both international and regional journals relevant to forensic entomology, including works on insect ecology, developmental biology, and applied forensic sciences. The database also facilitates standardized metadata exportation required for bibliometric visualization.

The search strategy was designed to capture all documents related to *Calliphoridae* and PMI estimation. To achieve this, a combination of keywords and Boolean operators was used, specifically: (“forensic entomology” OR “postmortem interval” OR “PMI” OR “Calliphoridae” OR “blow flies” OR “Diptera”) The search was conducted within titles, abstracts, and keywords to maximize the inclusiveness of relevant literature. Only documents published up to the year 2025 were considered, and the language filter was restricted to English to ensure international comparability. To maintain academic rigor, only journal articles and books were included, while other types such as conference proceedings, editorials, and notes were excluded.

The initial search retrieved a total of 625 records, consisting of 624 journal articles and 1 book. Data extraction was performed on May 11, 2025. Each record was manually screened to confirm its relevance to forensic entomology and Calliphoridae. No duplicates or irrelevant entries were detected, indicating that all documents matched the search criteria.

After refinement, the dataset was exported in Microsoft Excel (.xlsx) format for data cleaning and organization. Descriptive analyses were conducted to identify publication trends by year, country of origin, and journal source. Additionally, keyword frequency analysis was used to determine dominant research topics and recurring thematic areas within the literature. To improve the strength of the bibliometric analysis, visualization and network mapping were done with VOSviewer software. This tool allowed for the creation of co-authorship, keyword co-occurrence, and country collaboration networks. These networks help in better understanding the relationships within the dataset. Using VOSviewer works well with

descriptive statistical analysis by offering graphical representations of scientific structures. This enhances the analytical depth of the study.

3 RESULT AND DISCUSSION

The bibliometric analysis revealed a total of 625 publications related to *Calliphoridae* and post-mortem interval (PMI) estimation, encompassing 624 journal articles and 1 book indexed in Scopus up to 2025. The results demonstrate that research involving necrophagous insects particularly blow flies has undergone steady and significant growth over the past several decades, reflecting the increasing importance of forensic entomology as a scientific and investigative discipline (Zhai, 2024).

A clear upward trend in publication frequency was observed, especially within the last ten years. This growth coincides with the global expansion of forensic science programs, the increased availability of molecular and imaging technologies, and the standardization of insect developmental data in various climatic zones (Figure 1).

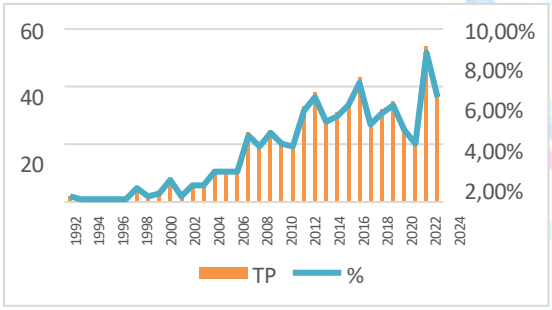

Fig. 1 Graph of publication trend from 1992 – 2025

The trend also signifies a gradual transition from localized, descriptive studies to global, data-driven investigations that emphasize reproducibility and standardization. This transformation reflects the broader evolution of biological sciences toward more interdisciplinary and evidence-based practices, where molecular tools, ecological modeling, and quantitative analytics increasingly guide scientific inquiry. As forensic entomology becomes more integrated with modern biological and forensic frameworks, research outputs naturally shift toward methodologies that offer stronger precision, comparability, and global relevance (de Melo Silva et al., 2024).

Within this broader developmental trajectory, the publication pattern from 2020 to 2022 presents a noticeable disruption. The sharp decline during these years aligns closely with the global impact of the COVID-19 pandemic, which profoundly affected scientific productivity across disciplines. Restrictions on laboratory access, the suspension of field experiments, limitations on human and material mobility, and the reallocation of institutional resources toward pandemic-related priorities collectively hindered the progress of entomological research. Forensic entomology, which relies heavily on controlled insect rearing, decomposition trials, and seasonally dependent field sampling, was particularly vulnerable to these constraints, resulting in the temporary stagnation reflected in the publication trend. As global conditions stabilized, the significant rise in publications observed in 2024 demonstrates the field's rapid recovery and renewed momentum. The reopening of laboratories, reinstatement of field activities, and revival of previously halted projects allowed researchers to resume and expand their work.

The distribution of publications across countries revealed that research activity is both geographically diverse and globally interconnected (Figure 2).

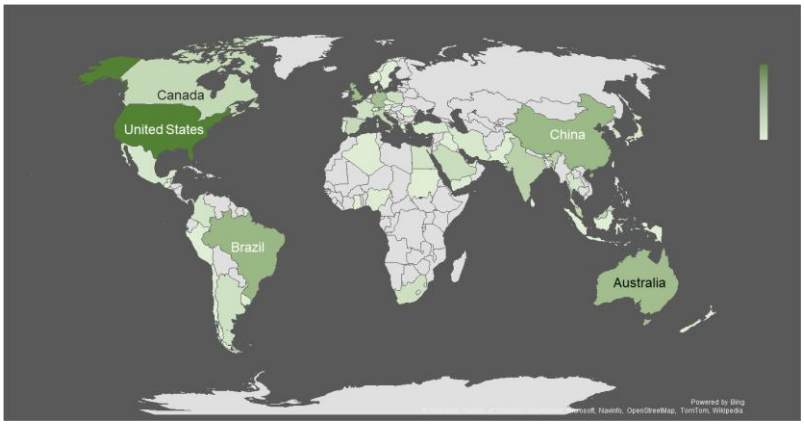

Fig. 2 World Distribution of the research.

The United States, Brazil, and China emerged as the most productive contributors, reflecting not only research capacity but also ecological diversity. The dominance of these three nations demonstrates a balance between long-established forensic institutions in the United States and rapidly developing research infrastructures in emerging economies (Wang et al., 2021). The involvement of tropical and subtropical countries such as Brazil also enriches the ecological understanding of blow fly species, which are often region-specific and influenced by environmental variables such as temperature and humidity (Silva, et al., 2023). This diversity contributes significantly to refining PMI estimation models applicable to various climatic conditions and also indicates that future progress in forensic entomology may rely more on geographically diverse datasets instead of just data from temperate regions. (Guimarães et al., 2022).

In addition to national productivity, the results also highlight the concentration of publications in a limited number of high-impact journals. The majority of studies were published in *Forensic Science International*, *Journal of Medical Entomology*, and *Journal of Forensic Sciences*. These journals act as the central channels for disseminating entomological and forensic knowledge, bridging applied and fundamental research (Table 1).

Table 1. Top 10 most active journal

Source Title	TP	%
Forensic Science International	134	21.44
Journal of Medical Entomology	89	14.24
Journal of Forensic Sciences	80	12.80
Forensic Science Medicine and Pathology	14	2.24
Journal of Forensic and Legal Medicine	14	2.24
Insects	12	1,92
Tropical Biomedicine	12	1.92
Egyptian Journal of Forensic Sciences	10	1.60

The recurring publication of *Calliphoridae*-related studies in these outlets underlines the interdisciplinary character of forensic entomology, one that integrates biological observation, field experimentation, and legal application. It also reflects the field's increasing academic legitimacy and institutional recognition within forensic sciences (Buelvas et al., 2024).

The keyword analysis provides further insight into thematic developments within this body of literature. The most frequent keywords such as *forensic entomology*, *postmortem interval*, *Calliphoridae*, *Diptera*, and *larva*, represent the fundamental components of the field (Table 2).

Table 2. Ten most searched keywords

Keywords	TP	%
Forensic Entomology	495	79.20
Animals	401	64.16
Animal	373	59.68
Diptera	371	59.36
Article	349	55.84
Calliphoridae	303	48.48
Larva	277	44.32
Nonhuman	263	42.08
Forensic Science	229	36.64

International Journal of Legal Medicine	55	8.80
Medical and Veterinary Entomology	16	2.56
Postmortem Changes	217	34.72

Calliphoridae, and *larva* shows that most studies continue to focus on identifying blow fly species and understanding how their growth can be used to estimate the post-mortem interval (PMI). These keywords remain dominant because they represent the fundamental components of insect-based forensic work, especially the developmental patterns of Diptera, which are still the most reliable indicators for PMI estimation (Bambaradeniya et al., 2023). While high-frequency keywords show the basic structure of the field, their continued presence suggests a saturation in main research themes. However, the rise of terms related to molecular identification, environmental factors, and developmental modeling points to a slow broadening of research focus. This pattern reflects a growing discipline that is moving beyond simple descriptive studies to tackle more complex and interconnected scientific questions.

The presence of broader terms, especially "animals" is largely due to how databases classify scientific articles. Because insects belong to the kingdom *Animalia*, many journals and indexing systems automatically attach the keyword "animals" to any zoological study. This makes the term appear frequently even when the articles specifically discuss blow flies. Likewise, the consistent appearance of "Diptera" reflects the central role of true flies in forensic investigations, since most PMI-related studies involve species such as *Lucilia sericata*, *Chrysomya rufifacies*, and *Calliphora vicina* (López-García and Martín-Vega, 2025).

The recurring keywords also reflect the growing focus on larval growth, temperature effects, and environmental influences, topics that have become increasingly important in recent validation studies. Research conducted in the last decade has shown that variables such as rearing temperature, humidity, and substrate type can significantly affect larval development and oviposition behavior, leading to differences in PMI estimates (Rusch et al., 2025). Many regions still rely on morphology because it is simple and accessible, but more recent publications highlight the rising use of DNA-based identification and temperature-dependent development models to improve precision. This demonstrates a gradual shift from basic descriptive studies toward more standardized and analytical approaches in forensic entomology.

The frequent appearance of keywords such as *forensic entomology*, *postmortem interval*, *Diptera*,

In summary, the results of this bibliometric study demonstrate a dual pattern of growth: an expansion in research volume and a deepening of methodological sophistication. The sustained dominance of *Calliphoridae* as the principal model organism for PMI estimation reinforces their indispensable role in forensic practice. At the same time, the emergence of new analytical methods signals the ongoing modernization of forensic entomology as a data-driven discipline (Bedair et al., 2025).

4 CONCLUSIONS

This bibliometric analysis provides a structured overview of research on *Calliphoridae* and their role in post-mortem interval (PMI) estimation within forensic entomology. The study of 625 publications indexed in Scopus up to 2025 revealed a steady increase in scientific output over the past decade, demonstrating the growing global attention toward insect-based forensic analysis. This upward trend reflects the integration of entomological data into forensic practice and the establishment of *Calliphoridae* as a key model for PMI estimation. The findings highlight a methodological evolution from traditional morphological approaches to the incorporation of molecular tools, developmental models, and quantitative analysis. Research is now characterized by stronger interdisciplinary collaboration and broader geographic participation, led by countries such as the United States, Brazil, and China. The concentration of publications in leading journals also signifies the academic maturity and international recognition of forensic entomology as a data-driven science. Even in silence, insects remain nature's most objective witnesses, preserving the truth of time when all else fades.

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