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Bibliometric Analysis of Magnetic Resonance Imaging in Feline Anatomy from 2010 to 2024

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ABSTRACT

Magnetic Resonance Imaging (MRI) is a sophisticated diagnostic tool that allows for detailed imaging of feline anatomy, particularly the neurological and musculoskeletal systems. This study aimed to evaluate research trends, productivity, and global contributions in feline MRI between 2010 and 2024 using bibliometric analysis. Using the Web of Science database, we identified original articles on cat (*Felise catus*) MRI published between 2010 and 2024. Bibliographic data, citation information, keywords, citation networks, and co-citation patterns were extracted and analyzed using the VOSviewer program and Bibliometrix R package. A total of 971 articles were retrieved, with these articles accumulating 13.351 citations (12.943 of which were self-citations). In 2024, the study recorded the highest number of citations (2.089), with an h-index (Hirsch index) of 56.USA emerged as the leading country in terms of publications (n = 320), with research contributions from 62 countries in total. English was the predominant language of publication. The most active research area was Veterinary Sciences (n = 523), followed by significant contributions from other disciplines. Wiley was the most prolific publisher (n = 232), while *Veterinary Radiology Ultrasound* published the most articles (n = 72). Analysis indicates a steady increase in cat MRI publications and a concentration of contributions in specific countries and journals. The findings highlight the growing importance of MRI in veterinary anatomy and emphasize the need for broader international collaboration to advance clinical and research applications.

This bibliometric analysis shows a steady increase in publications and citations in the field of feline magnetic resonance imaging (MRI) between 2010 and 2024, with studies largely concentrated in the US and within specific journals and publishing houses. The findings highlight the growing importance of MRI in veterinary anatomy and clinical practice, and the need for broader international collaboration.

Keywords: Bibliometrics, Cat, Feline, *Felise catus*, Magnetic Resonance Imaging

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INTRODUCTION

Magnetic resonance imaging (MRI), a multiplanar imaging method, is increasingly used for research in both medical and veterinary fields due to its sensitivity to soft-tissue detail and its non-invasive nature. MRI devices are primarily classified into three categories based on magnetic field strength: low-field (LF), intermediate-field (MF), and high-field (HF). HF-MRI scanners are used to obtain high-precision images of body tissues. LF-MRI devices are more widely used in veterinary medicine [1,2].

MRI applications in cats (*Felis catus*) span a wide range, from the detailed description of typical anatomical structures to the characterization of neurological, orthopedic, and oncological pathologies. Technological advances, particularly the introduction of high-resolution (e.g., 3T) devices, have enabled the in vivo imaging of subtle anatomical structures previously detectable only in postmortem studies [3,4].

Systematic documentation of cat anatomy using MRI and reference atlas studies in clinical practice and research is advancing rapidly due to technological advancements. The clinical anatomy atlas, published by reconstructing brain structures and describing typical morphological structures in slices obtained using a 1.5 T device and appropriate sequences, provides a practical reference for clinicians [5]. Such atlases serve as essential references for visualizing neurological examination findings and as a basis for future studies[6].

MRI is valuable not only in neuroanatomy but also in defining the musculoskeletal system. Analysis of the cat hip joint using both low- and high-field MRI images has been conducted to examine muscle, ligament, and neural structures. Differences in image quality and contrast between LF-MRI and HF-MRI have highlighted the limitations of its clinical applicability [2,7].

Despite this proliferation of diverse and interdisciplinary literature in the field, a comprehensive bibliometric synthesis of the quantitative production, geographic distribution, author/institution concentrations, magnetic field strength, and sequence profiles, main thematic clusters, and citation impact of cat anatomy-MRI publications spanning the period 2010–2024 has not yet been systematically published. Bibliometric approaches provide a historical and conceptual map of a field by quantitatively analyzing indicators such as publication counts/citation trends, the most productive and influential authors and institutions, collaboration networks, keyword evolution, and co-citation/co-occurrence thematic clusters. For this purpose, both data extraction from indexes such as Web of Science, Scopus, and PubMed, and network analysis and thematic mapping using tools such as VOSviewer and Bibliometrix (R), are recommended [8].

This article presents a bibliometric assessment of studies using MRI in the context of cat anatomy published between 2010 and 2024. The prominent objectives are to: (1) describe annual publication and citation trends; (2) identify the most productive authors, institutions, and countries; (3) identify main thematic clusters (neuroanatomy, orthopedics/musculoskeletal, oncology, morphometry, imaging methodologies, etc.) and their evolution over time; (4) identify trends and gaps in terms of magnetic field strengths, sequence types (e.g., T1, T2, FLAIR, 3D MPRAGE), and in vivo versus post-mortem approaches used; (5) draw directional inferences regarding intra-field collaboration networks and citation impact. For these purposes, literature will be collected from primary data sources, such as Web of Science Core Collection, Scopus, and PubMed using keyword and Boolean strategies. Software, including Bibliometrix and VOSviewer, will be used for bibliometric analysis. Indicators sought will include production (year, journal), impact (citation count, h-index), co-authorship, co-citation, keyword co-occurrence, and thematic map/evolution [8].

The anticipated contributions include providing a historical and thematic map of MRI research in feline anatomy, highlighting research gaps and standardization needs by documenting methodological heterogeneity, and identifying priority collaboration partners for researchers and clinicians. We believe this comprehensive map will be a valuable resource for developing reference resources for clinical practice and for planning future research programs.

METHODS

Research Design and Search Methodology

The bibliometric analysis method was employed to conduct a bibliographic review, a retrospective study. The Web of Science Core Collection (WoSCC) electronic database, which provides a comprehensive and consistent collection of data for export and is widely used by scholars, was utilized to construct the literature dataset. The WoSCC has a long history of being a trustworthy source for biomedical research, providing a strong and dependable foundation for research that serves as the primary data source for this study. Its capacity to give thorough citation data was highlighted.

Data Collection

Magnetic resonance imaging" or "MR imaging" or "MRI" AND "cat" or "cats" or "feline" (Topic) were used as search terms to retrieve data. To eliminate bias and account for the frequent updates of the WoSCC database, the literature search

was conducted in a single day (October 2, 2025). The search was undertaken from 2010 to October 2nd, 2024. Since the year 2025 had not yet ended at the time of the screening, articles from 2025 were not included in the study.

Standards for Study Selection

A thorough search of the WoSCC using the terms Magnetic resonance imaging" OR "MR imaging" OR "MRI" AND "cat" OR "cats" OR "feline" (Topic) yielded a total of 1.395 items. The year 2025 was then excluded from the analysis due to a lack of comprehensive data, resulting in a total of 1,305 findings. The search was then narrowed by excluding review articles, case reports, editorial material, notes, meeting abstracts, proceeding papers, letters, book chapters, and corrections from the document types tab, resulting in 1.136 hits. The Science Citation Index Expanded Index was used, producing a total of 971 results. The titles and abstracts were then reviewed, yielding a total of 971 results, as shown in **Table 1**.

Table 1. *Search Algorithm*

Search Criteria	Result Count
Initial search	1.395
After excluding articles published in 2025	1.305
After selecting the document type	1.136
WOS Index (SCI) type	971

Network Analytics

This bibliometric study used VOSviewer (version 1.6.10, Leiden University, The Netherlands) and the Bibliometrix R package [9,10] to import data and identify trends, collaborations, and notable findings. Furthermore, the software was used to collect and review data related to authorship, linkages, keywords, citations, and thematic words.

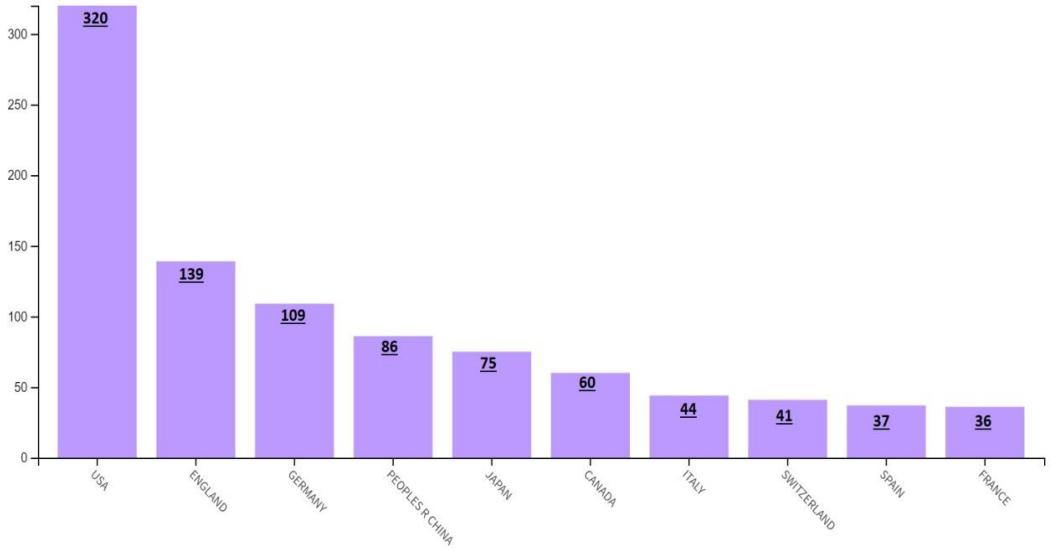

Figure 1. *Top ten most efficient countries*

Data Collection

The data, considered essential and extracted in plain text format, included record titles, publication years, names of the journals in which the research papers were published, author names, keywords, names of the institutions with which the authors were affiliated, and countries of origin. The total number of articles and citations retrieved from the WoSCC database was considered in the analysis. The WoS publications were saved as TXT files and then exported to Microsoft Office Excel 2019 (Los Angeles, CA, USA) for additional analysis. The program aided in the analysis of keywords, co-occurrences, citations, co-authorship, and co-citations.

RESULTS

Publications in nine languages were created during the study period, which lasted from 2010 to 2024. The most commonly used language was English (**Table 2**).

Table 2.The languages in which articles have been published.

Languages	Total number of publications	% of 97
English	942	97.01%
German	12	1.24%
Portuguese	4	0.41%
Hungarian	3	0.31%
Polish	3	0.31%
Spanish	3	0.31%
Turkish	2	0.21%
Czech	1	0.10%
French	1	0.10%

A total of 62 countries were published between 2010 and 2024. **Figure 1** shows the ten countries with the most publications.

Over the course of the study, which ranged from 2010 to 2024, 73 independent research areas were discovered. **Table 3** shows the most intensively explored areas.

Between 2010 and 2024, a total of 1,349 affiliations were published. The institutions/organizations associated with the ten journals with the most publications are shown in **Figure 2.**

Between 2010 and 2024, ten entries were detected, representing 107 different publishers. **Table 4** lists the most prolific publishers.

A total of 228 articles have been published on the topic. **Table 5** includes the 10 journals with the most publications.

The articles evaluated yielded a total of 13.351 citations (12.943 of which were self-citations), for an average h-index of 56. It is notable that 2022 had the greatest number of publications (86), while the biggest number of citations were made in 2024 (2.089). (**Figure 3**).

Our bibliometric study revealed the most commonly used keywords, as shown in **Figure 4.** The font size of the keywords was found to be closely proportional to their frequency of recurrence in articles.

Table 3. Most active research areas

Research Areas	Total number of publications	% of 97
Veterinary Sciences	523	53.86%
Neurosciences Neurology	171	17.61%
Radiology, Nuclear Medicine Medical Imaging	79	8.14%
Science Technology Other Topics	47	4.84%
Chemistry	30	3.09%
Engineering	28	2.88%
Biochemistry Molecular Biology	21	2.16%
Materials Science	21	2.16%
Anatomy Morphology	20	2.06%
Zoology	20	2.06%

Showing first 10 out of entries

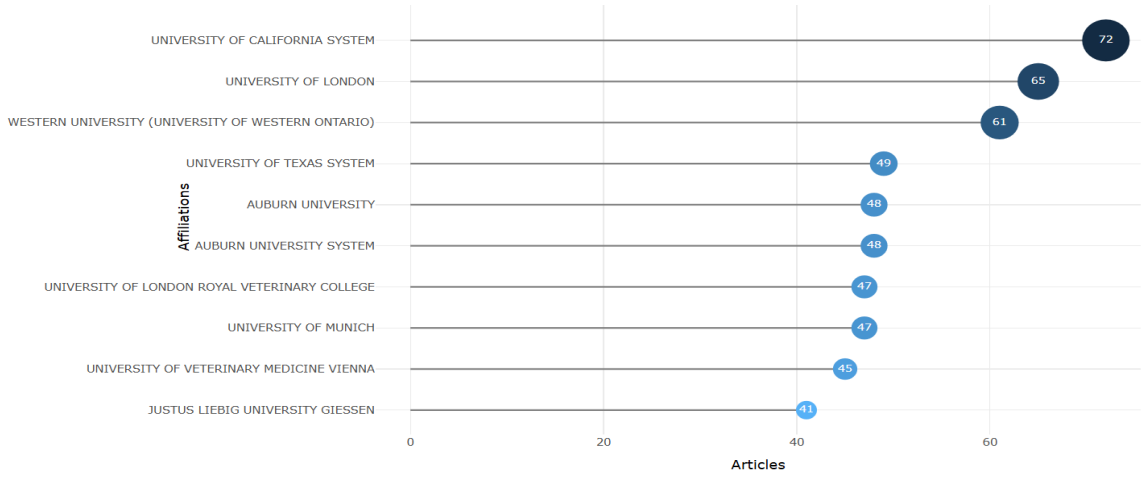

Figure 2. Institutions/organizations affiliated with the ten journals with the most publications

In the network representation of bibliographic coupling between nations, the size of the bubbles was proportional to the volume of research undertaken in each country. The width of the lines joining countries shows the degree of their coupling, whereas the line colors represent the cluster to which each country has been assigned. For this study, we included at least one document and ten citation from each country (**Figure 5**).

Figure 6 depicts the associations between authors who have received at least three citations.

DISCUSSION

MRI is a non-invasive imaging modality widely used to evaluate musculoskeletal soft tissues and identify various pathological patterns (edema, fatty infiltration, atrophy, and masses). The technique relies on the behavior of hydrogen protons in tissues in response to magnetic fields and radiofrequency energy, and converts these behavioral differences into high-contrast grayscale anatomical images. Despite this superiority in soft tissue resolution, the primary indication for MRI in veterinary practice is the diagnosis of intracranial and spinal diseases [11,12].

Gravitational analysis has revealed that the MRI literature clusters along two distinct research axes, depending on magnetic field strength. Low-field systems (0.2-0.5 T) hold a prominent place in the research landscape due to their widespread availability and clinical accessibility. In comparison, high-field systems (≥ 3 T) have gained a dominant position in basic scientific research due to their superior spatial resolution and microanatomical detail [2]. This dual structure highlights the need for a balance between clinical applicability and scientific detail.

This study conducted a bibliometric analysis of MRI studies on cat anatomy published between 2010 and 2024, comprehensively assessing the field's development, thematic trends, and scientific productivity dynamics. A review of studies conducted between 2010 and 2024 revealed a steady increase, with a further rise after 2020. This demonstrates that research on the use of high-resolution MRI systems in cats remains relevant and that advances are being made in this field. Accordingly, it can be predicted that MRI systems will be used to diagnose various diseases in cats in the years to come. For example, MRI systems can be used to distinguish between different metabolic/neurodegenerative encephalopathies in cats [13]. Similarly, low-field MRI could be used to image the palatine tonsils in cats [14]. In conclusion, we believe that the use of MRI in the diagnosis of feline diseases is expected to increase in the coming years.

Recent scientific literature has witnessed a significant increase in MRI studies of cat anatomy. Studies that make substantial contributions to the field [15,16] confirm this growing interest and provide valuable guidance for researchers entering the field. The primary objective of the present study is to systematically present global trends, prominent research foci, geographic concentrations, and collaboration networks in the field. Furthermore, gaps in the existing literature are identified by analyzing leading authors, publications, and journals in the field, and potential directions for future research are suggested.

The distribution of the 971 articles analyzed by language reveals the absolute dominance of English in scholarly communication. Accounting for 97.01% of publications (942

articles), English stands out as the universal language in the field. The contribution of other languages is quite limited, with German in second place with 12 articles (1.24%), followed by Portuguese (4 articles, 0.41%), Hungarian, Polish, and Spanish (3 articles each, 0.31%). Turkish is represented by two articles (0.21%), while Czech and French are represented by one article each (0.10%). This distribution confirms the indispensable role of English in international academic

Table 4. Most prolific publishers

Publishers	Total number of publications	% of 97
Wiley	232	23.89%
Elsevier	151	15.55%
Springer Nature	79	8.14%
Frontiers Media Sa	75	7.72%
Sage	61	6.28%
Amer Veterinary Medical Assoc	36	3.71%
Mdpi	26	2.68%
Japan Soc Vet Sci	19	1.96%
Amer Animal Hospital Assoc	16	1.65%
Public Library Science	15	1.55%

Showing first 10 out entries

Table 5. Journals publishing the most articles

Journals	Total Records	% of 97
Veterinary Radiology Ultrasound	72	7.41%
Frontiers In Veterinary Science	46	4.74%
Journal of Feline Medicine And Surgery	43	4.43%
Journal of Veterinary Internal Medicine	42	4.32%
Neuroimage	29	2.99%
Javma Journal of The American Veterinary Medical Association	27	2.78%
Journal of Veterinary Medical Science	19	1.96%
Journal of Small Animal Practice	17	1.75%
Journal of The American Animal Hospital Association	16	1.65%
Plos One	14	1.44%

Showing 10 out of entries

visibility and impact, while also demonstrating that publications in other languages contribute to the local knowledge base within the field.

Between 2010 and 2024, 62 countries/regions published in the field of feline MRI anatomy. Figure 2 shows the top 10 countries by the number of publications. The United States is the clear leader with 320 publications. China leads with 199 publications, followed by the United Kingdom with 86, Japan with 75, Brazil with 60, Germany with 44, South Korea with 41, India with 37, Italy with 36, Turkey with 35, and France with 33. This distribution demonstrates that research activity in the field is geographically diverse, but the United States holds a distinct production advantage in this area. Furthermore, in addition to European countries with traditionally strong veterinary research infrastructures, emerging economies such as China, Brazil, India, and Turkey are also making increasing contributions to the field.

A total of 1,349 institutions published in the field of feline MRI anatomy between 2010 and 2024, representing the top ten institutions with the most publications. The University of California System is the clear leader with 72 publications. It is followed by the University of London with 63, Western University (University of Western Ontario) with 61, the University of Texas System with 49, and Auburn University and Auburn University System with 48 each. Other notable research institutions on the list include the Royal Veterinary College, University of London (47), the University of Munich (47), the University of Veterinary Medicine Vienna (48), and Justus Liebig University Giessen (40). This distribution clearly demonstrates that well-established university systems in North

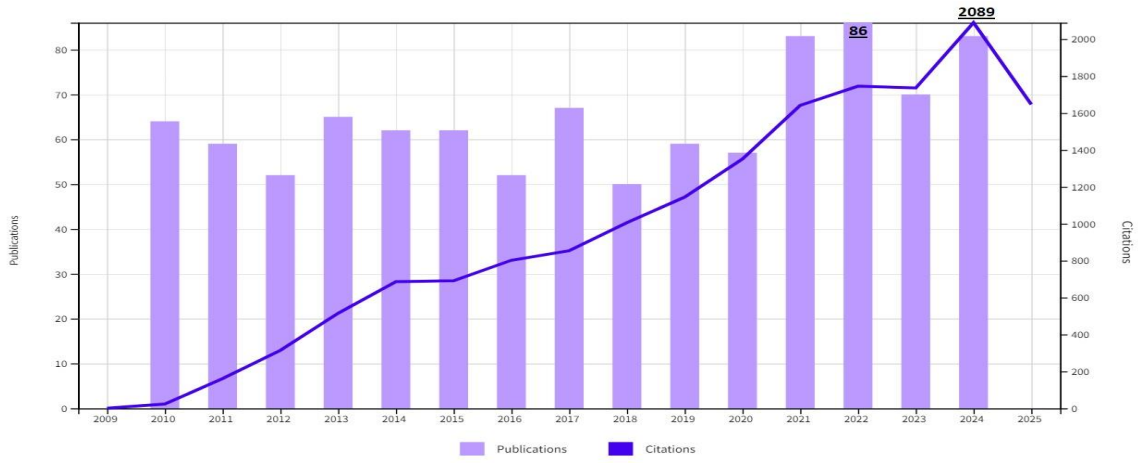

Figure 3. Publication and citation frequency

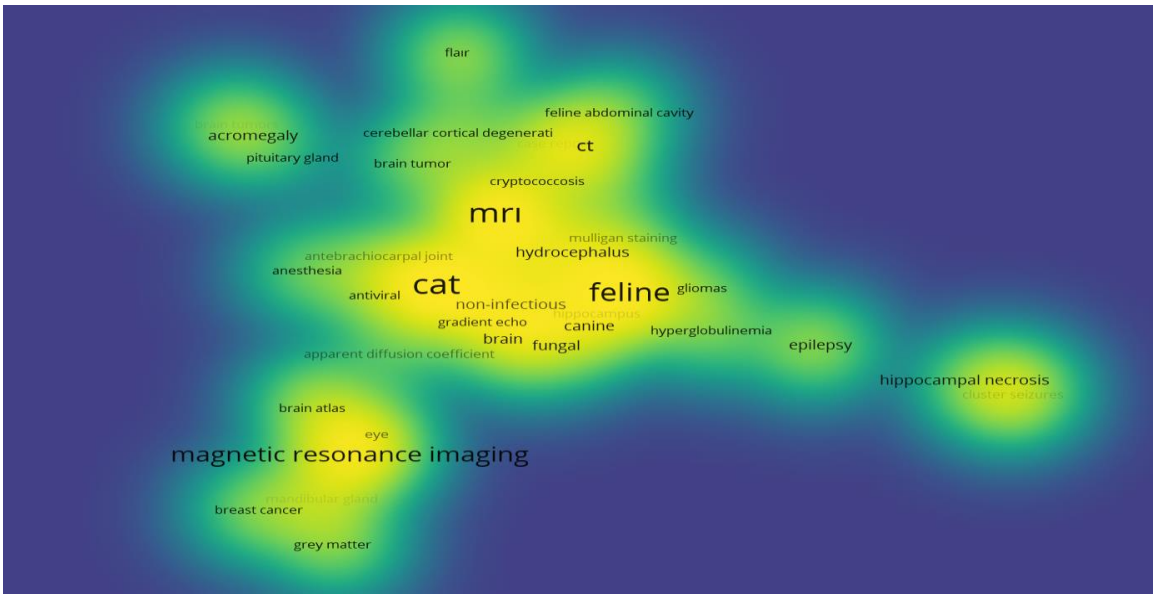

Figure 4. Keyword visualization map of articles

America (USA and Canada) and Europe (UK, Germany, and Austria), and particularly those specializing in veterinary medicine, are driving knowledge production in this specific research area.

Between 2010 and 2024, studies of feline MRI anatomy have expanded across 73 different research areas. An examination of the top ten most intensively researched areas reveals that Veterinary Sciences has the highest priority, with 523 publications (53.86%). Neurosciences and Neurology rank second with 171 publications (17.61%), followed by Radiology, Nuclear Medicine, and Medical Imaging with 79 publications (8.14%). Other disciplines such as Other Science and Technology Subjects (4.84%), Chemistry (3.09%), and Engineering (2.88%) have also made significant contributions to the field. Other important research areas, with lower representation, are Biochemistry, Molecular Biology, and

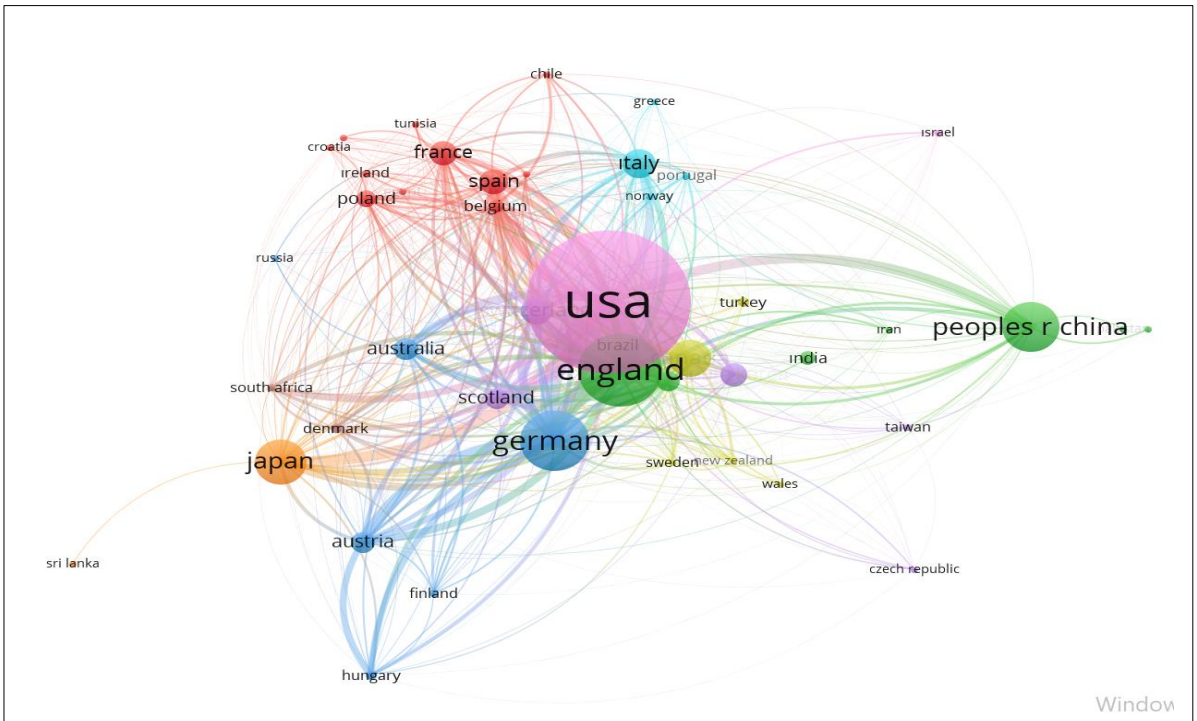

Figure 5. Network visualisation of bibliographic coupling between countries

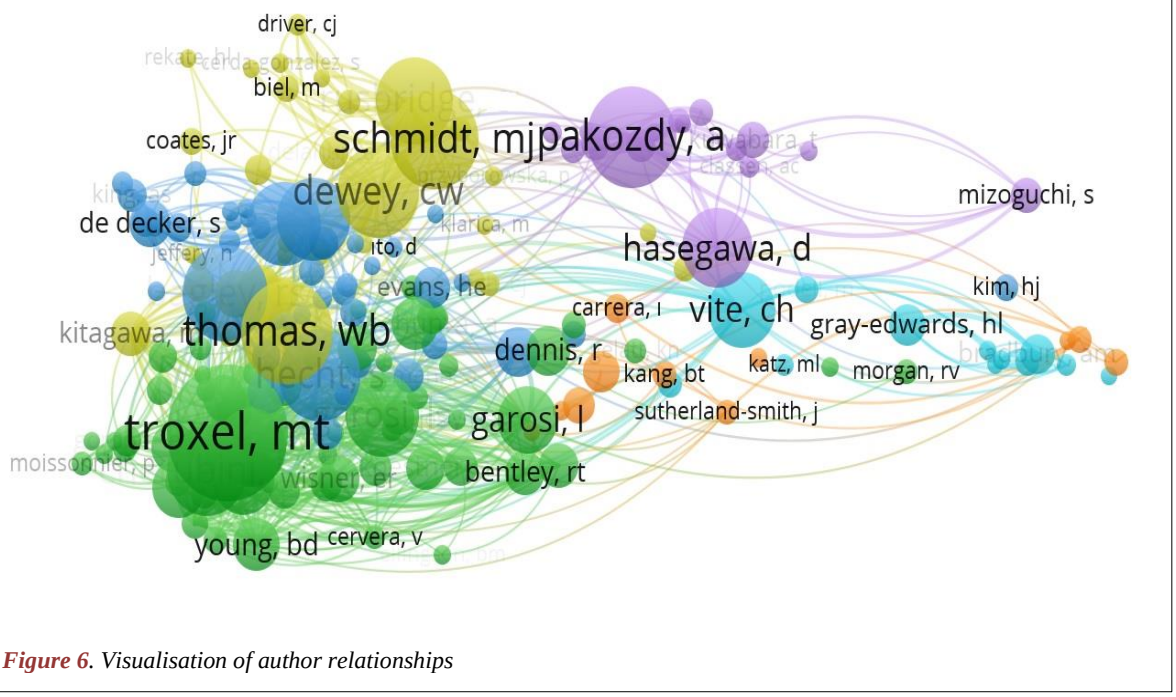

Figure 6. Visualisation of author relationships

Materials Science (2.16% each), Anatomy and Morphology, and Zoology (2.06% each). This distribution reveals that the subject, although mainly focused on clinical veterinary medicine and neurology, also has an interdisciplinary character.

The evaluated articles received a total of 13,351 citations, 12,943 of which were self-citations. The average h-index of the studies was calculated as 56. The highest number of publications was in 2022, with 86 articles, while the highest number of citations was in 2024, with 2,089 (Figure 3). These findings suggest that academic production in the field peaked in 2022, but the scientific impact of the research (number of citations) peaked in 2024. A high self-citation rate may indicate that the field is relatively specialized.

Keyword analyses revealing research trends in feline MRI indicate that scientific focus is prominently clustered around terms such as "brain," "neuroimaging," "anatomy," and "diagnostic imaging." This supports the central role of MRI technology in feline neurology, particularly in the assessment of brain pathologies and structural morphology. In contrast, the relatively weaker representation of themes related to "musculoskeletal system," "oncology," and especially "morphometry" within the network suggests a significant research gap in these subspecialties. To address this imbalance in the existing literature, it is recommended that advanced studies be encouraged that focus on quantitative morphometric analysis of feline musculoskeletal structures and various neoplastic entities. Such targeted research would significantly help fill existing knowledge gaps in the field and expand the scope of the veterinary imaging literature.

Between 2010 and 2024, 107 different publishers were identified in this field. An examination of the top ten publishers reveals that Wiley leads with 232 publications (23.89%). Elsevier (15.55%), Springer Nature (8.14%), Frontiers Media SA (7.72%), and Sage (6.28%) share the top five positions. Among specialized institutional publishers, the American Veterinary Medical Association (3.71%), MDPI (2.68%), Japan Veterinary Science Association (1.96%), American Animal Hospital Association (1.65%), and Public Library of Science (1.55%) stand out. This distribution demonstrates that both traditional large publishing houses and specialised professional organizations carry out publishing activities in the field.

The analysis clearly demonstrates that the United States has contributed the most to scientific research on MRI of feline anatomy. This is thought to be due to its early access to this imaging technology, advanced research capabilities, and strong clinical infrastructure. However, countries such as the United Kingdom, Germany, France, and Japan have also made significant contributions to this specialized field of research. In contrast, contributions from developing countries, such as Turkey, have been more limited. This suggests the need for greater support for specialized scientific capacity and technical infrastructure in these countries.

Research findings indicate that publications in feline MRI anatomy are concentrated in specific journals. Specialized journals such as Veterinary Radiology & Ultrasound (7.41%), Frontiers in Veterinary Science (4.74%), and the Journal of Feline Medicine and Surgery (4.43%) account for a significant share of publications in this field and play a central role in shaping its knowledge base. The inclusion of Neuroimage (2.99%), a leading neuroimaging journal, alongside general veterinary journals such as the Journal of Veterinary Internal Medicine (4.32%) and the Journal of the American Veterinary Medical Association (2.78%), demonstrates the interdisciplinary nature of the topic and its strong connection to both clinical and basic sciences. This distribution reflects the multidisciplinary nature of feline MRI anatomy research, with publications spanning both veterinary and basic medical sciences.

When examining collaborations and relationships among authors with at least three citations, the bibliometric network map reveals the collaboration networks of leading researchers in the field. Key researchers highlighted in the visualization include Driver CJ, De Decker S, Coates JR, Biel M, Schmidt MJ, and Pakozdy A. An examination of the network structure reveals the central positions of researchers such as Dewey CW, Ito D, and Bentley RT. Furthermore, authors such as Klares M, Carrera I, Dennis R, and Garosi L also have strong connections. This network map demonstrates that scientific production in the field of cat MRI anatomy is structured around specific research groups and collaborations. The fact that some researchers (such as Gray-Edwards HL, Mizoguchi S, and Kim HJ) are located more peripherally in the network may indicate different research focuses or relatively new researchers. This visual analysis contributes to the understanding of knowledge flows and collaborative dynamics in the field.

A triangulation analysis reveals global research trends in feline MRI anatomy. A strong collaborative network spanning the United States, Canada, the United Kingdom, Japan, and several European countries reflects the field's international character. Centrally located authors such as Schmidt MJ, Hasegawa D, and De Decker S play a leading role in knowledge generation in the field. Keyword analysis reveals that research focuses primarily on themes such as "magnetic

resonance imaging," "brain," "cat," "dog," and "central nervous system lesions."

Limitations

It is worth noting that this study is subject to several limitations. Firstly, it relies solely on the Web of Science Core Collection, which may have resulted in the exclusion of relevant articles indexed in other databases such as Scopus or Google Scholar. Secondly, the analysis is limited to peer-reviewed publications, which may overlook valuable non-peer-reviewed or non-English literature. Furthermore, the search terms used may not have covered all relevant studies, particularly those using different terminology for MRI applications in feline anatomy. Finally, the exclusion of data from 2025 onwards limits the ability to fully reflect the latest developments and research trends. These factors may constrain the comprehensiveness of the findings.

CONCLUSION

In conclusion, this bibliometric analysis of feline MRI studies highlights the increasing importance of advanced imaging techniques in veterinary anatomy and diagnostics. The expanding literature demonstrates that MRI is increasingly recognised as a valuable tool for understanding feline neurological, musculoskeletal, and internal structures. The findings also underscore the need for continued international collaboration and exploration of new research areas to further advance the clinical and academic applications of MRI in feline medicine.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper and that they have approved the final version.

Ethical Approval

Bibliometric studies do not require ethics committee approval.

Declaration of Conflicting Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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