

THE TRENDS OF CAMEL RESEARCH IN NORTH AMERICA: A BIBLIOMETRIC APPROACH

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ABSTRACT

Camels are witnessing global attraction even in countries outside the natural camel habitat. This study aims to provide a comprehensive bibliometric analysis of camel research in North America, identifying key trends, influential contributors, and collaborative networks. Data was sourced from the Scopus database, yielding 786 papers on camel research affiliated with institutions in the United States and Canada. Bibliometric tools such as VOSviewer and R Studio's Bibliometrix package were used to visualise and analyse the data. The bibliometric analysis of camel research in North America highlights substantial collaborative efforts between the North American countries and international partners. The data spans 493 sources, with an annual growth rate of 1.89%. The research involves 3127 authors and a notable international co-authorship rate of 52.04%. Camel research in North America spans multiple disciplines, including Agricultural and Biological Sciences, Medicine and Veterinary Sciences, Chemistry, Genetics and Molecular Biology, Immunology and Microbiology, Environmental Science, Engineering, and Social Sciences. This interdisciplinary approach underscores the broad impact and significance of camel studies. The international partnerships have facilitated significant advancements in understanding zoonotic diseases, genetic diversity, and the nutritional benefits of camel milk, underscoring the importance of maintaining robust international research networks to enhance the quality and impact of camel studies. This bibliometric analysis highlights the growing significance of camel research in North America, with strong international collaborations driving advancements. However, gaps remain in integrating advanced technologies and exploring socio-economic impacts in non-traditional regions. Continued investment and international collaboration are essential to address these gaps and drive innovative research initiatives.

Key words: Bibliometric analysis, camel research, interdisciplinary collaboration, North America, publication trends

Camel research holds substantial importance due to the unique characteristics and vital roles camels play in arid and semi-arid regions (Adah *et al*, 2023). Camels are renowned for their exceptional adaptability to harsh environments, making them invaluable for sustaining livelihoods in regions where other livestock might not thrive (Sahoo, 2020). They provide essential resources such as milk, meat, and transportation, and their resilience against extreme temperatures and water scarcity positions them as key assets in the face of climate change (George, 2024). Moreover, camels have unique physiological and genetic traits that offer significant insights into medical and biological sciences, contributing to advancements in understanding disease resistance, metabolic processes, and potential biomedical applications (Hedayat-Evrigh *et al*, 2020; Ming *et al*, 2020).

Recently, we provided a bibliometric analysis of camel research, which showed increasing global attention (Kandeel *et al*, 2023). This surge in interest

can be attributed to a growing recognition of camels' ecological and economic significance, as well as their potential contributions to global health and scientific knowledge. Researchers in the United States and Canada have been particularly active in studying various aspects of camel biology, health, and management (Camel sciences and economy in the world: current situation and perspectives). The collaborative efforts between North American institutions and international partners have led to significant advancements in understanding camels' role in zoonotic diseases, genetic diversity, and the nutritional benefits of camel milk.

The primary objectives of this study are to provide a comprehensive bibliometric analysis of camel research in North America, identifying key trends, influential contributors, and collaborative networks. By analysing a robust dataset sourced from the Scopus database, this study aims to map the evolution of camel research over time, highlighting

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significant periods of growth and identifying the most productive researchers and institutions. Additionally, this study seeks to elucidate the interdisciplinary nature of camel research, exploring how collaborations between North American and international researchers have contributed to the advancement of this field. Furthermore, this study intends to show the global relevance of camel research and its implications for various scientific and practical domains. By identifying gaps in the existing literature and highlighting emerging trends, this study aims to foster stronger international collaborations and drive innovative research initiatives.

Materials and Methods

Data Source and search strategy

The data was sourced from the Scopus database using a targeted search query: TITLE (camel) AND (LIMIT-TO (AFFILCOUNTRY , "United States") OR LIMIT-TO (AFFILCOUNTRY , "Canada")). This search yielded a total of 786 papers. The data extraction process involved gathering essential bibliographic details for each paper, including the title, authors, abstract, keywords, publication year, source (journal or conference), document type, and subject area.

Inclusion and exclusion criteria

The inclusion criteria for the bibliometric analysis on camel research in North America were established to ensure the relevance and quality of the data collected. Studies were included if they were indexed in the Scopus database, focused on camel research, and affiliated with institutions in the United States or Canada. The search was conducted using a specific query that targeted articles with the term "camel" in the title and limited the results to those affiliated with North American countries. Additionally, only peer-reviewed articles, reviews, conference papers, letters, book chapters, notes, and short surveys were considered to provide a comprehensive overview of the scholarly contributions in this field. Exclusion criteria were applied to maintain the dataset's integrity and relevance. Duplicate records were checked to avoid redundancy, and erratum records were excluded to focus on original research contributions.

Data Cleaning and Preprocessing

The data from Scopus database were exported in CSV file. The data were cleaned and pre-processed to remove duplicates and irrelevant records.

Bibliometric analysis

The bibliometric analyses were conducted using two primary tools: VOSviewer and R Studio with the Bibliometrix package (Aria and Cuccurullo 2017; Arruda *et al*, 2022; Wong 2018). VOSviewer was employed for constructing and visualising bibliometric networks, such as co-authorship, and keywords networks.

Publication Trends Analysis

Trends over time were examined to comprehend the expansion of research in this area, focusing on annual publication numbers, the most productive authors, and significant papers. Descriptive statistics were computed to give an overview of the dataset, covering the distribution of papers by year, document type, and subject matter.

Results and Discussion

Dataset characteristics

The dataset comprises 786 articles, each detailing various aspects of scholarly articles indexed in Scopus. The data includes 1) the authors information, such as their names, full names, and unique ID. Additionally, the dataset captures the titles of the articles, providing a quick reference to the subject matter of each entry. 2) Bibliographic details of the articles, including the year of publication, the source title (journal or conference name), volume, and issue numbers.

The provided PRISMA flow diagram presents a systematic approach to the bibliometric analysis of camel research trends in North America (Fig 1). The screening process, dated June 10th, 2024, identified a total of 786 records, 784 of which were deemed suitable for inclusion in the bibliometric analysis after confirming there were no duplicates, and 2 erratum records were removed.

Document Types

The bar chart illustrates the distribution of various document types included in the bibliometric analysis of camel research in North America (Fig 2). The data shows that out of the 784 total records, the majority are research articles (634), followed by review papers (41), conference papers (36), letters (22), book chapters (20), notes (17), editorials (11), and short surveys (3). The x-axis of the bar chart represents the number of documents, while the y-axis lists the different types of articles. This representation underscores the predominance of primary research articles in the field and highlights

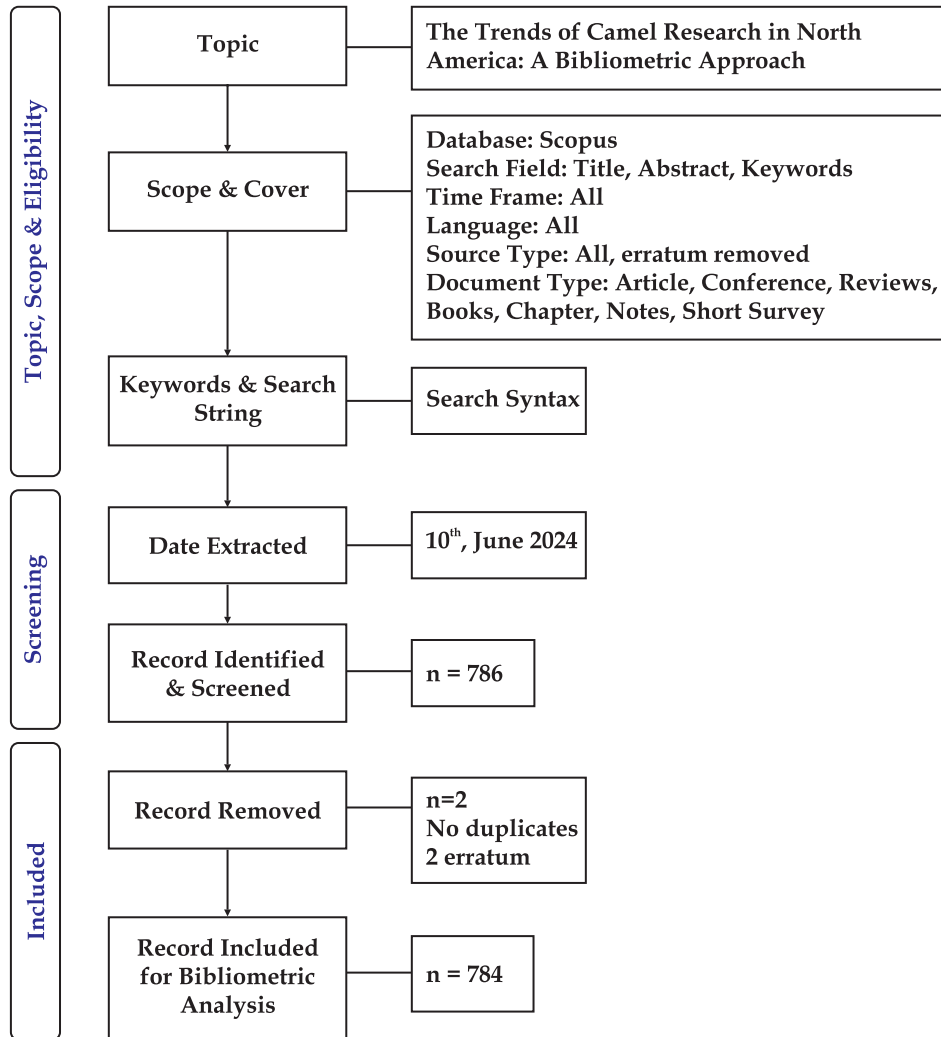


Fig 1. PRISMA flowchart for the bibliometric analysis on trends of camel research in North America.

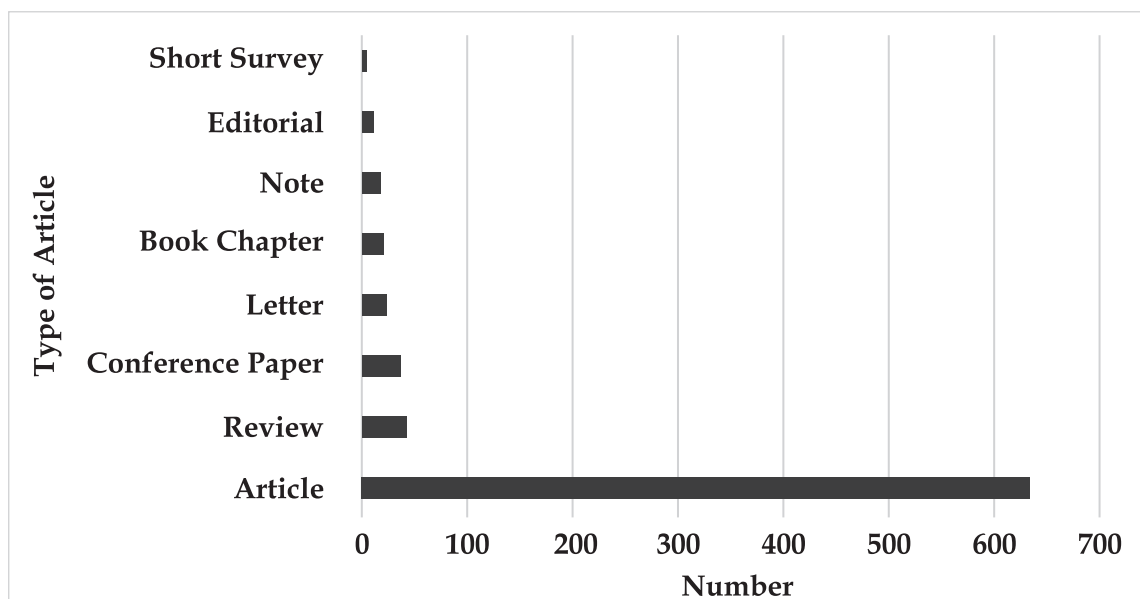


Fig 2. Distribution of document types in camel research in North America.

the diverse mediums through which camel research is communicated.

Publication Trend

The trends in camel research publications in North America can be delineated into three distinct phases based on the graph provided (Fig 3). The first phase, spanning from 1859 to the mid-20th century, is characterised by a sparse and inconsistent publication output. During this period, the number of publications remained very low, often with multiple years passing without any new articles. This phase reflects the nascent stage of camel research in North America, where interest and resources dedicated to this field were minimal. The sporadic publications during this time may have been driven by isolated scientific inquiries or specific historical events that briefly captured academic interest.

The second phase, from the mid-20th century to 2008, marks a period of gradual growth and increased consistency in camel research publications. Starting around the 1960s, there is a noticeable, albeit slow, rise in the number of publications. This phase is indicative of a growing but still limited interest in camel research, possibly fuelled by expanding academic institutions and a broader recognition of the ecological and economic importance of camels. During this period, the research output began to stabilize, with a small but steady stream of publications each year, setting the stage for more significant developments in the subsequent phase.

The third phase, from 2009 to 2024, is characterised by a sharp and sustained increase in the number of camel research publications. The data showed a clear upward trend, with the number of publications accelerating rapidly, peaking in recent

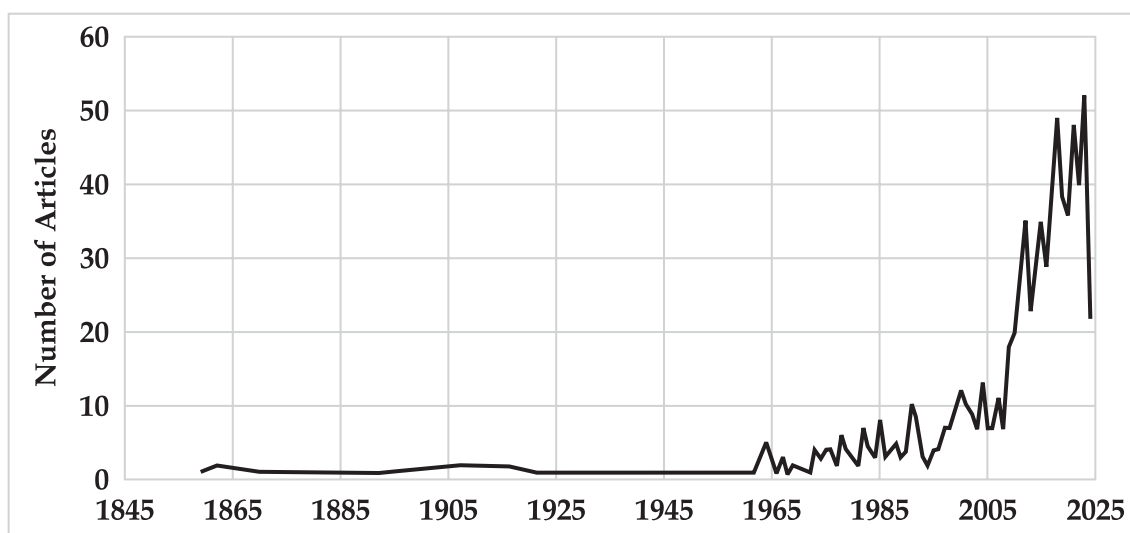


Fig 3. The Trend of publications in camel research in North America.

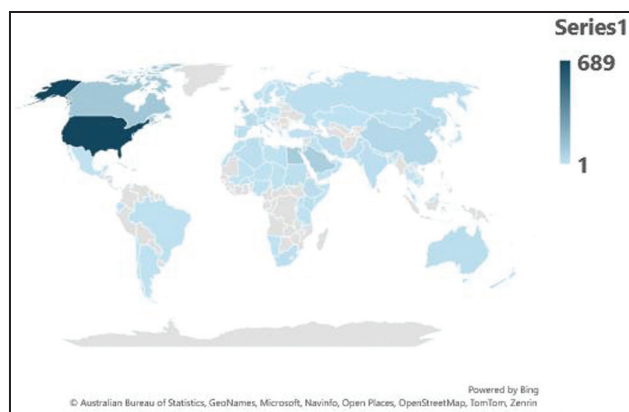


Fig 4. Geographic distribution of camel research publications in North America and in collaboration with other countries. The intensity of the colour shading indicates the number of publications, ranging from 1 to 689.

years, particularly in 2021-2023. This explosive growth can be attributed to that camel studies have become a well-established and actively pursued area of scientific inquiry in North America.

International collaboration

The geographic distribution of camel research publications from North America, with a focus on collaborative work with other countries, reveals significant trends in academic contributions (Fig 4). The United States leads by a substantial margin, producing 689 publications. Canada, with 112 publications, also shows a strong research presence.

The collaborative nature of camel research is evident from the involvement of several countries. Egypt (94 publications) and Saudi Arabia (83

publications) are notable partners. These countries' high publication numbers highlight the importance of collaborative research efforts. The United Kingdom (51 publications) and the United Arab Emirates (46 publications) also have significant academic output, indicating strong international partnerships with North American researchers.

Other countries such as China (40 publications), France (29 publications), Germany (24 publications), and Jordan (23 publications) contributed to the global research landscape through collaborations. These numbers reflect diverse research interests and the importance of international collaborations in advancing camel research. The involvement of countries like Kenya (20 publications) and Ethiopia (18 publications) in Africa underscores the collaborative efforts to address region-specific challenges and leverage local expertise. The widespread distribution of collaborative publications across various countries demonstrates a global recognition of the importance of camel research, with contributions spanning from North America to Europe, Asia, and Africa.

Active institutions

The bar chart in Fig 5 shows the number of camel research publications produced by various institutions in North America and their collaborations with other countries. The Fig was set to display affiliations with 10 or more publications. The x-axis represents the number of publications, while the y-axis lists the institutions involved. The data highlights the significant contributions of multiple institutions from Asia and Africa implying the predominance of collaboration research.

King Saud University stands out with the highest number of publications, indicating its leading role in camel research, likely due to its geographical and cultural proximity to camel populations. This prominence is followed by Columbia University, and the Centers for Disease Control and Prevention (CDC). These institutions are known for their strong research programs and resources, which likely facilitate extensive studies and collaborations.

Other notable institutions include Washington State University Pullman, the University of South Florida, and the University of Florida, all of which have made significant contributions to the field. The presence of international institutions like Cairo University, Suez Canal University, and the United Arab Emirates University highlights the collaborative nature of camel research, emphasising the global

effort to advance knowledge in this area. The diverse range of institutions, including veterinary schools, universities, research centers, and specialized institutes, underscores the interdisciplinary and collaborative approach required to address the complexities of camel research.

The most active funding agents

The bar chart in Fig 6 illustrates the contributions of top funding agencies to camel research projects, highlighting those with five or more funded projects. The x-axis represents the number of funded projects, while the y-axis lists the funding agencies involved.

The National Institutes of Health (NIH) stands out as the most prominent funding agency, supporting the highest number of projects, with a total of 37. This highlights the NIH's commitment to diverse research areas, including camel studies, which may intersect with broader health and biomedical research interests. The National Science Foundation (NSF) follows closely with 32 funded projects, reflecting its role in promoting scientific research and education across various disciplines, including the biological and environmental sciences related to camels.

Other notable funding agencies include the National Institute of Allergy and Infectious Diseases (NIAID) and the National Cancer Institute (NCI), each supporting 27 and 14 projects respectively. The National Natural Science Foundation of China (NSFC) and the U.S. Department of Health and Human Services (HHS) also contribute significantly, with 13 and 12 projects funded, respectively, showing international and interdisciplinary support for camel research. Additional key funding sources include the Biotechnology and Biological Sciences Research Council (BBSRC) with 9 projects, King Abdulaziz City for Science and Technology (KACST) with 9 projects.

The top publishing journals

The analysis of journals publishing camel research reveals a diverse and interdisciplinary landscape, underscoring the multifaceted nature of this field (Fig 7). The Journal of Camel Practice and Research leads with 20 publications, highlighting its specialisation and central role in disseminating camel-specific studies. This journal serves as a dedicated platform for researchers focusing on various aspects of camel biology, health, and management, reflecting its importance in the academic community dedicated to camel studies.

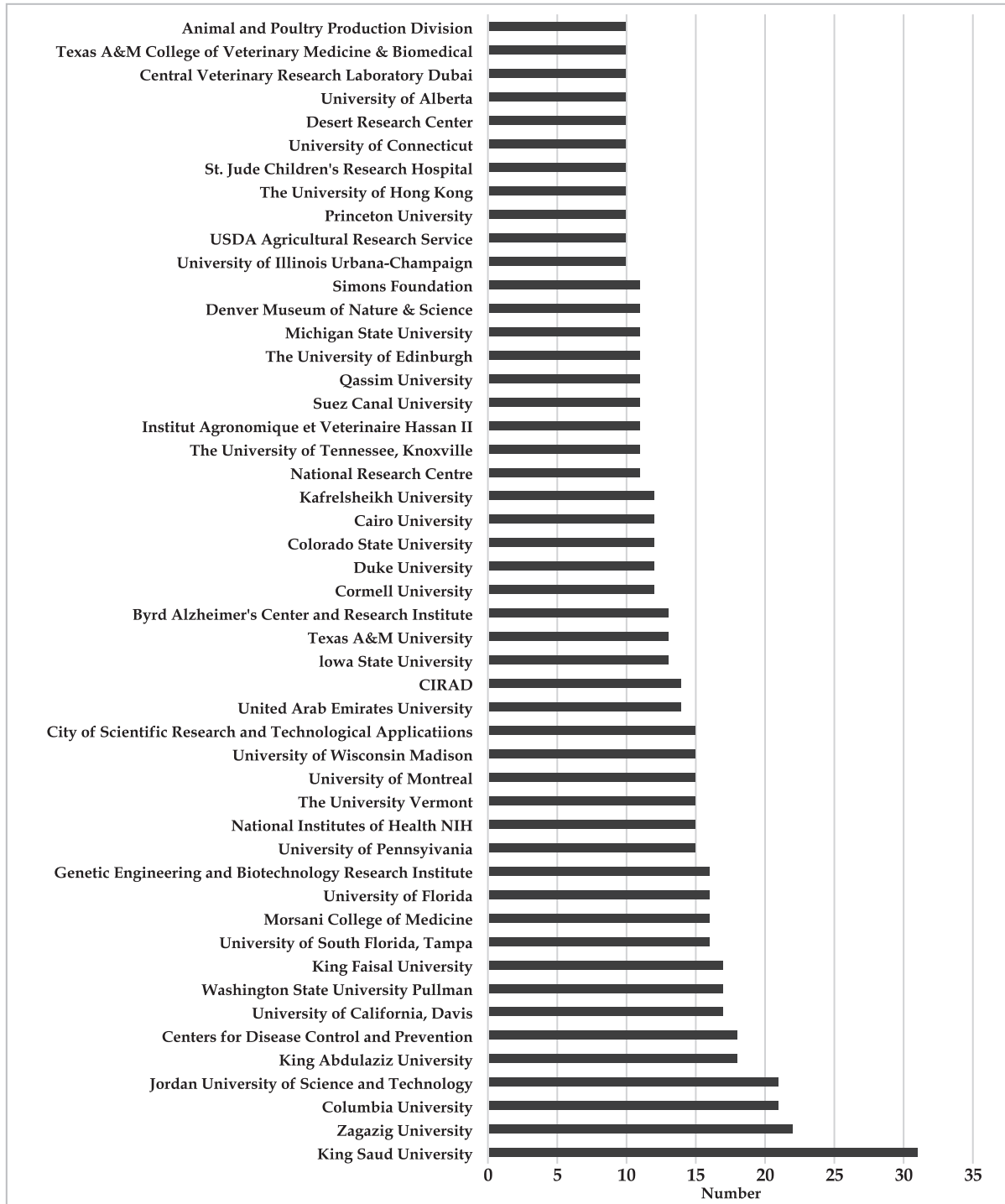


Fig 5. Active institutions of camel research publications in North America and in collaboration with other countries. The listed affiliations include only those having 10 or more publications.

Veterinary and health-related journals also play a crucial role in camel research. The Journal of the American Veterinary Medical Association and Emerging Infectious Diseases have published 11 and 10 articles, respectively, indicating a strong interest in the veterinary and zoonotic disease aspects of camel research.

The diversity of journals, such as Animal Reproduction Science, Journal of Dairy Science, and PLOS ONE, which have each published multiple camel research articles, reflects the wide-ranging applications and interests in camel studies. From reproductive science and dairy production to general scientific inquiries and public health implications,

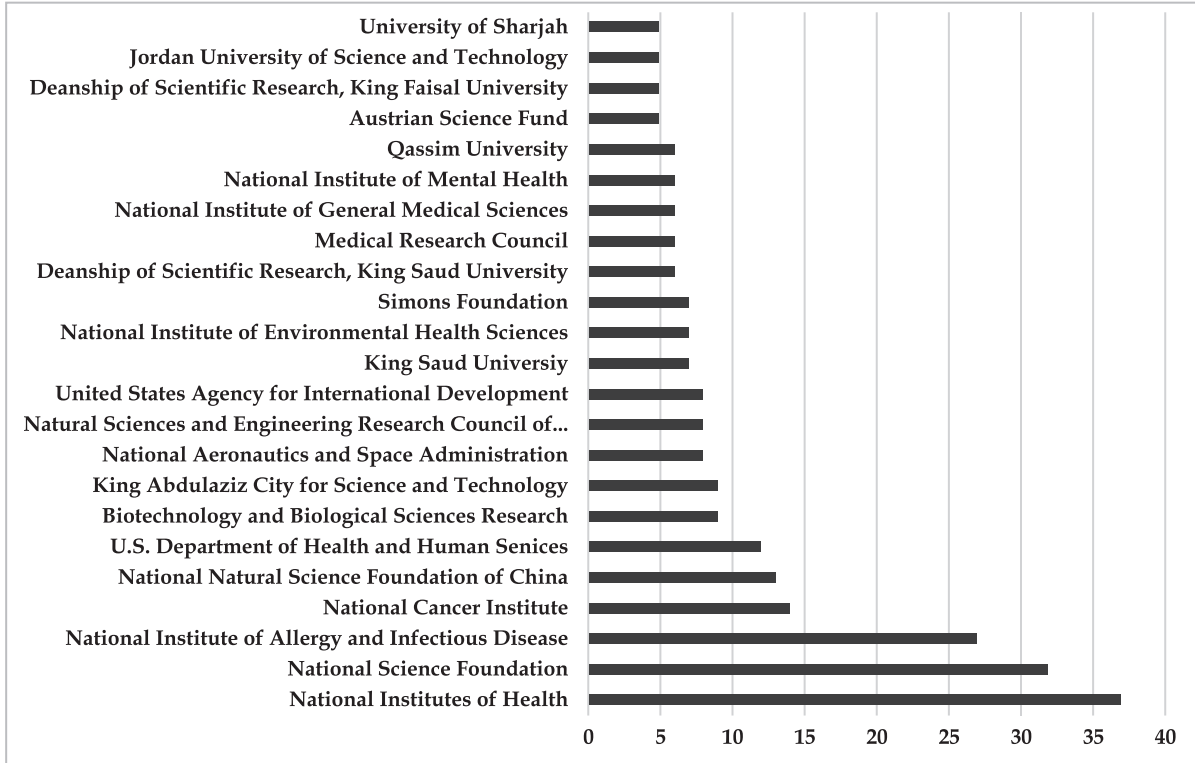


Fig 6. Funding agencies with five or more camel research projects.

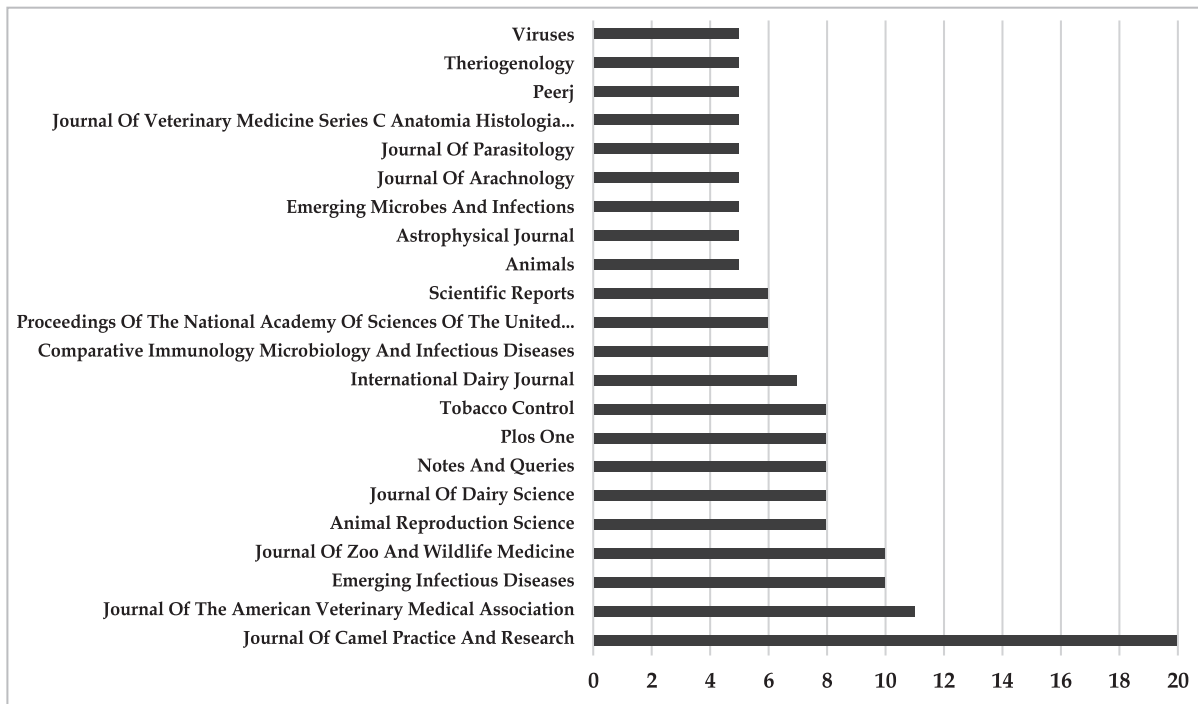


Fig 7. Journals with five or more camel research publications.

these journals show the interdisciplinary nature of camel research.

Academic disciplines

The bar chart in Fig 8 illustrates the distribution of camel research publications across a wide range

of academic disciplines. The x-axis represents the number of publications, while the y-axis lists the academic fields. This distribution highlights the interdisciplinary nature of camel research and its relevance across multiple domains.

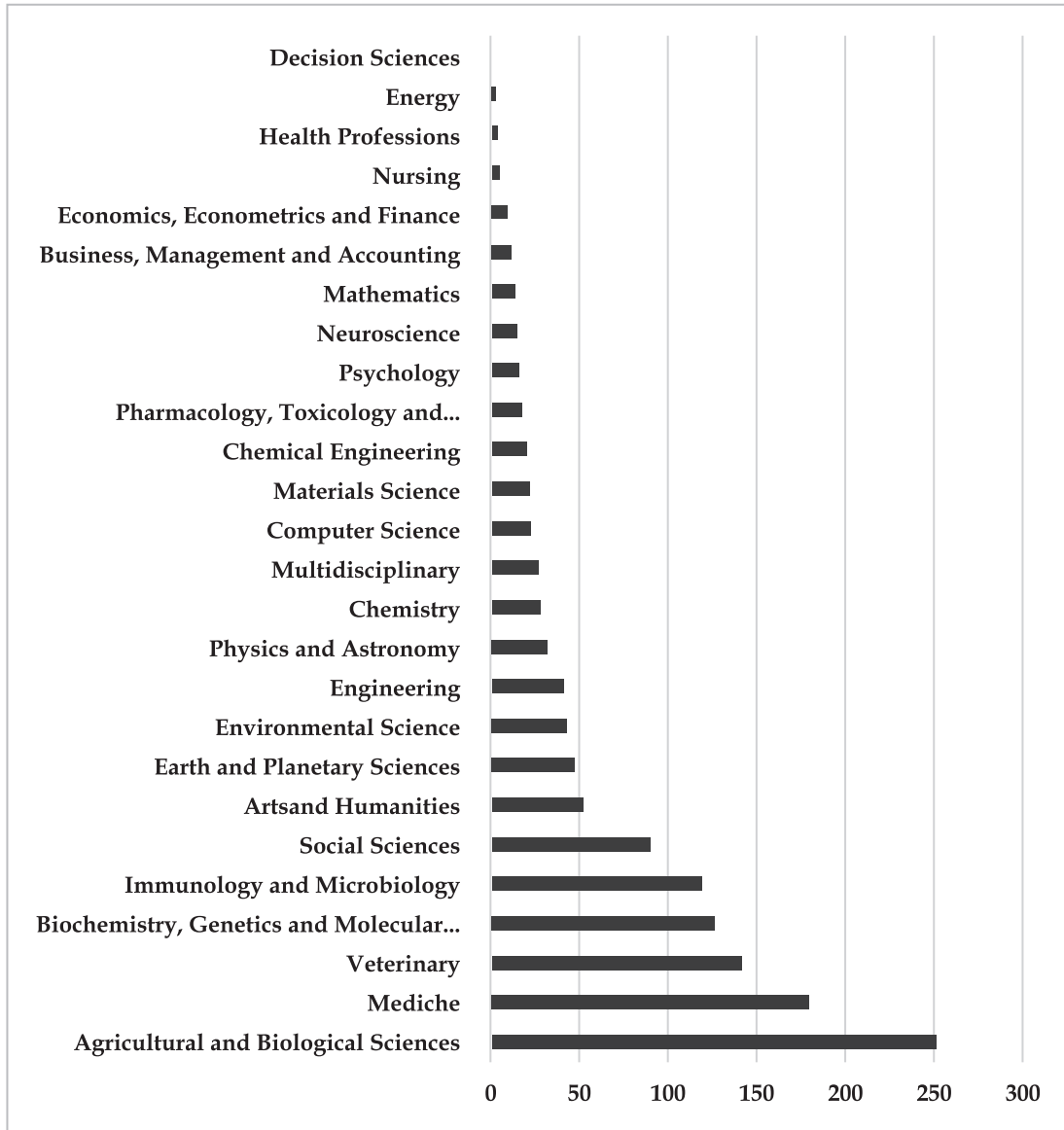


Fig 8. Distribution of camel research publications across various academic disciplines.

Agricultural and biological sciences dominate the chart with the highest number of publications, reaching 250. This prominence underscores the central role of camels in agricultural research and their biological significance, including studies on camel physiology, genetics, and their utility in farming systems.

Medicine and veterinary sciences also feature prominently, with 180 and 142 publications, respectively. The significant number of publications in these fields highlights the health and veterinary aspects of camel research, including disease prevention, treatment, and overall animal health management.

Other notable fields include chemistry, genetics and molecular biology, and immunology and

microbiology, each with substantial contributions. These disciplines focus on the molecular and genetic aspects of camel biology, exploring areas such as disease resistance, genetic diversity, and molecular mechanisms underlying camel physiology. The presence of camel research in fields like Environmental Science, Engineering, and Social Sciences further illustrates the diverse applications and broad impact of camel studies.

Bibliometric Coupling Analysis of the Top Collaborations

The authors are grouped into three clusters based on their collaborative networks (Fig 9). Cluster 1 includes Benaissa, M.H., Burger, P.A., Faye, B., Kaidi, R., and Youngs, C.R. This cluster

indicates a strong interconnected network with notable contributions from Faye, B., who has the highest number of documents (12) and significant link strength (15). Cluster 2 features Ali, M.A., Kayali, G., Shehata, M.M., and Webby, R.J., with Ali, M.A. showing the highest total link strength (14) and document contributions (7). Cluster 3 includes Alagaili, A.N., Daszak, P., Munster, V.J., And Van Doremalen, N., where Munster, V.J. leads with 10 documents and notable link strength (10), indicating significant collaborative influence.

The number of documents authored by each researcher varies, highlighting their productivity and influence in the field. Faye, B. and Munster, V.J. stand out with 12 and 10 publications respectively, reflecting substantial research contributions. The link strength metric, which indicates the degree of collaboration, is highest for Ali, M.A., Faye, B., and Kaidi, R., showing their extensive collaborative efforts. Authors like Benaissa, M.H. and Youngs, C.R. also demonstrate strong link strengths, emphasising their roles in interconnected research networks.

The average publication year provides insights into the temporal trends of these researchers' contributions. Researchers like Burger, P.A., Faye, B., and Ali, M.A. have more recent average publication years (around 2016 and 2019), indicating ongoing research activities and recent contributions to the field. In contrast, authors like Kayali, G. and Shehata, M.M. have slightly older average publication years (around 2014), suggesting an earlier peak in their research output. The distribution of publication years across these authors reflects both longstanding contributions and emerging research activities, highlighting the dynamic and evolving nature of camel research.

Co-occurrence of Keywords

The co-occurrence of keywords was done to represent the research cooperation trends. The input

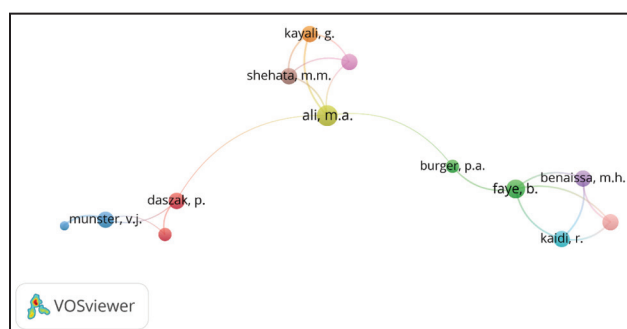


Fig 9. Bibliometric coupling analysis of author contributions and collaboration in camel research.

data were set to a minimum of 10 times keywords co-occurrence. Of 6731 keywords 176 met this threshold.

The VOSviewer visualisation and the co-occurrence map data provide a comprehensive view of the most frequently occurring topics and their interconnections in camel research. Each node represents a keyword or topic, with the size indicating its frequency and the links illustrating the co-occurrence with other keywords (Fig 10).

The keyword “camel” forms the central node of the network, highlighting its primary importance in the dataset. Closely connected to it are significant topics like “dromedary”, “camel milk”, “genetics”, and “physiology”. These connections indicate that a large portion of the research focuses on the biological and physiological aspects of camels, as well as specific interests in camel milk and genetic studies.

The network also shows strong interdisciplinary connections. Keywords like “human”, “female”, “animal tissue”, and “immunology” illustrate the crossover of camel research into areas of human health, veterinary sciences, and broader biological studies. For instance, the presence of “human” and “female” nodes, along with “immunology”, suggests significant research on zoonotic diseases and the health implications of camel products on humans.

Certain clusters reveal emerging or niche research areas. Keywords such as “antibiotic resistance”, “virus transmission”, and “serology” indicate a growing focus on infectious diseases and public health. The connections to “MERS-CoV” and “coronavirus infections” reflect recent research trends likely influenced by outbreaks of Middle East Respiratory Syndrome.

The inclusion of geographic-specific keywords like “United States”, “Egypt” and “Saudi Arabia”,

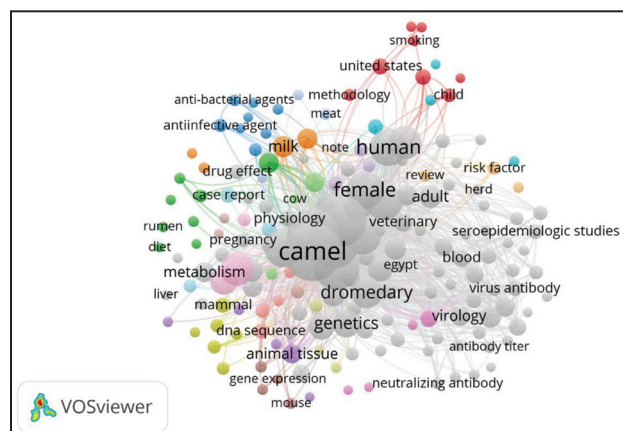


Fig 10. Bibliometric coupling analysis of keywords co-occurrence in camel research.

along with demographic terms such as “child”, “adolescent”, and “adult”, points to studies focusing on specific regions and population groups.

The co-occurrence network analysis reveals 22 distinct clusters, each representing a focused thematic area in camel research. In the top 10 clusters, Cluster 1, encompassing keywords such as “adolescent”, and “child”, highlights research themes related to public health and human demographics. This cluster suggests significant interest in the impact of camel-related factors on human health, including zoonotic diseases and nutritional studies involving camel products. The presence of keywords like “united states” and “young adult” further indicates that this research might be geographically focused on regions with substantial camel populations or significant camel product consumption.

Clusters 2 through 5 primarily focus on biological and anatomical studies. Cluster 2 includes keywords like “bacteria”, “fermentation”, and “microbiology”, indicating research on microbial communities associated with camels and their fermentation processes. Cluster 3, with keywords such as “anti-bacterial agents”, “antibiotic resistance”, and “*Escherichia coli*”, underscores the importance of addressing bacterial pathogens and the effectiveness of antibiotics in camel health management. Meanwhile, Cluster 4, featuring “artiodactyla”, “mammal”, and “histology”, focuses on the anatomical and histological characteristics of camels and related species, revealing an interest in the structural and morphological analysis of these animals.

Clusters 6 through 10 highlight advanced research methodologies and genetic studies. Cluster 6, with keywords like “major clinical study”, “procedures”, and “randomised controlled trial”, emphasises the use of clinical trials and evidence-based research approaches in camel studies. Cluster 7, including “camel milk”, “milk protein”, and “milk”, focuses on the nutritional and biochemical properties of camel milk, exploring its health benefits and nutritional value. Cluster 8, featuring “gene expression”, “human cell”, and “mouse”, highlights genetic and cellular research involving camels, human, and mouse cells to understand genetic expressions and their implications. Cluster 9, with “antibodies”, “antibody”, and “single-domain antibodies”, centres on immunological studies, exploring various antibodies and their roles in immune responses related to camels. Finally, cluster 10, including “DNA sequence”, “molecular genetics”,

and “sequence analysis, DNA”, underscores the application of molecular genetics and sequencing techniques in camel research, revealing advanced genetic research trends in this field.

The diversity of clusters in the co-occurrence network analysis reflects a robust and interdisciplinary research landscape in camel studies. The 22 clusters cover a wide range of topics, from public health and microbiology to advanced genetic research and clinical studies, indicating the multifaceted nature of camel research and its relevance to various scientific and health-related fields.

Bibliometric Analysis of the Top Highly Cited Publications

The dataset comprises a variety of highly cited research articles focusing on camel-related studies, spanning several decades and involving multiple countries (Table 1). These studies highlight significant contributions in fields such as infectious diseases, veterinary sciences, and public health. The oldest article in the dataset, “Isolation and structure of an untriakontapeptide with opiate activity from camel pituitary glands” by Li and Chung, dates back to 1976 and has amassed 530 citations, indicating its lasting impact on biochemical research. This paper, published in the prestigious “Proceedings of the National Academy of Sciences of the United States of America,” underscores early explorations into bioactive peptides derived from camels.

Recent studies in the dataset, such as “Chronic Infection with Camelid Hepatitis E Virus in a Liver Transplant Recipient Who Regularly Consumes Camel Meat and Milk” by (Lee *et al*, 2016) and “Middle East Respiratory Syndrome Coronavirus Infection in Dromedary Camels in Saudi Arabia” by (Alagaili *et al*, 2014), reflect contemporary research priorities. These papers, cited 428 and 374 times respectively, discuss the zoonotic diseases and their transmission between camels and humans. The involvement of multiple countries (USA, UK, Singapore for the former, and USA, Saudi Arabia for the latter) highlights the global collaborative effort to understand and mitigate these health risks. Notably, these studies were published in high-impact journals like “Gastroenterology” and “American Society for Microbiology,” further attesting to their scientific significance.

The dataset also includes impactful public health studies, such as those examining the influence of marketing on children’s recognition of

Table 1. The Topmost Highly Cited Publications in Camel Research in North America and in Collaboration with other Countries.

Title	Authors	Journal	Affiliations Countries	Year	Citations	References
Isolation and structure of an untriakontapeptide with opiate activity from camel pituitary glands	Li C. H. Chung D.	Proceedings of the National Academy of Sciences of the United States of America	USA	1976	530	(Li and Chung, 1976)
Chronic Infection with Camelid Hepatitis e Virus in a Liver Transplant Recipient Who Regularly Consumes Camel Meat and Milk	Lee G. H. Tan B. H. Chi-Yuan Teo E. Lim S. G. Dan Y. Y. Wee A. Kim Aw P. P. Zhu Y. Hibberd M. L. Tan C. K. Purdy M. A. Teo C. G.	Gastroenterology	USA, UK, Singapore	2016	428	(Lee <i>et al</i> , 2016)
Middle east respiratory syndrome coronavirus infection in dromedary camels in Saudi Arabia	Alagaili A. N. Briese T. Mishra N. Kapoor V. Sameroff S. C. de Wit E. Munster V. J. Hensley L. E. Zalmout I. S. Kapoor A. Epstein J. H. Karesh W. B. Daszak P. Mohammed O. B. Ian Lipkin W.	American Society for Microbiology	USA, Saudi Arabia	2014	374	(Alagaili <i>et al</i> , 2014)
The CAMELS data set: Catchment attributes and meteorology for large-sample studies	Addor N. Newman A. J. Mizukami N. Clark M. P.	Hydrology and Earth System Sciences	USA, UK	2017	313	(Addor <i>et al</i> , 2017)
Brand Logo Recognition by Children Aged 3 to 6 Years: Mickey Mouse and Old Joe the Camel	Fischer P. M. Schwartz M. P. Richards J. W. Goldstein A. O. Rojas T. H.	JAMA: The Journal of the American Medical Association	USA	1991	296	(Fischer <i>et al</i> , 1991)
Seroepidemiology for MERS coronavirus using microneutralisation and pseudoparticle virus neutralisation assays reveal a high prevalence of antibody in dromedary camels in Egypt, June 2013	Perera, R. A. Wang, P. Gomaa, M. R. El-Shesheny, R. Kandeil, A. Bagato, O. Siu, L. Y. Shehata M. M. Kayed A. S. Moatasim Y. Li M. Poon L. L. Guan Y. Webby R. J. Ali M. A. Peiris J. S. Kayali, G.	Eurosurveillance	USA, China, Egypt, Hong Kong	2013	271	(Perera <i>et al</i> , 2013)

MERS coronaviruses in dromedary camels, Egypt	Chu D. K. W. Poon L. L. M. Gomaa M. M. Shehata M. M. Perera R. A. P. M. Zeid D. A. El Rifay A. S. Siu L. Y. Guan Y. Webby R. J. Ali M. A. Peiris M. Kayali G.	Emerging Infectious Diseases	USA, Egypt, Hong Kong	2014	240	(Chu <i>et al</i> , 2014)
RJR Nabisco's Cartoon Camel Promotes Camel Cigarettes to Children	Difranza, J. R. Richards J. W. Paulman P. M. Wolf-Gillespie N. Fletcher C. Jaffe R. D. Murray D.	JAMA: The Journal of the American Medical Association	USA	1991	234	(Difranza <i>et al</i> , 1991)
Antibacterial and antiviral activity of camel milk protective proteins	El Agamy E. S. I. Ruppanneb R.	Journal of Dairy Research	Canada, France, Egypt	1992	220	(El Agamy and Ruppanneb 1992)
Replication and shedding of MERS-CoV in upper respiratory tract of inoculated dromedary camels	Adney D. R. van Doremalen N. Brown V. R. Bushmaker T. Scott D. de Wit E. Bowen R. A. Munster V. J.	Emerging Infectious Diseases	USA	2014	214	(Adney <i>et al</i> , 2014)

cigarette brands and the seroepidemiology of MERS coronavirus in camels. For instance, Fischer *et al* (1991) "Brand Logo Recognition by Children Aged 3 to 6 Years: Mickey Mouse and Old Joe the Camel," with 296 citations, published in "JAMA: The Journal of the American Medical Association," investigates early brand recognition and its implications for public health. Similarly, Perera *et al* (2013) study on MERS coronavirus in Egyptian camels, cited 271 times, reveals a high prevalence of antibodies in camels, offering crucial insights into disease transmission dynamics.

Recent interest in camel research fields has surged (Kandeel *et al*, 2023), driven by the growing recognition of camels' ecological, economic, and health-related significance (Masebo *et al*, 2023). This heightened interest is particularly evident from the sharp increase in publications in the past decade, with substantial contributions from North American institutions in collaboration with international partners. Advances in molecular genetics, vaccines and immunology, and zoonotic disease research have positioned camels as important subjects in understanding disease transmission and developing

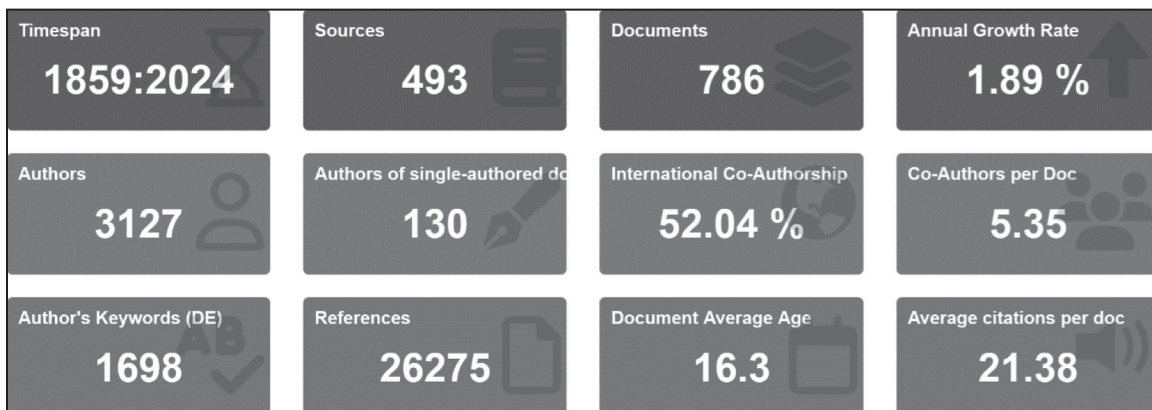


Fig 11. Summary of camel research statistics in North America.

biomedical applications (Abri and Faye, 2019; Ahmed and Mahmoud, 2023; Al Ramadan *et al*, 2021). Additionally, the unique properties of camel milk and its potential health benefits have spurred research in nutrition and food sciences. The advent of AI technologies is expected to revolutionize camel health and welfare (Alsalem *et al*, 2024).

Summary of camel research in North America

Fig 11 presents a detailed summary of camel research statistics in North America from 1859 to 2024. It includes data spanned 493 sources and 786 documents, showing an annual growth rate of 1.89%. The research involves 3127 authors, with 130 single-authored documents, and a notable international co-authorship rate of 52.04%. Each document averages 5.35 co-authors, with a total of 1698 author's keywords and 26,275 references. The average age of documents is 16.3 years, and they receive an average of 21.38 citations per document.

Fig 12 presents a three-field plot illustrating the associations between countries, affiliations, and keywords in camel research in North America. The left column (AU_CO) represents various countries, including Italy, USA, Brazil, China, Saudi Arabia, and others. The middle column (AU_UN) shows affiliations with prominent research institutions such as Inner Mongolia Agricultural University, King Abdulaziz University, Jordan University of Science and Technology, King Saud University, and many more. The right column (ID) lists the most frequently used keywords in camel research, such as "camel," "article," "nonhuman," "animals," "dromedaries," and others. This visualisation highlights the

network of international collaborations, institutional contributions, and key research themes prevalent in the field of camel studies in North America. While USA is dominating in the right column, the middle column shows collaboration between USA and a lot of universities overseas.

Strengths and limitations of this study and future directions

The strengths of the bibliometric analysis of camel research are manifold. First, the comprehensive data collection from the Scopus database ensures a robust and extensive dataset, encompassing a wide range of publications and document types. This inclusivity allows for a thorough examination of trends, key contributors, and collaborative networks. Additionally, the identification of significant periods of growth and the mapping of international collaborations highlight the global nature and interdisciplinary scope of camel research.

Despite its strengths, this bibliometric analysis of camel research has several limitations. One major limitation is the reliance on the Scopus database, which, although comprehensive, may not include all relevant publications, especially those in non-indexed regional journals or grey literature. Additionally, the analysis primarily focuses on quantitative measures such as publication counts and citation metrics, which may not fully capture the qualitative aspects of research impact and innovation.

Future direction involves fostering stronger ties between researchers in North America and those in camel-rich regions such as the Middle East and Africa. This includes tackling zoonotic diseases, which

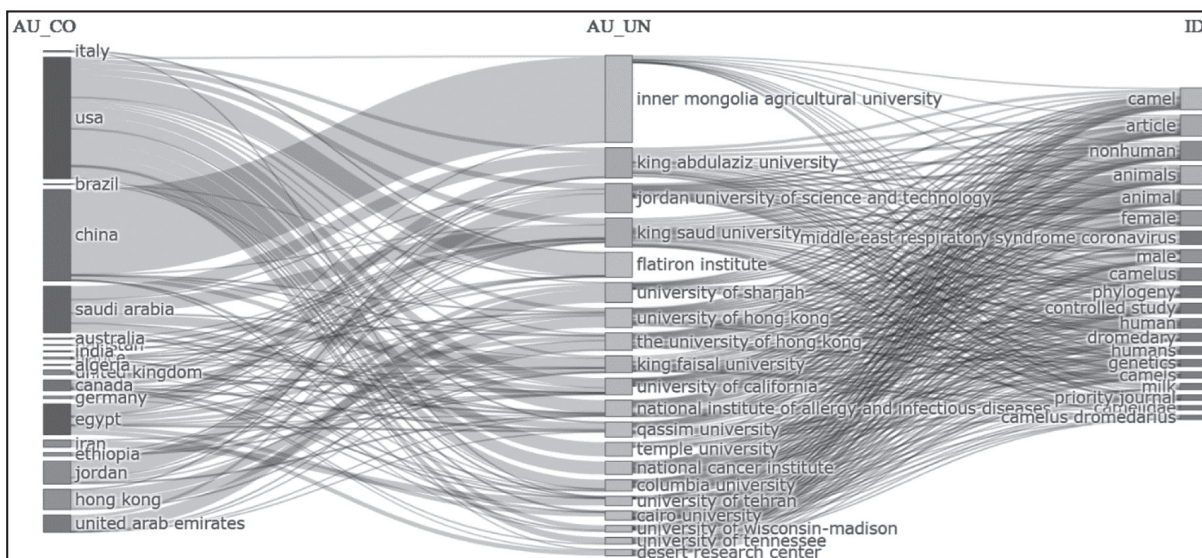


Fig 12. Three-field plot for countries, affiliations and keywords association in camel research in North America.

have significant public health implications, as well as addressing issues related to climate change and sustainability, where camels' resilience offers valuable lessons. Furthermore, the integration of advanced technologies such as artificial intelligence and big data analytics into bibliometric studies can provide deeper insights into research trends and impact, guiding policy-making and funding decisions.

Conclusions

This bibliometric analysis underscores the growing significance of camel research in North America, driven by the ecological and economic importance of camels. The study reveals robust collaborative efforts between North American researchers and international partners, leading to advancements in understanding zoonotic diseases, genetic diversity, and the nutritional benefits of camel milk. Despite these achievements, gaps remain in integrating advanced technologies and exploring the socio-economic impacts of camel products in non-traditional regions. Addressing these gaps through continued investment and fostering international collaborations is essential to drive innovative research and enhance the overall impact of camel studies.

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

Not applicable

Competing interests

There is no conflict of interests

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Authors' contributions

"Conceptualisation, M.K.; methodology, M.K.; software, M.K.; validation, M.K.; formal analysis, M.K.; investigation, A.A. and M.K.; resources, M.K.; data curation, A.A. and M.K.; writing – original draft preparation, M.K.; writing – review and editing, A.A. and M.K.; funding acquisition, A.A. and M.K. All authors have read and agreed to the published version of the manuscript.

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