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Research Article

Mapping the Conceptual Structure of Beekeeping from 1980 to 2020

Yusuf Shehu Folaranmi Gbolahan[1,*], Akinyemi Babatope Ebenezer[2], Popoola Oluwabunmi Oluwaseun[3]

[1]Department of Agricultural Economics and Extension, University of Fort Hare, Alice, SOUTH AFRICA.
[2]Department of Animal Science, Michigan State University, East Lansing MI, USA.
[3]Department of Agricultural Economics and Extension, University of Fort Hare, Alice, SOUTH AFRICA.

ABSTRACT

This article reports on the evolutionary beekeeping research trends between 1980 and 2020. The authors used bibliometric methods to retrieve data from Clarivate Analytics, Web of Science (WoS) and Elsevier's Scopus databases and analysed it with the use of Biblioshiny. A title-specific algorithm was used to extract articles and refined the search by limiting the results to the English language and specific data sources. A total of 735 publications by 1029 authors in 165 journals were identified. The study identified subjects such as the biology of beekeeping and bee diseases, among others, as well developed in beekeeping research. The study recommends more rigorous research on the high mortality rate of bees where contesting issues are still prevalent, like genetically modified organisms, pesticides, and the impact of pollination services on bee health.

Keywords: Beekeeping, Database, Bibliometric analysis, Research domains, Publication trends.

Correspondence:
Yusuf Shehu Folaranmi Gbolahan
Department of Agricultural Economics and Extension, University of Fort Hare, Alice, SOUTH AFRICA.
Email: fyusuf@ufh.ac.za; gbolahan4la@yahoo.com
ORCID: 0000-0002-4156-1221

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INTRODUCTION

A wide-ranging search through academic databases and web directories like Google Scholar, ScienceDirect, Scopus, and SciELO, amongst others, provides sizeable results for research productivity and articles on bees in different scientific disciplines, especially in the natural and social sciences fields. This indicates an extensive effort on the part of researchers to enhance the global knowledge on beekeeping. Over the years, research has influenced global knowledge development in more ways than can be expressed. One of such activities is the sharing of research results through publications in journals. Publishing is critical to demonstrating academic excellence and knowledge sharing.[1] It also preserves and validates research work.[2] As such, academic journals are essential media for intellectual communication, knowledge transfer, exchange of ideas, and sharing of new knowledge within the academic environment;[3,4] and more importantly, a crucial enabler to carrying out bibliometric assessments. It is a standard practice to assess the knowledge base of a profession as it matures.[5] Bibliometrics is the "quantitative study of literature as reflected in bibliographies, which provides insight into the growth of literature and how research findings are disseminated to readers of journals in a specified field of academic research".[6] In this sense, bibliometric studies have become critical in evaluating areas of research in any field of discipline; in this instance, the beekeeping research landscape.

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Beekeeping production is especially significant for modern agriculture,[7] as it plays various critical global economic and environmental functions;[8] part of which includes generating supplementary revenue particularly for resource-poor communities and stimulating the inclination to protect the natural environment.[9] Due to its relevance, diverse research has been carried out predominantly on the biology of bees and beekeeping practice.[8] As such, there is an abundance of scientific literature in academic journals on diverse subject matters related to bees and its production. Common amongst the subjects of discourse are - (i) beekeeping practices.[10] (ii) Bee products and marketing.[11] (iii) Economics of beekeeping.[12] (iv) Contributions of bees to livelihoods and income.[13] (v) Opportunities and constraints in beekeeping.[14] (vi) Bee production efficiency.[15] (vii) Beekeeping and forest conservation.[16] (viii) Beekeeping and employment.[17] (ix) Bee keeping development.[9] As such, it is important to evaluate the extent of scientific research contributions to understand beekeeping production as a niche, the areas of research strengths, and possible weaknesses and gaps that require further research responsiveness. A bibliometric analysis of a number of these articles could appropriately map these research areas and identify research needs for future research.

The aim of this paper is to fill this research gap by using a novel approach in this research area: bibliometric methods. Interest in bibliometric research analysis has been on the rise in recent times.[18] It is a research tool to map the literature within a research field.[19] Bibliometrics is defined as "the application of statistical methods on published literature to analyze publication trends with time and to shed light on influential researchers, countries, and institutions in the field".[20] To the best of our knowledge, an analysis of the literature on beekeeping using bibliometric methods has not yet been carried out. The paucity of bibliometric reviews in the field is indicative of the significance of this study. This article aims to consolidate the state-of-the-art academic research on beekeeping by creating a bibliometric study of the literature published since 1980, in various disciplines. Citation data were collected through WoS and Scopus and were analysed using Biblioshiny. The paper's specific objectives are to investigate the growth pattern of the beekeeping literature, to determine the conceptual structure of beekeeping, and to examine the state of knowledge diffusion in the landscape of the beekeeping literature. The next section of the paper reviews the literature on the concept of beekeeping. Section three presents the methodologies, which describe the data collection and analytical procedure. Section four details the results of the data analysis implemented in Section three. Finally, Section five wraps up the discussion of the results with concluding remarks.

A Synopsis of Beekeeping as an Enterprise

Beekeeping production remains a long-standing environmental-friendly enterprise.[21] Although indigenous to Africa and Europe, bee practice has become globalized.[22] As indicated in the diverse literature, beekeeping is a viable enterprise on many continents. Cases in point are (i) Europe - Romania,[23] (ii) Western Asia and South-East Europe - Turkey,[24] (iii) North-Eastern Europe - the Republic of Latvia,[25] (iv) North-America - Mexico,[26] (v) Asia - China,[27] (vi) South Asia - Nepal,[12] and (vii) Oceania - New Zealand,[28] amongst many others. Hussein's 2001 study listed a number of countries on the African continent where beekeeping is practiced, such as Burundi, Cameroon, Central African Republic, Chad, Congo, Gabon, Rwanda, Zaire, Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, and Zimbabwe.[29] Tanzania, Nigeria, Kenya, and Ethiopia have also been recognised as major producers.[29] Ethiopia was identified as one of the largest honey producers in the world and the largest in Africa, ranking among the top ten producers in the world as of 2015.[30] This shows how boundless bee production is around the world.

Although still widely practiced using traditional modes of operation (manual operating systems of management, maintenance, and honey extraction), a contemporary automated apiary keeping technique termed 'precision beekeeping' is increasingly being recognised across the board.[21,31] This improved beekeeping technology has been able to raise the annual production level of honey.[21,31] However traditional or modernized beekeeping practice is, there is a vast body of evidence showing that the art itself is exceptionally beneficial in diverse ways, from aiding plant reproduction processes to maintaining a balance in the environment.[32,33] The literature[34,35] stress the absolute importance of bee pollination processes to agricultural production, food chains, forest regeneration, wildlife, and the overall conservation of the environment. There are also multiple socio-economic benefits attached to it. It promotes rural self-reliance and diversification,[36] stimulates downstream processing of products for exportation,[37] generates sustainable livelihoods for people, and invigorates socio-economic development.[38] Studies[39,40] note that the initial investment in beekeeping is not capital intensive. It requires limited land space that may not necessarily be fertile, and it uses less technical labour, knowledge, and skills. It is also not in competition with other resource-tasking elements of farming systems.

Beekeeping production is evident to be a self-reliant livelihood activity that transforms economic life; relieving hardship, hunger, unemployment, social vices, and abject poverty.[41] Investing in beekeeping could considerably moderate vulnerability to poverty, as it is a reliable natural source that stimulates socioeconomic development.[38] Beekeeping activities are substantively aligned with the concept of smallholder agricultural development and could, indeed, be very well integrated into larger agricultural or forestry schemes.[36] It is one of the vast forest natural resources whose highly valued products are commonly regarded as non-wood/timber forest products that could be harnessed to promote the value of forest resources, encourage reforestation projects, and especially benefit deprived local communities.[42] The marketing of bee products is also crucial in generating local and national revenue to boost an economy, as it also offers a wide range for the production and marketing of honey and other bee products.[43] The global demand for honey, for example, is higher than the supply rate, making it a valuable and high-priced commodity.[44] As such, the marketing element of bee products is significant to boost the economic lives of producers as well as other actors in the marketing chain. Beekeeping practice offers a range of products such as honey, bee wax, bee bread, bee venom, pollen, and propolis, which a beekeeper could sell from a sole farm enterprise.[45]

As resourceful as bee production is, it is not without its challenges. Like any other subsector in the livestock industry, beekeeping is plagued with a number of complex issues.[46] Some of the constraints include the dearth of beekeeping management knowledge, technology utilization, knowledge transfer from research organizations,[47] forest fires, lack of modern apiaries, poor credit facilitation, poor productivity, processing and marketing, feeble sanitary and quality assurance examination, and limited extension- and advisory services.[48] Colony morbidity and mortality[7] and significant threats such as ants and parasitic invasion in beehives[45] affect production efficiency. The dearth of

Table 1: Search strategy and inclusion criteria.

Stage	Inclusion criteria	Documents retrieved from WoS	Documents retrieved from Scopus
1	Select the Web of Science Core Collection Editions = A&HCI, BKCI-SSH, BKCI-S, CCR-EXPANDED, ESCI, IC, CPCI-SSH, CPCI-S, SCI-EXPANDED, SSCI		
2	Search and select all documents that contain the word 'beekeeping' in the title (i.e. title algorithm search)	972	1045
3	Select the time span 1980 – 2020	937	1001
4	Select the document type 'article'	573	557
5	Select only documents written in English	543	522
6	Merge documents from WoS and Scopus and remove duplicates	741 (324 duplicates removed)	

Table 2: Main information on data.

Description	Results
Main Information on Data	
Timespan	1980:2020
Sources (Journals, Books, etc)	165
Documents	735
Average years of publication	14
Average citations per documents	3,269
Average citations per year per document	0,3739

bee forage due to deforestation, chemical poisoning, lack of proper cooperatives, and institutional support systems[49] are some of the existing challenges faced by a significant number of bee farmers. Thus, the need to put in place adequate intervention schemes to address critical issues threatening the industry that include the enhancement of extension and advisory services, breeding programs, marketing structure, apiculture policies and research, are very germane.[48] The research element is again emphasized in this study, as it is critical to identify key areas where there is a need to enhance bee production and marketing across the globe.

METHODOLOGY

Selection strategy

The study retrieved publications on beekeeping from the Web of Science (WoS) and Scopus databases following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines.[50] The PRISMA procedure follows a checklist that describes the protocol adopted for selecting the collection of articles used in a systematic literature review, and it is commonly used to ensure replicability and transparency. We collected bibliometric data on July 17, 2021 to identify all publications related to the field of beekeeping by defining the following search query "TITLE (beekeeping) AND PUBYEAR > 1979 AND PUBYEAR < 2021 AND (LIMIT-TO [DOCTYPE, "ar"]) AND (LIMIT-TO [LANGUAGE, "English"])" on Scopus and "beekeeping (Title) and Articles (Document Types) and English (Languages) Timespan: 1980-01-01 to 2020-12-31 Web of Science Core Collection Editions = A&HCI, BKCI-SSH, BKCI-S, CCR-EXPANDED, ESCI, IC, CPCI-SSH, CPCI-S, SCI-EXPANDED, SSCI" on the Web of Science. We followed six inclusion search strategies concerning beekeeping and they are reported in Table 1.

Data loading and converting

The merged data matching the inclusion criteria, including all their metadata from the Web of Science and Scopus databases from our final collection, was loaded and converted into an R data frame using bibliometrix[51] since it contains a more extensive set of techniques and is suitable for practitioners through Biblioshiny.[52]

The Sample

After additional filtering of the 741 final documents in the 1980-2020 timespan, the database (the created sample) consists of 735 publications by 1029 authors, which were published in 165 journals (Table 2). Our search covered empirical articles published in peer reviewed journals from 1980 to 2020 inclusively. During this period, an average year of publication of 14, an average citations per document of 3.26, and average citations per year per document of 0.37 were reported. The researchers that authored the retrieved documents have appearances of 1480; the authors of single-authored documents were 202, whereas multiauthored documents were 827. With respect to authors' collaborations, 458 documents were authored by a single author, 0.71 documents per author, 1.4 authors per document, 2.01 co-authors per document, and a collaboration index of 2.99.

The annual scientific production is presented in Figure 1. An annual growth rate of 10.95% was observed. Although the annual scientific production of beekeeping publications indicates a consistent growth in the number of publications from 1980, a spike in annual scientific production was observed in 1991 and

Description	Results
References	3601
DOCUMENT TYPES	
Article	721
Article; book chapter	5
Article; proceedings paper	9
DOCUMENT CONTENTS	
Keywords Plus (ID)	659
Author's Keywords (DE)	680
AUTHORS	
Authors	1029
Author Appearances	1480
Authors of single-authored documents	202
Authors of multiauthored documents	827
AUTHORS COLLABORATION	
Single-authored documents	458
Documents per Author	0,714
Authors per Document	1,4
Co-Authors per Document	2,01
Collaboration Index	2,99

Source: Authors, 2021.

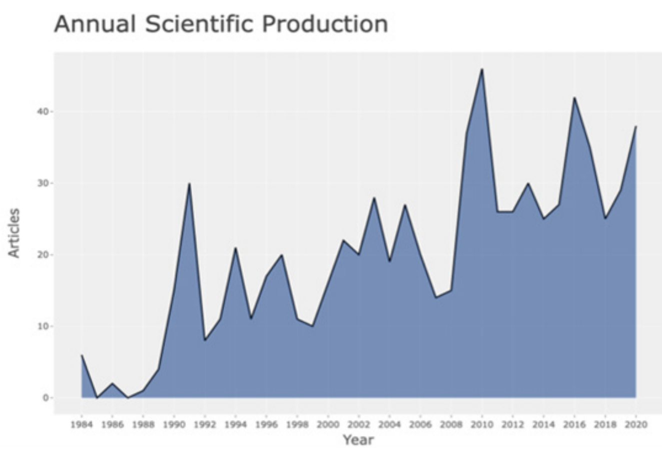

Figure 1: Annual Scientific Production.

2010. The volume of scientific production in beekeeping has been on the high side in the last decade.

Data analysis

The retrieved data using co-occurrence and network analysis to generate a thematic map. A thematic map is a Cartesian representation of the term clusters identified performing a cluster analysis, on a co-occurrence network. It allows for easier interpretation of the research themes developed in the framework. The analyses were based on KeyWords Plus, which are words or phrases that frequently appear in the titles of the references cited in an article but do not appear in the title of the article itself. They are extracted from the articles using a statistical algorithm based on the cited references in the article. KeyWords Plus is a unique feature of both WoS and Scopus. The algorithm is based on a supervised machine learning approach that automatically assigns a set of keywords, namely, Keyword Plus, from a glossary defined by a team of experts. This approach uses the bibliography of the article to identify research topics and then label the document with a set of keywords plus. The use of KeyWords Plus offers several advantages over other databases and the author's keyword list, in such a way that terms are extracted from a standardized glossary, defined for the analyzed subject categories.

Using Keywords Plus, we generated the co-occurrence network, which was used to establish the relationship between the keywords. Each keyword represents a node or vertex of the network, and the edge connecting two nodes is proportional to the number of times two keywords are included in the same keyword list. The stronger the edge, the higher the relationship between two keywords within a paper,[53] thus allowing to provide a graphical visualization of potential relationships among keywords. In the network, it is possible to identify groups of strongly interrelated terms that represent themes or topics. In this study, we used the Louvain community detection algorithm[54] because it generates the best results when applied to different benchmarks of community detection methods.[55]

The clusters identified by the co-occurrence network were plotted on a thematic map according to Callon's centrality and Callon's density rank values along the two axes.[56] The X-axis represents the centrality, that is, the degree of interaction of a network cluster compared to other clusters appearing in the same graph. This can be read as a measure of the importance of a theme in the development of the research field. The Y-axis symbolizes the density, which measures the internal strength of a cluster network, and can be assumed as a measure of the development.[57-59] The graphical representation of themes in the four quadrants in which they are plotted, allows identification of the following properties: (1) Motor themes (first quadrant): the cluster network is characterized by high centrality and high density, meaning that they are well developed and important for the structuring of a research field; (2) Highly developed and isolated themes (second quadrant): they are characterized by high density and low centrality, meaning that they are of limited importance for the field, since they do not share important external links with other themes; (3) Emerging or declining themes (third quadrant): they have low centrality and low density, meaning that they are weakly developed and marginal. The identification of emerging or declining trends of a theme requires a longitudinal analysis through a thematic evolution:[51] splitting the timespan into different time slices allows to identify the trajectory, whereby a direction toward the top of the map over time identifies an emerging trend, while a direction toward the lower left quadrant would identify a declining trend; (4) Basic and transversal themes (fourth quadrant): they are characterized by high centrality and low density, namely, they are important concerning general topics that are transversal to different research areas of the field.

RESULTS

The disaggregated data related to the main information on beekeeping, sliced into four periods, are reported in Table 3. Between 1980 and 1990, 14 documents related to beekeeping were published. However, this number increased to 154, 218, and 311 papers between the period 1991 to 2000, 2001 to 2010, and 2011 to 2020, respectively. This means that the scientific production of beekeeping studies increased several times during the following years. Substantial increases were also observed for Keywords Plus, Author Keywords, Authors, Author Appearance, and Authors of multiauthored documents, and singleauthored documents. Hence, these data support the notion that there is a considerable increase in the number of researchers that are working on beekeeping studies.

The Conceptual Structure: Thematic Evolution of Beekeeping Research

The thematic map showing the analysis of KeyWords Plus is shown in Figure 2. The analysis identified seven clusters, represented in a thematic map, according to their centrality and density ranking. Although three clusters were characterized by high centrality and high density and was positioned in the first quadrant as a motor theme, the cluster with the name "bees, pollination, bee" has the highest centrality and density than "honey, apiculture, pollen" and "*apis mellifera, apoidea*, beekeeping" clusters. Two clusters, namely "*apis mellifera* disease American foulbrood" and "*hymenoptera apidae* management" are located in the Basic Theme quadrant with high centrality and low density. The clusters "hives" and "honey-bees and honey production impact" are emerging themes with low centrality and density. The most frequent words were "honey", "*apis mellifera*", "bees", "apiculture", "*apoidea*", "*hymenoptera*", "beekeeping", "pollination" "*apidae*", "pollen", "honey-bees", and "management".

Applying the minimum number of co-occurrence threshold of five, three out of the 74 keywords in this period met the predetermined conditions and there was only one cluster. The words "*apis mellifera*," and "beekeeping" were dominant in 1991 to 2000 (Figure 3). The density visualisation of these two keywords indicates that "beekeeping" and "*apis mellifera*" were the most frequently used. Although both keywords occurred five times during the period under study, however, "beekeeping" has an equal total link strength of six; just like "*apis mellifera*" has a total link strength of five.

In this period, among 352 keywords used, only 11 keywords met the minimum threshold, and three clusters were formed. In the first cluster, the words "*apoidea*," "*hymenoptera*" and "beekeeping" had a high frequency of usage and were in the hotspot domain within beekeeping research. The term "honey" appeared in the second cluster. The most used keyword during the period 2001 to 2010 in beekeeping research is "*apoidea*" with 23 occurrences, and a total link strength of 33 (Figure 4).

In this interval, 26 items out of 808 keywords met the five-co-occurrence threshold. The first cluster, which can be referred to as the apiculture cluster where "apiculture" appeared 41 times with a total link strength of 220, currently constitutes the main theme of beekeeping research during the ongoing period of 2011 to 2020 (Figure 5).

DISCUSSION

The bibliometric analyses identified several areas of emerging research issues. However, this discussion focused on research with high density and centrality, that is, themes that are well-developed and significant to the structure of the study. These are the bee diseases, the social dimension of beekeeping, and beekeeping research collaborations. Evolutionary development of research on beekeeping from 1980-2000 mainly focused on the biology of beekeeping (Figures 2 and 3). The dimension, however, changed between 2001-2010 when the research focus shifted to other areas within beekeeping (Figure 4). For example, various research studies were observed on varroa disease, and this must have influenced the intensive research observed between 2011-2015 that focused more on the biology of beekeeping. Varroa became

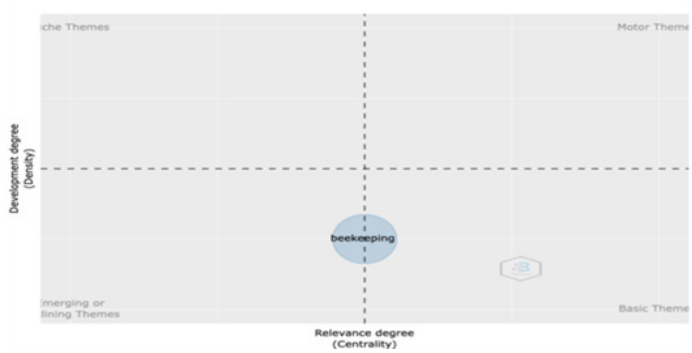

Figure 2: Thematic evolution of beekeeping research from 1980-1990.

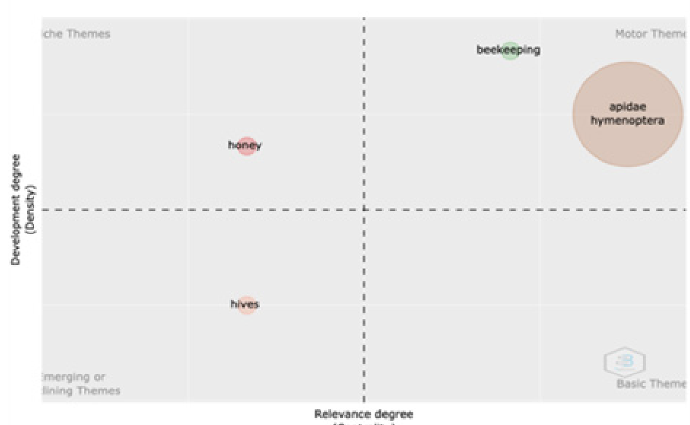

Figure 3: Thematic evolution of beekeeping research 1991-2000.

Table 3: Main information about collection.

Main information about collection				
Timespan	1980:1990	1991:2000	2001:2010	2011:2020
Documents	14	154	218	311
Sources	8	16	37	101
Keywords Plus (ID)	32	61	205	371
Author's Keywords (DE)	11	26	109	454
Average citations per document	8.286	3.123	2.601	3.797
Authors	19	135	234	597
Author Appearances	22	198	362	780
Authors of single-authored documents	9	76	69	72
Authors of multi-authored documents	10	59	165	525
Single-authored documents	11	122	154	162
Documents per Author	0.737	1.14	0.932	0.521
Authors per Document	1.36	0.877	1.07	1.92
Co-Authors per Documents	1.57	1.29	1.66	2.51
Collaboration Index	3.33	1.84	2.58	3.52

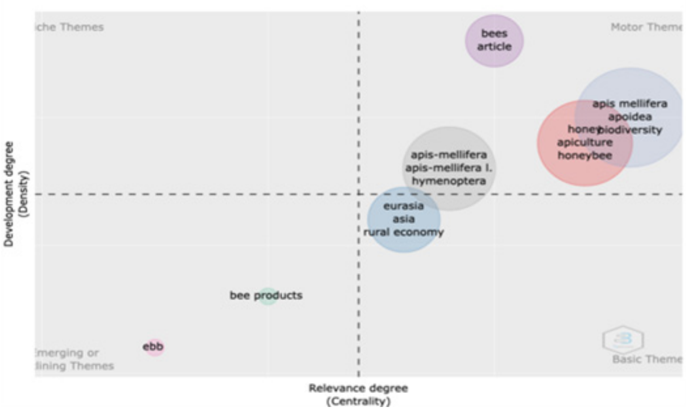

Figure 4: Thematic evolution of beekeeping research from 2001-2010.

Figure 5: Thematic evolution of beekeeping research from 2011-2020.

devastating in the beekeeping industry, with high destruction of apiaries observed in several parts of the world. Initially, the challenges of honeybee pests were of limited importance in Africa, but of recent, there has been a high incidence of exotic diseases and pests, as well as home-grown problems that have become a threat to honeybees, beekeeping and honeybee- pollination in Africa.[60] Among these are capensis and varroa mites as a major disease and pest.[60] Research on varroa mite in Africa has intensified since discovered.[61,62] Honeybees are vital in Africa, for both ecological and economic reasons.[63] The bees play a significant role in the environment. Their economic importance in food production, and as a result, their health is considered of paramount importance.[64] Honeybees for pollination and ecological services, has also been well documented in Africa.[65,66] Pollination boosts crop productivity in terms of quality and quantity and production of colony products, such as wax, royal jelly, bee venom, honey, pollen, and propolis.[64]

Apis mellifera is the most important managed species for agricultural pollination across the world.[67] However, the increased decline in the population of insect pollinators, especially bee species, due to colony collapse has become an exigent issue in the apicultural industry and academic community.[68,69] The decline has repercussive environmental and economic implications.[70] There has been numerous debates on the root cause of colony failure. However, there appears to be no single causative factor for these colossal losses.[71] Rather, the increased mortality rates are being attributed to multiple interrelating biotic and abiotic environmental stressors.[70-72] Loss also varies with time and place.[69] The identified factors from previous studies also include pesticides, varieties of parasites, pathogens (causing diverse bacterial, viruses and fungal infections), malnutrition/starvation, improper apiary management, and various forms of environmental stressors.[69,73,74] Others include urbanization and intensive agricultural production,[68,70] widespread cultivation of genetically modified organisms [GMOs][75-78] and, climate change.[79] A number of these factors have existed long before now, however, but their level of intensity has increased in recent years due to increased global industrialization.[74]

Pesticides are documented as being one of the budding stressors of the bee population.[80] In fact, it is the most contentious cause for the decline of bees.[68] Fungicides, herbicides, nematicides, and insecticides are pesticides; a range of chemicals used in controlling pests.[71] There were immediate concerns on the effects of pesticides on the bee population when the use of pesticides to control pests and weeds were introduced for agricultural production.[81] Even though there are economic benefits in using pesticides, it has brought bee wellbeing and the agricultural industry into direct conflict.[68] Several laboratory studies, which demonstrate that pesticides affect the behavior, foraging, memory, sense of smell, and impair the detoxification process of honeybees, have been observed,[72] and the cognitive abilities of bees.[74] Although there is stiff opposition from the agrochemical industry and farming unions against evidences substantiating that pesticide use contributes to bee population decline[68] as such, there are ongoing debates as to the accuracy of quantifying the level of bee population exposure to pesticides that could indeed be lethal.

Urbanization and intensified farming

The rapid rate of urbanization and intensified agricultural production are accounted to be responsible for the degradation and loss of natural habitats required for bee survival.[68,70] The current approach of intensive farming and extensive production of monoculture crops, leads to the loss of flower-rich environment, and hence, affecting food availability for bees causing them to feed on pollens from unnatural monotonous crops. This, in turn, affects their diets,[68] and highlights the issue of malnutrition. Intensive agriculture and extensive monoculture reduce the availability of alternative feeding, constraining the dietary variation of plant species with arrays of nutritional contents such as proteins, vitamins, lipids, amino acids, and mineral contents.[70,74,79] Additionally, wild bees also lose their nesting sites.[68,70,79]

Genetically Modified Organisms (GMO)

GMO has been identified as a possible attributing cause of pollinators' population decline. This has been a subject of discourse across the board.[75,78] The increased use of natural habitats in agricultural lands for the production of Genetically Modified (GM) crops is putting pressure on the stability of the ecosystem. This is because the GM crops are either insect-resistant or herbicide-resistant with a significant number having both traits. As such, recent data have raised concerns that this may promote intensified production of GM crops, thereby increasing the pressure on biodiversity.[76,77] The widespread commercialization of GM crop production, particularly herbicide tolerant plants, poses a significant threat to biodiversity.[75] GM crops are speculated as promoting monocultures' threat to biodiversity, which, as earlier indicated, affects food availability and nutrition for the bee population.[77] The production of herbicide tolerant crops affects the growth of weeds in crops, which is also an alternative forage source for bees. Therefore, widespread production of these GM crops could lead to bee starvation.[70] GM crops also produce toxins for resistance against pests. For example, transgenic insecticidal crops may also cause harm to potentially beneficial nontarget insect population like the bees.[75,77] Although there are claims that the evidences provided for the negative effects of honeybees feeding on GM crops have not been proven,[70] more research is, however, still needed in this area.

Beekeeping for livelihood/achieving sustainable development goals

"Beekeeping" as a keyword was common from the early 1980's. However, the focus on using beekeeping to address social issues became prominent in late 1990. This aligned well with the United Nations Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) in the years 2000 and 2015, respectively. The MDGs commit world leaders to combat poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women.[82] Several articles direct attention to see how beekeeping could contribute towards the achievement of some of the MDGs that include MGDs 1, 3, 7, and 8; that is, to eradicate extreme poverty and hunger, women empowerment to ensure environmental sustainability, and develop a global partnership for development, respectively.[83] The MDG 8, namely the global partnership for development, was observed from the collaboration on beekeeping for development within the African continent and the rest of the world, which was very low. For example, South Africa (SA) has the highest collaboration programme on beekeeping with Germany (11 counts), Switzerland (7 counts), China (6 counts), and Australia (5 counts). Collaboration within the African academe was at a low edge. For example, only two counts were observed between SA and Kenya while we have one count each between SA and Nigeria, Egypt, Benin Republic, Burkina Faso and Sudan. Scientific collaboration is more established today than it was several years ago.[84] However, findings indicate weak collaborations between African university researchers on beekeeping. Academic engagement could be a precursor to more creativity and innovative ideas, as it has a positive association with academics' subsequent scientific productivity.[85] Research collaboration has been described to be beneficial for combining multiple skillsets and tackling applied problems with solutions that transcend disciplinary boundaries.[86] More collaborations by African researchers on beekeeping would benefit the continent, considering the beekeeping value chain that are yet to be fully exploited.

CONCLUSION AND RECOMMENDATIONS

This study presents an avant-garde attempt to map out the existing scientific literature on beekeeping research across diverse academic fields from 1980 to 2020, centred on data retrieved from the Elsevier's Scopus and Web of Science databases. Investigating the evolution and trend of beekeeping research, major research purviews, authorship, and scope of research collaboration, were some of the core objectives set to be accomplished by this study through the bibliometric method of data analysis. The researchers adhered strictly to the required stages of data collation, processing and cleaning, and used standard software tools. Findings revealed a remarkable increase in the cumulative number of articles related to beekeeping published within the period of study. The paper succeeded in baring the key research domains in beekeeping studies, providing an illustrative trend (graphical and mapping) in beekeeping research in the said period, and breaking down the research domains into categories of subject areas that are fully or underdeveloped, with high- or low centrality, and high or low density. In its discussion, the study focussed on well-documented critical research focus areas, particularly in recent years. Areas such as the significance of honeybees for pollination and ecological system services, bee diseases, a decline in bee population, and colony collapses/failures are attributed to multiple interrelating biotic and abiotic environmental stressors such as pesticides, varieties of parasites, pathogen malnutrition/starvation, improper apiary management, urbanization and intensive agricultural production, widespread cultivation of Genetically Modified Organisms [GMOs], and climate change. The social dimension of beekeeping trending research theme in this study's discussion brings the diverse existing literature on beekeeping for livelihood enhancement and for achieving the global sustainable development goals, to the fore. As such, the identified major articles on beekeeping in this study have provided further insight into research gaps that require high priority responsiveness. These gaps could guide future research areas in the beekeeping field. The study recommends that more rigorous research are needed on the high mortality rate of bees where contesting issues are still prevalent like GMO, pesticides, and the impact of pollination services on bee health.

AUTHORS' CONTRIBUTION

Yusuf, S.F.G: Conceptualization, literature search, writing, review and editing. Akinyemi, B.E.: Conceptualization, visualization, methodology, data collection, data analysis, literature search, writing. Popoola, O.O.: Conceptualization, literature search, writing and organization.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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