

Perspectives of Malaysian Stingless Bees Based on Bibliometric Analysis: A Review

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Stingless bees or kelulut are considered the best pollinators for various types of fruits and vegetables. Moreover, their honey boasts tremendous nutritional and therapeutic properties, offering traditional and contemporary avenues for treating a mess of illnesses. In this regard, several institutions in Malaysia are actively researching kelulut to identify the potential to increase visibility and acceptance in the global market. This purposeful study was conducted to analyse the publication pattern of 292 papers related to kelulut research in the Scopus database for a period of ten years (2013-2022). The findings showed an increase in terms of the number of annual publications, namely 59 papers with cumulative citations of 1177. An analysis of the performance of institutions in Malaysia identified UPM as having the highest number of publications (62 papers) compared to other institutions. In terms of the number of sponsorships, the Ministry of Higher Education Malaysia is the highest contributor with 53 papers. The United States of America is the highest foreign sponsor with a total publication of 12 papers. Analysis based on kelulut bee species, *Heterotrigona itama* is a well-known species based on the highest co-occurrence in VosViewer analysis (38 co-occurrences). It is hoped that this study can provide a true picture of the publication of papers in Scopus related to kelulut research in Malaysia and can build awareness among researchers and authors to increase the publication of introducing terms of its application and Malaysian kelulut-based products on the international stage.

Keywords: stingless bee research; bibliometric analysis; VosViewer; co-occurrence; Malaysia apiculture.

I. INTRODUCTION

Stingless bees, locally known as kelulut or Tantadan for several native tribes in Sabah have been, the focus of attention for several areas of research in Malaysia. Kelulut plays an important ecological role as a pollinator for many wild plant species and appears to be a good candidate for use in commercial crop pollination, particularly for fruit and seed-producing crops, fibre-producing crops such as cotton and hemp, medicinal plants, and crop species for livestock such as alfalfa and clover (Jaapar *et al.*, 2016; Layek *et al.*, 2021; Meléndez Ramírez *et al.*, 2018). Traditionally, kelulut

products such as honey and propolis have not only been used as food and beverage flavouring but also as a remedy for several ailments and have been practiced for decades (Ij *et al.*, 2018; Rao *et al.*, 2016; Zulkhairi Amin *et al.*, 2018). Accordingly, modern science has proven the potential value of kelulut products as antioxidants, anti-inflammatory, cytotoxic, and antimicrobial (Arung *et al.*, 2021; Goh *et al.*, 2021; Yaacob *et al.*, 2018; Kasimin *et al.*, 2022; Wahid *et al.*, 2022). The diversity of species and uniqueness of kelulut are obviously tourist attractions, thus increasing income for local entrepreneurs.

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The increase in kelulut research in Malaysia is directly proportional to the demand for and production of kelulut-related products (Mustafa *et al.*, 2018; Razali *et al.*, 2021; Saludin *et al.*, 2019). The trend of kelulut-related publications can be observed in the number of annual publications and the number of citations that have been recorded in the Scopus database. Scopus is recognised as the largest database of abstracts and citations for equivalent evaluation literature such as scientific journals, books, and conference proceedings, covering a wide range of research areas (Burnham, 2006; Sabullah *et al.*, 2015; Singh *et al.*, 2021). Therefore, the purpose of this paper is; i) to analyse the field of research and the trend of the number of research papers on the theme of kelulut; ii) to show research contributions from some of the most productive academic institutions as well as fundraisers both locally and internationally, and; (iii) to highlight general terms, research topics, names of journals and some of the potential kelulut species studied. This study will have a positive impact on researchers, policymakers, and individuals in terms of the proliferation of research ideas as well as introducing Malaysian stingless bees globally.

II. RESEARCH METHODS

A. Data Sources and Search Strategies

A comprehensive search was conducted online on November 1, 2023, using the Scopus database. The search term is in English, "Stingless bee". The detailed search strategy is presented in Figure 1. The publication period is 10 years from 2013 to 2021. Searches are performed on one day to avoid bias due to daily database updates. In this study, the number of articles was limited to those from Malaysia, and the search results found 292 articles that met the filtering criteria. Data is exported in the form of a csv file that contains information such as citation information, bibliographic information, abstracts, and keywords, as well as some additional information such as trade name and manufacturer, entry number and chemicals, conference information and references.

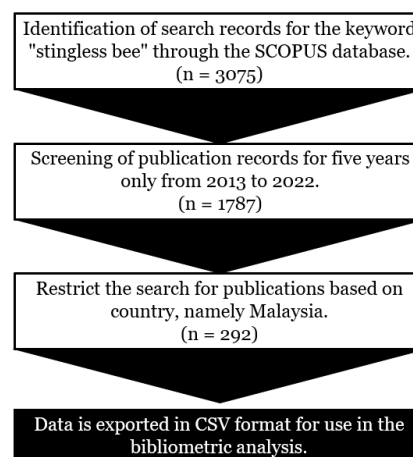


Figure 1. Workflow of data collection and screening for data vetting via MS Excel and data for bibliometric analysis using VosViewer before descriptive and evaluative results and analysis.

B. Bibliometric Analysis

Through the Scopus website, search results are also analysed in the form of data based on the number of documents by year, documents by affiliate, documents by country/region, documents by field of study, and documents by sponsor, and all analysis results are exported in csv format. Citation records are also taken by viewing an overview of the citations, then exported in csv format. VOSviewer software (version 1.6.14) developed by van Eck and Waltman (2018) was used to analyse the relationships between the most productive countries, research institutions, and frequently used keywords. We performed cluster analysis and generated a social network map (consisting of nodes and links) for co-occurrence, for all keywords and searches for stingless bee species by VOSviewer. Filtering is done to remove the duplication of words - keywords that are present. Clusters were also acquired by VOSviewer by analysing the frequency with which similar keywords appeared in different documents.

III. SUMMARY OF RESEARCH FINDINGS

A. Research Fields and Publication Patterns

Scientific research on kelulut in Malaysia is divided into 25 types of research areas (Figure 2). Agricultural science and biology dominate almost half of the field of stingless bees at 40.07 %, followed by biochemistry, genetics and molecular biology (16.44 %), engineering (15.41 %), chemistry (14.73

%), medicine (14.73 %), environmental science (10.27 %) and Pharmacology, Toxicology and Pharmaceutics (10.27%). While the other fields are below 10 % which is less than 23 total publications between 2013 and 2022. The variety of research fields related to stingless bees in Malaysia will have a positive impact on introducing kelulut-based products at the global level.

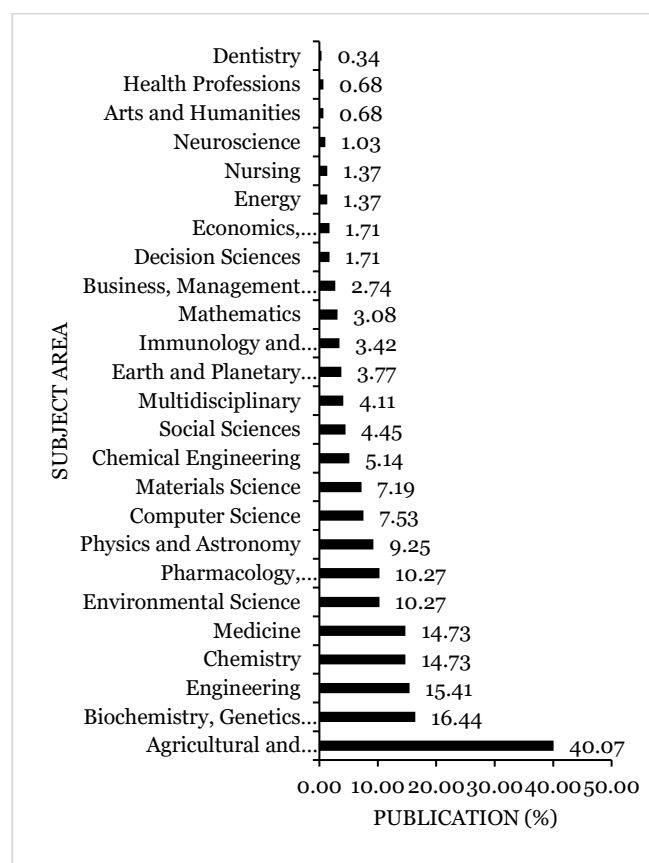


Figure 2. Types of fields related to the study of kelulut in Malaysia based on a total of 292 publications for a range of 10 years (2013 - 2022).

The pattern of publications in the period of 10 years (2013 - 2022) displays a total of 292 papers related to kelulut in Malaysia that have been published in various journals indexed in Scopus. The number of publications is in line with the number of citations which show an increase from a year to a year. A significant increase was observed in 2016 where more than 10 publications were produced compared to previous years and increased more than fivefold at the end of 2022.

This was also supported by an exponential increase in the number of citations with a cumulative total of 2731. Globally, Malaysia ranked second after Brazil (1183 papers),

followed by the United States (274 papers), Mexico (191 papers), and another 75 countries under 100 articles related to kelulut research since the first publication in 1861.

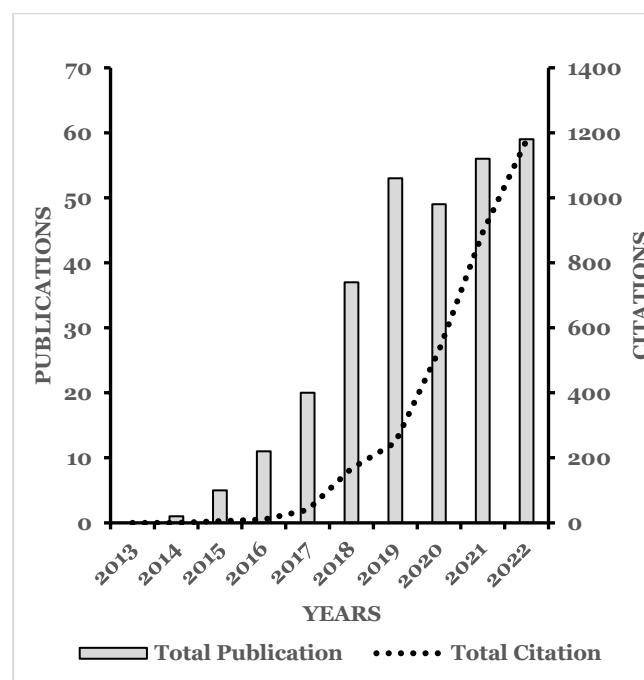


Figure 3. Number of annual publications and citations on kelulut indexed in Scopus from 2012 to 2021.

B. Institutions and Sponsorship

The Scopus Database data shows more than 100 local and foreign affiliates/agencies/institutions involved in kelulut research in Malaysia. Table 1 has listed the top 10 institutions in terms of the 10-year number of publications from 2013 to 2022, all from within Malaysia. UPM topped the top chart with 69 papers followed by UMT with 52 papers, while USM and UTM with 34 and 30 papers, respectively. Although UTHM had only 20 papers, the number of citations was quite high (101: CPY 5.05) placing it in fourth place after UPM, UMT, and UTM, and sharing the same number of citations with USM which is 432 (CPY 6.26), 158 (CPY 3.04), 120 (CPY 4.00), and 101 (CPY 2.97), respectively.

All kelulut-related research conducted in Malaysia has 48 local sponsors; 79.2 %, as well as those from foreign sponsorship; 19.8 %. Table 2 shows the 10 highest local sponsorships in terms of the number of published papers in Scopus that funded the research.

Table 1. Ranking of the top 10 institutions conducting research on kelulut in Malaysia from 2013 to 2022. The ranking is based on the number of publications followed by the highest to lowest number of citations.

Rank	Affiliation	TP	TC	CPY
1	Universiti Putra Malaysia (UPM)	69	432	6.26
2	Universiti Terengganu (UMT)	52	158	3.04
3	Universiti Sains Malaysia (USM)	34	101	2.97
4	Universiti Teknologi Malaysia (UTM)	30	120	4.00
5	Universiti Kebangsaan Malaysia (UKM)	23	73	3.17
6	Universiti Sultan Zainal Abidin (UniZA)	21	58	2.76
7	Universiti Malaysia Pahang (UMP)	20	49	2.45
8	Universiti Tun Hussein Onn Malaysia (UTHM)	20	101	5.05
9	Malaysian Agricultural Research and Development Institute (MARDI)	18	71	3.94
10	Universiti Teknologi MARA (UiTM)	17	34	2.00

TP = Total Publications

TC = Total Citations

CPY = Citation per paper

Table 2. Ranking of the top 10 local sponsors in that fund research on kelulut in Malaysia.

Rank	Sponsor	TP*
1	Ministry of Higher Education, Malaysia	83
2	Universiti Putra Malaysia	23
3	Universiti Sains Malaysia	19
4	Universiti Malaysia Pahang	14
5	Universiti Kebangsaan Malaysia	13
6	Universiti Tun Hussein Onn Malaysia	12
7	Universiti Teknologi Malaysia	12
8	Universiti Malaysia Terengganu	10
9	Institut Penyelidikan dan Kemajuan Pertanian Malaysia	4
10	Universiti Teknologi MARA	4

*TP = Total Publications

The Ministry of Higher Education Malaysia is the highest contributor with 83 published papers, followed by UPM with 23, and USM with 11 papers. 31 global entities listed as contributors to kelulut research are shown in Table 3. The United States comprising nine organisations contributed for 11 research, followed by four organisations from Australia contributing four research projects, three organisations from Brazil contributing four research projects, and one organisation from Taiwan contributing two research projects. Other organisation from each country such as Jordan, China, Vietnam, the Netherlands, Spain, Singapore, Taiwan, India, Canada, Japan, Switzerland, Indonesia, Spain, South Africa and UNESCO contributed only one research project.

Table 3. List of sponsors from global entities that fund research on kelulut in Malaysia.

Country	Sponsors	NP
The United State of America	Glaucoma Research Foundation	2
	University of Southern Maine	2
	Biology Department, Gannon University	1
	Directorate for Biological Sciences	1
	National Science Foundation	1
	Rutgers, The State University of New Jersey	1
	Sigma Xi	1
	U.S. Department of Agriculture	1
	Yale University	1
Australia	James Cook University	1
	Queensland Health	1
	University of Queensland	1
	University of Sydney	1
Brasil	Ministério da Ciência, Tecnologia e Inovação	2
	Empresa Brasileira de Pesquisa Agropecuária	1
	Fundação de Amparo à Pesquisa do Estado de São Paulo	1
Taiwan	Ministry of Science and Technology, Taiwan	2
	Council of Agriculture	1
Vietnam	Stiftung Vinetum	
Jordan	Al-Zaytoonah University of Jordan	1
China	China Postdoctoral Science Foundation	1
Netherlands	Foundation for Fundamental Research on Matter	1
Spain	Ministerio de Educación, Cultura y Deporte	1
Singapore	Ministry of Education – Singapore	1
India	National Agri-Food Biotechnology Institute	1
Canada	Natural Sciences and Engineering Research Council of Canada	1

Japan	Research Institute for Humanity and Nature	1
Switzerland	Stiftung Vinetum	1
Indonesia	Universitas Muhammadiyah Surakarta	1
South Africa	University of Mpumalanga	1
Spain	Ministerio de Educación, Cultura y Deporte	1
UNESCO	United Nations Educational, Scientific and Cultural Organization	1

NP= Number of Publications

C. List of Most Productive Journals

Since the 10-year publication, a total of 292 journals have been recorded related to kelulut research in Malaysia. Only the top 10 journals are selected and sorted based on the following criteria: 1) highest to lowest number of publications, 2) if the number of publications is the same, the order is started with the highest to lowest CiteScore score. All the journals are owned by different publishers, and four of them are academic publishers based in Malaysia, namely the Malaysian Society of Applied Biology, Rynnye Lyan Resources, Universiti Putra Malaysia Press, and Universiti Kebangsaan Malaysia Press (Table 4).

Table 4. 10 most productive journals based on the number of papers published since year 2014.

Rank	Source Title	Publisher	TP	CS(H)
1	Malaysian Applied Biology	Malaysian Society of Applied Biology	14	0.7 (11)
2	Molecules	Multidisciplinary Digital Publishing Institute	11	6.7 (199)
3	Journal of Apicultural Research	Taylor and Francis Ltd.	10	4.8 (66)
4	Serangga	Universiti Kebangsaan Malaysia Press	10	1.0 (8)
5	Food Research	Rynnye Lyan Resources	9	1.5 (15)
6	Journal of Physics Conference Series	IOP Publishing Ltd.	9	1.0 (91)
7	Pertanika Journal of Tropical Agricultural Science	Universiti Putra Malaysia Press	8	1.4 (20)
8	Malaysian Journal of Analytical Sciences	Malaysian Analytical Sciences Society	8	1.0 (21)
9	IOP Conference Series Earth and Environmental Science	IOP Publishing Ltd.	8	0.8 (41)
10	Malaysian Journal of Microscopy	Universiti Putra Malaysia Press	8	0.6 (19)

CS = CiteScore referenced databases through access <https://www.scopus.com/sources.uri>

H = H index referenced databases through access <https://www.scimagojr.com/>
TP = Total publications

The Malaysian Journal of Applied Biology has 4.8 % of the total papers published. The three journals in second, third and fourth place, namely Molecules (11 TP), Journal of Apicultural Research (10 TP), and Serangga (10 TP). Journal of Physics Conference Series and Food Research have 6.89 %. The IOP Conference Series Earth and Environmental Science alone has 3.1 %. Molecule Journal, despite having the highest CiteScore score and H index, is only ranked second on the list. Pertanika Journal of Tropical Agricultural Science, IOP Conference Series Materials Science and Engineering, Malaysian Journal of Analytical Sciences, and last on the list, Malaysian Journal of Microscopy, contribute 2.7% of total publications.

Figure 4 shows that five clusters from 111 items have been automatically generated by VosViewer software (only five minimum numbers of co-occurrences of a keyword) representing pollination and ecology (red cluster), honey composition and physicochemical analysis (green cluster), antioxidant and antimicrobial activities (blue cluster), stingless bee species diversity (yellow cluster) and probiotics, enzymes, and lactic acid bacteria (purple cluster). It is clear that 'Stingless bee' is the most frequently encountered keyword with 100 occurrences and 103 links to other keywords, making up the total strength of the links (TLS), which is 815. Several parameters related to the physicochemical properties for the determination of honey quality such as pH, moisture, and electrical conductivity, have been determined as 11, 18, and 6 occurrences, respectively. The major sugar profiles in honey such as glucose, fructose and sucrose, share a similar number of occurrences, which is 6. Meanwhile, the carbohydrate keyword has 12 occurrences with 148 TLS.

Ultimately, such studies provide researchers with some broad guidelines for identifying potential as well as conducting further research in related fields.

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