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Mosquito sensor - A bibliometric review

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Abstract:

Mosquitos need to be monitored and controlled. Sensor-based technology is effective in preventing and controlling mosquitos. A wide range of sensors is used for mosquito surveillance. Sensor technology is used for, mosquito species-related studies; prevention of mosquito-transmitted diseases; mosquito surveillance systems. This bibliometric study is based on 81 Scopus documents on sensor technology applications for mosquito control and the bibliometric patterns are visualized. The United States of America leads in the publication of documents, collaborations, and research funding related to research on sensor technology applications for mosquito control. Future researchers can work on the sensor technology used for mosquito surveillance, mosquito species identification, and for controlling mosquito breeding.

Keywords:

Bibliometrics, Sensor, Monitoring, Mosquito, Water, Automation, Disease

1. Introduction

Mosquitos are small flies, in the family "Culicade". Mosquitos are a great concern for public health due to the chances of transmission of diseases through mosquito bites and blood feeding (Afify and Potter, 2022). The mosquito can transmit dangerous diseases including Zika fever, malaria, dengue (Brittanica, no date; US EPA, no date)(De Souza Silva *et al.*, 2018), yellow fever (Brittanica, no date)(Campos *et al.*, 2020)(De Souza Silva *et al.*, 2018), and filariasis (Brittanica, no date). The blood-sucking habit of female mosquitos, for maturing their eggs is causing the transmission of diseases. The mosquito lays eggs on the water surface (Brittanica, no date; US EPA, no date)(Hur and Wheat, 2022); marshes, swamps, temporary pools, and puddles (US EPA, no date).

Mosquitos are of different variants including the Aedes mosquito, Culex mosquito, and Anopheles mosquito. The life cycle of a mosquito differs on basis of variant and heavily depends upon its environment (Brittanica, no date). Mosquito prevention can be through various modes and the conventional measures include covering by cloths, usage of mosquito repellents, avoidance of breeding conditions of mosquitos, and use of nets and screens for windows, doors, and beds (Brittanica, no date; US EPA, no date).

The sensor technology can be used for a variety of purposes concerning mosquitos. The majority of the users are for remote and real-time monitoring of the mosquitos (González-Pérez *et al.*, 2022). This helps in cost reduction and human exposure to mosquito habitats. For proper mosquito prevention, and control and for initiating actions, the identification and classification of mosquito species are very essential. The sensor technology can be deployed for mosquito identification and species classification (González-Pérez *et al.*, 2022) (Linthicum *et al.*, 1991; Li and Principe, 2017) (de Nadai *et al.*, 2021) (Mukundarajan *et al.*, 2017) (Evangelista, 2019) (Silva *et al.*, 2015).

Many sensors including optical sensors facilitate the automated identification and classification of mosquitos. The advanced sensor technology can also be used for developing mosquito surveillance systems for the prevention and control of mosquito-related diseases (Catry *et al.*, 2018) (Hassan, Nogoumy, and Kassem, 2013)(Hassan and Onsi, 2004)(Salim *et al.*, 2017) (Campos *et al.*, 2020); Simon Hay, Bob Snow and David Rogers (1998). This is by installing the sensors in mosquito habitats and vulnerable areas with chances of disease spread through mosquito transmission.

The popular sensors used for mosquito surveillance are acoustic and optical (González-Pérez *et al.*, 2022); synthetic aperture radar remote-sensing (Catry *et al.*, 2018); orbital remote sensor (da Silva *et al.*, 2020); optical sensors (de Nadai *et al.*, 2021)(González-Pérez *et al.*, 2022); temperature sensors and air relative humidity sensors (de Freitas *et al.*, 2020)(Ritchie *et al.*, 2011); wireless sensors (Hur and Eisenstadt, 2015)(Evangelista, 2019); satellite sensors (Hassan, Nogoumy and Kassem, 2013)(Hassan and Onsi, 2004) surface acoustic wave (SAW) sensors (Salim *et al.*, 2017).

The existing literature includes very few reviews on mosquito sensing. The use of nano-based formulations for diagnosis and control of mosquito-borne diseases is reviewed (Campos *et al.*, 2020); Simon Hay, Bob Snow, and David Rogers (1998) have reviewed the predicting mosquito habitat to malaria seasons using remotely sensed data. Similarly, very few bibliometric details are available on this research topic. Moreover, very rare systematic literature reviews are available on mosquito detection using sensors are available. This research gap of limited bibliometric information is taken up in this paper.

This bibliometric review aims to consolidate the literature on mosquito sensing. The bibliometric patterns are analyzed in this review and the agenda for further research. This bibliometric pattern helps the readers in identifying the various sensor applications related to mosquito observation and the bibliometric details. This paper has sections for introduction, followed by the literature review, methodology, bibliometric analysis, and conclusion.

2. Literature Review

Mosquito prevention and control are essential for avoiding serious health challenges and technology can be relied on for this purpose, including sensor technology (De Souza Silva *et al.*, 2018). Synthetic aperture radar remote sensing can be used for preventing the spread of malaria in wetland conditions (Catry *et al.*, 2018). The orbital remote sensor is used to define macro-mesoscale structural controls and stratigraphic/contact relations of the Mosquito Magmatic Suite (da Silva *et al.*, 2020). Sensor technology integration in mosquito surveillance helps with real-time and remote monitoring of mosquitos (González-Pérez *et al.*, 2022). Modern mosquito surveillance uses acoustic and optical sensors; along with machine learning techniques for the automatic classification of mosquitoes based on their flight characteristics (González-Pérez *et al.*, 2022). Sensor technology can rely on automated insect recognition, including mosquitos (Linthicum *et al.*, 1991; Li and Principe, 2017). The optical sensors are used for automated mosquito species identification by detecting the wingbeat frequencies (WBF). However, the WBF may vary depending on the body size and temperature of female Aedes mosquitos. Optical sensors are ideal tools to capture these variations (de Nadai *et al.*, 2021). The optical sensors are also used for generating accurate automatic classification of mosquitoes by genus and sex (González-Pérez *et al.*, 2022). The wireless sensors can also be deployed for the sensing of the wingbeat pattern of mosquitos in remote and independent monitoring systems, developed using an infrared sensor to detect wingbeat patterns. This helps in mosquito classification by identifying wing beat patterns (Evangelista, 2019). Machine learning and signal processing can be used for developing low-cost sensors for identifying flying insect species, including that mosquito species (Silva *et al.*, 2015). The other sensors used for the studies related to mosquitoes include temperature sensors and air relative humidity sensors (de Freitas *et al.*, 2020)(Ritchie *et al.*, 2011); wireless climate monitoring systems (Hur and Eisenstadt, 2015); mobile phones as acoustic sensors for mosquito surveillance (Mukundarajan *et al.*, 2017). The satellite sensors can be used for remote sensing of landscape features associated with mosquito breeding (Hassan, Nogoumy and Kassem, 2013)(Hassan and Onsi, 2004). The surface acoustic wave (SAW) sensors can be effectively used for detection of the female Aedes mosquito in human habitations (Salim *et al.*, 2017).

Future researchers can focus on sensor technology innovations for better mosquito surveillance, mosquito-related disease observation, sensor technology usage for mosquito species identification, mosquito classification, and measures for controlling mosquito breeding. Remote and real-time monitoring of the above themes also offers scope for further research. Future researchers can also focus on sensor technology innovations and the development of new technology-oriented applications for mosquito surveillance and mosquito control. Moreover, the existing literature has taken up only very few mosquito-transmitted diseases for sensor-based control. Future researchers can take initiative for developing sensor-based solutions for all other mosquito-related diseases

3. Review Methodology

This bibliometric analysis related to sensor-based mosquito control is prepared by using Scopus resources. This paper used the Boolean “Mosquito AND prevention OR control AND Sensor”. The search was on titles and abstracts. This query on Scopus obtained eighty-one documents. Thirty-seven of these documents are available on open access. The eighty-one documents include fifty articles, nineteen conference papers, six reviews, one book, and five conference reviews. Seventy-eight of these documents were in English and found one document of Portuguese, French, and Russian. This literature review is based on selected documents. The literature that has inspired the framework of this bibliometric study used in this paper

(Bhandari, 2020; Anand, Bharti, and Singh, 2021; Arora and Jain, 2021; Badogu, Kumar and Kumar, 2022; Bharej, 2022)

For the paper selection process the unrelated documents, incomplete records, anonymous articles, and duplicates are checked, and found no anonymous articles or duplicate records. Incomplete records, anonymous articles, and irrelevant records are not used for the literature review. This bibliometric review includes several limitations and the limited number of publications available for review is a serious drawback. The scheme of article selection for the literature review section is shown in fig.1. Eighty-one Scopus articles are used for bibliometric analysis.

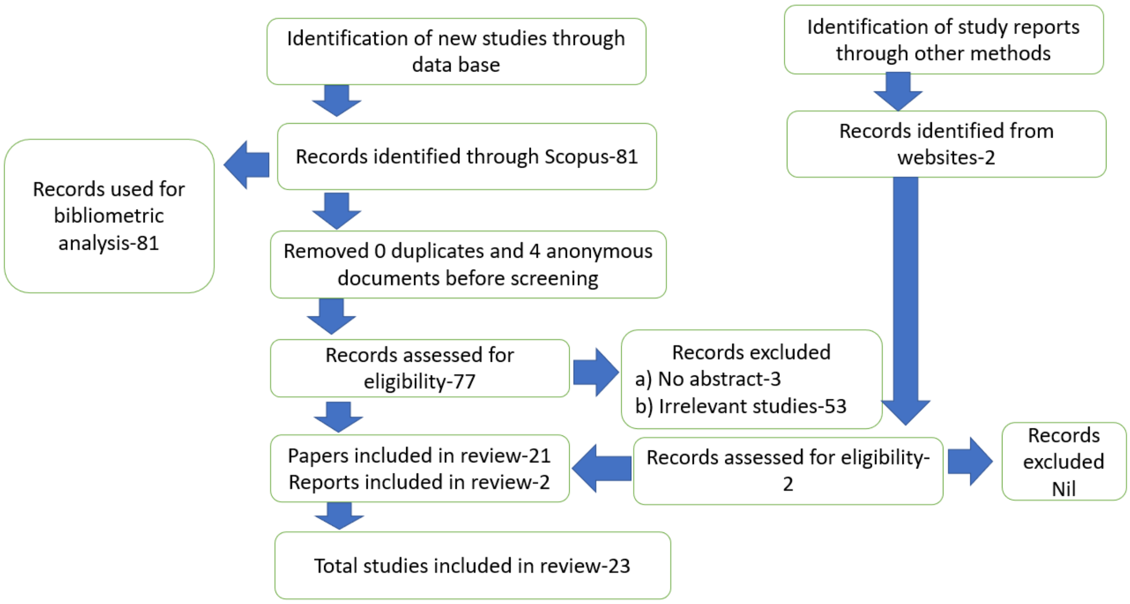

Figure.1: Article selection model

4. Results

4.1. Analysis of Document Sources

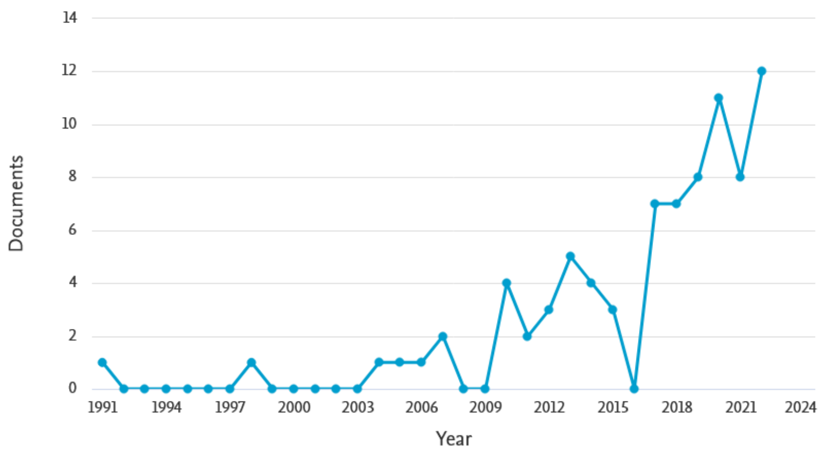

Figure. 2: Annual production of papers

Among 81 documents from Scopus sources, the majority of them are written after 2003. Publishing is increasing on yearly basis except in 2008-09 and 2015 (refer to fig. 2)

Table. 1: Leading document sources

Source documents	Publications	Citations	Average citation
Malaria Journal	2	119	59.5
Plos Neglected Tropical Diseases	2	45	22.5
Journal of South American Earth Sciences	2	7	3.5

Malaria Journal, Plos Neglected Tropical Diseases, and Journal of South American Earth Sciences have two publications on this topic. Malaria Journal has 119 citations with an average of 59.5 per publication. Plos Neglected Tropical Diseases and Journal of South American Earth Sciences have 45 and 7 citations respectively (refer to table 1).

4.2 Author analysis

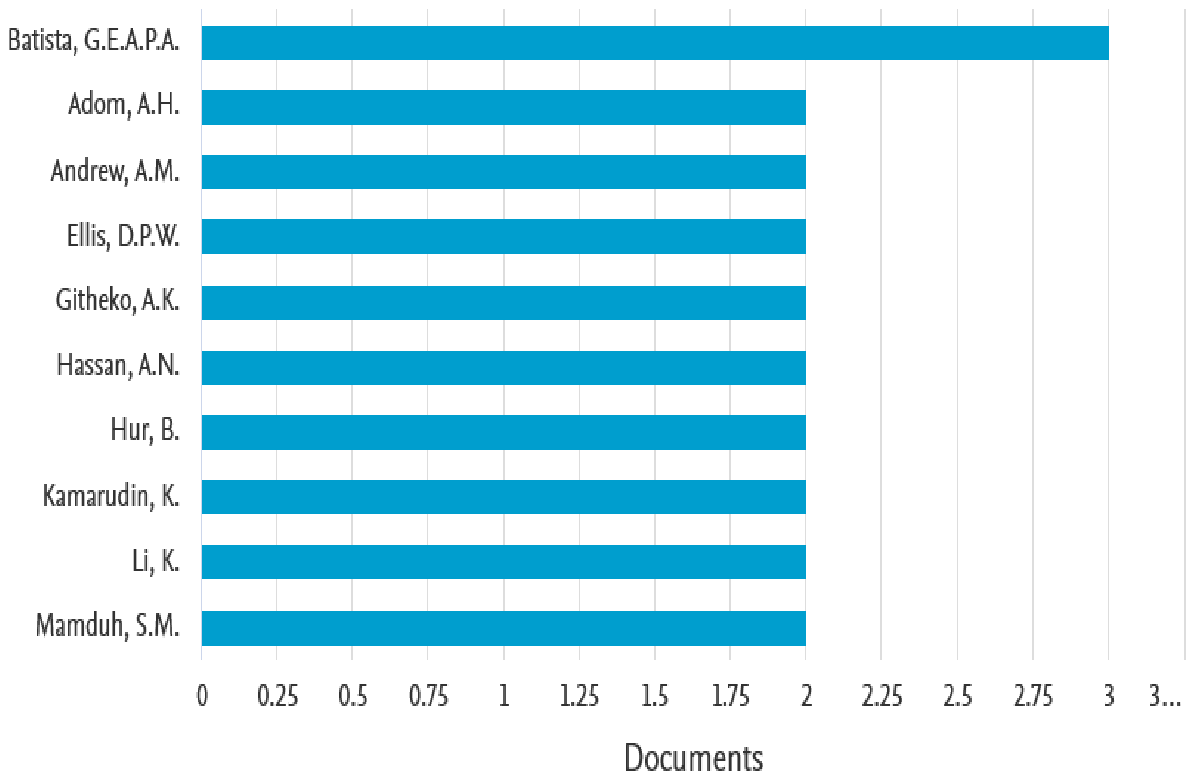

Figure 3: Leading authors

Batista G.E.A.P.A. has three publications on this topic. Adom A H, Andrew A M, Ellis D P W, Githeko AK, Hassan A N. Hur B, Kamarudin K, Li K, and Mamduh S M have two publications each (refer to fig.3). Very limited collaboration exists among authors (refer to fig.4)

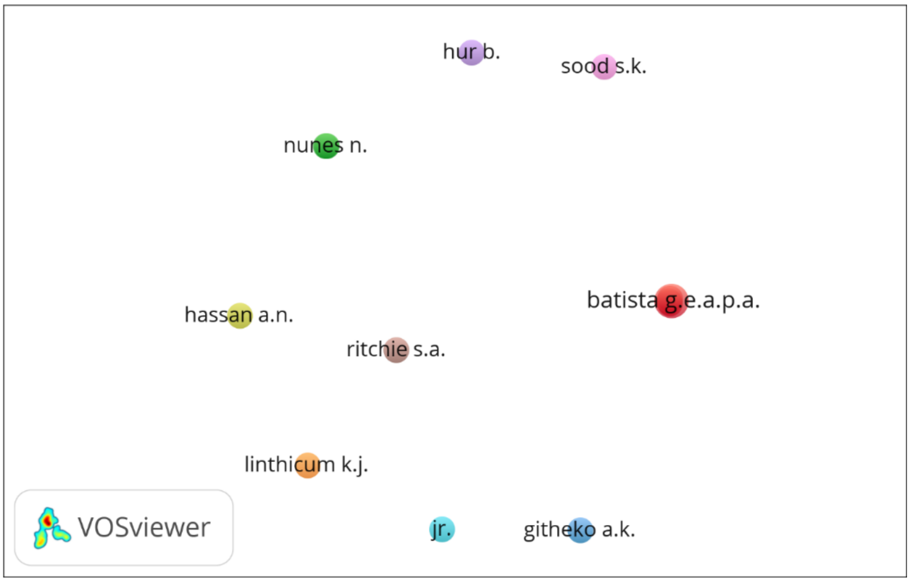

Figure. 4: Author collaborations

4.3. Country Analysis

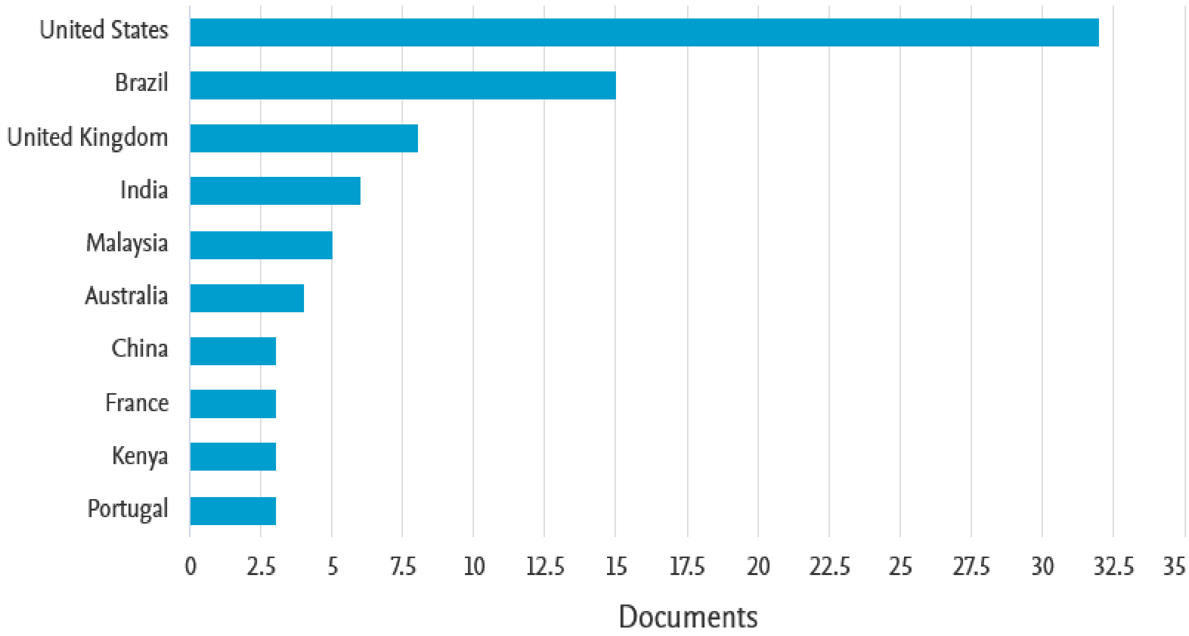

Figure. 5: Leading countries

The United States of America has 32 publications on this topic, followed by Brazil with 15 publications (refer to fig. 5). The United Kingdom and India have 8 and 6 publications respectively. The United States of America and Brazil have research connections with Australia, Malaysia, India, and the United Kingdom (refer to fig. 6).

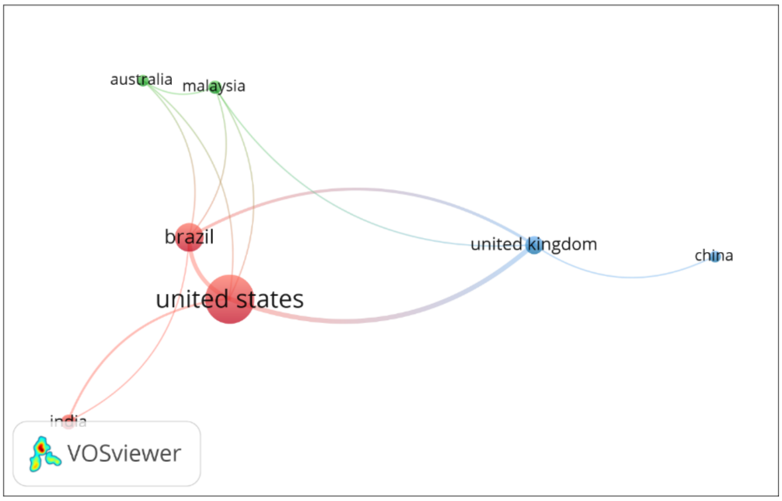

Figure. 6: Country collaborations

4.4. Keyword analysis

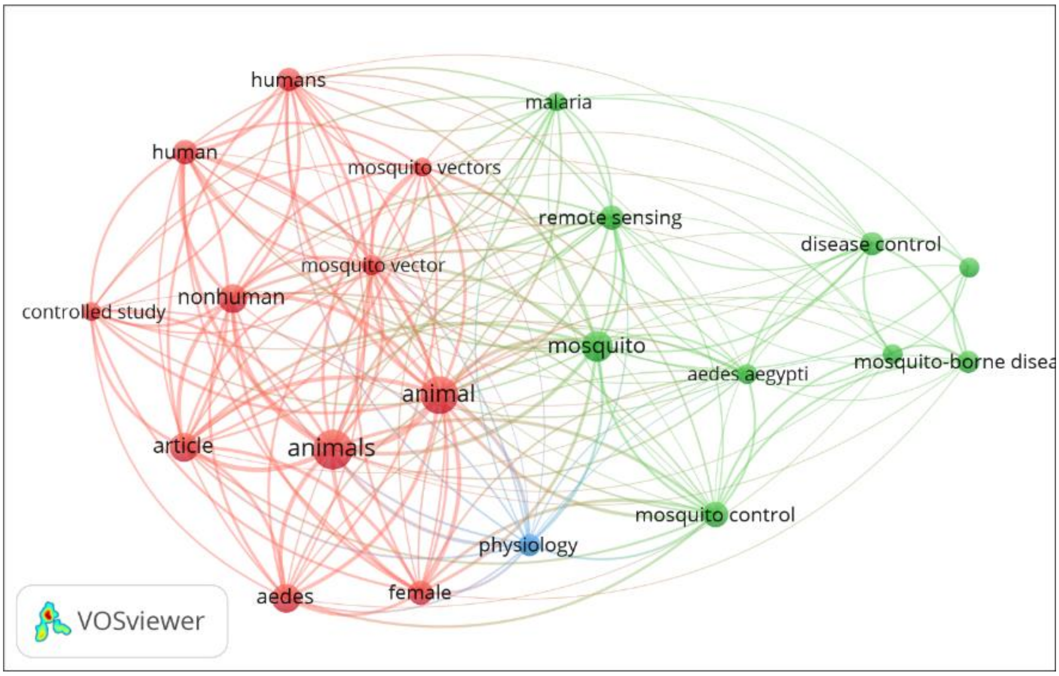

Figure. 7: Important keywords

The popular keywords in this topic are mosquito vector animal animals, female, Aedes, article, controlled study, human, humans, mosquito, malaria, remote sensing, mosquito control, and disease control (refer to fig.7).

4.5. Analysis of affiliations and Sponsorships:

The University of Sao Paulo has five publications on this topic, followed by the University of Florida, the University of Oxford, and the University of California with four publications each (refer to figure 8). The National Institutes of Health has five funded documents on this topic (refer to fig. 9).

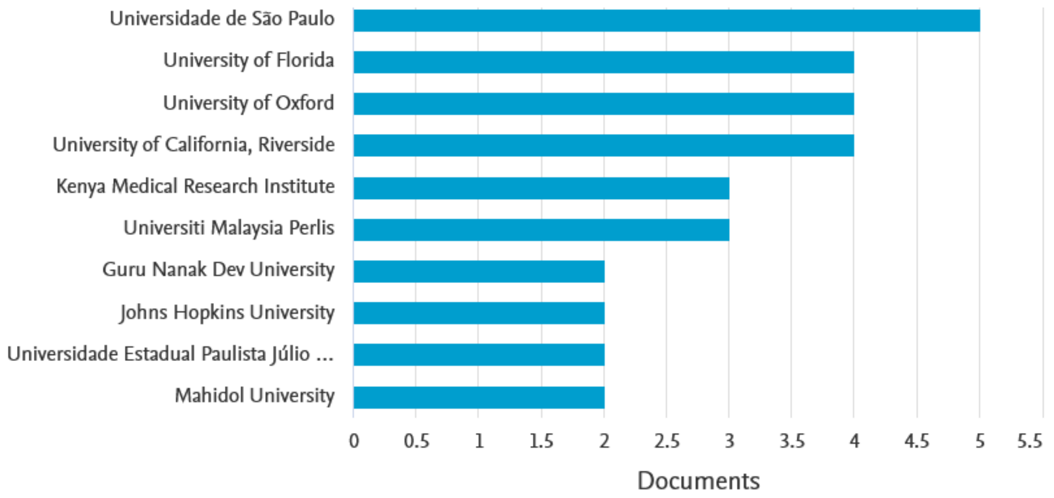

Figure. 8: Important research organizations

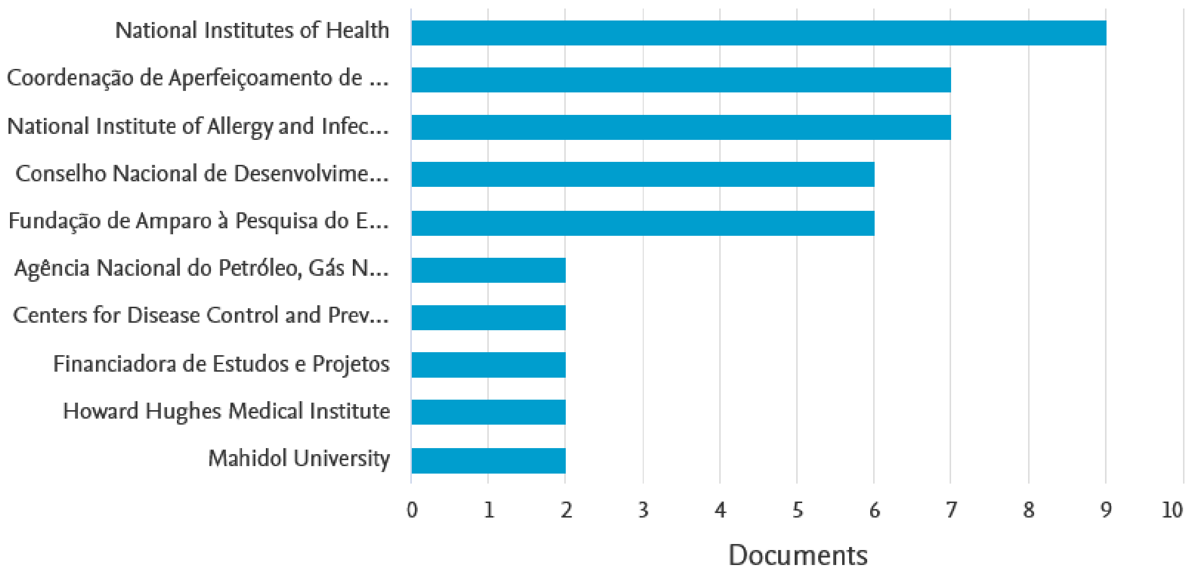

Figure. 9: Leading sponsors

5. Conclusions:

Mosquitos can transmit several dangerous diseases. Disease control and treatments could be one option and the control and prevention of mosquito bites should be given more priority. Other than the conventional methods, sensor technology can be used for the efforts for preventing and controlling mosquitos. A variety of sensors are used for this effort. The leading sensor types for this purpose include optical sensors, surface acoustic wave (SAW) sensors, wireless sensors, orbital remote sensors, optical sensors, temperature sensors, satellite sensors, and humidity sensors. The sensor technology can be used for a variety of purposes the usage including mosquito identification and species classification; prevention and control of mosquito-related diseases; development of mosquito surveillance systems; for disease monitoring and control.

Very few reviews are on this topic and so limited publications are directly related to the usage of sensor technology for mosquito control. The other challenges of the research on this topic are related to collaboration. The themes for further research can be related to the development of innovative sensors for better mosquito surveillance, disease observation, mosquito species identification, and controlling mosquito breeding. Researchers can take initiative by focusing on individual diseases and individual mosquito variants.

Malaria Journal is the leading document source and Batista G.E.A.P.A leads in document publications. Limited collaboration exists among authors. Moreover, around 40% of publications are by the United States of America and this paper recommends improving the research and funding on sensor technology for mosquito prevention and control as it is directly related to the health of individuals. There is a need for enhanced collaborations too. However, active collaboration exists among countries. The leading research organizations are from Brazil, the United States of America, and the United Kingdom. The leading funding agency is from the United States of America.

6. References:

1. Afify, A. and Potter, C. J. (2022) 'Genetically Encoded Calcium Indicators for Functional Imaging of Mosquito Olfactory Neurons', *Cold Spring Harbor Protocols*, 2022(11), pp. 533–536. doi: 10.1101/pdb.top107683.
2. Anand, D., Bharti, V. and Singh, S. (2021) 'Systematic review on the smart energy transmission through "sMART GRID" - An application of IoT', in Sharma V. Srivastava R., S. M. (ed.) *Proceedings - 2021 3rd International Conference on Advances in Computing, Communication Control and Networking, ICAC3N 2021*. Institute of Electrical and Electronics Engineers Inc., pp. 563–568. doi: 10.1109/ICAC3N53548.2021.9725663.
3. Arora, P. and Jain, A. (2021) 'Cyber Security Threats and Their Solutions Through Deep Learning: A Bibliometric Analysis', in Sharma V. Srivastava R., S. M. (ed.) *Proceedings - 2021 3rd International Conference on Advances in Computing, Communication Control*

and Networking, ICAC3N 2021. Institute of Electrical and Electronics Engineers Inc., pp. 1944–1949. doi: 10.1109/ICAC3N53548.2021.9725480.

4. Badogu, K., Kumar, R. and Kumar, R. (2022) '3D Printing of Glass Fiber-Reinforced Polymeric Composites: A Review', *Journal of The Institution of Engineers (India): Series C*, 103(5), pp. 1285–1301. doi: 10.1007/s40032-022-00873-1.
5. Bhandari, D. D. (2020) 'A systematic review and research trends in crown gall', *Plant Cell Biotechnology and Molecular Biology*, 21(65–66), pp. 92–99. Available at: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85097871097&partnerID=40&md5=61ef3b5c420956229e086c07184cb8b9.
6. Bharej, K. (2022) 'A Bibliometric Analysis on eWOM and Consumer Behavior', in Chandani A. Divekar R., C. K. N. J. K. (ed.) *Springer Proceedings in Business and Economics*. Springer Nature, pp. 183–200. doi: 10.1007/978-981-19-4892-3_12.
7. Brittanica (no date) 'Mosquito', *Encyclopedia Brittanica*. Available at: https://www.britannica.com/animal/mosquito-insect (Accessed: 7 December 2022).
8. Campos, E. V. R. *et al.* (2020) 'Recent Developments in Nanotechnology for Detection and Control of Aedes aegypti-Borne Diseases', *Frontiers in Bioengineering and Biotechnology*, 8. doi: 10.3389/fbioe.2020.00102.
9. Catry, T. *et al.* (2018) 'Wetlands and malaria in the amazon: Guidelines for the use of synthetic aperture radar remote-sensing', *International Journal of Environmental Research and Public Health*, 15(3). doi: 10.3390/ijerph15030468.
10. Evangelista, I. R. S. (2019) 'Bayesian Wingbeat Frequency Classification and Monitoring of Flying Insects Using Wireless Sensor Networks', in *IEEE Region 10 Annual International Conference, Proceedings/TENCON*. Institute of Electrical and Electronics Engineers Inc., pp. 2403–2407. doi: 10.1109/TENCON.2018.8650550.
11. de Freitas, A. F. *et al.* (2020) 'Radiation balance in caatinga ecosystem preserved for a year drought in semiarid pernambucano [A ocorrência de arboviroses em diferentes tipologias do espaço geográfico e sua relação com as condições microclimáticas na cidade de joão pessoa/pb]', *Revista Brasileira de Geografia Fisica*, 13(7), pp. 3571–3584. doi: 10.26848/rbgf.v13.07.p3571-3584.
12. González-Pérez, M. I. *et al.* (2022) 'A novel optical sensor system for the automatic classification of mosquitoes by genus and sex with high levels of accuracy', *Parasites and Vectors*, 15(1). doi: 10.1186/s13071-022-05324-5.
13. Hassan, A. N., Nogoumy, N. E. and Kassem, H. A. (2013) 'Characterization of landscape

features associated with mosquito breeding in urban Cairo using remote sensing', *Egyptian Journal of Remote Sensing and Space Science*, 16(1), pp. 63–69. doi: 10.1016/j.ejrs.2012.12.002.

14. Hassan, A. N. and Onsi, H. M. (2004) 'Remote sensing as a tool for mapping mosquito breeding habitats and associated health risk to assist control efforts and development plans: a case study in Wadi El Natroun, Egypt.', *Journal of the Egyptian Society of Parasitology*, 34(2), pp. 367–382. Available at: https://www.scopus.com/inward/record.uri?eid=2-s2.0-4644223404&partnerID=40&md5=a7fca74db98b6a990339bab23444c27d.
15. Hay, S. I., Snow, R. W. and Rogers, D. J. (1998) 'From predicting mosquito habitat to malaria seasons using remotely sensed data: Practice, problems and perspectives', *Parasitology Today*, 14(8), pp. 306–313. doi: 10.1016/S0169-4758(98)01285-X.
16. Hur, B. and Eisenstadt, W. (2015) 'Low-power wireless climate monitoring system with RFID security access feature for mosquito and pathogen research', in Urien P., P. S. (ed.) *2015 1st Conference on Mobile and Secure Services, MOBISECSERV 2015*. Institute of Electrical and Electronics Engineers Inc. doi: 10.1109/MOBISECSERV.2015.7072871.
17. Hur, B. and Wheat, C. B. (2022) 'Water Analysis Quadcopter Platform Development for Mosquito Research via Capstone project', in *ASEE Annual Conference and Exposition, Conference Proceedings*. American Society for Engineering Education. Available at: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85138305832&partnerID=40&md5=cc13ba840086e76861595cedc020bd03.
18. Li, K. and Principe, J. C. (2017) 'Automatic insect recognition using optical flight dynamics modeled by kernel adaptive ARMA network', in *ICASSP, IEEE International Conference on Acoustics, Speech and Signal Processing - Proceedings*. Institute of Electrical and Electronics Engineers Inc., pp. 2726–2730. doi: 10.1109/ICASSP.2017.7952652.
19. Linthicum, K. J. *et al.* (1991) 'Towards real-time prediction of Rift Valley fever epidemics in Africa', *Preventive Veterinary Medicine*, 11(3–4), pp. 325–334. doi: 10.1016/S0167-5877(05)80019-4.
20. Mukundarajan, H. *et al.* (2017) 'Using mobile phones as acoustic sensors for high-throughput mosquito surveillance', *eLife*, 6. doi: 10.7554/eLife.27854.
21. de Nadai, B. L. *et al.* (2021) 'The impact of body size on Aedes [Stegomyia] aegypti wingbeat frequency: implications for mosquito identification', *Medical and Veterinary Entomology*, 35(4), pp. 617–624. doi: 10.1111/mve.12540.

22. Ritchie, S. A. *et al.* (2011) 'A secure semi-field system for the study of Aedes aegypti.', *PLoS neglected tropical diseases*, 5(3), p. e988. doi: 10.1371/journal.pntd.0000988.
23. Salim, Z. T. *et al.* (2017) 'Frequency-based detection of female Aedes mosquito using surface acoustic wave technology: Early prevention of dengue fever', *Microelectronic Engineering*, 179, pp. 83–90. doi: 10.1016/j.mee.2017.04.016.
24. Silva, D. F. *et al.* (2015) 'Exploring Low Cost Laser Sensors to Identify Flying Insect Species: Evaluation of Machine Learning and Signal Processing Methods', *Journal of Intelligent and Robotic Systems: Theory and Applications*, 80, pp. 313–330. doi: 10.1007/s10846-014-0168-9.
25. da Silva, P. H. *et al.* (2020) 'Structural controls and stratigraphic setting of sills: Example of the Central Atlantic Magmatic Province in the Parnaíba Basin, Northeast Brazil', *Journal of South American Earth Sciences*, 101. doi: 10.1016/j.jsames.2020.102606.
26. De Souza Silva, G. C. *et al.* (2018) 'Technologies to combat aedes mosquitoes: A model based on smart City', *Studies in Health Technology and Informatics*. Edited by S. D. J. B. S. Rotegard A.K. Davalos Alcazar A.G., 250, pp. 129–133. doi: 10.3233/978-1-61499-872-3-129.
27. US EPA (no date) *General Information about Mosquitoes, United States Environmental Protection Agency*. Available at: https://www.epa.gov/mosquitocontrol/general-information-about-mosquitoes (Accessed: 7 December 2022).

Cite as

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