

GLOBAL OCCURRENCE PATTERNS OF *Aedes* MOSQUITOES BASED ON BIODIVERSITY DATABASE RECORDS

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DOI: <https://doi.org/10.5281/zenodo.19658114>

Received
19 February 2026

Accepted
29 March 2026

Published
20 April 2026

ABSTRACT

Mosquitoes of the genus *Aedes* are widely distributed and play an important ecological and public health role as vectors of several arboviral diseases. Understanding their global distribution is essential for ecological assessment and vector surveillance. In this study, occurrence records of *Aedes* mosquitoes were obtained from the Global Biodiversity Information Facility and analyzed to evaluate global distribution patterns. After data cleaning and filtering, a total of 69,541 occurrence records from 188 countries were included in the analysis. Country-wise assessment revealed that the highest number of records originated from the United States, followed by Spain, Italy, Mexico, and Australia. Spatial visualization demonstrated a widespread global distribution, with higher concentrations in tropical and subtropical regions. The findings highlight the extensive geographic range and ecological adaptability of *Aedes* mosquitoes and demonstrate the usefulness of open biodiversity databases for large-scale ecological studies. This study provides a data-driven overview of *Aedes* distribution and supports the integration of biodiversity informatics into vector monitoring and public health research.

Keywords: *Aedes*, mosquito distribution, biodiversity databases, global occurrence, vector ecology, public health entomology

INTRODUCTION

Mosquitoes are among the most significant groups of insects due to their ecological importance and their role as vectors of numerous human diseases. Within this group, the genus *Aedes* comprises several species of global concern, particularly due to their capacity to transmit arboviruses such as dengue, Zika, and chikungunya (Bhatt et al., 2013; Kraemer et al., 2015). The widespread distribution and ecological adaptability of *Aedes* mosquitoes have contributed to their successful establishment across diverse climatic regions, especially in tropical and subtropical environments (Messina et al., 2019).

The global expansion of *Aedes* species has been strongly influenced by environmental changes, urbanization, and increased human mobility. Many species, including *Aedes aegypti* and *Aedes albopictus*, have developed close associations with human habitats, utilizing artificial containers and urban structures as breeding sites (Powell et al., 2018). This adaptation has facilitated their dispersal across continents, often aided by international trade and transportation networks (Kraemer et al., 2019). As a result, understanding their distribution patterns has become increasingly

important for both ecological research and public health planning.

In recent years, the availability of large-scale biodiversity databases has provided new opportunities to analyze species distribution at a global scale. Platforms such as the Global Biodiversity Information Facility offer extensive occurrence data that can be used to investigate spatial patterns and biodiversity trends (Beck et al., 2014). However, despite the increasing use of such databases, comprehensive analyses focusing specifically on the global occurrence patterns of *Aedes* mosquitoes remain limited.

The present study aims to analyze the global distribution of *Aedes* mosquitoes using occurrence data obtained from GBIF. By examining spatial patterns and country-wise distribution, this study provides a data-driven overview of the geographic spread of *Aedes*. The findings contribute to a better understanding of the ecological distribution of this important mosquito genus and highlight the value of biodiversity informatics in vector research.

MATERIALS AND METHODS

Data Source

Occurrence data for *Aedes* mosquitoes were obtained from the Global Biodiversity Information Facility, an open-access platform providing global biodiversity records. Data were retrieved using the scientific name *Aedes* at the genus level. Only records with available geographic coordinates were considered for analysis to ensure spatial accuracy.

Data Filtering and Preparation

The downloaded dataset was initially screened to remove incomplete and unreliable records. Entries lacking geographic coordinates (latitude and longitude) were excluded. Records with zero or invalid coordinates were also removed. Duplicate records based on identical geographic coordinates were eliminated to avoid spatial redundancy.

The final cleaned dataset consisted of 69,541 occurrence records representing *Aedes* mosquitoes across multiple geographic regions. Data processing and cleaning were performed using the RStudio environment (R version 4.5).

Data Analysis

Descriptive statistical analyses were conducted to evaluate the global distribution patterns of *Aedes* mosquitoes. The total number of occurrence records was calculated, and country-wise distribution was assessed by summarizing the number of records per country using standard data manipulation techniques in R. The number of unique countries represented in the dataset was also determined to assess the global coverage of occurrence records. These analyses provided an overview of the geographic distribution and relative abundance of records across regions.

Spatial Visualization

Spatial visualization of occurrence data was performed to illustrate the global distribution of *Aedes* mosquitoes. Geographic coordinates were plotted on a world map using R-based visualization packages. A global distribution map was generated to display the spatial spread of occurrence records. Additionally, a bar chart representing the top countries with the highest number of records was produced to highlight regional differences in occurrence frequency. All graphical outputs were generated using R and exported in high-resolution format suitable for publication.

Software and Tools

All data processing, analysis, and visualization were conducted using RStudio with relevant packages including dplyr, ggplot2, and maps. Data handling and preliminary inspection were optionally supported using Microsoft Excel.

RESULTS

A total of **69,541 occurrence records** of *Aedes* mosquitoes were analyzed after data cleaning and filtering. The dataset comprised records from **188 countries**, indicating a broad global distribution of the genus. Country-wise analysis revealed that the highest number of occurrence records originated from the **United States (16,997 records)**, followed by **Spain (15,555 records)**. Other countries with notable record counts included **Italy (5,245 records)**, **Mexico (5,101 records)**, and **Australia (3,237 records)**.

The global distribution map demonstrated a widespread occurrence of *Aedes* mosquitoes across multiple continents, with higher concentrations observed in tropical and subtropical regions. Additionally, significant record densities were also observed in parts of Europe and North America,

likely reflecting both ecological suitability and higher sampling efforts. Overall, the results highlight the extensive geographic range and ecological adaptability of *Aedes* mosquitoes in diverse environmental conditions.

Table 1. Top countries with the highest number of *Aedes* occurrence records based on GBIF data. Only the top 15 countries are shown for clarity, while the complete dataset is provided as supplementary material.

Country	n	Country	n	Country	n
US	16,997	NL	1,435	DZ	69
ES	15,555	CA	1,282	MA	68
IT	5,245	SE	1,102	GA	65
MX	5,101	TH	919	GF	65
AU	3,237	DE	785	IL	65
AT	2,126	FI	678	AM	64
HU	2,025	GB	665	TN	58
CO	1,696	NZ	664	ME	57
FR	1,637	GR	598	PR	56

Note: a. Data represent the number of occurrence records of *Aedes* mosquitoes obtained from the Global Biodiversity Information Facility (GBIF).

b. The table is arranged in a multi-column format to improve readability and fit within a single page without omitting any records.

c. Country codes follow the ISO 3166-1 alpha-2 standard (e.g., US = United States, ES = Spain).

d. Values (n) indicate the total number of occurrence records per country after data cleaning and removal of duplicate and invalid geographic coordinates.

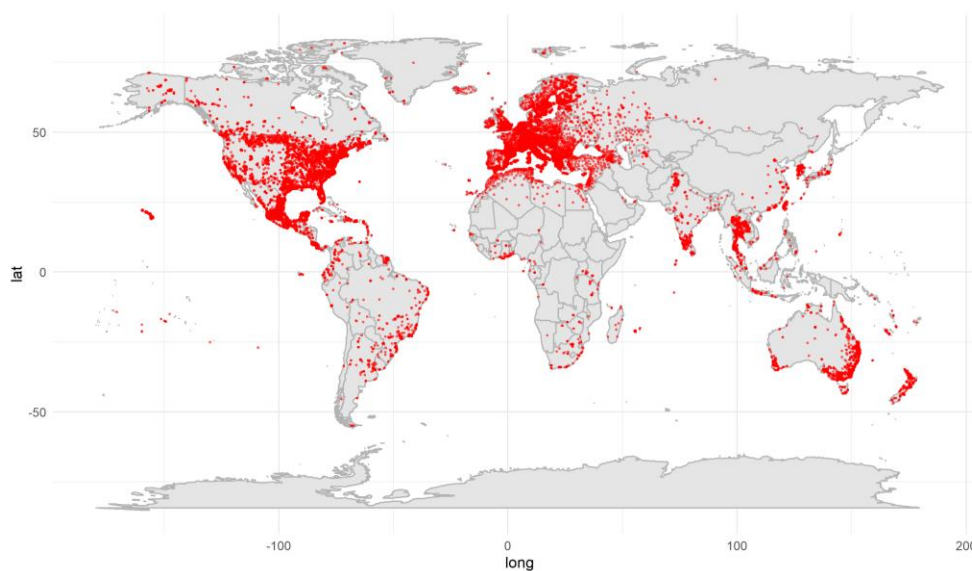


Figure 1. Global distribution of *Aedes* mosquito occurrence records. Each point represents a recorded occurrence, illustrating the widespread presence of the genus across different geographic regions.

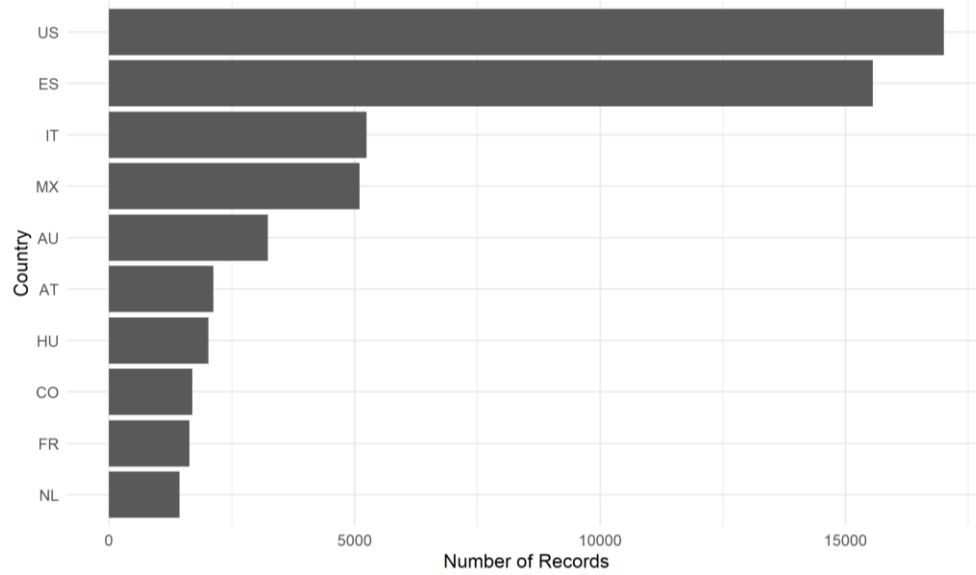


Figure 2. Top 10 countries with the highest number of *Aedes* occurrence records. The United States and Spain show the highest record counts, followed by Italy, Mexico, and Australia.

DISCUSSION

The present study demonstrates the extensive global distribution of *Aedes* mosquitoes based on a large set of occurrence records derived from the Global Biodiversity Information Facility. The wide geographic coverage observed in this study highlights the ecological plasticity of *Aedes* species, which are known to occupy a broad range of climatic zones, particularly in tropical and subtropical regions (Kraemer et al., 2015). The concentration of records in warmer regions is consistent with the temperature-dependent life cycle and breeding ecology of these mosquitoes (Messina et al., 2019).

The higher number of occurrence records in countries such as the United States and several European nations may reflect both favorable environmental conditions and increased surveillance efforts. Previous studies have emphasized that occurrence data from biodiversity databases are often influenced by sampling intensity and reporting infrastructure, which are typically higher in developed regions (Beck et al., 2014; Meyer et al., 2016). Therefore, the observed distribution patterns should be interpreted as a

combination of ecological reality and data availability.

The widespread occurrence of *Aedes* across multiple continents also underscores its adaptability to human-modified environments. Many species within this genus, particularly *Aedes aegypti* and *Aedes albopictus*, are closely associated with urban and peri-urban habitats, where artificial water containers provide suitable breeding sites (Powell et al., 2018). This ecological association with human environments facilitates their dispersal and establishment in new regions, often aided by global trade and transportation networks (Kraemer et al., 2019).

Furthermore, the global presence of *Aedes* mosquitoes has important implications for public health, as several species are known vectors of arboviral diseases such as dengue, Zika, and chikungunya (Bhatt et al., 2013). Although the present study focuses primarily on distribution patterns rather than disease dynamics, the results highlight the importance of continuous monitoring and data-driven approaches in understanding vector ecology. The integration of biodiversity informatics with public health

surveillance can provide valuable insights for early warning systems and vector control strategies.

Despite its strengths, this study has certain limitations. The use of occurrence records from open-access databases may introduce biases related to uneven sampling effort, taxonomic inconsistencies, and spatial data gaps (Meyer et al., 2016). Additionally, the absence of temporal and environmental variables limits the ability to infer causal relationships between distribution patterns and ecological factors. Future studies could incorporate climate data and predictive modeling approaches to provide a more comprehensive understanding of *Aedes* distribution dynamics.

CONCLUSION

This study provides a comprehensive overview of the global distribution of *Aedes* mosquitoes using large-scale occurrence data. The results demonstrate the widespread presence of the genus across diverse geographic regions, with higher occurrence densities in tropical and subtropical areas. The findings emphasize the ecological adaptability of *Aedes* mosquitoes and their close association with human environments. Moreover, the study highlights the value of open-access biodiversity databases in supporting rapid and cost-effective ecological research. Such data-driven approaches can contribute to improved vector monitoring and informed decision-making in public health and environmental management.

Authors' Contributions

The author solely conceived the study, performed data analysis, interpreted the results, and wrote the manuscript.

Acknowledgements

The author acknowledges the Global Biodiversity Information Facility (GBIF) for providing open-access biodiversity data used in this study.

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