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Study on mosquito diversity (Diptera: Culicidae) in different pockets of Madurai district, Tamilnadu, India

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Abstract
During the period of August 2014 to January 2015, a survey was conducted for the present study. The results of the survey revealed that a total of 169 organisms were collected from 15 different species belonging to 5 genera: *Culex, Aedes, Armigeres, Anopheles,* and *Mansonia*. The prevalent species in the study areas are listed in Table 1. It is worth noting that *Armigeres* and *Mansonia* were represented by only one species each. *Aedes*, on the other hand, was represented by five species: *Aedes scatophagoides, Aedes pallidostriatus, Aedes aegypti, Aedes albopictus, and Aedes vitatus*. Similarly, *Culex* was represented by five species: *Culex vishuni, Culex quinquefasciatus, Culex tritaneorhyncus, Culex infula*, and *Culex fucocephala*. Anopheles, the last genus, was represented by three species: *Anopheles subpictus, Anopheles culcifaciens,* and *Anopheles stephensi*. The study also recorded various diversity measures of mosquito fauna in Madurai during the study period from August 2014 to January 2015. These measures include the Simpson's index value (0.109), Dominance index (0.891), Reciprocal Simpson's index value (9.176), Shannon's index (3.49), Berger-Parker Dominance Index (0.207), Inverted Berger-Parker dominance index (4.829), Margalef Richness index (2.729), Menhinick index (1.51), Buzas and Gibson's Index (0.748), and Gini coefficient (6.08). In terms of Beta diversity, the absolute beta value was 14, while Whittaker's and Sorensen's index were both 1. The Routledge beta-R index was -5, the Jaccard index was 100%, and the Mountford index was 15.38. Furthermore, the study found that the maximum density of mosquito populations occurred in October, while the minimum density was observed in August.

Keywords: Mosquito diversity, Madurai, alpha diversity, beta diversity

Introduction
The term biodiversity pertains to the variety of flora and fauna in an ecosystem. It encompasses the abundance of life forms present in a given ecological community. The insect world has always been a subject of fascination, not only for Entomologists studying their structure and function, but also for individuals involved in various environmental initiatives. Insects exhibit remarkable diversity owing to their capacity to adjust to environmental changes. Mosquitoes, in particular, are of significant importance in terms of public health due to their exceptional adaptability and ability to coexist with humans. These insects are responsible for transmitting numerous diseases to over 700 million people annually. (Taubes, 1997).

The mosquito is the predominant insect family that significantly impacts human health worldwide. Despite numerous efforts to manage them, these highly adaptable mosquitoes persistently thrive alongside humans, relying on them and their domesticated animals for sustenance [1]. In addition to causing blood loss, they have the ability to transmit various diseases such as filariasis, malaria, yellow fever, Japanese encephalitis, dengue, and more [2-3]. The proliferation of these mosquitoes worldwide can be attributed to their voracious feeding habit, high fecundity rate, dispersal potential, and successful exploitation of the environment [3]. Mosquito-borne illnesses presently pose significant health challenges in tropical and subtropical regions, and no region of the globe is exempt from this peril [4]. Land use modifications, including deforestation, urbanization, and agriculture, have the potential to impact the abundance, diversity, and composition of mosquito populations. The primary driver of deforestation in Southeast Asia is the expansion of oil palm plantations, which may lead to an increased occurrence of mosquito-borne illnesses, such as dengue fever. The primary objective of this study is to examine the variation in mosquito population in Madurai district and its neighboring areas.

Materials and Methods
Mosquito sampling
The mosquito collection was conducted in the designated areas exclusively during nighttime from August 2014 to January 2015, following standard protocols. A total of 32 sampling sites were chosen within and around the Madurai district. Additionally, random collections were made every fortnight. Detailed information regarding mosquito species and their habitats was recorded on a data sheet. Immediately after collection, the mosquitoes were rendered unconscious and killed using ether. They were then stored in separate vials and sorted and identified based on their genera and subsequently their species. This systematic procedure was followed for each collection. The adult female mosquitoes that were collected were identified using the standard key provided by the experts at the Centre for Research in Medical Entomology (ICMR) in Madurai.

Data analysis
The current study utilized various statistical tools to determine both Alpha and Beta diversity. These tools included the Simpson Index, Dominance Index, Margalef

Index, Berger-Parker, Menhinick Index, Rényi Entropy/Hill Numbers, Buzas and Gibson's Index, Gini Coefficient, Equitability Index, Absolute beta Value, Whittaker's Index, Sørensen's similarity index, Jaccard Index, Routledge beta-R Index, and Mountford Index. All calculations were performed using an online calculator available at www.alyoung.com.

Results and discussion

During the period of August 2014 to January 2015, a survey was conducted as part of the present study. The survey revealed a total of 169 organisms collected from 15 different species belonging to 5 genera. These genera include *Culex, Aedes, Armigeres, Anopheles, and Mansonia*, which were found to be prevalent in the study areas (Table.1). It is worth noting that *Armigeres* and *Mansonia* were represented by only one species each. *Aedes*, on the other hand, was represented by five species, namely *Ae. scatophagoides*, *Ae. pallidostriatus*, *Ae. aegypti*, *Ae. albopictus*, and *Ae. vitatus*. Similarly, *Culex* was also represented by five species, including *Cu. vishuni*, *Cu. quinquefasciatus*, *Cu. tritaneorhyncus*, *Cu. infula*, and *Cu. fucocephala*. Lastly, *Anopheles* was found to have three species, namely *An. subpictus* and *An. stephensi*.

During the study period of Aug2014 to Jan 2015 in Madurai, a range of diversity measures were used to record the mosquito fauna. The Simpson's index value (0.109), Dominance index (0.891), Reciprocal Simpson's index value (9.176), Shannon's index (3.49) were used to show the alpha diversity. Additionally, the Berger-Parker Dominance Index (0.207), Inverted Berger-Parker dominance index (4.829), Margalef Richness index (2.729), Menhinick index (1.51), Buzas and Gibson's Index (0.748), and Gini coefficient (6.08) were also utilized.

The absolute beta value in Beta diversity is 14, with Whittaker's index being 1 and Sorensen's index being 1 as well. The Routledge beta-R index is -5, while the Jaccard index is 100%. Lastly, the Mountford index stands at -15.38. The index value of *Culex quinquefaciatus* -0.035, *Culex tritaeniorhynehus*- 0.059, *Culex infula*- 0.029, *Culex vishnui*- 0.19, *Culex fucocephala* -0.029, *Armigeres subelbatus*- 0.07, *Anopheles subpictus* – 0.07, *Anopheles subpictus* – 0.04, *Anopheles stephensi* – 0.02, *Aedes albopictus* – 0.20, *Aedes vittatus* – 0.07, *Aedes egypti* -0.03, *Aedes scatophagoides* -0.011, *Aedes pallidostriatus* – 0.017, *Mansonia uniformis* – 0.041.

It is widely recognized that certain mosquitoes, which were initially attracted to animals and forests, have adjusted their feeding habits to target humans, becoming associated with human settlements and even urban areas as a result of deforestation. The extent to which humans become involved in specific host-parasite cycles will be influenced by the impact of their actions on vector breeding grounds, the ability of mosquitoes to adapt to new environments, the existence of animal reservoirs, and human behavioral patterns.

The *Aedes albopictus*, commonly referred to as the 'Asian tiger mosquito', is an adult mosquito that serves as a carrier for chikungunya and dengue fever (WHO, 2006). Typically found in the wild, this species breeds in rock and tree holes within forested regions. However, due to deforestation, this mosquito has adapted to breeding in discarded tires in various parts of India [6, 9]. *Ae. vittates* typically reproduces in natural bodies of water such as rainwater accumulated in rock pools and serves as a carrier of yellow fever in African nations. On the other hand, *Ae. walbus* larvae were obtained from the stagnant pools created by the water trapped amidst the rocks.

In their study conducted at Darjeeling, it was observed that these larvae possess the capability to thrive in this particular habitat. The researchers noted a higher occurrence of algal growth in stagnant stream pools, which were formed by the water trapped between rocks. It was also found that *Aedes walbus* had adapted to breed in such pools, where the water had low detritus and a greater amount of algal growth [7, 11].

Cx. vishnui, an adult mosquito species belonging to the genus *Culex*, is known for its zoophilic behavior and outdoor resting habits. This species is considered a vector for Japanese encephalitis in India, Malaysia, and Taiwan, and is commonly found in rural areas across these regions [8, 10, 12, 13]. During the summer season, they may seek refuge indoors, but generally, they prefer to relax in shaded areas surrounded by vegetation. The current survey discovered that *Ae. albopictus*, a vector of dengue hemorrhagic fever, was once a sylvatic species in India. Meanwhile, *Cx quinquefasciatus* is a primary vector of urban filariasis caused by periodic *Wu. bancroftii*.

During the study period, the month of October stood out as the time when the mosquito populations reached their highest density. Conversely, the month of August witnessed the lowest density of mosquito populations. In order to effectively conserve biodiversity, it is crucial to gather baseline data on all fauna and flora, including the lesser-known groups. This is because every organism, regardless of its recognition, plays a vital role as a producer, consumer, pollinator, or decomposer.

The study area is characterized by a range of micro and macro climatic conditions, which support a wide array of invertebrate fauna. Among these, mosquitoes are particularly noteworthy as they contribute significantly to the conservation and preservation of biodiversity. This research has demonstrated that the diversity indexes commonly employed in environmental assessments, primarily for tracking changes in organism diversity, can also be utilized to monitor mosquito species.

It is recommended to utilize diversity indexes for tracking mosquito vector species across various locations with regards to habitat type, latitude, and land use. The data collected during monitoring should be utilized to predict the impact of environmental changes on mosquito populations. As changes in the abundance of adult mosquito species are greatly affected by the addition or removal of breeding sites in the study habitats, it is crucial to study the factors that regulate immature mosquito dynamics in the area.

Table 1: Shows the mosquito species collected from August 2014 to January 2015

S. No	Species Name	No. of Species	Aug – sep 2014	Oct- Nov 2014	Dec14-Jan-15
1	*Culex quinquefaciatus*	6	+	+	+
2	*Culex tritaeniorhynehus*	10	-	+	+
3	*Culex infula*	12	-	+	-

4	*Culex vishnui*	33	+	+	+
5	*Culex fucocephala*	5	-	+	-
6	*Armigeres subelbatus*	12	+	+	-
7	*Anopheles subpictus*	13	+	+	+
8	*Anopheles subpictus*	8	-	+	-
9	*Anopheles stephensi*	5	-	+	-
10	*Aedes albopictus*	35	+	+	+
11	*Aedes vittatus*	12	-	+	+
12	*Aedes egypti*	6	-	+	-
13	*Aedes scatophagoides*	2	-	+	-
14	*Aedes pallidostriatus*	3	-	+	-
15	*Mansonia uniformis*	7	-	+	-
	Total	161	5	15	6

Conclusion

The current research reveals that the Madurai District experiences a variety of mosquito populations as a result of haphazardly constructed areas, urbanization, the decline of natural predators such as frogs and dragonflies in reservoirs, and alterations in mosquito behavior as reported by other researchers. These factors may contribute to the rise in mosquito populations in and around the Madurai District.

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