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Dengue vector breeding ecology in Madurai district: Heat map cluster analysis

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Abstract
In the past ten years, Madurai District has been experiences of severe epidemics of dengue. These outbreaks coincided with a high increase in populations of Ae. albopictus that assists its sister taxon *Ae. aegypti* in most areas sampled. The goal of this work was to analyze the entomological investigation of the two Aedes species in Madurai district which has to face these arboviroses. The study area of Madurai District lies between 9°30' and 10° 50' of North latitude and from 77°00' to 78° 30' of East longitude. The purpose of selection of the study area is to investigate the spatial distribution of Aedes female mosquitoes and to analyze various factors, for example, mosquito sex, composition, rural and urban dissemination of selected species, container wise breeding and seasonal breeding are related and grouped in a heat map. The study was mainly based on primary data. The heat map grouping were made dependent on the sampling of Aedes mosquitoes collected for one year, from March 2017 – Feburary 2018 in dry and wet season in seven taluks of Madurai district in both rural and urban areas. Arc GIS used to analyze female per positive houses and to identify *Aedes* mosquitoes breeding variation. Principal Component Analysis, (PCA) used to explore the cluster of sex and composition of mosquitoes in rural and urban regions in dry and wet season.

Keywords: vector breeding, heat map, principle component analysis, GIS

1. Introduction
In the past ten years, Madurai District has been experiences of severe epidemics of dengue [1], These outbreaks coincided with a high increase in populations of Ae. albopictus that assists its sister taxon *Ae. aegypti* in most areas sampled [2]. The goal of this work was to analyze the entomological investigation of the two Aedes species in Madurai district which has to face these arboviroses. The heat map is one of the most prominent techniques for presenting the gene expression data. This is normally used to represent the degree of articulation of genes over various equivalent examples. Various factors, for example, mosquito sex, composition, rural and urban dissemination of selected species, container wise breeding and seasonal breeding are related and grouped in a heat map. The representation highlights of heat map can help to promptly understand the information by relegating various hues to every quality. Cluster of genes with comparative or boundlessly extraordinary articulation esteems are effectively observable.

The cluster heat map is a combination of many different graphic displays developed by statisticians over more than a century. A heat map is an ordinarily utilized representation instrument, which can give hints to data mining and has wide possibilities for application in the field of medical science [2] A heat map shows information through shading profundity, which is natural and decipherable, and can help non-analysts comprehend and dissect information [4, 5].

A heat map can likewise assist with investigating the connection between each lead through cluster assessment. Cluster assessment is a measurable investigation method, which orders the exploration objects into moderately homogeneous gatherings [6, 7].

Cluster investigation gives extra data to assist forecaster with finding the interconnection of each lead. The result of cluster investigation can be drawn as tree maps in the heat map. The tree diagram joined to the heat map shows the whole cycle of bunching and shows which leads are assembled from the visual level [8] Jian-Peng *et al.* 2016 portray the sporadic examples of

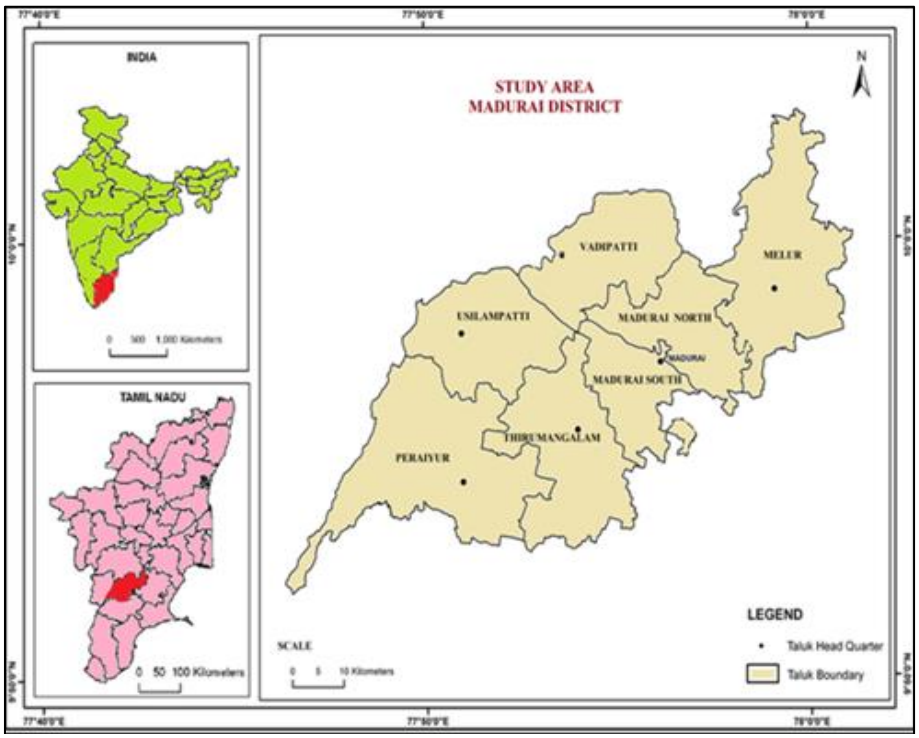
dengue cases in various urban communities; he made heat maps of the mean estimation of the propotion of cases for every city in every week. The weekly cases were standardized by the most extreme number of cases every week, and characterized by whether they were in the Pearl River Delta (PRD) or non-Pearl River Delta (NPRD) locale [9].

The cluster heat map is notable in the natural sciences and is one of the most broadly utilized charts in the biological sciences [10].

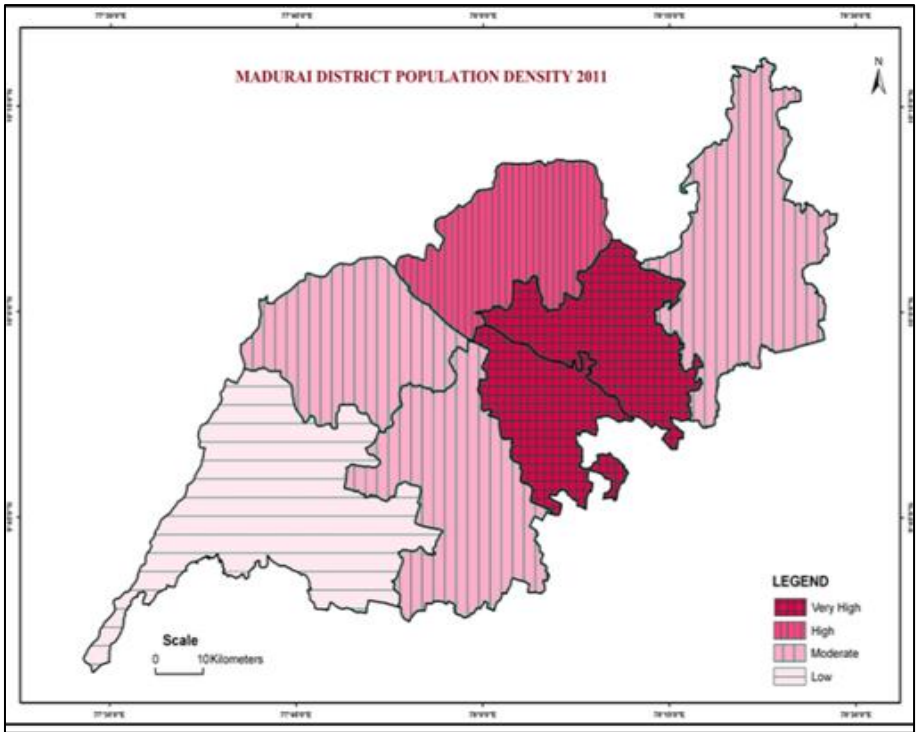
In recent years, GIS has been used in a number of studies to tackle several communicable and non-communicable diseases [11, 12, 13] GIS is a system designed to capture and analyze data using spatial trends. In this study GIS Used to analyze female per positive houses and to identify *Aedes* mosquitoes breeding variation based on Bio –Geo- Eological characteristics.

2. Study Area

Madurai District lies between 9°30’ and 10° 50’ of North latitude and from 77°00’ to 78° 30’ of East longitude. It is bordered by Dindigul and Tiruchirapalli districts on the north, Sivaganga district on east, Virudhunaga on the South and Theni district on the west.



Map1: Study Area



Map 2: Population Density

Madurai district administers 3, 710 square kilometers of areas. The total number of population of the district is 30,38,252. The Very high density is noted in Madurai south taluk with 4768 person per sq km followed by Madurai North taluk with 1290 person per sq km. High density with 486 persons per sq km is found in vadipatti taluk. Moderate density is noted in Melur (401), Thirumangalam (406), and Usilampatti Taluk with 410 persons per sq km. Lowest density with 246 person per sq kmis found in Peraiur Taluk.

3. Materials and Methods

In the study area larvae and pupae were were collected using a dipper and transferred to a plastic bottle using a wide-mouthed pipette. The collected mosquitoes larvas and pupas were stored in water filled cups enclosed with netting. Collected samples reared until adult stage and then identified by Dissection microscope (Figure-1)Usually, larvae and pupae were sampled at the same time as adults. For each species, the numbers of individuals, date of capture and location site were recorded. The emerged mosquito's specimen's morphology was identified at ICMR lab in Madurai, to find out mosquito composition and Gender category.

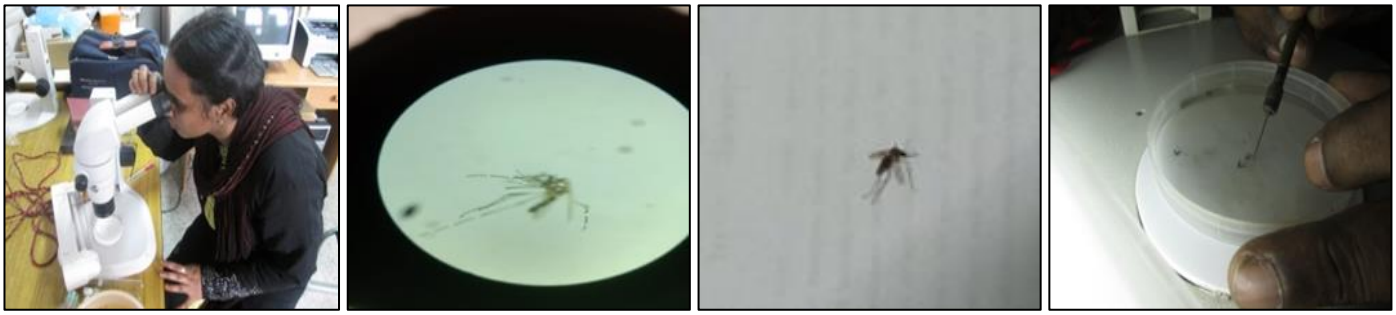


Fig 1: Aedes Composition and Gender identification using NIKKON Dissection microscope by the author in ICMR

4. Methods of data collection

In the present study the heat map grouping is made dependent on the sampling of Aedes mosquitoes was conducted one year, from March 2017 – Feburary 2018 in dry and wet season in seven taluks of Madurai district in both rural and urban areas. Immature mosquitoes larvas and pupas are gathered from 705 houses in seven taluks of Madurai district.

4.1. Study Tools

The cluster heat map double dendrogram and Principle Component Analysis PCA used to explore the cluster of sex and composition of mosquitoes in rural and urban regions in dry and wet season. The most important tool of analysis for geographers is cartographic interpretation and analysis of data with the help of the GIS maps.

5. Statistical Analysis

Heat maps are appropriate for predict a lot of multi-dimensional information and can be utilized to recognize groups of columns with comparative qualities, as these are shown as regions of comparable shading. The aim of this study was to identify and categorize *Aedes* mosquitoes breeding variation based on Bio –Geo- Ecological characteristics. Aedes breeding was also analyzed to determine more attractive container. The results were processed by principal component analysis (PCA) and hierarchical clustering. The growing dengue cases based of elevated mosquito breeding sites should encourage mosquitoes breeding and disease transmission.

6. Results

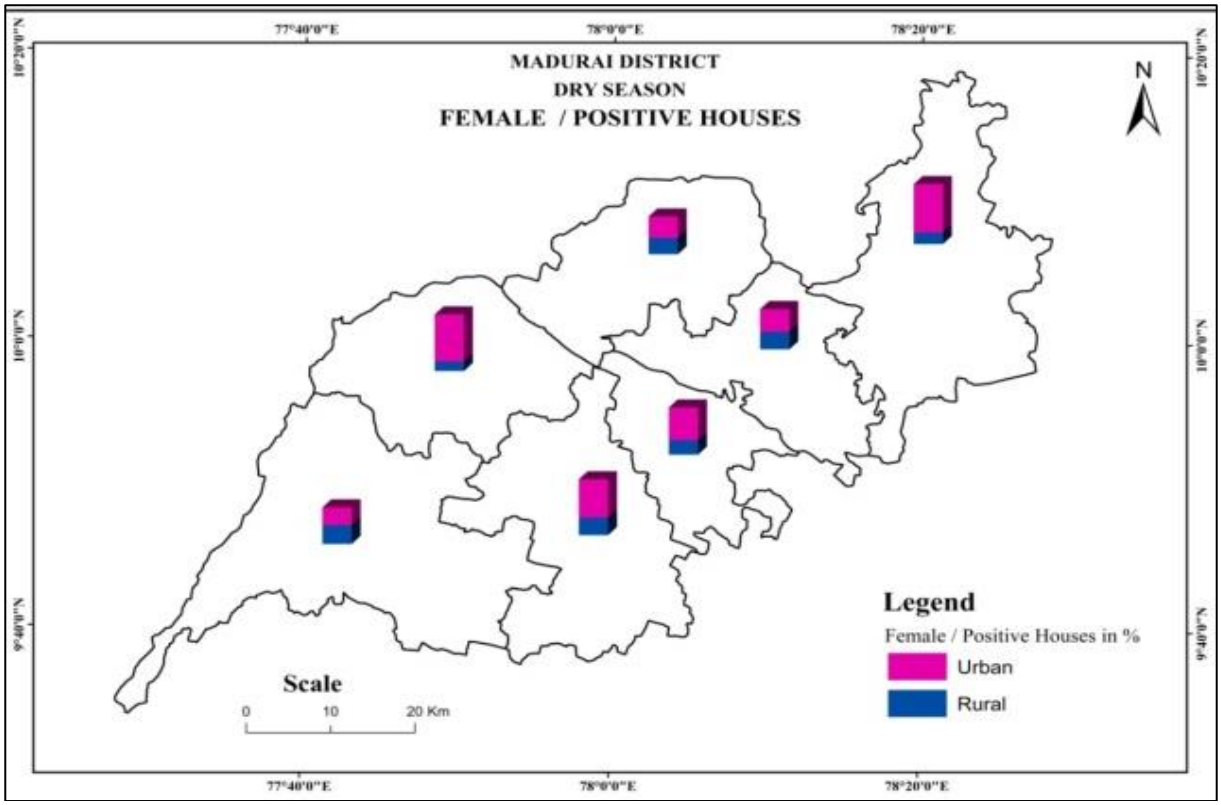
Aedes aegypti and Ae. albopictus are the foremost mosquito vectors of dengue fever [14] These species prefer laying their eggs in natural, human made container, such as cistern, grinding stone, tires, plastic buckets, and trash in general, and thrives in close immediacy to humans. The adult Ae. aegypti wants to rest inside and feed on people during light hours . Mostly females Ae. aegypti may spend their lifetime in or around the houses where they rise as grown-ups [15]. Despite the fact that outbreaks of DF/DHF are very much archived in Madurai district. The counteraction and control of dengue flare-ups basically rely upon the epidemiological investigation of cases and mosquito vector. The emerged adult are classified into container wise, area wise and season wise and were identified at ICMR Madurai to find out sex and mosquito composition. The results were then tabled as sex wise, Composition wise, area wise, and season wise to find out high risk area with the help of Adult Premise Index. The Female Per Positive Houses (FPPH) calculated by the following formula

$$\text{Adults Per Positive House} = \frac{\text{Number of collected adult female } \textit{Aedes} \text{ mosquitoes}}{\text{Positive houses}}$$

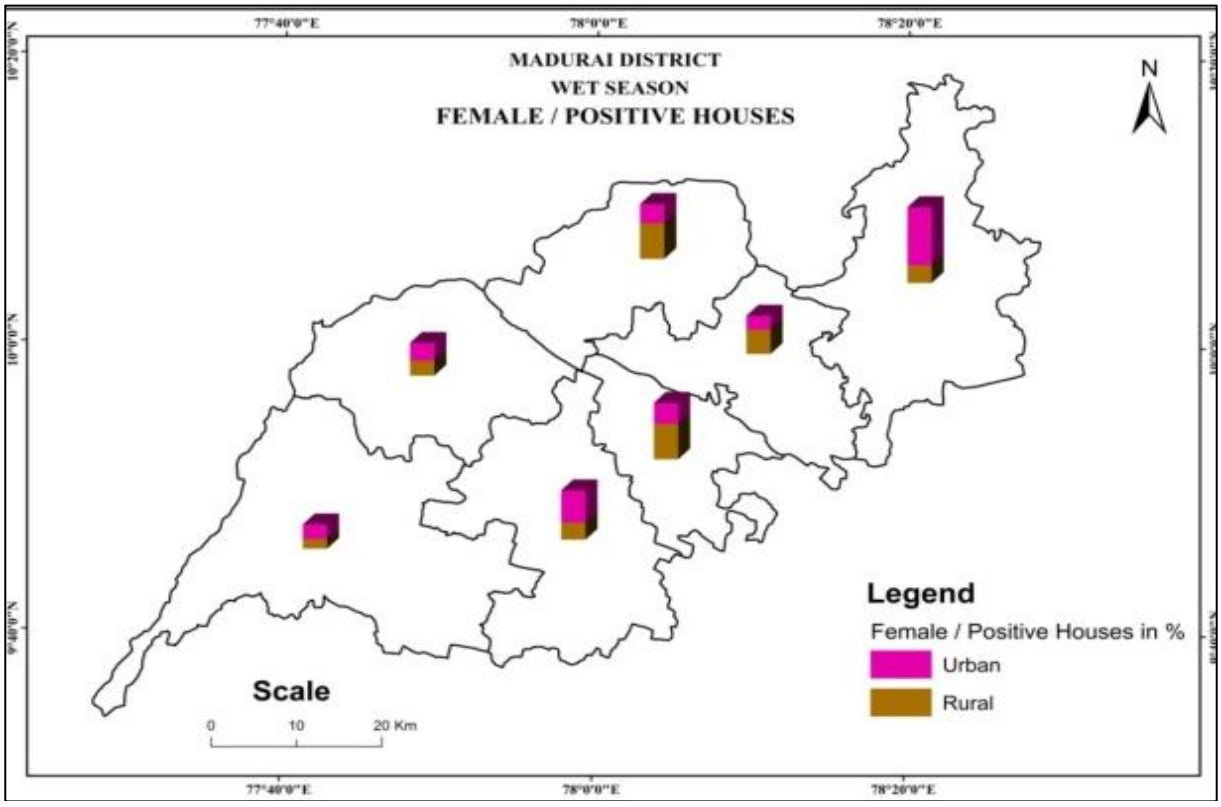
Table 1: Aedes Female Per Positive Houses In Rural And Urban Aresa In Dry And Wet Season

S. N	Taluk Name	Area	Adult Female /positive houses DRY Season	Adult Female /positive houses WET season
1.	Maduari North	Rural	2.00	3.00
		Urban	2.57	3.50
2.	Madurai South	Rural	1.66	3.66
		Urban	3.70	2.88
3	Melur	Rural	1.31	2.44
		Urban	5.50	6.00
4	Vadipatti	Rural	1.87	1.83

		Urban	2.42	1.71
5	Usilampatti	Rural	1.09	1.75
		Urban	5.33	2.20
6	Thirumangalam	Rural	2.00	3.20
		Urban	4.33	3.33
7	Peraiyur	Rural	2.16	1.12
		Urban	2.00	2.25



Map 3: Rural and Urban Aedes FPPH Dry Season



Map 4: Rural and Urban Aedes FPPH Wet Season

In analyzing the variation of female per positive houses in dry and wet season (Table: 1 and Map 3& 4) divulges among 7 taluks 6 containers were high in FPPH in urban areas in dry season and 5 taluks in wet season. The percentage of FPPH were high in urban areas of Melur taluk in both wet and dry season 5.50% in dry season and 6.00 %. in wet season and in rural areas 1.31% in dry season and 2.44%^ in wet season. this shows that urban areas of Melur taluk are at high threat of dengue transmission in both dry and wet season. Like Melur taluk the area of Madurai north, Thirumangalam, and Usilampatti taluks the FPPH high in urban areas in both wet and dry season.

In Madurai north 2.57% in urban in dry season and 3.50 % in wet season and in rural areas 2.00 % in dry and 3.00 % in wet season. In Thirumangalam, 4.33% in urban in dry season and 3.33 % in wet season and in rural areas 2.00 % in dry and 3.20 % in wet season. In Usilampatti, 5.33% in urban in dry season and 2.20 % in wet season and in rural areas 1.09 % in dry and 1.75 % in wet season.

The area of Madurai south and Vadipatti the FPPH high in urban areas in dry season and rural areas in wet season.In Madurai south taluk 3.70% in dry season 2.88 % in wet season in urban areas and in rural areas 1.66% in dry season and 3.66 % in wet season. In Vadipatti taluk 5.33% in dry season 2.20 % in wet season in urban areas and in rural areas 1.87 % in dry season and 1.83 % in wet season .In Peraiyur the percentage of FPPH high in rural areas in dry season and urban areas in wet season, about 2.16 % in rural areas and 2.00% in urban areas in dry season and 2.00 % in urban areas and 2.25 % in urban and 1.12% in rural in wet season.In Peraiyur the percentage of FPPH high in wet season in uban areas.

The analysis of FPPH shows urban areas are at high risk of FPPH compare to rural areas in all taluks and the risk of FPPH were high in wet season compare to dry season in all taluks.

Notwithstanding the above with the assistance of Cluster Heat map and Principal Component Analysis,(PCA) used to explore the cluster of sex and composition of mosquitoes in rural and urban regions in dry and wet season. The aim of this study was to identify and categorize *Aedes* mosquitoes breeding variation based on Bio –Geo- Eological characteristics. Aedes breeding was also analyzed to determine more attractive container. The results were processed by principal component analysis (PCA) and hierarchical clustering. The growing dengue cases based of elevated mosquito breeding sites should encourage mosquitoes breeding and disease transmission. The goal of this work was to revise the entomological investigation of the two Aedes species in Madurai district which has to face these arboviroses.

The species Aedes aegypti was clustered in number of containers in dry season compared to the species Aedes albopictus was found only few containers. Breeding sites were mostly found in man-made environments such as discarded containers, used tires, abandoned buckets, Aedes aegypti was significantly influenced in dry season container by the sampling region.

Similarly, the species *Ae. albopictus* was clustered in number of containers in wet season compared to the species Aedes aegypti was found only few containers. Breeding sites were mostly found coconut shell, tree hole, bushes etc., The heat map results divulges Aedes aegypti populations exhibited high dissemination infection rates for dengue virus in dry season and the be of assistance of secondary vector *Ae. albopictus* boost the infection rate in wet season

Table 2: Heat map and a result of Cluster analysis of Aedes Mosquitoes container wise breeding

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
CI	2.72	2.52	3.11	2.72	4.86	4.28	1.16	0.77	1.11	0.89	1.78	1.11	3.57	2.68	0.89	0.67
BA	1.16	1.36	0.97	1.55	2.72	2.33	1.75	2.14	2.23	2.68	2.46	1.78	4.25	3.80	0.22	0.00
GS	1.36	1.36	0.97	0.58	3.89	3.50	1.55	1.75	2.01	1.34	3.13	3.57	3.80	3.35	0.44	0.44
EP	1.55	1.55	2.52	1.55	5.64	3.89	2.33	1.94	2.23	1.34	2.68	1.34	3.35	3.13	0.67	0.22
TY	0.77	0.58	0.38	0.19	3.30	3.50	1.36	0.97	0.67	0.44	0.00	0.00	1.78	3.13	0.89	0.22
OT	1.16	0.97	2.14	2.52	2.91	3.50	2.14	1.55	2.90	2.46	4.25	4.92	4.69	4.02	3.35	2.90

6.1. Heat Map And A Result of Cluster Analysis of Aedes Mosquitoes Biodiversity

The heat map provides an automatic grouping mosquito species cluster in various containers (Figure-2) A cutoff needs to be provided, and the dendrogram tree will be cut at the height of cutoff. The samples will be divided into several groups and labeled by different colors at the cutoff level. The consequence of a various leveled clustering estimation is shown in a heat map as a dendrogram, which is a tree-structure of the order. Section dendrograms show the separation (or closeness) between the factors (the chose cell esteem segments). A column dendrogram where the separation between the lines were determined. The section dendrogram is attracted a similar path as the line dendrogram, yet shows the separation or likeness between the factors (the cell esteem segments).

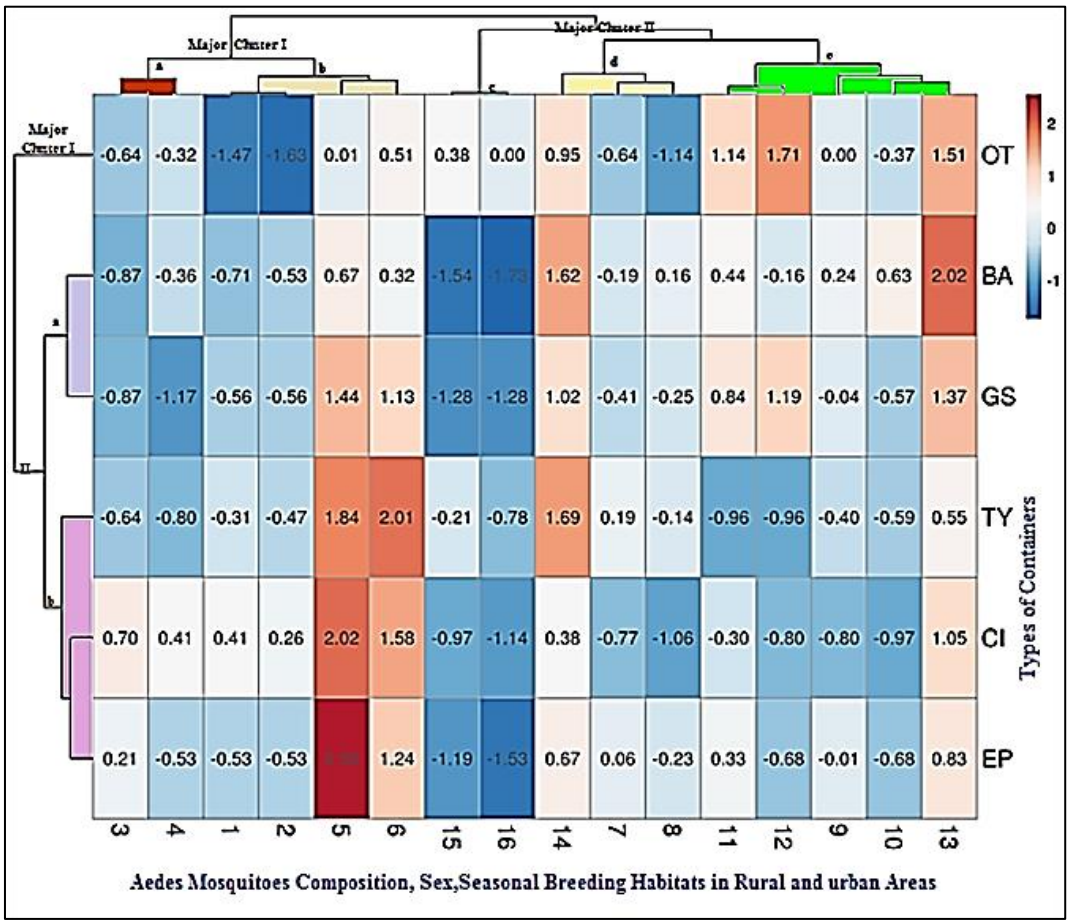


Fig 2: Heat map and a result of Cluster analysis of Aedes Mosquitoes Biodiversity

Columns Designation

1. D.*Ae*.ae RM%	5. D.*Ae*.ae UM%	9. W.*Ae*.ae RM%	13. W.*Ae*.ae UM%
2. D.*Ae*.ae RF%	6. D.*Ae*.ae UF%	10.W.*Ae*.ae RF%	14. W.*Ae*.ae UF%
3. D.*Ae*.al RM%	7. D.*Ae*.al UM%	11.W.*Ae*.al RM%	15. W.*Ae*.al UM%
4. D.*Ae*.al RF%	8. D.*Ae*.al UF%	12.W.*Ae*.al RF%	16. W.*Ae*.al UF%

D-Dry Season-Wet Season, Ae.ae –*Aedes aegypti*, Ae.al- *Aedes albopictus*, R – Rural U-Urban, M-Male Mosquitoes F-Female Mosquitoes

Rows Designation

CI-cistern,
BA-Barrel,
GS-Grinding stone,
EP-Eatherned Pot,
TY-Tyres,
OT-Other containers

6.1.1. Analysis of Aedes Mosquitoes

In the Cluster analysis of Aedes Mosquitoes the elevated *Ae. aegypti* species were grouped into two major clusters

Cluster –I

The first major cluster consisted of both species Aedes aegypti and Aedes albopictus male and female mosquitoes in rural and urban areas in dry Season. The first cluster further subdivided into two minor clusters *(a-b)*.

The minor cluster *a* was composed exclusively of *Ae. albopictus* male and female mosquitoes in rural areas in dry season. *Ae*. albopictus was generally characterized by average or low values in most description only except cistern male (0.70) and female (0.41)in dry season.

The minor cluster *b* comprised *Ae. aegypti* species both male and female in rural and urban area dry season. Ae. aegypti male and female were grouped in the minor cluster *b* in dry season different from minor cluster *(a)* in terms of species and area. Compare to rural areas *Ae. aegypti* both male and female were abundant in dry season in urban areas and mosquitoes breeding positively loaded in all containers. The value ranges from (0.01-2.56) and particularly aedes aegypti female clustered in tyers(2.01),cistern(1.58),Eartherened pot (1.24) in dry season.

Cluster –II

The second major cluster was subdivided into three minor clusters *(c-e)* The minor cluster *(c)* contained *Ae. albopictus* male and female mosquitoes in urban areas in wet season. In wet season *Ae. albopictus* male and female characterized by relatively small areas and low values only except of barrel (-1.54 –1.73)and eartherned pot(-1.19- -1.53).

The minor cluster *(d)* grouped urban Aedes species in wet and dry season in urban areas. In wet season the female *Ae. aegypti* were high above the mean level in Tyre(1.69),Barrel(1.62),Grinding stone(1.02) in Urban areas. Dissimilar to wet season, both male and female *Ae. albopictus* were negatively above the mean level in dry season in urban areas.

The minor cluster *(e)* was extremely composed of wet season. In wet season *Ae. albopictus* male and female rural mosquitoes are highly clustered in other containers (1.71) for example bushes, tree holes, broken jars, etc., and grinding stone (1.19). Dissimilar to *Ae. albopictus* the Ae. Aegypti male and female in rural areas having low values below the average level in most cells except Barrel (0.63) in rural areas. Dissimilar to rural areas the urban Ae. Aegypti male seems to be above the average level in all cell and particularly high in barrel (2.02) others (1.51) Grinding stone(1.37).

6.1.2. Analysis of Containers

In the cluster analysis of containers wise breeding of *A*edes mosquitoes the elevated containers were grouped into two major clusters

Cluster –I

The first major cluster placed on others for example bushes, tree holes, broken jars, etc., In wet season aedes species breeding were Hetrogeneous in rural and urban areas in others containers. *Ae. albopictus* were clustered in rural areas in these sites compare to male (1.14), female (1.71). in wet season. Dissimilarly *Ae. aegypti* were highly clustered in urban areas in these sites compare to male (1.51) female (0.95) in wet season.

Cluster –II

The Second major cluster subdivided into two minor clusters *(a-b).* The minor cluster*(a)* composed of Barrel and Grinding stone . *Ae. aegypti* cluster seems high in barrel containers compared to grinding stone in both wet and dry season in urban areas. In barrel containers *Ae. aegypti* male (2.02)and female (1.62) seems to be high above the mean levle in wet season in urban areas compared to dry season male (0.67),female(0.32). Similarly in grinding stone male (1.37) and female (1.02).Dissimilarly *Ae. alpopictus* in rural areas highly cluster in grinding stone male (0.84) and female (1.19) compare to barrel male (0.44), female(-0.16) in wet season.

The minor cluster *(b)* composed of Tyre, Cistern Eartherned pot. Homogeneously *Ae. aegypti* male and female was found to be high above the mean level (1.58 to 2.56) in Tyre, cistern and eartherned pot in dry season. Similarly the male aedes aegypti seems high in cistern (1.05) and eartherned pot (0.83) in wet season in urban areas. Dissimilarly in rural areas aedes aegypti male and female negatively below the mean level in others (-1.47),(-1.63) and low positive values seems in cistern containers(0.26 - 0.41) in dry season. Similarly *Aedes* albopictus female in urban areas have the high positive values on tyers (1.69) in wet season.

6.2. Analysis of Aedes Species Breeding Behaviour Using Principle Component Analysis

The objective of principal component analysis is to reduce the dimensionality of the data set, but retain as much of the original variability in the data as possible. The algorithm calculates eigenvalues and eigenvectors from the covariance matrix for each variable and lists these eigenvalues in order from largest to smallest. Larger eigenvalues denote that the variable should remain in the database. Variables with smaller eigenvalues will be removed according to preference. Unit variance scaling is applied to rows; SVD with imputation is used to calculate principal components. X and Y axis show principal component 1 and principal component 2 that explain 63.2% and 20.1% of the total variance, respectively. N = 16 data points .

Table 3: Aedes Species Breeding Behaviour

	Rotated Component Matrix						
	Variables	Components					
		1	2	3	4	5	6
Wet Season	D.Ae.aeRM	1.14					
	D.Ae.aeRF	1.23					
	D.Ae.alRM	0.82					
	D.Ae.alRF	1.20					
	D.Ae.alUF	0.92					
	W.Ae.aeRF	1.05					
	W.Ae.alUM	2.16					
	W.Ae.alUF	2.80					
	D.Ae.alUM	0.61					
Dry Season	D.Ae.aeRM		1.35				
	D.Ae.aeRF		1.31				
	D.Ae.alRM		1.10				
	.D.Ae.aeUM		1.48				
	D.Ae.aeUF		0.83				
	W.Ae.aeRM		0.52				
	D.Ae.alUF			1.15			
	W.Ae.aeRF			1.08			
Aedes albopictus	D.Ae.alRM				0.75		
	D.Ae.alRF				0.63		
	W.Ae.alRM				0.79		
						0	0
Individual		0.63	0.20	0.07	0.05	0.03	0.01
Cumulative		0.63	0.83	0.91	0.96	0.99	1.00

Extraction Method:Principle Component Analysis Rotation Method: SVD with imputation is used to calculate principal components
X and Y axis show principal component 1 and principal component 2 that explain 63.2% and 20.1% of the total variance, respectively. N = 16 data points.

6.2.1. Factor –I: Wet Season *Ae. albopictus*

In the first dimension nine positive loadings are perceived. The high positive scores seems in *Ae. albopictus* urban male (2.80) and female mosquitoes (2.16) in wet season. Compare to wet season low positive loadings seems in female albopictus breeding in urban (0.92) and male in rural (0.82) in dry season .female Aedes aegypti rural mosquitoes found to be high in wet (1.05) and dry season(1.23).This confirm *Ae. albopictus* breeding high in wet season in urban areas and aedes aegypti breeding high in dry and wet season in rural areas.

6.2.2. Factor –II: Dry Season *A*e. Aegypti

The second dimension highlights dry season .This factor consists of 5 variables with positive scores. Among 5 variables 4variables rotated in dry season *Ae. aegpti* urban male (1.48), rural male (1.35), rural female (1.31) and urban female (0.83). Compare to *Ae. aegypti Ae. albopictus* rural male (1.10) only. This reveals *Ae. aegypti* is a principal species abundantly breeds in dry season in both rural and urban areas. This might be the reason for the abundance of human made water filled containers in and around human habitats during dry season. *A*e. aegypti is an arthropod closely associated with humans and their habitats. They are mostly anthropophilic (Ponlawat *et al.* 2005) with high preference to breed in artificial water containers.

6.2.3. Factor –III Breeding Behavior

This factor consists of two variables. The positive scores seems in dry season *Ae. albopictus* urban female (1.15) and wet season *Ae. aegypti* rural female (1.08). Ae. albopictus inhabits densely vegetated rural areas. (Eritja *et al.*, 2005). It can also establish and survive during dry season in urbanized areas. Similarly *Ae. aegypti* will change the spatial and temporal dispersal pattern of habitat utilization and can also breed in wet season in rural areas.

6.2.4. Factor –IV Rural Mosquito *Ae. albopictus*

The fourth factor consist of three variables Wet season aedes albopictus rural male (0.79) and Dry season aedes albopictus rural male (0.75)and female(0.63). this factor revels *Ae. albopictus* particularly breed in rural areas in both wet and dry season.

6.3. Aedes Species Seasonal Breeding

The samples labeled in the screen plot exposed which species are on the left and which one are on the right. The loading scores determine which genes have the largest effect on where samples are plotted in the PCA plot. The loading scores for PC1 accounts for 63.2% of the variation in the data. Genes that push samples to the left side of the will have large negative values and genes that push samples to the right will have the large positive values. Since we are interested in both sets of genes, we will use the abs 0 function to sort based on the number's magnitude rather than from high to low.

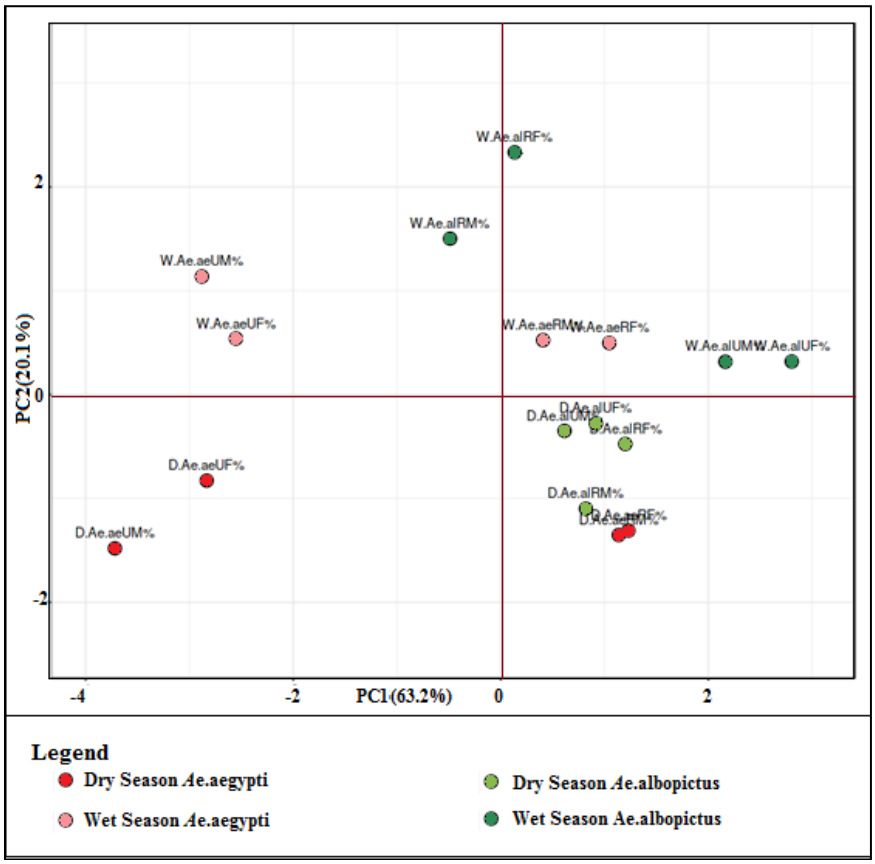


Fig 3: *Aedes* species Seasonal Breeding

Cluster –I Wet season

In wet season *Ae. albopictus* highly clustered compared to aedes aegypti . In dry season aedes aegypti highly clustered compared to aedes albopictus. In Wet season *Ae. albopictus* Male (2.16) and female (2.80) highly clustered in Urban areas compare to wet season rual area only male (0.79).

Cluster-II Dry season

In dry season *Aedes aegypti* urban male(1.14) rural female (1.23) highly clustered compared to urban male (1.48) female (0.83).

Ae. albopictus urban Female (0.92) *Ae. albopictus* rural Female(1.20) *Ae. albopictus* rural male (0.82) *Ae. albopictus* urban male (0.92) seems to be high in urban areas in Dry season.

The screen plot proves (Figure-3) that *Ae. albopictus* female breeding high in urban areas (2.80) in wet season and in rural areas (0.92) in dry season. *Ae. aegypti* is a secondary vector for dengue transmission which support *Ae. aegypti* primiray dengue vector in dry season in both rural and urban areas.

7. Discussion

The present study find out that in wet season the female *Ae.* aegypti were high above the mean level in Tyre (1.69), Barrel (1.62), Grinding stone (1.02) in Urban areas. Similarly a number of studies the result shows Drums, jars, and tires have been recognized as primary sources of *Aedes* mosquitoes elsewhere in Southeast Asia Lao *et al.* [16] Chan *et al.* [17], Aldstadt *et al.* [18].

The analysis of Aedes species breeding behaviour using principle component analysis reveals *Ae. albopictus* breeding high in wet season in urban areas and *Aedes aegypti* breeding high in dry and wet season in rural areas. Similarly Sanders *et al.* [19]. categorize *Ae. aegypti* and *Ae. albopictus* were significantly more present in sites featuring no or low vegetation and residential sites. Variables associated with *Ae. albopictus* presence and abundance varied between cities and highlighted the urban nature of the species. His study highlighted the distribution of *Ae. aegypti* geographically and within the urban context, indicated potential habitat preferences of container-breeding mosquito species in small towns,

Ae. albopictus a secondary vector for dengue transmission which support *Ae. aegypti* primiray dengue vector in dry season in both rural and urban areas. This reveals *Ae. aegypti* is a principal species abundantly breeds in dry season in both rural and urban areas. Similarly Abreu *et al.* [21]. explains that *Ae. aegypti* was the most prevalent species exhibiting an increasing abundance along rural-to-urban gradient towards an higher abundance in urban areas.

In Wet season *Ae. albopictus* Male (2.16) and female (2.80) highly clustered in Urban areas compare to wet season rural area only male (0.79). Li *et al.* [22] also revealed that, urban areas showed higher capacity to support *Aedes* breeding sites and larvae than suburban and rural areas. The higher numbers of positive breeding sites and higher abundance of *Aedes* mosquito larvae may be due to the destruction of natural vegetation coverage for infrastructure buildings in the urbanized areas that may affect biological factors.

The screen plot proves that *Ae. albopictus* female breeding high in urban areas (2.80) in wet season and in rural areas (0.92) in dry season. *Ae. aegypti* is a secondary vector for dengue transmission which support *Ae. aegypti* primiray dengue vector in dry season in both rural and urban areas. recent literature demonstrates that *Ae. Albopictus* is competitively superior at the larval stage Meara *et al.* [23] and Barrera *et al.* [24].

8. Conclusion

In Madurai district *Ae. Aegypti* and *Ae. albopictus* has unmitigated its geographical distribution in both rural and urban areas in wet and dry season.

Dengue primary vector was *Ae. aegypti*. The secondary vector *Ae. albopictus* were found to be highly susceptible to chikungunya virus. In the light of this study, the primary vector *Ae. aegypti* and furthermore Ae. albopictus may have been involved in the recent outbreaks of dengue epidemics in Madurai district, Changes are predominantly driven by human activities and the rainfall regime that provide suitable breeding sites for the highly anthropophilic mosquito Ae. Albopictus

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10. References

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