WHO collaborating Centre for Research and Training in Lymphatic filariasis and Integrated Vector Management.

Mosquito Biodiversity (Diptera: Culicidae) in Auroville, Puducherry

REPORT SUBMITTED TO

THE AUROVILLE
PUDUCHERRY

BY

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Introduction

Mosquitoes are of great significance for their nuisance biting and their role in the transmission of several parasitic and viral diseases viz. malaria, lymphatic filariasis, dengue, zika, yellow fever, chikungunya, Japanese Encephalitis etc. The breeding habitat diversity determines mosquito abundance, resulting in the transmission of different pathogens (Adebote et al., 2008; Emidi et al., 2017). Only, 10% of the mosquito species recorded are efficient vectors of pathogens with considerable public health significance (Manguin and Boete 2011), that have been historically responsible for some of the worst epidemics mankind has witnessed. The principal vectors of diseases belong to three genera viz. *Anopheles*, *Aedes* and *Culex*, of which some mosquito species are highly and successful invasive in nature e.g. *Aedes albopictus* and lately *Anopheles stephensi* The description and understanding of mosquito biodiversity is significant in the context of the risk associated with invasive species, emergence and spread of Vector Borne Diseases (VBDs). Rapid transportation networks have placed the people at risk of acquiring new strains of familiar diseases or completely new diseases (Guimera et al., 2005). The economic development, tourism and human migration have resulted in mobilities of the vectors and pathogens (Tatem et al., 2006), concurrently increasing mosquito biodiversity globally.

Landscape changes and altered environment resulting due to human action influence epidemiology of disease indirectly through changes in bio-ecology and host-seeking behaviors of vectors searching for alternative habitats and new blood-feeding sources (Enayati and Hemingway 2010, Keesing et al., 2010, Kweka et al., 2016).

Studies undertaken with a view to prepare a check list of mosquitoes of Puducherry between 1995-97, had covered a small area of the Auroville. Three Aedine species and one species of genus Verrallina were recorded (Rajavel et al., 2004). Over two decades have elapsed, since these observations were documented. A lot of infrastructural developments, changes in the demography and land use including water control systems (water management) within the Auroville have taken place. Such alterations must have had an impact on the ecological balance within which mosquitoes find new opportunities to breed, expand their populations and transmit diseases. Such a scenario necessitated to undertake new surveys of the current fauna of mosquito species within Auroville. Description on these lines will enable to understand the mosquito biodiversity. Information on the prevalence, diversity and distribution of mosquitoes in Auroville, assumes significance in the context of emerging mosquito borne pathogens and

choose from available vector control options. Therefore, a cross-sectional study was carried out to assess the prevailing status of mosquito diversity (species richness), abundance of different species of mosquitoes and most importantly to map the distribution of water bodies/habitats supporting mosquito larval breeding.

Methodology

Study area: Auroville is an experimental township in Villupuram district, Tamil Nadu and parts of which come under the Union territory of Puducherry. Auroville township spans an area of about 20 km^2, mainly used for realizing dream of global human unity.

Demography, Climate, Developmental activities, Crops, Tourism & Vector borne diseases: The demographic profile fluctuates continually year after year. As of January 2018, the population is 3218. People hailing from 59 nations are residents of Auroville (Figure 1). Climate is humid with fluctuations in temperature during different seasons of the year. Average annual rainfall recorded by the Auroville meteorological station is 125 cms. Construction of residential buildings, maintenance of existing buildings, engagement of media persons by the Information Technology department, waste water treatment plant, in house research wing, town planning, afforestation activities, water table management, printing and manufacturing fancy jewelries form the core activities of Auroville. Rice is cultivated as an annual crop in 9% and vegetables in 6% of the cultivable area. Besides, millets are also grown in Auroville. Tourism constitutes an important source of economy. During the chikungunya outbreak in 2006, 441 cases were reported in Kuilapalyam. Subsequently, twenty cases of dengue were reported.

Study design: Grids of 500 × 500 meters was overlaid on google map covering an area of 8.08 sq. km^2 of Auroville. 15 proportionate grids were selected in consultation with authorities of Auroville. The area within each of the 15 grids served as the sampling site for entomological survey (Figure 2).

Entomological survey and mapping: A cross-sectional entomological survey was carried out between 1st February-4th March 2020. The immatures were collected from all available types of larval breeding sources, ranging from manmade, artificial and natural habitats. Each larval habitat was georeferenced and global geographical positioning system (GPS) coordinates of the breeding places were recorded using Epi Info and were plotted using ArcGIS software. Adult collections using mechanical/oral aspirator were carried out in cattle farm, tree hole and human dwellings.

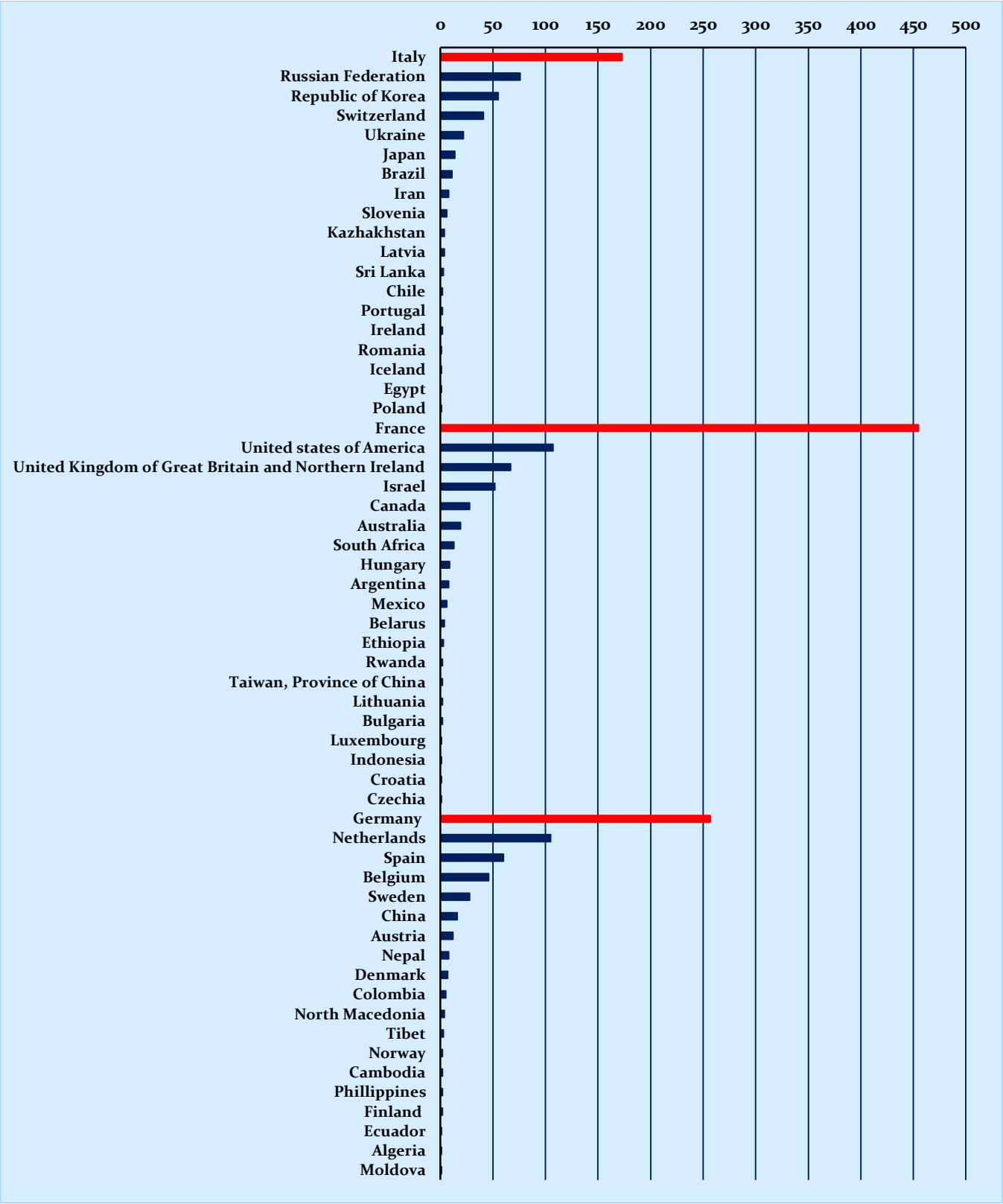

Figure 1. Inhabitants of Auroville from different parts of the world

Mosquito Biodiversity and Species Dominance: Indices used to characterize species diversity, evenness and dominance viz. Shannon-Weiner diversity index (*H'*), Simpson's index, Margalef's index (D_{Mg}) and Pielou index (*J*) were computed.

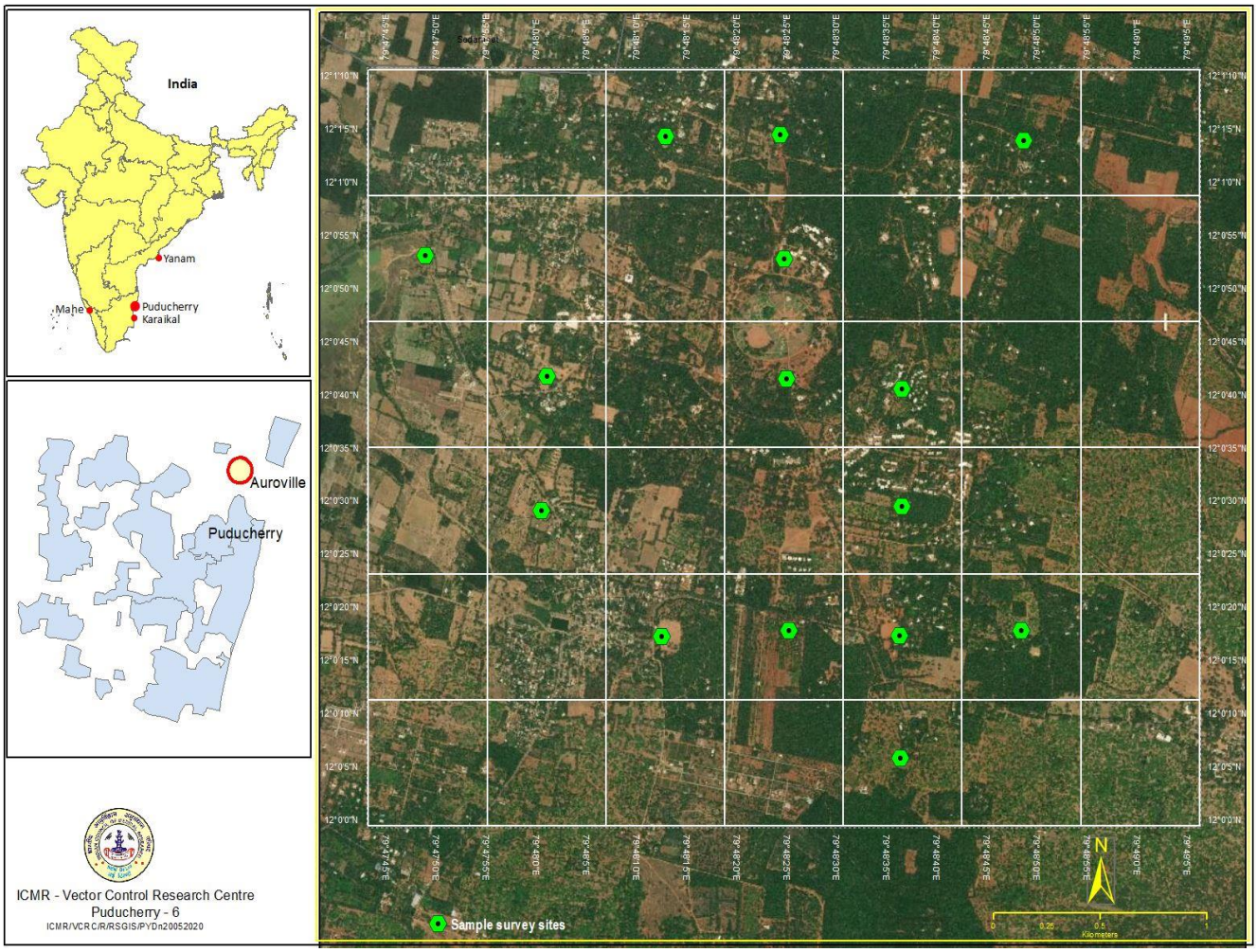

Figure 2. Location of sampling sites at Auroville

RESULTS

Larval sampling: A total of 62 mosquito-positive larval habitats were sampled. Anopheline larvae were found in 2 habitats, and 1 of these habitats (1.9 %) had only anophelines (Table 1). Culicine larvae were found in 50 habitats, and 41 of these habitats (80.4%) had only culicines. Both anopheline and culicine larvae were found in 9 habitats (17.6%), suggesting that the mosquito larvae from the subfamilies Culicinae and Anophelinae coexist one in every 5/6 habitats.

Spatial distribution of mosquito breeding habitats: Considering, the Matrimandir Globe at the Centre of the Auroville campus and based on latitudes and longitudes, four directions to the Auroville campus was derived. This enabled to visualize the spatial distribution of mosquito breeding habitats (Figure 3). Thirteen habitats were located in northeast i.e. adjoining Matrimandir globe, Citradines, Mithra Residential Areas, Ilaignarkal Education Centre, Youth Centre, Transition School, Dhana and Centre for Scientific Research (CSR) and Foundation Centre. Cement tanks, artificial ponds, ground pools and tree holes, were the observed breeding habitats. The northwest direction comprised seventeen habitats in the neighborhoods of Windaraa farm, Kottakarai, Arunthatipuram, Irumbai Tank, Unity Pavilion, Tibetan Pavilion, Savithri Bhavan, Bharat Nivas, Auroville Visitor Centre. Cattle farm, ground pools, lake margins, cement tanks, artificial ponds, outdoor collections and human dwellings constituted the breeding habitats. The southeast covered neighborhoods of human scapes, vikas, Luminosity, swayam community, prathna, pitanga, samasti, post office, certitude Ground, telephone exchange, Pitachandikulam Forest, Abri Sun farm and Charler Garden. Twenty-eight breeding habitats, comprising cement tanks, ant trap holders, artificial ponds, dug well, syntax tanks, grinding stone, earthen pot and discarded tires, were inspected in these locations. The neighborhoods in southwest direction comprised places such as Udavi School, Botanical and Buddha gardens. Four breeding habitats comprising only soak pit and cement tanks were inspected.

Table 1: Distribution of Anopheline and Culicine mosquito larvae in a total of 62 aquatic habitats sampled for mosquito larvae in Auroville, Puducherry (February-March 2020)

	Number of Habitats (%)	Larval Habitats										
		DT	AP	DWL	GS	ST	GP	CT	ATH	EP	LM	SP
Anopheline Versus *Culicine*												
Presence of *Anopheline* only	1 (1.9)	0	0	0	0	0	1	0	0	0	0	0
Presence of *Culicine* only	41 (80.4)	1	2	0	2	1	5	25	2	1	1	1
Presence of both *Anopheline*s and *Culicines*	9 (17.6%)	0	2	1	0	0	0	5	0	0	1	0
	51 (100.0)	1	4	1	2	1	6	30	2	1	2	1

DT- Discarded Tires ST- Syntax tank AP- Artificial Pond GP- Ground Pool EP- Earthen Pot DWL- Dug Well CT- Cement Tank LM- Lake Margins
GS- Grinding Stone ATH- Ant Trap Holders SP- Soak Pit

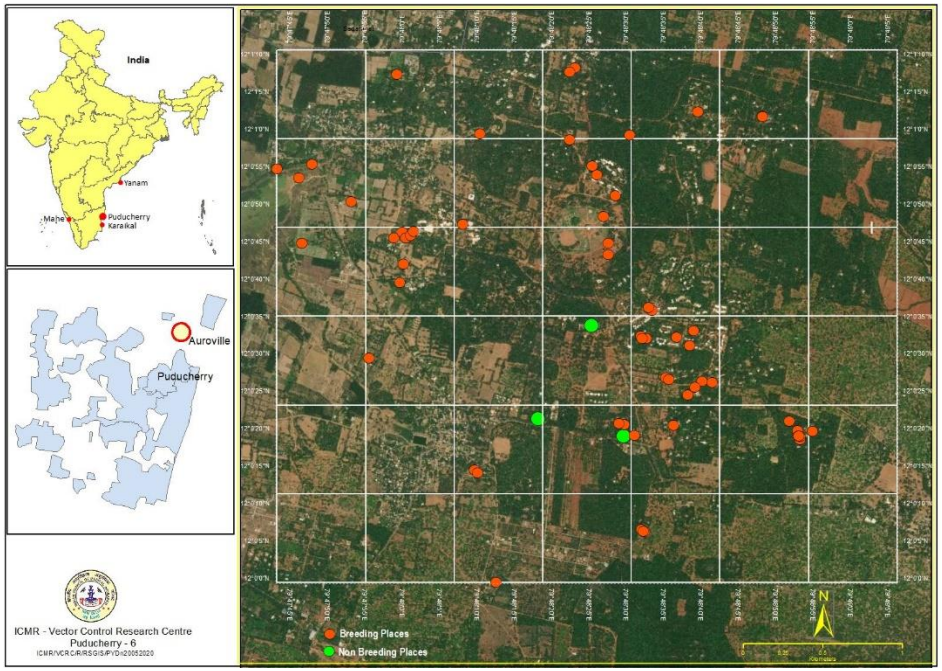

Figure 3. Spatial distribution of mosquito breeding habitats in Auroville

Habitat and Species Diversity: The larval habitats could be grouped into 12 categories (Table 2). The Anophelines were detected in relatively cleaner waters, while the Culicines were found to breed in muddy waters. The log transformed frequency of breeding habitats is depicted in Figure 4. Five permanent macrotype mosquito breeding habitats i.e. cement tanks, ground pool, artificial pond, dug well, syntax tank and seven temporary microtype mosquito breeding habitats i.e. outdoor collection, grinding stone, cattle farm, earthen pot, lake margins, human dwellings, discarded tyres and soak pits were found across Auroville. Cement tanks were the predominant breeding habitats, which constituted 57% (39/69) among the habitats sampled. This was followed by ground pool (8.7%, 6/69) and artificial pond (5.8%, 4/69). The rest of the habitats were negligible. An array of 18 species were found to breed in twelve habitats. The species diversity with respect to the individual habitats is presented in Figure 5. Maximal number of mosquito species was observed in cement tanks (n=12), which was followed by ground pool (n=9) and artificial pond (n=8). Six species of Culex, two species of Anopheles and one species each of *Lutzia*, *Armigeres*, *Stegomyia* and *Fredwardsius* were detected.

Faunistic, Species Composition and Systematics: A total of 750 mosquito larvae and 84 resting adults were collected from 15 sampling points, spanning an area of 7 km^2. Out of 750 larvae, 610 emerged, of which 106 got disfigured. Therefore, 504 mosquitoes were identified. The systematic study recorded a total of 18 species belonging to 11 sub-genera and 7 different genera. Genera included *Stegomyia*, *Fredwardsius*, *Anopheles*, *Armigeres*, *Culex*, *Lutzia* and *Mimomyia*. Of the 18 species recorded, 8 are new records for Auroville (Table 3).

Table: 2. Mosquito species recorded in different habitats (indicated by an ×) in Auroville

	Types of larval/resting habitats indicating the species preference														
Species name	**DT**	**AP**	**DWL**	**GS**	**ST**	**GP**	**CT**	**ATH**	**EP**	**LM**	**SP**	**TH@**	**CF@**	**OC@**	**HD@**
Anopheles barbirostris	-	×	×	-	-	×	×	-	-	-	-	-	×	-	-
Anopheles subpictus	-	-	-	-	-	-	×	-	-	×	-	-	-	-	-
Anopheles pallidus	-	-	-	-	-	-	-	-	-	-	-	-	×	-	-
Anopheles vagus	-	-	-	-	-	-	-	-	-	-	-	-	×	-	-
Culex nigropunctatus	-	-	-	-	-	-	×	-	-	-	-	-	-	-	-
Culex brevipalpis	×	×	-	-	×	×	×	-	-	-	×	×	-	-	×
Culex gelidus	-	-	-	-	-	×	×	-	-	-	×	×	×	×	-
Culex bitaeniorhynchus	-	×	-	-	-	×	-	-	-	-	-	-	-	-	-
Culex quinquefasciatus	-	×	-	-	×	-	×	×	-	×	×	×	-	×	×
Culex pseudovishnui	-	-	-	-	-	-	-	-	-	×	-	-	-	-	-
Culex tritaeniorhynchus	-	-	-	-	-	-	-	-	-	-	-	-	×	-	-
Culex minutissimus	-	×	×	-	-	-	×	-	-	-	-	-	-	×	-
Culex mimulus	-	×	×	-	×	×	×	×	-	-	-	-	-	-	-
Lutzia fuscana	-	-	-	-	-	×	×	-	-	-	-	-	-	-	-
Mimomyia chamberlaini	-	-	-	-	-	-	-	-	-	×	-	-	-	-	-
Armigeres subalbatus	×	-	-		×	-	×	-	-	-	×	-	×	×	-
Stegomyia albopicta	×	-	-	×	-	×	×	×	×	-	-	×	-	×	-
Fredwardsius vittatus				×			×								-

DT- Discarded Tires, ST- Syntax tank, CF- Cattle Farm, OC- Outdoor Collection, AP- Artificial Pond GP- Ground Pool, EP- Earthen Pot, TH- Tree Hole, DWL- Dug Well, CT- Cement Tank LM- Lake Margins, HD- Human Dwellings, GS- Grinding Stone, ATH- Ant Trap Holders, SP- Soak Pit

@ Resting Collections

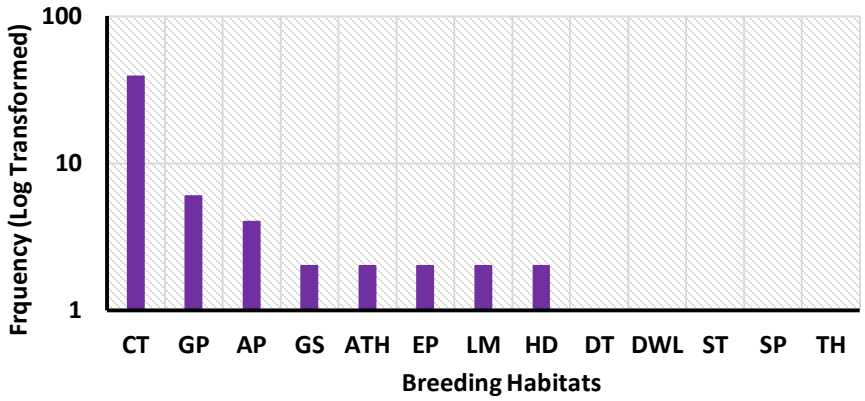

Figure 4: Frequency of breeding habitats (N=62)

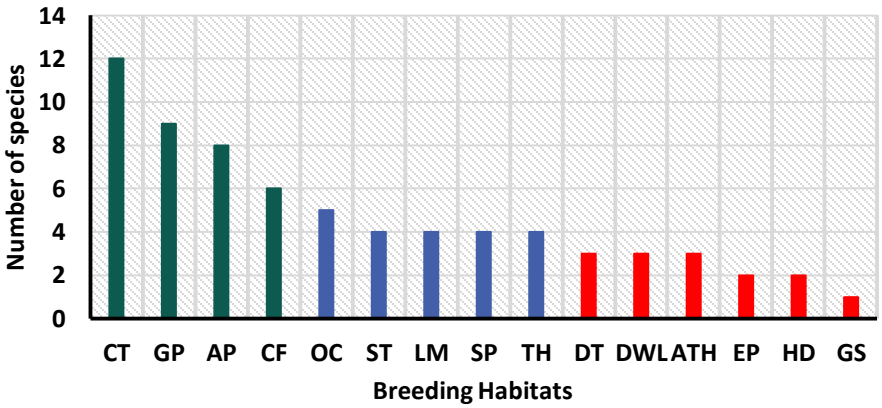

Figure 5. Species diversity in different habitats

Table 3: ***List of Culicid species recorded in Auroville, Puducherry***

1	*Stegomyia (Stegomyia) albopicta* Skuse 1895
2	*Fredwardsius vittatus* Bigot 1861
3	*Anopheles (Anopheles) barbirostris* Van der Wulp 1884
4	*Anopheles (Cellia) subpictus* Grassi 1899
5	*Anopheles (Cellia) vagus* Doenitz 1902[1]
6	*Anopheles (Cellia) pallidus* Theobald 1901[1]
7	*Armigeres (Armigeres) subalbatus* Coquillett 1898
8	*Culex (Oculeomyia) bitaeniorhynchus* Giles 1901[1]
9	*Culex (Culex) gelidus* Theobald 1901[1]
10	*Culex (Culex) pseudovishnui* Colless 1957[1]
11	*Culex(Culex) quinquefasciatus* Say 1823[1]
12	*Culex(Culex) mimulus* Edwards 1915[1]
13	*Culex (Culex) tritaeniorhynchus* Giles 1901
14	*Culex(Eumelanomyia) brevipalpis* Giles 1902
15	*Culex (Culiciomyia) nigropunctatus* Edwards 1926
16	*Culex (Lophoceraomyia) minutissimus* Theobald 1907
17	*Lutzia (Metalutzia) fuscana* Weidemann 1820
18	*Mimomyia (Mimomyia) chamberlaini* Ludlow 1904[1]

[1]A species reported from Auroville for the first time

Of the 18 species recorded, the *Culex* genus was predominant (58%) followed by *Stegomyia* (23%), *Armigeres* (11%) and *Anopheles* (4%). This comprised 8 species belonging to three medically important genera viz. *Anopheles*, *Culex* and *Stegomyia*. Species wise break up shows that *St*. *albopicta* (114/504, 23.0%) predominated followed by *Cx*. *gelidus* (64/504, 13%) and *Cx*. *quinquefasicatus* (63/504, 12.5%). *An*. *barbirostris* and *An*. *subpictus* constituted 2.4% and 1% respectively (Figure 6).

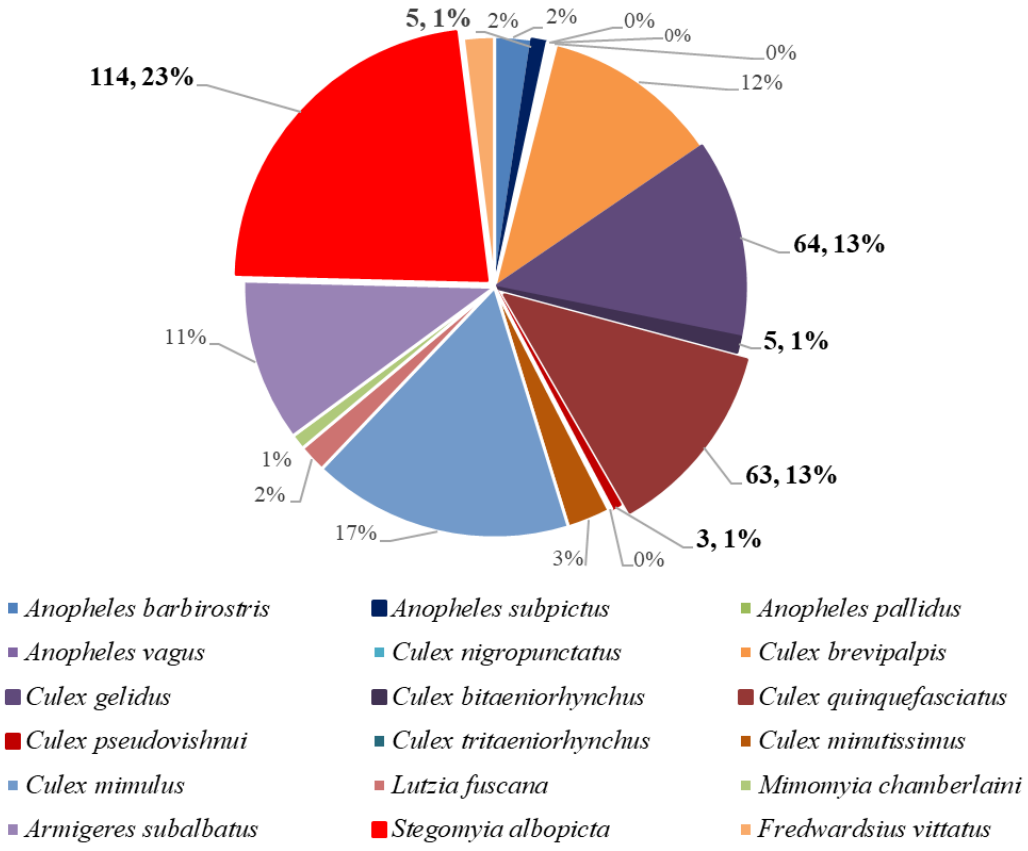

Figure 6. Species composition

Species richness and evenness: A total of 504 individuals, morphologically belonging to 18 species and seven traditionally recognized genera, were collected and identified. The species diversity was calculated for 15 sampling locations, where the larval collection was conducted during the study period. The alpha (α) biodiversity estimates are presented in Table 4. Analysis of α biodiversity indices shows that Auroville environment is diverse (S = 18; D_{Mg}= 2.732 [95% CI, 2.732-2.732]). The Shannon-Weiner (*H*'= 2.199 [95% CI, 2.133-2.276]) and the Simpson indices (λ= 0.8619 [95% CI, 0.8496-0.8723]) highlights species richness, evenness and dominance. However, the evenness of Pielou index (*J*'=0.5011[95% CI=0.4688-0.5408]) was observed.

Table: 4. Alpha *(α) biodiversity estimates, Auroville*

Individuals	504
Specific Richness (*S*)	18
Shannon-Weiner Index (H')	2.199 (95% CI, 2.133-2.276)
Margalef Index (D_{Mg})	2.732 (95% CI, 2.732-2.732)
Simpson Index (λ)	0.8619 (95% CI, 0.8496-0.8723)
Evenness of Pielou index (*J'*)	0.5011 (95% CI, 0.4688-0.5408)

CONCLUSIONS

1. The present study is the first on mosquito biodiversity in Auroville in recent times. Selection of oviposition sites by Anopheline and Culicine mosquitoes was distinguishable. Although there was overlapping in habitat preference, the oviposition site selectivity was noticeably different between the Anophelines and Culicines.
2. Spatial distribution of mosquito breeding habitats could be delineated.
3. Preference of *St. albopicta* for breeding in a wide spectrum of habitats indicates diverse preference of this mosquito species in choosing oviposition sites.
4. Of the 18 species recorded, 8 species are being reported for the first time in Auroville. Three medically important genera viz. *Anopheles*, *Culex* and *Stegomyia* were recorded.
5. Notable dominance of *St. albopicta*, renders Auroville receptive to different arbo-viral pathogens.
6. Although, *An. subpictus* in Auroville constituted a low proportion, a constant vigil is necessary. The presence of these mosquito vectors necessitates long term systematic studies in this ecosystem.
7. The abundance of mosquito species indicates species diversity and evenness. Prevailing conditions can provide suitable environment for the establishment of different species of mosquitoes in this ecosystem.
8. Considering the socio-demographic characteristics of Auroville, in-depth studies to assess the association between biodiversity of vectors and risk of Vector Borne Diseases will be useful.

RECOMMENDATIONS

1. Syntax tanks to be provided with tightly closed lids, accessible for inspection
2. Cement tanks to be closed with tightly (air tight/hermetically sealed) closed lids.
3. Introduction of top water minnow or mosquito fish *Gambusia affinis* in cement tanks, guppy fishes (*Poecilia reticulata*)- can be introduced water bodies with minimal pollution @ 5 fish/m^2
4. Source reduction of habitats like grinding stone, earthen pot & discarded tires every month
5. Trimming of vegetation around lake margins.

REFERENCES

1. David A. Adebote, Sonnie J. Oniye & Yunus A. Muhammed. 2008. Studies on mosquitoes breeding in rock pools on inselbergs around Zaria, northern Nigeria. **J Vector Borne Dis** 45, March 2008, pp. 21–28

2. Basiliana Emidi, William N. Kisinza, Bruno P. Mmbando, Robert Malima & Franklin W. Mosha. 2017. Effect of physicochemical parameters on *Anopheles* and *Culex* mosquito larvae abundance in different breeding sites in a rural setting of Muheza, Tanzania. **Parasites & Vectors,** Vol:10, 304

3. S Manguin, C Boëte. 2011. Global impact of mosquito biodiversity, human vector-borne diseases and environmental change. In: Importance of Biological interactions in the study of biodiversity-Edited by Jordi Lopez-Pujol. ISBN 978-953-307-751-2

4. R. Guimerà, S. Mossa, A. Turtschi, and L. A. N. Amaral. 2005. The worldwide air transportation network: Anomalous centrality, community structure, and cities' global roles. **Proceedings of the National Academy of Sciences** (PNAS);102 (22) 7794-7799.

5. A. J. Tatem, D.J. Rogers, S. I. Hay. 2006. Global Transport Networks and Infectious Disease Spread. **Advances in Parasitology**, Volume 62: 293-343

6. A. Enayati and J. Hemingway. 2010. Malaria Management: Past, Present, and Future. **Annual Review of Entomology**, Vol. 55:569-591

7. Felicia Keesing, Lisa K. Belden, Peter Daszak, Andrew Dobson, C. Drew Harvell, Robert D. Holt, Peter Hudson, Anna Jolles, Kate E. Jones, Charles E. Mitchell, Samuel S. Myers, Tiffany Bogich & Richard S. Ostfeld. 2010. Impacts of biodiversity on the emergence and transmission of infectious diseases. **Nature.** Vol 468: 647–652

8. Eliningaya J. Kweka, Epiphania E. Kimaro and Stephen Munga. 2016. Effect of Deforestation and Land Use Changes on Mosquito Productivity and Development in Western Kenya Highlands: Implication for Malaria Risk. **Front. Public Health**, 26 October 2016 https://doi.org/10.3389/fpubh.2016.00238

9. A R Rajavel 1, R Natarajan, K Vaidyanathan. 2004. A checklist of mosquitoes (Diptera: Culicidae) of Pondicherry, India with notes on new area records. **J Am Mosq Control Assoc.** 20(3):228-32.

Annexure

Details of water bodies/habitats surveyed in Auroville

S.No	Locations	Habitats	N
1	CSR	Cement Tanks	2
2	Irumbai Tank	Lake Margins	1
3	Savithri Bhavan	Cement Tank	1
4	Ilaignarkal Education Centre	Cement Tank- (1) Tree Hole - (1)	2
5	Windaraa farm	Cattle Farm	1
6	Kottakarai	Ground Pool - (1), Cement Tank- (1)	2
7	Arunthatipuram	Natural Pond -(1), Ground Pool -(2)	3
8	Unity Pavilion	Artificial Pond	1
9	Bharat Nivas	Ground Pool	1
10	Tibetian Pavilion	Ground Pool -(1), Artificial Pond- (2), Cement Tank-(1)	4
11	Matrimandir Globe	Artificial Pond -(3), Ground Pool- (1)	4
12	Dhana	Cement Tank-(2)	2
13	Transition School	Cement Tank- (1)	1
14	Youth Centre	Cement Tank - (1)	1
15	Foundation Centre	Cement Tank -(1)	1
16	Buddha Garden	Cement Tank-(1)	1
17	Udavi School	Cement Tank-(2)	2
18	Botanical Garden	Soak Pit - (1)	1
19	Auroville Visitor Centre	Cement Tank- (1), Ground Pool - (1)	2
20	Prathna	Dugwell- (1), Cement Tank-(1)	2
21	Pitachandikulam Forest	Cement Tank-(4),Ant Trap Holders-(1), Earthen Pot- (1), Grinding Stone-(1)	7
22	Vikas	Ant Trap Holders-(1), Cement Tank-(2)	3
23	Luminosity	Cement Tank-(1), Discarded Containers-(1)	2
24	Abri-Sun Farm	Cement Tank-(1), Discarded tires-(1)	2
25	Charler Garden	Cement Tank	1
26	Auroville Post Office	Cement Tank-(1), Syntax Tank-(1)	2
27	Telephone Exchange	Cement Tank	1
28	Human Scpaes	Cement Tank	2
29	Certitude Ground	Earthen Pot	1
30	Samasti- Pitanga	Cement Tank	4
31	Swayam Community	Cement Tank	1
32	Citradines, Mithra residential areas	Cement Tank	1