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Diversity and distribution of tree hole mosquitoes in Puducherry Union Territory, India

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ABSTRACT

Objective: To study diversity and distribution of tree hole mosquitoes at Puducherry Union Territory.
Methods: Random collections were carried out in tree holes at collection sites by using suction tube. Mosquitoes are identified by standard entomological procedures.
Results: A total of 235 mosquitoes were collected from tree holes, comprising 3 genera and 12 species. They are, *Aedes aegypti, Aedes albopictus, Aedes stokesi, Aedes simpsoni, Anopheles subpictus, Anopheles stephensi, Anopheles culiciformis, Anopheles maculatus, Culex quinquefasciatus, Culex pseudovishnui, Culex tritaeniorhynchus*, and *Culex decens*. The results reveal that *Aedes* species is the dominant species in tree holes. Simpson's dominance index and Shanon-Wiener diversity index of 0.1827 and 0.8336 were respectively recorded for all tree hole mosquitoes.
Conclusions: The diversity studies of tree hole mosquitoes in the study area are necessary for the implementation of appropriate control strategies.

1. Introduction

Mosquitoes are the worst enemy of mankind since dawn of time and act as a vector of several diseases[1] such as malaria, filariasis, Japanese encephalitis and dengue fever, which are transmitted by the three genera of mosquitoes, namely, *Anopheles*, *Culex* and *Aedes*. A total of 40 million people in India suffer from mosquito borne diseases annually. There are over 3 000 mosquito species belonging to 34 genera in the world. Surveys are essential for the planning, operation and evaluation of any effective mosquito control program[2]. In general, the term biodiversity comprises the diversity of species and their complex interplay with the abiotic, non living features of their environment. It relates to the range of species and ecosystems[3].

Most of the mosquito faunastic studies in India have been done are related to the geographic location[4]. These studies provide information on the distribution of mosquito species in different regions or states[5]. They are widely distributed throughout the world and occur in a variety of habitats. The distribution of adult mosquitoes is associated with various environmental factors and these may include availability of oviposition sites, natural resting sites and man-made resting sites[6]. Tree holes are segregated separate habitats with many interrelations of the organisms. There is water in the tree holes in which there may be several types of bacteria, molds, algae and many types of animals. The mosquito larvae form an important part of the animal life of the tree holes but only link in the complex food cycle[1]. Karaikal and Puducherry districts of Puducherry Union Territory are endemic for malaria and dengue fever. A proper study on mosquito fauna in this region will help to find out the distribution pattern of different seasons as well as different ecological conditions. It will also provide a database of the mosquitoes of this area. Therefore, the present study aims to investigate the abundance of larva, pupa and mature adult mosquitoes in the tree holes and their survival.

2. Materials and methods

The present study was conducted from July to September 2013. Two collection sites of tree hole mosquitoes were selected in Pondicherry Union Territory.

2.1. Study areas

2.1.1. Karaikal

Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA) is situated in the Karaikkal district and it is located in 10°58'9.655 8" N latitude and 79°46'17.489 4" E longitude.

2.1.2. Puducherry

Pondicherry University (PU) is located at Pondicherry and it is situated in 12°0'57.24" N latitude and 79°51'30.6" E longitude.

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Both study campus, the surroundings of the area have been planted with vegetation and lot of trees, providing ideal resting sites for mosquito breeding.

2.2. Collection and identification

Mosquito collection was carried out in the selected sites using standard methods[7]. A random sampling method was carried out across the study area by selecting all the suitable trees (having tree holes) to accommodate immature forms of mosquitoes. The adult mosquitoes were collected from the tree hole with the help of suction tube (having small sieve, a siphon or by a rubber suction bulb to remove the mosquitoes from the tree holes. A rubber tube about one half inch diameter and 2 feet in length with an eight inch piece of glass tubing inserted makes satisfactory siphon) and human bait net also used for adult collection[8]. The collected adult mosquitoes preserved in plastic vials containing powdered naphthalene balls. The collected immature (larvae and pupae) were brought to the laboratory and cultured separate trays, fed with larval food (yeast and dog biscuits in 3:1 ratio). After the adult emergence, the mosquitoes were identified. Each collected mosquito has been identified into genera and species by using standard mosquito identification keys[9-11]. The voucher specimens are present in the Department of Zoology, Annamalai University, Annamalainagar.

2.3. Statistical analysis

Mosquito sampling were analyzed quantitatively to determine the total abundance, percentage abundance of each species identified during the study period, as well as Shannon-Wiener diversity index (H) and Simpsons dominance index (C) in the area. Shannon-Wiener diversity index (H) was used in calculating *t'* to test for significant differences in diversity and dominance of mosquito species[3].

3. Results

During the study period, a total of 235 mosquito species (122 adults, 78 larvas and 35 pupa) were collected in selected areas during the study period from July to September in 2013. The mosquito species belonging to 12 species in 3 genera: *Aedes* (4 spp., n = 139), *Anopheles* (4 spp., n = 23), *Culex* (4 spp., n = 73) (Table 1). The complete catalog of species collected from tree holes is listed below: *Aedes aegypti (Ae. aegypti)* (Linnaeus, 1972), *Aedes albopictus* (*Ae. albopictus)* (Skuse, 1895), *Aedes stokesi* (*Ae. stokesi*) (Evans, 1929), *Aedes simpsoni* (*Ae. simpsoni*) (Theobald, 1905), *Anopheles subpictus (An. subpictus)* (Grassi, 1899), *Anopheles stephensi (An. stephensi)* (Liston, 1901), *Anopheles culiciformis (An. culiciformis)* (Cogill, 1903), *Anopheles maculates* (*An. maculates)* (Theobald, 1901), *Culex quinquefasciatus* (*Cx. quinquefasciatus*) (Say, 1823), *Culex pseudovishnui* (*Cx. pseudovishnui)* (Colless, 1957), *Culex tritaeniorhynchus* (*Cx. tritaeniorhynchus)* (Giles, 1901) and *Culex decens (Cx. decens)* (Theobald, 1901). On the whole, *Ae. aegypti* had the highest dominance of 74 mosquitoes, representing 31.4% of the total mosquito population and was followed by *Ae. albopictus* 19.1% and *Cx. quinquefasciatus* 16.1%.

Among the study regions, the occurrence of mosquitoes was more in PU campus (144), and least in PAJANCOA (90), and indicated in Table 2. The distribution of adult mosquitoes was associated with various environmental factors and these may include: availability of oviposition sites and natural resting sites. Tree holes provided the ideal resting place for mosquito breeding. The study campuses of PAJANCOA and PU have lot of vegetation like *Delonix rigia*, *Kigelia pinnata*, *etc.*, and tree holes.

A total of 235 mosquito species were collected in both study area in the period of July (42), August (52) and September (141), and indicated in Table 3. The distribution pattern of mosquitoes showed the highest number of mosquitoes was in September and followed by August.

Table 1

Diversity of tree hole mosquito species recorded in the both study area PAJANCOA and PU during the study period July to September 2013.

Name of the Species	Number of species	Percentage (%)
Ae. (Stegomyia) aegypti (Linnaeus)	74	31.4
Ae. (Stegomyia) albopictus (Skuse)	45	19.1
Ae. (Albuginosus) stokesi (Evans)	14	5.9
Ae. (Stegomyia) simpsoni (Theobald)	6	2.5
An. (Cellia) subpictus (Grassi)	12	5.1
An. (Cellia) stephensi (Liston)	7	2.9
An. (Anopheles) culiciformis (Cogill)	3	1.2
An. (Cellia) maculates (Theobald)	1	0.4
Cx. (Culex) quinquefasciatus (Say)	38	16.1
Cx. (Culex) pseudovishnui (Colless)	26	11.0
Cx. (Culex) tritaeniorhynchus (Giles)	8	3.4
Cx. (Culex) decens (Theobald)	1	0.4
Total	235	100.0

Table 2

Mosquitoes sampled and identified as male and female mosquitoes in study areas.

Name of the species	PAJANCOA			PU			Total number of species
	M	F	T	M	F	T	
Ae. aegypti	9	14	23	13	38	51	74
Ae. albopictus	8	13	21	9	15	24	45
Ae. stokesi	2	4	6	2	6	8	14
Ae. simpsoni	-	2	2	3	1	4	6
An. subpictus	4	1	5	4	3	7	12
An. stephensi	3	2	5	2	-	2	7
An. culiciformis	-	3	3	-	-	-	3
An. maculates	-	-	-	-	1	1	1
Cx. quinquefasciatus	7	9	16	16	6	22	38
Cx. pseudovishnui	4	5	9	9	8	17	26
Cx. tritaeniorhynchus	-	-	-	5	3	8	8
Cx. decens	-	-	-	1	-	1	1
Total	37	53	90	64	81	145	235

Table 3

Monthly (July, August and September 2013) record of tree hole mosquitoes in study areas of Puducherry Union Territory.

Mosquito species	July	August	September	Total
Ae. aegypti	6	18	50	74
Ae. albopictus	4	5	36	45
Ae. stokesi	0	9	5	14
Ae. simpsoni	0	2	4	6
An. subpictus	3	3	6	12
An. stephensi	0	1	6	7
An. culiciformis	1	0	2	3
An. maculates	0	0	1	1
Cx. quinquefasciatus	21	8	9	38
Cx. pseudovishnui	6	1	19	26
Cx. tritaeniorhynchus	0	5	3	8
Cx. decens	1	0	0	1
Total	42	52	141	235

Computations for diversity and dominance indices for tree hole mosquitoes sampled at PAJANCOA and PU campuses are shown in Table 4. Simpson's diversity values of 0.1827 and Shanon-Weinner diversity index value of 0.8336 were recorded for the tree hole mosquitoes during the study month of July-September 2013 at both study areas. *Ae. aegypti* was the most frequent species with diversity values of 0.0991 (Simpson's) and 0.1580 (Shannon-Wiener), *Ae. albopictus* 0.0366 (Simpson's), 0.1374 (Shannon-Wiener) and *Cx. quinquefasciatus* with 0.0261 (Simpson's) and 0.1279 (Shannon-Wiener). Ecological statistics demonstrated the difference in diversity between species at tree holes.

Table 4

Species diversity and dominance indices for tree hole mosquitoes sampled at PAJANCOA and PU.

Name of the species	fi	fi log fi	fi log^2 fi	Pi	(Pi)^2 or (ni/Ni)^2	Ni(ni-1)/ N(N-1)	Pi log Pi	Pi In Pi	Pi(In Pi)^2	Shannon-Wiener index H = (N log N-∑ fi log fi/N) (or)-(Pi log Pi)	Simpson's dominance index C = ∑(ni/N)^2
Ae. aegypti	74	138.3200	258.5486	0.3148	0.0990	0.0982	-0.1580	-0.3638	0.4205	0.1580	0.0991
Ae. albopictus	45	74.3945	122.9850	0.1914	0.0366	0.0360	-0.3174	-0.3164	0.5232	0.1374	0.0366
Ae. stokesi	14	16.0457	18.3890	0.0595	0.0035	0.0033	-0.0729	-0.1678	0.4737	0.0729	0.0035
Ae. simpsoni	6	4.6689	2.6324	0.0255	0.0006	0.0005	-0.0406	-0.0935	0.3432	0.0406	0.0006
An. subpictus	12	12.9501	13.9726	0.0510	0.0026	0.0024	-0.0659	-0.1517	0.4516	0.0659	0.0026
An. stephensi	7	5.9156	4.9980	0.0297	0.0008	0.0007	-0.0453	-0.1044	0.3672	0.0453	0.0008
An. culiciformis	3	1.4313	0.6828	0.0127	0.0001	0.0001	-0.0240	-0.0550	0.2421	0.0240	0.0001
An. maculates	1	0.0000	0.0000	0.0010	0.0000	0.0000	-0.0030	-0.0060	0.0477	0.0030	0.0000
Cx. quinquefasciatus	38	60.0317	94.8252	0.1617	0.0261	0.0255	-0.1279	-0.2946	0.5368	0.1279	0.0261
Cx. pseudovishnui	26	36.7893	52.0494	0.1106	0.0122	0.0118	-0.1057	-0.2435	0.5361	0.1057	0.0122
Cx. tritaeniorhynchus	8	7.2247	6.5232	0.0340	0.0011	0.0010	-0.0499	-0.1149	0.3887	0.0499	0.0011
Cx. decens	1	0.0000	0.0000	0.0010	0.0000	0.0000	-0.0030	-0.0060	0.0477	0.0030	0.0000
∑	235	357.7718	575.6062	0.9929	0.1826	0.1795	-0.8336	-1.9176	4.3788	0.8336	0.1827

fi: Abundance of species; *N*: Total number of individuals; Pi: Proportion of individuals found in the species; In*:* The natural (Naperian) logarithms ($\log_e$); (ni/N)^2 = (Pi)^2.

4. Discussion

The choice of PAJANCOA and PU campus for this study, was to serve as regular blood meal sources for mosquitoes. In campus, the human (students) and animals provide blood meal regularly. Such constant interaction between animal and human populations on one side and mosquito population on the other had the potential for diseases transmission to students and staff members of the PAJANCOA and PU campuses.

The yellow fever virus exists normally in animal reservoir (monkey) which is maintained by several forest mosquitoes. With animals acquiring the infection by frequently going to forests or their neighborhood where they become composed to the bites of infected wild mosquitoes. An infected animal subsequently returns to the village where the virus is transmitted to non infected persons by domesticated species of mosquitoes[12]. Only *Aedes* and *Culex* species were high in frequency in the both study areas. All the mosquitoes collected were apparent to health danger. Karaikal and Puducherry districts are well known to be involved in disease transmission, through *Ae. aegypti* and *Cx. quinquefasciatus* are known to be capable of transmitting yellow and dengue fever, and lymphatic filariasis[13].

Presence of *Ae. aegypti*, *An. stephensi* and *Cx. quinquefasciatus* is the principle vector of dengue, malaria and filariasis respectively[14]. Analysis of the diversity and relationship between adult mosquitoes and habitats can provide a useful tool that can target the most suitable habitats like tree hole for the control of vector and nuisance mosquitoes. The results of the present study are helpful to understand the population of adult mosquitoes emerging from tree holes and to exploit ways to undertake cost effective larval control in the irrigation farms in Puducherry Union Territory.

Vector mosquitoes of filariasis, dengue fever, chikungunya and Japanese encephalitis were recorded in the study areas. The diversity studies and the factors influence the density and diversity pattern of mosquitoes in the peri-urban areas are necessary for the implementation of appropriate control strategies. Evaluation of larval mosquito habitats in terms of species composition and resources helps to understand the bio-ecology and related control measures of pest and vector mosquitoes.

Conflict of interest statement

We declare that we have no conflict of interest.

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