International Journal of Mosquito Research

ISSN: **2348-5906**
CODEN: **IJMRK2**
IJMR 2015; 2 (2): 19-23

Received: 03-01-2015
Accepted: 06-04-2015

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Mosquito diversity and vector species status in and around Nagpur city of Maharashtra state, India

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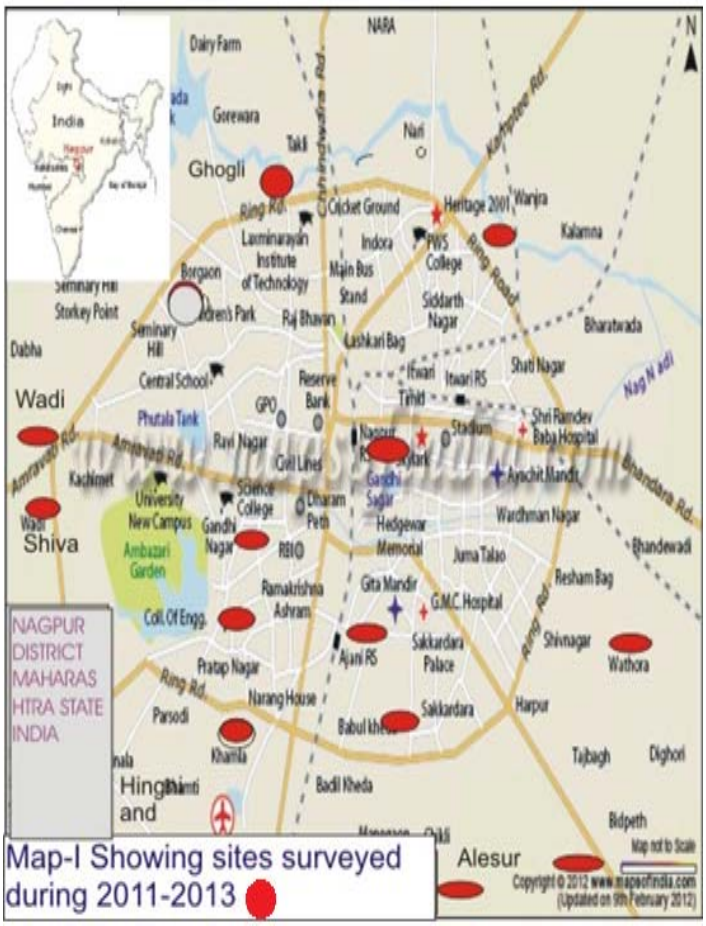
Abstract
The present study gives an overview of data on the biodiversity of mosquitoes and vector species status occurring at 13 sites in and around Nagpur city of Maharashtra state, India. This study carried out from January 2011 to December 2013. A total of 4018 adults and 27108 larvae were collected. Collected larvae were reared until adult immergence. The mosquito fauna belong to five genera (*Aedes, Anopheles, Culex, Armigeres* and *Mansonia*) and nineteen species. *Anopheles* genus contributed eight species, *Culex* five, *Aedes* three, *Armigeres* two and *Mansonia* only one species. The highest population of *Cx. quinquefasciatus* (24.1%) followed by *Ar. subalbatus* (12.1%), *An. subpictus* (10.7%) and eight known vector species identified. *Cx. quinquefasciatus* the lymphatic filaria vector was found to be the more prevalent vector species in all areas of the city and surrounding villages. The mosquito species diversity *(H)* in winter 2.472 was significantly higher than rainy 2.398 and summer 2.008 seasons, while total number of individuals in rainy season was significantly higher than winter and summer. The paper indicates the importance of abiotic factors on mosquito dynamics which can be used as early warning indicators for the policy makers of mosquito vector borne disease control programme.

Keywords: Mosquito, diversity, Nagpur, *Culex, Aedes, Anopheles.*

1. Introduction
In recent years, the distribution range of both mosquitoes and mosquito borne diseases are proliferating in large number everywhere due to rapid urbanization, excessive deforestation and resistance among mosquitoes to insecticides [1]. Despite several attempts have been made to control them, these remarkably adapted insects continue to coexist with man, feeding on him and his domesticated animals [2].
According to Harbache (2013) [3], a total of 3539 species of mosquitoes belonging to 112 genera are found on this earth. In general, mosquitoes stand out most among the numerous species of blood sucking arthropods that co-exist with human. Most of these species act as vectors of different pathogens that cause malaria, dengue fever, yellow fever, lymphatic filariasis, Japanese encephalitis and other serious disease to humans [4].
The warmer climates in tropical areas allow these insects to be active all year round since their ideal conditions for proliferation in an environment which is hot and humid with moderate rainfall a typical tropical condition. In hot climate they are able to be more active and the rainfall gives them aquatic sites for larval and pupal stages [5]. Because of their medical importance, it is essential to make an inventory of the diversity of mosquitoes in different places periodically, which forms the baseline to study bionomics of vector species as well as correlations with the abiotic factors of the environment and to make strategy for the control over mosquito born diseases [6].

2. Materials and methods
2.1 Study sites
The present study was carried out in and around Nagpur city of Maharashtra state India which is located 21° 9′ 0″ Northern latitude 79° 5′ 24″ Eastern longitude. Thirteen sites at Nagpur city and surrounding villages were selected for mosquito collection (Map-1). Selection of study sites considered direction, posh and slum areas, around lakes, gardens, near hilly areas, forest area, dense populated area and along slow flowing shore of the river in the city.



2.2 Mosquito collection and identification

Mosquitoes were collected from randomly selected houses, cattle sheds and outdoor of each sites during different seasons from 2011 to 2013. The catching of adult and larval mosquitoes was carried out according to standard entomological surveillance guidelines [7-9]. While entering in the house purpose of the investigation was explained to the head of each of the households selected. Permission to enter each of the household was sought and the right to refuse or withdraw at any time was respected. Collected adults and larval forms of mosquitoes were brought to the laboratory. The larvae were reared up to emergence. All the adult mosquitoes were identified using standard identification keys of each genus [10-17].

2.3 Data analysis

The number of individuals of each species present was recorded. The Simpson's index (D) [18], Pielou's evenness index (J), Margalef richness index (M), Shannon's diversity index (H) [19] and distribution abundance of species designed by the method of Rydzonicz and Lonc [20] used for statistical analysis.

2.4 Meteorological data

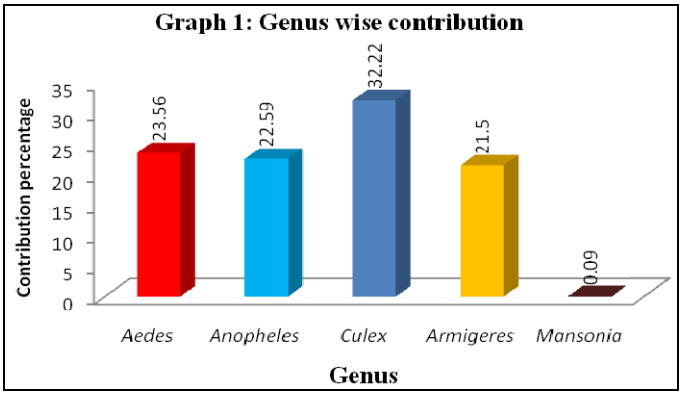
Monthly average of maximum and minimum temperature and humidity, as well as rainfall data of study period obtained from Meteorological Department (https://weatherspark.com/history/33913/2011/Nagpur-Maharashtra-India) to analyze the mosquito population dynamic with the abiotic factors (Table 1).

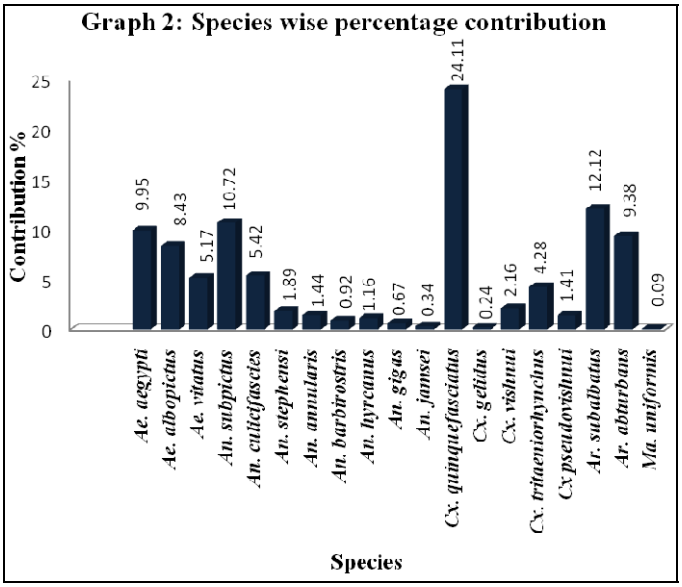
Table 1: Meteorological data of Nagpur from 2011 to 2013.

Month	2011			2012			2013		
	Average Temperature (Max/Min in° C)	Average rainfall (mm)	Average humidity (Max/Min)	Average Temp. (Max/Min in ° C)	Average rainfall (mm),	Average humidity (Max/Min)	Average Temp. (Max/Min in ° C)	Average rainfall (mm)	Average humidity (Max/Min)
January	28/18	0.0	80/30	28/13	14.8	80/30	28/13	40.8	81/30
February	33/17	49.9	70/25	32/17	0.0	70/25	33/17	109.4	70/25
March	37/22	2.3	58/22	37/22	19.2	58/22	38/21	12.6	58/22
April	42/27	2.2	54/19	41/27	9.0	52/20	42/27	11.6	52/18
May	46/28	33.4	49/20	42/28	13.6	49/20	44/28	0.0	48/18
June	37/27	104.2	80/32	37/27	12.4	75/40	38/27	151.0	70/40
July	33/25	33.8	95/64	31/24	139.8	95/68	32/25	459.8	95/70
August	31/24	272.4	95/70	31/24	274	95/70	30/23	521.9	95/70
September	32/24	163.6	94/60	32/24	57	95/58	31/22	108.1	94/60
October	32/20	0.0	90/41	31/20	11	91/41	32/20	109.0	91/43
November	31/17	0.0	88/38	31/17	0.0	88/38	31/17	0.4	88/38
December	28/15	0.0	85/35	29/14	8.6	85/35	28/13	6.8	87/36

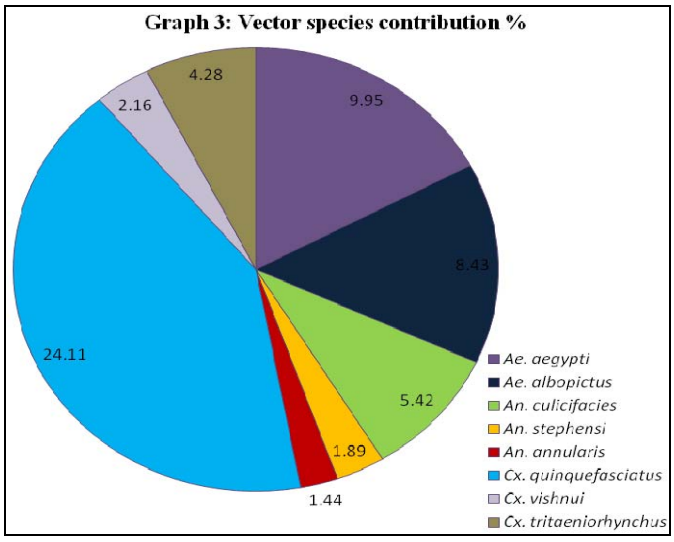
3. Result and Discussion

A total of 4018 adults and 27108 larvae were collected from different sites and in different season. The collected mosquitoes belonged to five genera (*Aedes, Anopheles, Culex, Armigeres* and *Mansonia* (Graph-1)) and nineteen species (Graph-2). *Anopheles* genus dominated with eight species, *Culex* five, *Aedes* three, *Armigeres* two and *Mansonia* was representing only one species. The population of *Cx. quinquefasciatus* (24.1%) was the highest followed by *Ar. subalbatus* (12.1%) and *An. subpictus* (10.7%). Maximum density of mosquito species occurred in the post monsoon period only.

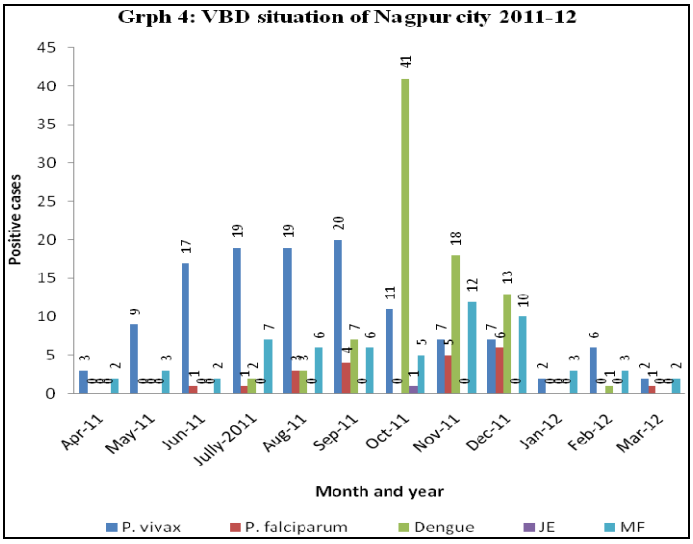




The vector species identified were *An. culicifacies, An. anularis* and *An. stephensi* for malaria, *Cx. quinquefasciatus* for lymphatic filaria, *Cx. vishnui, Cx. tritaeniorhynchus* for Japanese Encephalitis and *Ae. aegypti*, *Ae. albopictus* for dengue and chikungunya fever (Graph-3). Due to the occurrence of high density of vector species in the study area, vector borne disease epidemics could easily be initiated by the arrival of parasite source or favorable climatic factors for the quiescent parasites to become active [21], and each of the species observed could easily adopt the parasites and may become potential vector. The epidemiological significance of the diverse mosquito species observed in the study area should therefore not be underestimated.



Epidemiological data of Nagpur city for 2011-12 [22] shows prevalence of mosquito borne diseases (Graph-4) co-relating with the vector species observed in this area. The incidence of high lymphatic filarial cases in the area coincided with high population of vector *Cx. quinquefasciatus.* In slum areas of the city and surrounding villages, poor sanitation and open drainage system cause rise in density of this vector species. Due to scarcity of water in summer, water is stored for more than ten days and continuous use of water coolers throughout the summer develop into the major source of breeding for *Aedes* and *Anopheles* species. As well as the open mines around the Nagpur city favors high degree of diversity of anopheline group of mosquitoes in rainy season.



Diversity indices (Shannon-Weaver index, Simpson's index), richness (Margalef index) and evenness (Pielou index) for three different seasons were calculated. Sannon-Weaver index is little higher in winter (2.472) than rainy season (2.398) and lower in summer season (2.008). Similarly species richness (Margalef index) was also little higher in winter season (2.423) and lower in rainy season (2.397). Values of evenness index also exhibits a similar trend, it was highest in winter season (0.839) and lowest in summer season (0.742). Total number of individual observed here more in rainy season (1823) followed by winter (1682) and summer (513). Natural log (2.944) and number of species (19) is equal in rainy and winter season (Table 2). Among 19 species, *Ae. aegypti, Ae. albopictus, Ae. vitatus, An. subpictus, An. anularis, An. barbirostris, An. hyrcanus, An. gigas, Cx. quinquefasciatus, Cx. tritaeniorhynchus, Ar. subalbatus* and *Ar. abturbans* were constantly distributed. *An. culicifacies, An. jamsei, Cx. vishnui* and *Cx. psuedovishnui* frequently distributed. *An. stephensi* moderately, *Cx. gelidus* infrequent and *Ma. uniformis* sporadically distributed (Graph 5). A significant variation in mosquito density and species richness was observed in the different study sites (Table 3) may be due to the observed differences of breeding sources available, planned and unplanned area of the city and surrounding villages. The highest population of mosquito species observed in the rainy season of 2012, when the maximum and minimum humidity and temperature was 95%/70%; 31°C/24°C, respectively, and rainfall was 274mm. While minimum density of mosquito species was observed in the summer of 2011, when the maximum and minimum humidity was 49%/20%; temperature was 46°C/27°C and rainfall recorded was 33.4mm. Thus the maximum and minimum temperature 31°C/24°C, humidity 95%/70%, and rainfall 274mm is an ideal condition for the proliferation of mosquito species. Environmental parameters around these levels can be used as early warning for the outbreaks of mosquito population which is directly related to mosquito vector borne diseases. These finding indicated that in winter the diversity is highest because of stagnant water bodies.

Table 2: Biostatic indexes.

Index	Summer	Rainy	Winter
Total no. of species (S)	15	19	19
Total no. of individuals(N)	513	1823	1682
Natural log of species(In S)	2.708	2.944	2.944
Natural log of individuals(In N)	6.240	7.508	7.428
Margalef's index (M)	2.243	2.397	2.423
Simpson's index (1/D)	5.524	8.558	9.263
Shannon-Weaver index (H)	2.008	2.398	2.472
Pielou's index (J)	0.742	0.814	0.839

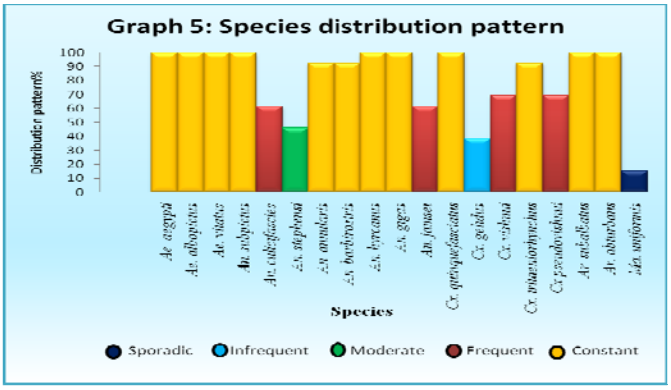


Table 3: Site wise abundance of species.

Genus	Species	Distribution pattern of all sites													
		Madavghorad	Shiva	Vihirgaon	Ghogli	Alesur	Gumthi	Ajani	Wadi	Ambazari	Wathoda	Babulkheda	Bajajnagar	Bardi	Distribution pattern
Aedes	*aegypti*	*	*	*	*	*	*	*	*	*	*	*	*	*	100%
	albopictus	*	*	*	*	*	*	*	*	*	*	*	*	*	100%
	vitatus	*	*	*	*	*	*	*	*	*	*	*	*	*	100%
Anopheles	*subpictus*	*	*	*	*	*	*	*	*	*	*	*	*	*	100%
	culicifacies	*	*	*	*	*	*	-	*	*	-	-	-	-	61.53%
	stephensi	-	-	-	-	-	-	*	*	*	*	*	-	*	46.15%
	annularis	*	*	*	*	*	*	*	*	*	*	*	*	-	92.3%
	barbirostris	*	*	*	*	*	*	*	-	*	*	*	*	*	92.3%
	hyrcanus	*	*	*	*	*	*	*	*	*	*	*	*	*	100%
	gigas	*	*	*	*	*	*	*	*	*	*	*	*	*	100%
	jamsei	-	*	*	*	*	-	*	*	*	*	-	-	-	61.53%
Culex	*quinquefasciatus*	*	*	*	*	*	*	*	*	*	*	*	*	*	100%
	gelidus	-	*	-	-	*	*	*	*	-	-	-	-	-	38.46%
	vishnui	*	*	*	*	*	*	*	-	*	-	*	-	-	69.23%
	tritaeniorhynchus	*	*	*	*	*	*	*	*	*	*	*	-	*	92.3%
	pseudovishnui	*	*	*	*	*	*	*	-	*	-	*	-	-	69.23%
Armigeres	*subalbatus*	*	*	*	*	*	*	*	*	*	*	*	*	*	100%
	abturbans	*	*	*	*	*	*	*	*	*	*	*	*	*	100%
Mansonia	*uniformis*	-	-	-	-	-	-	-	-	*	*	-	-	-	15.38%

* Presence of species at site.

In previous study conducted in different areas of Maharashtra state, Sathe and Girhe (2001) [23] observed composition of nine species belonging to three genera *Culex*, *Anopheles* and *Aedes* in Kolhapur district. Shinde *et al.,* (2011) [24] identified three medical important genus *Aedes, Anopheles* and *Culex* in Parbhani district of Marathwada region, while this study identifies four medically important genus and eight vector species. Jaid *et al.,* (2011) [25] observed high density of *Anopheles* species, also reported the genus *Mansonia* sporadically from Jalna district of Marathwada region which is similar to this study.

This is probably the first exhaustive report of mosquito diversity and population dynamics in and around Nagpur city of Maharashtra. This report also highlighted the vector species status of this region.

4. Acknowledgements

The authors wish to thanks Mr. M. M. Deshpande, Zonal Entomologist, ADHS (Malaria) Nagpur for the help in identifying the mosquitoes.

5. Conclusion

It is inferred from the data obtained that different season, localities and available major breeding sources have different effects on mosquito species diversity and abundance. Obtained diversity of mosquito and vector species for Nagpur city and surrounding area is not only helpful to the study of mosquito biodiversity of central India, but will also help in formulating strategies for the control over mosquito borne diseases.

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