



Review Paper

**CLIMATE CHANGE, MOSQUITO DIVERSITY AND EPIDEMICS OF
MOSQUITO BORNE DISEASES IN INDIA**

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Abstract

Mosquitoes are important vectors responsible for spreading various diseases in human population. They belong to family *Culicidinae* of order Diptera. Mosquito fauna in the world 3700 species belong to 112 genera. In India 393 species of mosquitoes are occurring. Mosquitoes are very efficient vector of human diseases today. It has been estimated that worldwide 7 to 8% economy is spend only for control of mosquito borne diseases. Mosquitoes are potential vector of malaria, dengue and other diseases. Environmental factors impact on mosquito species diversity. The key findings of the research is that only 10% species of female mosquito species act as vector of different pathogen that spread diseases like dengue, malaria, elephantiasis, lymphatic filariasis etc. India rank fifth in terms of mosquito biodiversity after Brazil, Indonesia, Malaysia and Thailand. The study of mosquito diversity is essential to understand species abundance and species variation. It is evident that climate change, mosquito diversity and epidemics of mosquito borne diseases are interrelated with each other.

Key words: Mosquito, Species diversity, Climate change, Epidemics.

INTRODUCTION

Today vector borne diseases is big problem for the world. Mosquitoes act as harmful vectors for various diseases. Mosquitoes transfer diseases to about 700 million peoples annually. India is one of the countries where incidence of mosquito borne diseases are more Mosquitoes belongs to the orders Diptera in the family Culicidae. The British government studies the taxonomy of mosquito of the world which resulted in the publication of the monograph of the Culicidae in 1910. Only female mosquito can cause Chikungunya, yellow fever, Filariasis, Japanese encephalitis and other serious diseases

to human and livestock (service, 1996) in which at least two million people dies every year. Study of mosquito diversity and abundance is essential for management and controls of mosquitoes. India rank fifth in terms of mosquito biodiversity after Brazil, Indonesia, Malaysia and Thailand. This communication is an attempt to review the work on diversity and population dynamics of mosquitoes and their correlation with mosquito borne diseases.

Diversity of mosquito in India:

About 550 species of *Culex* (Linnaeus, 1778) have been described and most of them are form tropical and subtropical region. Bansal et al., (1994) reported *Culex* genus is medically important since several species act as vectors of lethal disease like lymphathatic filariasis, west Nile virus, Japanese encephalitis and avian malaria [1]. Borade et al., (2018) reported to the 9 species in Nasik area such as *Anopheles minimus*, *Anopheles annularis*, *Anopheles sondaicus*, *Anopheles subpictus*, *Anopheles philippinensis*, *Anopheles vagus*, *Anopheles culicifaciense*, *Anopheles pallidus*, *Anopheles theobaldi*[2]. Nundurker et al., (2014) the present study 8 species are identified. Such as *Anopheles theobaldi*, *Anopheleus culicifacius*, *A.pallidus*, *A.vaguss*, *A.minimus*, *A.subpictus*, *A.sondaicus*, *A.phelipinensis*[3]. Jaid et al., (2011) studied Diversity of mosquito Jalna urban species *Anopheles* 64%, *Culex* 11.61%, *Aedes* 19.61%, *Monsonia* 4.05% [4]. Mosquito vector states in Nagpur city studied by Karlekar and Raymond Andrew (2015) present study note mosquito diversity (H) winter 2.472 was significantly high than rainy season 2.398 indicated importance of abiotic factors [5]. Ecology of mosquitoes from Kolhapur district Sathe (2010) reported 22 species of mosquitoes belong to the genera *Anopheles*, *Culex* and *Aedes* which are potential vectors malaria chikungunya, dengue, chikungunya, Japanese encephalitis and filariasis [6]. Verma et al., (2012) studied diversity of mosquito they reported 7 species of mosquito belong to genera *Anopheles*, *Aedes* and *culex* are reported [7]. Amala et al., (2012) studies species composition and diversity of mosquito in areas of vellimalai in sirumalai hills and they report 3 genera and 13 species in which dominant genus *Anopheles* are present that area [8]. Devi and Jauhari (2005) reported 45 species belonging to 3 genera *anopheles*, *Culex*, and *Aedes* from Garwal (Uttaranchal state) [9]. Kumar et al., (2014) studied with surveillance of *Aedes aegypti* mosquitoes in Mumbai international seaport to monitor potential global health risks they studied *Aedes* mosquitoes are highly invasive and can

survive almost any climate condition [10]. Recent update of mosquito fauna of India reports 393 species belonging to 49 genera. The subfamily Anophelinae contains 61 species in one genus followed by culicidae with 332 species belonging to 48 genera. Bhattacharya et al., (2014) reported the highest number of 176 species in 33 genera [11]. Pramanik et al., (2007) studies seasonal prevalence of *Aedes aegypti* immature in Kolkata [12]. periyasamy et al., (2015) reported 6 genera and 23 species in Tamilnadu dominant species in this area *Culex mimulus*, *Culex quinquefasciatus*, *Culex vishnui*, *Culex khazani*, *Culex uniformis*, *Heizmania chandi*, *Heizmannia grenii*, *Heizmannia indica*, *Oclerotatus anureostriatus*, *Oclerotatus albotaeniatis* etc [13]. Datta et al., (2010) carry Entomological survey in Dibru-Saikhowa biosphere reserve in pre 3 seasons such as pre monsoon, monsoon, post-monsoon in during that period 52 species of mosquito and eleven genera detected [14]. Sahu et al., () study Identification of Anopheles fauna in a hyperendemic falciparum area of Orissa State, India and they report *An. fluviatilis* and *An. minimus* are the major two species in the transmission of malaria in Keonjhar district in Orissa [15]. Suganthi et al., (2014) carried survey of mosquito vector abundance in tribal residential area. They report 8 species of mosquitoes such as *Aedes aegypti*, *Aedes vittatus*, *Aedes albopictus*, *Culex quinquefasciatus*, *Anopheles subpictus*, *Culex gelidus*, *Culex nilgricus*, *Culex tritaeniorhynchus* [16]. P.C. Kanojja (2007) reported ecological study on mosquito vectors of Japanese encephalitis virus in bellary district state Karnataka. They collected 120113 mosquitoes collected at dusk belonged to 5 genera 24 species including 13 species and also reported *Culex tritaeniorhynchus* appears to have a major role in the transmission of JE virus district Bellari [17]. Kalita et al., (2014) studied in Guwahati mosquito vector survey carried out. They reported 7 mosquito species belong to four genera *Anopheles*, *Aedes*, *Mansonia*, and *Culex* [18]. Shinde et al., (2011) studied vector mosquito diversity in association with environmental factors [19]. K. Manimegalai (2010) studied the mosquito populations from Coimbatore Tamilnadu during study 13 species recorded. They reported the 13 mosquito diversity species this present *Culex quinquefasciatus* predominant species in north Coimbatore [20]. Sharma and Shukla et al., (2007) studied insecticide resistance in malaria vector *Anopheles culicifascies* in some tribal region Chhattisgarh [21]. Anushrita et al., (2015) studied prevalence of vector mosquitoes of major mosquito borne disease in Indira sagar projection Madhya Pradesh [22]. Singh et al., (2015) studied prevalence of *Aedes* mosquitoes in various localities of Gadchiroli [23]. Manzoor et al., (2013) studied

population Dynamics of mosquito species at Lahore college for woman university campus. they reported highest density of *Aedes* species was found in month April and lowest in December and January [24]. Balasubramanian et al., (2013) identified 44 species of mosquitoes in Alappuzha and Kottayam district of Kerala state [25].

G.Suhasini and C.H. Sammaiah (2014) studied diversity of mosquitoes different habitats of Warangal urban environment Telangana. They reported 7 species such as *Anopheles culicifacies*, *Anopheles stephensi*, *Anopheles annularis*, *Culex quinquefasciatus*, *Culex tritaeniorhynchus*, *Aedes aegypti*, *Aedes albopictus* [26].

Priyalika Tripathi and RB Gupta (2017) studied population dynamics of mosquito in urban and rural areas of Gwalior district, Madhya Pradesh, India. They collected 2658 mosquitoes collected that belong to 4 genera and 9 species such as *Aedes albopictus*, *Aedes aegypti*, *Anopheles stephensi*, *Anopheles annularis*, *Anopheles subpictus*, *Culex quinquefasciatus*, *Culex vishnui*, *Culex tritaeniorhynchus*, *Armigeres subalbatus*[27]. Maiby Thankachan and Arya Gopinath (2017) studied mosquito diversity in plantation area of Mananthavady, Wayanad district of kerala. they reported 17 species belong to 6 genera such as *Culex*, *Anopheles*, *Uranotaenius*, *Tripteroides* and *Armigeres* respectively [28].

P. Anandh and S.P. Sevarkodiyone (2017) studied mosquito diversity in sattur talak, Tamil nadu, India. They identified twelve species belong to four genera. Species are *Aedes aegypti*, *Aedes albopictus*, *Aedes scatophagoides*, *Anopheles barbirostris*, *Anopheles pallidus*, *Anopheles peditaeniatus*, *Anopheles stephensi liston*, *Anopheles vagus*, *Armigeres subalbatus*, *Culex tritaeniorhynchus*, *Culex quinquefasciatus*, *Culex vishnui* [29]

. Devi Moirangthem and Singh studied (2018) two *armigeres* species of Manipur, the easternmost northeast India. They studied general features of the armigeres of the two species from two external of Manipur and morech hill [30].

Pawar *et al.*, (2017) studied distribution and diversity of mosquito larve from Kopargaon tehsil seven species are identified during study. which are *Culex vishnui*, *Culex pseudovishnui*, *Culex quinquefasciatus*, *Aedes aegypti*, *Aedes albopictus* *Armigeres subalbatus* [31].

Amruthraj Radhakrishnan (2019) studied mosquito diversity in Ernakulum district of the kerala state, south India. They identified 26 species of mosquitoes belonging to 6

genera such as *Anopheles*, *Culex*, *Aedes*, *Mansonia*, *Armigeres* and *Toxorhynchites*. Species are identified *Aedes aegypti*, *Aedes albopictus*, *Aedes pipersalatus*, *Aedes vexans*, *Aedes vittatus*, *Anopheles barbirostris*, *Anopheles gigas*, *Anopheles jamesii*, *Anopheles karwari*, *Anopheles kochi*, *Anopheles nigerrimus*, *Anopheles sinensis*, *Anopheles stephensi*, *Anopheles subpictus*, *Anopheles tessellates*, *Anopheles vagus*, *Armigeres subalbatus*, *Culex bitaeniorhynchus*, *Culex fuscocephala*, *Culex gelidus*, *Culex quinquefasciatus*, *Culex sitiens*, *Culex tritaeniorhynchus*, *Mansonia annulifera*, *mansonia uniformis*, *Toxorhynchites splendens* [32].

Roshan. k. Padv (2019) studied common mosquitoes species in Tornmal hill station circle of Nandurbar district, Maharashtra. They reported 3 species such as *Aedes aegypti*, *Culex quinquefasciatus*, *Anopheles culicifascies* [33]. Pallavi et al., (2016) studied knowledge and practices regarding mosquito borne disease among people of an urban area in kalaburgi, Karnataka [34]. Boratne et al., (2010) studied predictors of knowledge of selected mosquito borne disease among adults of selected peri urban areas of Puducherry [35]. P. Suganthi et al., (2014) studied mosquito vector abundance in and around tribal residential areas. *Aedes albopictus* was found to be the most common species distributed equally in urban and rural areas. This study is help to control mosquitoes from breeding sites by them [16]. Kumar et al., (2017) studied mosquito borne disease awareness, attitude and practice among the rural population in Karnataka [36].

Table showing diversity of mosquito in India.

Sr. No.	Species	Collected by	Location	State
1	<i>Anopheles</i> , <i>Culex</i> , <i>Aedes</i> .	T.V. Sathe and Girhe (2001)	Kolhapur	Maharashtra.
2	<i>Anopheles</i> , <i>Culex</i> , <i>Aedes</i> .	Devi and Jauhari (2005)	Garwal	Uttaranchal states

3	<i>Culex tritaeniorhynchus</i> <i>Anopheles subpictus</i> <i>Anopheles peditaeniatus</i> <i>Culex quinquefasciatus</i> <i>Culex pseudovishnui</i> <i>Culex vishnui</i> <i>Culex gelidus</i> <i>Culex fuscocephala</i> <i>Culex bitaeniorhynchus</i> <i>Mansoni annulifera</i> <i>Mansoni uniformis</i> <i>Anopheles barbirostris</i>	P.C. Kanojia (2007)	Bellary district	Karnataka
4	<i>Culex quinquefasciatus</i> <i>Culex Pseudovishnu</i> <i>Culex gelidus</i> <i>Armigeres subalbatus</i>	K.Manimegalai (2010)	Coimbatore	Tamil Nadu
5	<i>Anopheles</i> <i>Aedes</i> <i>Culex</i> <i>Mansonia</i>	E.L.Jaid, S.V.Nikam B.V.More, J.C.Bhandari (2011)	Jalna	Maharashtra
6	<i>Anopheles culicifacies</i> <i>Anopheles stephensi</i> <i>Anopheles annularis</i> <i>Anopheles fluviatilis</i> <i>Culex quinquefasciatus</i> <i>Aedes aegypti</i>	Sonal. P. Verma (2012)	Akola and Talhara region	Maharashtra
7	<i>Anopheles stephensi</i> <i>Anopheles fluviatilis</i> <i>Anopheles culicifacies</i> <i>Culex quinquefasciatus</i> <i>Culex tritaeniorhynchus</i> <i>Culex vishnui</i> <i>Culex pseudovishnui</i> <i>Culex gelidus</i> <i>Aedes aegypti</i> <i>Aedes albopictus</i> <i>Mansonia uniformis</i>	Nandini S.Korgaonkar,Ashwani kumar et al.,(2012)	Goa	Maharashtra
8	<i>Aedes aegypti</i> <i>Culex quinquefasciatus</i> <i>Anopheles stephensi</i> <i>Anopheles subpictus</i>	Farkhanda Manzoor Aniqa Nasir Sabiha Fazal (2013)	Lahore	Pakistan
9	<i>Culex quinquefasciatus</i> <i>Culex tritaeniorhynchus</i> <i>Aedes Aegypti</i> <i>Anopheles minimus</i> <i>Aedes albopictus</i>	J.C.Kalita, Alak chdeka and Kaushik Mishra (2014)	Guwahati	Assam

10	<i>Anopheles culicifacies</i> <i>Anopheles stephensi</i> <i>Anopheles annularis</i> <i>Culex quinquefasciatus</i> <i>Culex tritaeniorhynchus</i> <i>Aedes aegypti</i> <i>Aedes albopictus</i>	G.Suhasini and c.h.sammaiah.(2014)	Warangal	Telangana
11	<i>Anopheleus theobaldi</i> <i>Anopheleus culicifacies</i> <i>Anopheleus vaguss</i> <i>Anopheleus pallidus</i> <i>Anopheles minimus</i> <i>Anopheleus subpictus</i> <i>Anopheleus sundaicus</i> <i>Anopheleus phelipinensis</i>	H.P.Nundurkar, R.N.Tayade (2014)	Amravati	Maharashtra
12	<i>Aedes aegypti</i> <i>Aedes vittatus</i> <i>Aedes albopictus</i> <i>Culex quinquefasciatus</i> <i>Anopheles subpictus</i> <i>Culex gelidus</i> <i>Culex nilgricus</i> <i>Culex tritaeniorhynchus</i>	P.suganthi, M.govindaraju, V.Thenmozhi, B.K.Tyagi(2014)	Sitheri and selur villages	Tamil Nadu
13	<i>Culex quinquefasciatus</i> <i>Anopheles vanlaru</i> <i>Anopheles barbirostris</i> <i>Anopheles vagus</i>	Vanlaruia et al., (2014)	Mizoram	North Eastern
14	<i>Anopheles stephensi</i> <i>Anopheles fluviatilis</i> <i>Culex quinquefasciatus</i> <i>Culex vishnui</i> <i>Aedes aegypt</i>	Anushrita, Nagpal et al., (2015)	Indira Sagar projection (MP)	Madhya Pradesh
15	<i>Aedes stegomyia</i> <i>Albopictus skuse</i>	Abhay kumar, Kaushal kumar, Sukhvir singh (2015)	Ports of Goa	Maharashtra
16	<i>Aedes aegypti</i> , <i>Aedes albopictus</i> <i>Aedes stokes</i> <i>Aedes simpsoni</i> <i>Anopheles subpictus</i> <i>Anopheles stephensi</i> <i>Anopheles culiciformis</i> <i>Anopheles maculates</i> <i>Culex quinquefasciatus</i> <i>Culex pseudovishnui</i> <i>Culex tritaeniorhynchus</i> <i>Culex decens</i>	Periyasamy senthamarai selven, Arulsamy jebanesan, C.M. Kumar. (2015)	Puducherry	Tamil Nadu

17	<i>Aedes aegypti</i> <i>Aedes albopictus</i> <i>Aedes vitatus</i> <i>Anopheles subpictus</i> <i>Anopheles culicifacies</i> <i>Anopheles annularis</i> <i>Anopheles barbirostris</i> <i>Anopheles hyrcanus</i> <i>Anopheles gigas</i> <i>Anopheles jamsei</i> <i>Culex quinquefasciatus</i> <i>Culex gelidus</i> <i>Culex vishnui</i> <i>Culex tritaeniorhynchus</i> <i>Culex pseudovishnui</i> <i>Armigeres subalbatus</i> <i>Armigeres abturbans</i> <i>Mansonia uniformis</i>	Sanjay karlekar and Raymond Andrew (2015)	Nagpur	Maharashtra
18	<i>Culex mimulus</i> , <i>Culex quinquefasciatus</i> , <i>Culex vishnui</i> , <i>Culex mimulus</i> , <i>Culex khazani</i> , <i>Culex uniformis</i> , <i>Heizmania chandi</i> , <i>Heizmannia grenii</i> , <i>Heizmannia..indica</i> <i>Oclerotatus..anureostriatus</i> , <i>anureostriatus</i> , <i>Oclerotatus albotaeniatis</i>	Periyasamy, Senthamarai selven, Arulsamy jebanesan, Govindaraj divya, Velu ramesh (2015)	Western ghat	Tamil Nadu
19	<i>Aedes aegypti</i> , <i>Aedes albopictus</i> , <i>Aedes scatophagoides</i> , <i>Anopheles barbirostris</i> , <i>Anopheles pallidus</i> , <i>Anopheles peditaeniatus</i> , <i>Anopheles stephensi liston</i> ,	P. Anandh And S.P. Sevarkodiyone (2017)	Sattur talak	Tamil Nadu

	<i>Anopheles vagus</i> , <i>Armigeres subalbatus</i> , <i>Culex tritaeniorhynchus</i> , <i>Culex quinquefasciatus</i> , <i>Culex vishnui</i>			
20	<i>Aedes albopictus</i> , <i>Aedes aegypti</i> , <i>Anopheles stephensi</i> , <i>Anopheles annularis</i> , <i>Anopheles subpictus</i> , <i>Culex quinquefasciatus</i> , <i>Culex vishnui</i> , <i>Culex tritanaerhynchus</i> , <i>Armigeres subalbatus</i> .	Priyalika Tripathi, RB Gupta (2017)	Gwalior District.	Madhya Pradesh
21	<i>Armigeres obturbans</i> <i>Armigeres aureolineatus</i>	Bhubaneshwari and Dhananjay Singh (2018)	Northeast India	Manipur
22	<i>Anopheles minimus</i> <i>Anopheles annularis</i> <i>Anopheles sundaicus</i> <i>Anopheles subpictus</i> <i>Anopheles philippinensis</i> <i>Anopheles vagus</i> <i>Anopheles culicifacies</i> <i>Anopheles pallidus</i> <i>Anopheles theobaldi</i>	Borade vinod, Bondage shivraj, Laxmikant shinde (2018)	Nashik	Maharashtra
23	<i>Aedes aegypti</i> , <i>Aedes albopictus</i> , <i>Aedes pipersalatus</i> , <i>Aedes vexans</i> , <i>Aedes vittatus</i> , <i>Anopheles barbirostris</i> , <i>Anopheles gigas</i> , <i>Anopheles jamesii</i> , <i>Anopheles karwari</i> , <i>Anopheles kochi</i> , <i>Anopheles nigerrimus</i> , <i>Anopheles sinensis</i> , <i>Anopheles stephensi</i> , <i>Anopheles subpictus</i> , <i>Anopheles tessellates</i> , <i>Anopheles vagus</i> , <i>Armigeres subalbatus</i> , <i>Culex bitaeniorhynchus</i> , <i>Culex fuscocephala</i> , <i>Culex gelidus</i> , <i>Culex quinquefasciatus</i> , <i>Culex sitiens</i> , <i>Culex tritaeniorhynchus</i> ,	Amruthraj Radhakrishnan (2019)	Ernakulum district	Kerala

	<i>Mansonia annulifera,</i> <i>mansonia uniformis,</i> <i>Toxorhynchites splendens.</i>			
24	<i>Aedes aegypti</i>	Kaushal Kumar	Mumbai	Maharashtra

Epidemics of mosquito borne- diseases in India:

World Health Organization (WHO) in 2010 stratified the current situation of dengue in India under category A, which means a major public health problem, leading cause of hospitalization and death among children. In India, National Vector Borne Disease Control Programme (NVBDCP) reported 28,055 dengue cases in 2010 from 31 out of 35 states in India (highest ever in a year). In 2013, a total of 22,092 dengue cases and 74 deaths were reported from the country (of which 23 deaths were from Maharashtra only). In Maharashtra state sporadic cases of dengue were reported in 1973, 1983. Recently the cases of Chikungunya are reported from villages Mungi, Balamtakli, and Madhi (district Ahamadnagar), Malegaon city (district Nasik), and all 8 districts of Marathwada region and in Vidharbh region 7 districts: Akola, Washim, Buldhana, Yeotmal, Nagpur, Wardha, and Chandrapur. Mumbai had recorded 116, 416, 1008, and 250 dengue cases in 2010, 2011, 2012, and 2013, respectively. Mosquito-borne diseases are major health problems in Maharashtra as in other parts of India. Pratip Shil studied (2020) rainfall and dengue occurrences in India 2010 – 2016 they reported that in between 2010 -2016 total 425,560 confirmed cases of dengue were registered in India. In Panjab (37,895), West Bengal (43,843), Punjab (37,895), Delhi-NCR (36,312), Tamil Nadu (33,370), Maharashtra (31,385), kerala (29,865), Gujarat (29,379), Odisha (28,492), Karnataka (27,290) in Sikkim (76), Himachal Pradesh (508), Uttarakhand (4703) and Jammu and Kashmir (2090) [37].

Mishra and Bhadoriya (2009) carried out an epidemiological study of filariasis in a village of district Datia, Madhya Pradesh [38]. A. K. Hati (2006) Studies on dengue and dengue haemorrhagic fever (DHF) in West Bengal State, India [39]. M. A. Ansari et al., (1998) studies seasonal prevalence of *Aedes aegypti* in five localities of Delhi [40]. Maninder pal singh pardal et al, (2009) studied malaria incidence showed a significantly increasing trend during the study period. Various important topographical, operational, environmental factors contributing to the high incidence of malaria in this population

have been discussed [41]. V. Dev et al., carry a review on Mosquito-borne diseases in assam, north-east India: current states and key challenges [42]. Mosquito borne viral diseases dengue and chikungunya and their current status of India is studied by Dayaraj Cecilia (2014) and they Studied current states of Chikungunya and dengue according to data national vector borne disease control programs the No. of cases reported to a 74454 for dengue with 167 death and 18639 for Chikungunya about 40% of world population are risk for diseases. Malaria alone infects some 247 million people [43]. Kumar et al., (2015) studied an epidemiological fever o outbreak in Aurangabad the study reveals that the epidemiological study of fever outbreak in Aurangabad [44]. Vala and patel et al., (2013) studied knowledge and practice regarding malaria in urban and rural areas of Rajkot district Rajasthan [45]. Chitra et al., (2014) they studied survey report on baseline data of mosquito distribution in tree holes of discreate ecosystem periods of different seasonal patterns[46].Fulmali et al., (2008), studied prevalence of dengue vector *Aedes Aegypti* in konkan region, Maharashtra, India. Indian.[47] Jorge et al., (2004) reported a novel approach the effects of fluctuation in temperature and rainfall on population growth and survival of immature forms of *Culex quinquefasciatus*

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