Journal of Environmental Biology
©Triveni Enterprises, Lucknow (India)
Free paper downloaded from: www.jeb.co.in

September 2010, 31(5) 781-785 (2010)
For personal use only
Commercial distribution of this copy is illegal

Survey of mosquito species in Nagaland, a hilly state of north east region of India

P. Dutta*, S.A. Khan, A.M. Khan, C.K. Sharma and J. Mahanta

Regional Medical Research Centre (ICMR), N.E. Region, Dibrugarh - 786 001, India

(Received: May 26, 2009 ; Revised received: January 05, 2010; Accepted: February 26, 2010)

Abstract: *In an entomological study conducted during monsoon and post- monsoon season in the hilly state of Nagaland, a total number of 58 mosquito species under 11 genera were recorded. Out of these, 21 species viz., Aedes aegypti, Ae. nigrostriatus, Ae. annandalei, Ae. vittatus, Ae.caecus, Ae. vexans, Armigeres kuchingensis, Culex fuscocephala, Cx. pseudovishnui, Cx. murrelli, Cx. brevipalpis, Cx. epidesmus, Cx. minor, Cx. whitmorei, Coquilittidae crassipes, Malaya jacobsoni, Ml. genurostris, Toxorhynchites splendens, Uranotaenia campestris, Mansonia dives and Ma. annulifera were recorded for the first time from this state. Eleven mosquito species recorded earlier were not detected in the present study. Thus, with the addition these 11 species, the total mosquito fauna of the state goes up to 69. All the recognized vectors of malaria in the northeast and the vectors of Japanese encephalitis and dengue are recorded in the present study*

Key words: *Mosquito vector, Nagaland, Japanese encephalitis, Dengue, Malaria*
PDF of full length paper is available online

Introduction

The ecosystem of northeastern region of India is very unique. The hilly and subhilly terrains, dense evergreen forests with very high rainfall are the main ecological components of the region. The climate is different from one region to another but basically it is humid and moist. North-East India has a predominantly humid sub-tropical climate with hot, humid summers, severe monsoons and mild winters. Along with the west coast of India, this region has some of the Indian sub-continent's last remaining rain forests. Nagaland has a largely monsoon climate with high humidity levels. Annual rainfall averages around 70-100 inches (1,800-2,500 mm), concentrated in the months of May to September. Temperatures range from 70°F (21°C) to 104°F (40°C). Therefore the region is very rich in flora and fauna. There are several reports of prevalence of different species of mosquito in humid and moist climatic conditions from different parts of the world (Dale and Knight, 2008; Rajavel and Natarajan, 2008; Nagpal and Sharma, 1983). Only very meagre information regarding mosquito fauna of Nagaland is available. Sarkar *et al.*, 1980 collected only a total of 16 species of mosquitoes at both immature and adult stages. Another survey at 1979, 13 species under 4 genera in larval stage and 28 species of 6 genera at adult stage were detected (Malhotra *et al*., 1982). Again a malaria mosquito survey was conducted and 23 species of anopheles were collected (Mishra *et al*., 1993). In recent years there are several reports of occurrence of vector borne diseases in this state (Dutta *et al*., 2004; Mohapatra *et al*., 1998). Considering the changes in the prevalence of mosquito species, it is essential to review the distribution and species composition of vector mosquitoes in a particular area for adopting appropriate vector control measures. There is no recent information about the mosquitoes of the state of Nagaland. To know the present status of the mosquito fauna of this hilly state with changing ecological condition, an entomological study was made in some areas of the state and the findings have been discussed with previously published reports.

* **Corresponding author:** duttaprafulla@ yahoo.com

Materials and Methods

Study area: Nagaland lies in the hills and mountains of the north-eastern part of the country with its capital in Kohima and a total area of just 16,579 km^2.

Nearly all of Nagaland is mountainous. In the north, the Naga Hills rise abruptly from the Brahmaputra valley to about 610 m and then increase in elevation toward the southeast to more than 6,000 feet. The mountains merge with the Patkai Range along the Myanmar border, reaching a maximum height of 3,826 m at Mount Saramati. The region is deeply dissected by rivers: the Doyang and Dikhu in the north, the Barak in the southwest, and the tributaries of the Chindwin River in the southeast.

Nagaland bears a monsoon climate. Annual rainfall averages between 1,800 and 2,500 mm and is concentrated in the months of May to September. Average temperatures decrease with greater elevation; in the summer, temperatures range from 21 to 40°C, while in the winter, it rarely drop below 4°C, but frost is common over higher elevations. Humidity is generally high. Forests cover about one-sixth of Nagaland. Below 4,000 feet are tropical and subtropical evergreen forests, containing palms, rattan, and bamboo, as well as valuable timber species, such as mahogany. Coniferous forests are found at higher elevations. Where clearing for jhum (shifting cultivation) has taken place, secondary growth of high grass, reeds, and scrub jungle has sprung up. The present entomological study was conducted in Tuli, Mukokchung, Dimapur, Medziphema and Kohima areas of the state (Fig.1).

Mosquito collection and identifications: Immature collections were made from different breeding habitats using WHO (1975) standard dippers. These were reared separately in plastic photo-film vials till the emergence of adults and were processed for proper identification. CDC miniature light-traps were also operated in bovine-sheds for sampling of adult mosquitoes. Mosquitoes collected were identified following the standard keys (Christophers, 1933; Barraud, 1934; Puri, 1955; Wattal and Kalra,1961; Harrison and Scanlon,1975; Rao, 1984) and mosquito nomenclature (Knight and Stone,1977; Reinert, 1975, 2001).

Results and Discussion

Mosquito surveys conducted during monsoon and post-monsoon season in the selected areas of Nagaland reveal the presence of 58 species of mosquitoes belonging to 11 genera (Table 1). In monsoon season 35 species and in post–monsoon

Table - 1: Genera and number of mosquito species recorded from Nagaland in different seasons

Genus	Monsoon	Post-monsoon	Total
Anopheles	17	19	22
Culex	9	16	16
Aedes	4	7	7
Ochleratus	1	2	2
Armigeres	1	2	2
Mansonia	2	3	3
Toxorhynchites	1	1	1
Coquillettidia	0	1	1
Malaya	0	2	2
Uranotaenia	0	1	1
Tripteroides	0	1	1
Total 11	**35**	**55**	**58**

Fig. 1: Large map showing the borders of Nagaland. Small map providing the regions of Nagaland, with the red dots (•) representating the study areas

Table - 2: Collection of mosquitoes numbers (immatures and adults) from different survey areas of Nagaland

Name of species	Medziphema-MA		Tuli		Kohima		Mukokchung		Dimapur	
	L	A	L	A	L	A	L	A	L	A
An. (Ano.) gigas		2			2		2		2	
An. (Ano.) nigerrimus	5		2		3		4		4	
An. (Ano.) peditaeniatus	3		5		4		3		5	
An. (Ano.) sinensis	3	2			4		3		2	
An. (Cel.) aconitus		5				3		3	3	5
An. (Cel.) annularis	5	7			5	7	5	12	11	17
An. (Ano.) barbirostris	7	3			2	3	3	5	4	
An. (Cel.) dirus	4	9				7		6		7
An. (Cel.) jamesii		4				3		3		5
An. (Cel.) kochi	9	10	7	11	9	15	6	9	7	11
An. (Cel.) karwari	11	19	9	17	7	11	11	15	4	15
An. (Cel.) maculatus	13	21	11	19	12	21	14	21	12	19
An. (Cel.) minimus		5		4		4		4	3	9
An. (Cel.) philippinensis	7	8			7	3	7	4	8	6
An. (Cel.) nivipes	4	2								
An. (Cel.) splendidus		5				4		6		4
An. (Cel.) tessellatues	3	4		3		2		7	3	7
An. (Cel.) vagus	8	11	13	21	11	23	9	14	11	20
An. (Cel.) culicifacies		3				2		4		3
An. (Cel.) jeyporiensis		7		7		7		7		11
An. (Cel.) fluviatilis		4				2		5		3
An. (Cel.) varuna		2				3		2		6
Cx. (Lut.) fuscanus			3						5	
Cx. (Cux.) murrelli			2							2
Cx. (Eum.) malayi			4							
Cx. (Cux.) quinquefasciatus	12	18	9	21	8	17	9	18	15	22
Cx. (Cux.) vishnui	7	12	11	18	3	12	4	11	11	19
Cx. (Cux.) pseudovishnui	3	6	4	11	2	9	2	4	7	9
Cx. (Cux.) fuscocephala	4	8								
Cx. (Cux.) gelidus		4		5						
Cx. (Cux.) tritaeniorhynchus	3	4	2	5						4
Cx. (Cux.) whitmorei		2								
Cx. (Cux.) epidesmus		1								
Cx. (Eum.) brevipalpis	2									
Cx. (Lop.) minor									3	
Cx. (Cux.) bitaeniorhynchus						3		2	3	2
Cx. (Cux.) mimulus						2	2		1	
Cx. (Cux.) pallidothorax					2					
Ma. (Mno.) annulifera		4				3				
Ma. (Mno.) uniformis		11				13				
Ma. (Mno.) dives		2				2				
Ae. (Stg.) aegypti	14				7		11		17	
Ae. (Stg.) albopictus	3		3		4		3		3	
Ae. (Stg.) vittatus	2									
Ae. (Stg.) annandalei	6		5		2		5		5	
Ae. (Adm.) nigrostriatus		3								
Ae. (Adm.) caecus	2									
Ae. (Adm.) vexans			6	3					7	9
Oc. (Fin.) pseudotaeniatus	2									
Oc. (Fin.) albolateralis	1									
Cq. (Coq.) crassipes		3				2				
Ar. (Arm.) kuchingensis	5		2		3			4	2	
Ar. (Arm.) subalbatus	2		1		2	1	2	1	1	
Tx. (Tox.) splendens	3				3		4		3	
Tp. (Trp.) aranoides	2				2		2		2	
Ml. (Mal.) genurostris	3				4				3	
Ml. (Mal.) jacobsonii	2				2		3			
Ur. (Ura.) campestris	4			1		2				

A = Adults of mosquito, L = Larval stage of mosquito

Table - 3: Status of occurrence of different species of mosquitoes from Nagaland and updated checklist

Mosquito species	Status
An. (Ano.) aitkenii James, 1903	♦
An. (Ano.) annandalei Baini Prashad, 1918	♦
An. (Ano.) barbirostris Van der Wulp, 1884	•♦
An. (Ano.) bengalensis Puri, 1930	♦
An. (Ano.) gigas Giles, 1901	•♦
An. (Ano.) lindesayi Giles, 1900	♦
An. (Ano.) nigerrimus Giles, 1900	•♦
An. (Ano.) peditaeniatus (Leicester), 1908	•♦
An. (Ano.) sinensis Wiedmann, 1828	♦
An. (Cel.) aconitus Doenitz, 1902	•♦
An. (Cel.) annularis Van der Wulp, 1884	•♦
An. (Cel.) culicifacies Gilles, 1901	•♦
An. (Cel.) dirus Peyton & Harrison,1979	•♦
An. (Cel.) fluviatilis James, 1902	•♦
An. (Cel.) jamesii Theobald, 1901	•♦
An. (Cel.) jeyporiensis James, 1902	•♦
An. (Cel.) karwari James, 1902	•♦
An. (Cel.) kochi Doenitz, 1901	•♦
An. (Cel.) maculatus Theobald, 1901	•♦
An. (Cel.) minimus Theobald, 1901	•♦
An. (Cel.) nivipes (Theobald), 1901	•♦
An. (Cel.) philippinensis Ludlow, 1902	•♦
An. (Cel.) splendidus Koidzumi, 1920	•♦
An. (Cel.) subpictus Grassi, 1899	♦
An. (Cel.) tessellatus Theobald, 1901	•♦
An. (Cel.) vagus Doenitz, 1902	•♦
An. (Cel.) varuna Iyengar, 1924	•♦
Ae. (Adm.) caecus (Theobald), 1901	•
Ae. (Adm.) nigrostriatus (Barraud), 1927	•
Ae. (Adm.) vexans (Meigen), 1830	•
Ae. (Neomelaniconion) lineatopennis (Ludlow), 1905	•♦
Ae. (Stg.) aegypti (Linnaeus), 1762	•
Ae. (Stg.) albopictus (Skuse), 1894	•♦
Ae. (Stg.) annandalei (Theobald), 1910	•
Ae. (Stg.) vittatus (Bigot), 1861	•
Oc. (Fin.) albolateralis (Theobald), 1908	•♦
Oc. (Fin.) pseudotaeniatus (Giles), 1901	•♦
Ar .(Arm.) kuchingensis Edwards, 1915	•
Ar .(Arm.) subalbatus (Coquillett), 1898	•♦
Cx. (Cux.) bitaeniorhynchus Giles, 1901	•♦
Cx. (Cux.) cornutus Edwards, 1922	♦
Cx. (Cux.) epidesmus (Theobald), 1910	•
Cx. (Cux.) fuscocephala Theobald, 1907	•
Cx. (Cux.) gelidus Theobald, 1901	•♦
Cx. (Cux.) mimeticus Noe, 1899	♦
Cx. (Cux.) mimulus Edwards, 1915	•♦
Cx. (Cux.) murrelli Lien, 1968	•
Cx. (Cux.) pseudovishnui Colless, 1957	•
Cx. (Cux.) quinquefasciatus Say, 1823	•♦
Cx. (Cux.) sinensis Theobald, 1903	♦
Cx. (Cux.) tritaeniorhynchus Giles, 1901	•♦
Cx. (Cux.) vishnui Theobald, 1901	•♦
Cx. (Cux.) whitmorei (Giles), 1904	•
Cx. (Cui.) pallidothorax Theobald, 1905	•♦
Cx. (Eum..) brevipalpis (Giles), 1902	•
Cx. (Eum.) malayi (Leicester), 1908	•♦
Cx. (Lop.) minor (Leicester), 1908	•
Cx. (Lut.) fuscanus Wiedemann, 1928	•♦
Cx. (Lut.) halifaxi Theobald, 1903	♦
Cq. (Coq.) crassipes (Van der Wulp), 1881	•
Ml . (Mao.) genurostris Leicester, 1908	•
Ml . (Mao.) jacobsoni (Edwards), 1930	•
Ma. (Man.) annulifera (Theobald), 1901	•
Ma. (Man.) dives (Schiner), 1868	•
Ma. (Man.) indiana Edwards, 1930	♦
Ma. (Man.) uniformis (Theobald), 1901	•♦
Tx. (Tox.) splendens (Wiedemann), 1819	•
Tp. (Rah.) aranoides (Theobald), 1901	•♦
Ur. (Ura.) campestris Leicester, 1908	•

• = *Recorded in present study,* ♦ = Recorded in earlier study

season 55 species of mosquitoes were recorded. A total of twenty seven Anopheles species were collected in the present study and out of these the major vectors of malaria viz, *An. dirus* (*An. baimai*), *An. minimus* and *An. philippinensis* were recorded from this state. Malaria is the major mosquitoborne disease affecting almost all the districts and among which the district Mokokchung has the highest incidence followed by Phek district (Mohapatra *et al*., 1998). The immature and adult collections of mosquitoes from different places surveyed are given in Table 2.

Among the 58 mosquitoes recorded in the present study, twenty one species viz, *Aedes aegypti, Ae. nigrostriatus, Ae. annandalei, Ae. vittatus, Ae. caecus, Ae. vexans, Armigeres kuchingensis, Culex fuscocephala, Cx. pseudovishnui, Cx. murrelli, Cx. brevipalpis, Cx. epidesmus, Cx. minor, Cx. whitmorei, Coquilittidae crassipes, Malaya jacobsoni, Ml. genurostris, Toxorhynchites splendens, Uranotaenia camprestris, Mansonia dives* and *Ma. annulifera* were recorded for the first time from this state. However, ten mosquito species encountered earlier (Sarkar *et al*., 1980; Malhotra *et al*., 1982; Mishra *et al*.,1993, Barraud, 1934) which were not found by us are *An. lindesayi, An.aitkenii, An.bengalensis, An.annandalei, An.subpictus, Ae.lineatopennis, Cx. halifaxi, Cx.sinensis, Cx. cornutus, Cx.mimeticus* and *Ma. indiana*. Thus with the addition of these eleven species, the total mosquito fauna of the state of Nagaland went up to sixty nine (Table 3). The composition of mosquito fauna is as follows: *Anopheles*- 22, *Culex*-16, *Aedes*-7, *Mansonia*-3, *Ochlerotatus*-2, *Armigeres*-2, *Malaya*-2 and one species each of *Coquillettidia*, *Toxorhynchites*, *Tripteroides* and *Uranotaenia*. Prominent potential vectors of Japanese encephalitis (Mourya *et al.,*1989; Chakravatry et al., 1981; Banerjee et al., 1979) recorded were *An. barbirostris*, *An. 'hyrcanus'* group, *Cx. vishnui*, *Cx. pseudovishnui, Cx. tritaeniorhynchus, Cx. epidesmus, Cx. gelidus, Cx. whitmorei, Cx. bitaeniorhynchus, Cx. fuscocephala* and *Ma. annulifera*. With regards to dengue, both the vectors viz, *Aedes aegypti* and *Ae. albopictus* were recorded. In recent time the progression of disease Japanese encephalitis to Nagaland is also observed. There is large paddy growing areas (jhum cultivation) in the state, the situation which is very much congenial for JE vector propagation in paddy field areas. The rearing of pig which acts as a source of JE virus infection for vector mosquitoes is also a common habit among the tribal population of

Nagaland. In some areas of Nagaland, seropositivity for dengue has also been detected (Baruah and Mahanta, 1996; Baruah *et al*., 1996; Dutta *et al*., 2004). Due to developmental activities in this hilly state, there is change of ecological conditions and overlapping of man-made situations which pose the proliferation of vector borne diseases specially dengue. Deforestation, rapid urbanization, industrialization, may be responsible for brought out changes in the eco-environment, which influence the changes in the prevalence of vector species in this region (Baruah et al., 2004). Therefore, the change of environmental conditions may have direct or indirect effect on disappearance of some species as well as reappearance or introduction of new species. Considering the mosquito fauna particularly the high prevalence of mosquito disease vectors, the state of Nagaland is always at risk for occurrence of out break of mosquito borne diseases.

Acknowledgements

Authors are thankful to the State Health authority of Nagaland for their kind cooperation and help during the period of entomological survey. Gratefulness is also due to Mr. P.K. Doloi and Mr. N.K. Baruah for their excellent technical assistance.

References

Banerjee, K., P.V.M. Mahadev, M.A. Ilkal, A.C. Mishra, V. Dhanda, G.B. Modi, G. Geeverghese, H.M. Kaul, P.S. Shetty and P.J. George: Isolation of Japanese encephalitis virus from mosquitoes collected in Bankura districts, West Bengal, duringOctober 1974 to December 1975. *Ind. J. Med. Res.,* **69**, 201 (1979).

Baruah, H.C. and J. Mahanta: Serological evidence of Den-2 activity in Assam and Nagaland. *J. Commun. Dis.,* **28**, 56-8 (1996).

Baruah, H.C., P.K. Mohapatra, M. Kire, D.K. Pegu and J. Mahanta: Haemorrhagic manifestations associated with dengue virus infection in Nagaland. *J. Commun. Dis.*, **28**, 301-3 (1996).

Baruah I., N.G. Das and S.C. Das: Studies of Anopheline fauna and malaria incidence in Dhansiripar PHC of Dimapur, Nagaland. *J. Vec. Borne Dis.,* **41**, 67-71 (2004).

Barraud, P.J.: The fauna of British India including Ceylon and Burma. *Taylor and Francis, London*, **5**, 1-463 (1934).

Chakravarty, S.K., A.K. Chakraborty, K.K. Mukherjee, A.C. Mitra, A.C.A. K. Hoti and M.S. Chakraborty: Isolation of Japanese encephalitis (JE) virus from Mansonia annulifera species of mosquitoes in Assam. *Bull. Cal. Sch. Trop. Med*., **129**, 3 (1981)

Christophers, S.R.: The fauna of British India including Ceylon and Burma. *Taylor and Francis, London,* **4**, 1-360 (1933).

Dale, P.E.R. and J.M. Knight: Wetlands and mosquitoes: a review. *Wetlands Ecol. Manage.,* **16**, 255-276 (2008)

Dutta, P., S.A. Khan, A.M. Khan, C.K. Sharma and J. Mahanta: Entomological observations on dengue vector mosquitoes following a suspected outbreak of dengue in certain parts of Nagaland with a note on their susceptibility to insecticides. *J. Environ. Biol.,* **25**, 209-212 (2004).

Harrison, B.A. and J.E. Scanlon: Medical entomology studies-II. The subgenus Anopheles in Thailand (Diptera: Culicidae). *Contrib. Amer. Entomol. Inst*., **12**, 1-307 (1975).

Knight, K.L. and A. Stone: A catalog of the mosquitoes of the world (Diptera: Culicidae). Entomological society of America. Box A. J. 4603 Calvert Road, College park, Maryland 20740 (1977).

Malhotra, P.R., P.K. Sarkar and M. Bhuyan: Mosquito survey in Nagaland. *Indian J. Publ. Hlth.*, **26**, 163-168 (1982).

Mishra, S.P., J. Nandi, M.V.V.L. Narasimham and R. Rajagopal: Malaria transmission in Nagaland, India. Part-I Anophelines and their seasonality. *J. Commun. Dis*., **25**, 62-66 (1993)

Mohapatra, P.K., A. Prakash, D. R.Bhattacharya and J. Mahanta: Malaria situation in North eastern region on India. *ICMR Bulletin*., **28**, 21-30 (1998).

Mourya, D.T., M.A. Ilkal, A.C. Mishra, J.P. George, U. Pant, S. Ramanujan, M.S. Mavale, H.R. Bhat and V. Dhanda: Isolation of Japanese encephalitis virus from mosquitoes collected in Karnataka state, India during 1985-1987. *Trans. R. Soc. Trop. Med. Hyg.,* **83**, 550 (1989).

Nagpal, B.N. and V.P. Sharma: Mosquitoes of Andaman Islands. *Ind. J. Malariol*., **20**, 7-13 (1983)

Puri, I.M.: Synoptic table for the identification of the anopheline mosquitoes of India. Health Bulletin No.10 IV (Edn. Manager of Publications, Delhi. (1955).

Rajavel A.R. and R. Natarajan: Mosquitoes of the mangrove forests of India: Part 7 - An Overview. *J. Am. Mosq. Cont. Assoc*. **24**, 478-488 (2008)

Rao Ramachandra, T.: The Anophelines of India (Rev.ed.) Malaria Research Centre (ICMR), Delhi (1984).

Reinert, John F.: Mosquito generic and subgeneric abbreviations (Diptera: Culicidae*). Mosquito Sys.*, **7**, 105-110 (1975).

Reinert, John F.: Revised List of abbreviations for genera and subgenera of Culicidae (Diptera) and notes on generic and subgeneric changes. *J. Am. Mosq. Control. Assoc.,* **17**, 51-55 *(*2001).

Sarkar, P.K., K.M. Rao, D.R. Nath, P.K. Das and H.C. Saikia: Mosquito fauna of certain places of Nagaland. *Ind. J. Med. Res*., **72**, 60-63 (1980).

Wattal, B.L. and N.L. Kalra: Regionwise pictorial keys to the female Indian Anopheles. *Bull. Nat. Soc. Ind. Mal. Mosq. Dis*., **9**, 85-131(1961).

WHO: Manual on practical entomology in malaria vector bionomics and organization of antimalaria activities, Part I and Part II. Offset Publication No. 13. World Health Organization, Geneva (1975).