# Potential Vectors of Dengue and the Profile of Dengue in the North-Eastern Region of India: An Epidemiological Perspective

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**Abstract**

A comprehensive entomological survey conducted during 2004–2005 in the seven states of the north-eastern (NE) region of India revealed that the region is very rich in mosquito fauna, especially *Aedes* and related species. The known dengue vectors, viz. *Aedes (Stegomyia) aegypti* and *Aedes (Stegomyia) albopictus*, being the container-breeder mosquitoes, were recorded from all the seven states in the present study, although in earlier surveys, *Ae. aegypti* was not recorded from Mizoram, Nagaland and Tripura. Profuse breeding of these two vectors of dengue was recorded in different container habitats originating from solid-waste materials frequently dumped in urban areas and industrial townships of the region. The breeding potential of *Ae. aegypti*, the primary vector of dengue in India, was more pronounced showing positive breeding in all types of solid-waste containers than *Ae. albopictus*, while in rural areas with rich natural vegetation, *Ae. albopictus* was the dominant species. However, in urban/industrial areas, the breeding preference of *Ae. aegypti* was noticed in old tyres, while *Ae. albopictus* preferred to breed in open battery boxes. Some parts of this region exhibited mild to prominent dengue virus activity particularly for DENV-2, while on one occasion, DENV-4 activity with haemorrhagic manifestations was also observed. In Nagaland, entomological studies carried out at two points of time, 1994 and 2004, provided clear evidence of replacement of *Ae. albopictus* by *Ae. aegypti*. With the evidence of dengue virus activity in the present as well as earlier studies, it is noteworthy that this region could be vulnerable to a widespread dengue outbreak situation in the near future.

**Keywords**: Dengue, *Aedes aegypti, Aedes albopictus*, solid waste, breeding habitats, dengue risk, north-eastern region of India.

## Introduction

The north-eastern (NE) region of India comprises of seven states, viz. Arunachal Pradesh, Assam, Manipur, Mizoram, Meghalaya, Nagaland and Tripura (located between 21°58´–29°3´ North latitude and 89°5´–97°3´ East longitude). The NE region, which has an area of 255128 sq km, has international borders on the north with China, east with Myanmar and on the south with Bangladesh; in the west, it is contiguous with the Indian state of West Bengal. Out of the total landmass of the north-eastern region, 45% of it is covered with tropical evergreen rain forests. The ecological changes resulting from urbanization, industrialization and deforestation over the past decades and other man-made situations have made a noticeable impact on *Aedes* mosquito breeding and species composition in this region.

Dengue fever was described in India on the basis of clinical symptoms as far back as 1921. From 1956 to 2001, several outbreaks

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occurred in different states of India and all the DENV serotypes (DENV-1, 2, 3 and 4) were found to circulate in these outbreaks. *Aedes (Stegomyia) aegypti* emerged as the major vector and *Aedes (Stegomyia) albopictus* was surmised to be playing some role in peripheral areas.[1,2]

In India, the occurrence of dengue outbreaks was restricted to large towns and cities only. However, the infection has now spread to rural areas as well with the introduction of safe drinking water schemes and consequent spread of *Ae. aegypti* to those areas.[3]

In this paper, comprehensive entomological data on the basis of our study during 2004–2005, as well as studies reported earlier (1996–2002) covering the seven north-eastern states of India, have been presented. The dengue virus activity as observed on certain occasions in some parts of this region, and its potential, given the present environmental conditions, have also been discussed.

# Materials and methods

## Entomological survey

The immature collections of *Aedes* mosquito were made from different breeding habitats using spoons/glass pipettes from container habitats covering four ecological niches, viz. urban, semi-urban, industrial and rural environmental situations. The larvae were link-reared in plastic vials till the emergence of adults, which were identified following the standard mosquito identification keys.

## Serological study

Serological observations were made in some areas where there were cases suspected to be of dengue. Blood samples were collected from these cases, and in the laboratory, sera were separated and processed for subjecting them to haemagglutination inhibition (HI) test[4] using the DENV virus strain and DENV immune peritoneal fluid (IPF) as control received from the National Institute of Virology (NIV) (ICMR), Pune. The HI-positive samples were confirmed by neutralization test done at the NIV.

# Results

## Prevalence of *Ae. aegypti* and *Ae. albopictus* in four ecological settings

The prevalence patterns of both these vector species as well as their breeding potential in different container habitats revealed that both *Ae. aegypti* and *Ae. albopictus* breed in artificial man-made environmental situations. In urban and industrial environments, the breeding of both these vectors is common and *Ae. aegypti* is the dominant species. In semi-urban environments, the preponderance of *Ae. albopictus* is more prominent than *Ae. aegypti*. Similarly, in rural environments having much vegetation, *Ae. albopictus* is the dominant species with negligible presence of *Ae. aegypti* (Figure 1). Table 1 shows the breeding of *Ae.*

Figure 1: ***Prevalence of potential dengue vectors in different environmental situations***

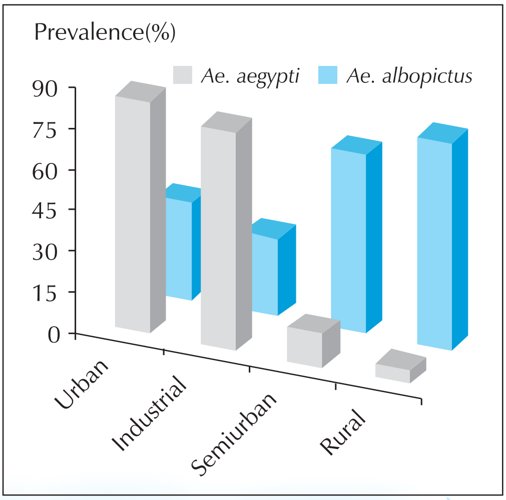

***Table 1:*** *Breeding pattern of Ae. aegypti and Ae. albopictus in different type of containers in four different environmental settings*

| Environmental settings | Types of containers searched (N) | CI for *Ae. aegypti* | CI for *Ae. albopictus* |
|---|---|---|---|
| Urban | Tyres (45) | 86.40 | 11.10 |
| | Battery boxes (40) | 25.00 | 75.00 |
| | Waste container (40) | 45.00 | 7.50 |
| | Discarded earthenware (32) | 47.55 | 8.70 |
| | Discarded paper cups (87) | 48.36 | 10.26 |
| | Discarded glass bottles (24) | 60.45 | 6.21 |
| | Tyres (35) | 84.85 | 8.57 |
| Industrial | Battery boxes (32) | 31.25 | 68.75 |
| | Waste iron containers (28) | 38.25 | 8.80 |
| | Discarded coal tar drum (18) | 38.71 | 12.40 |
| | Discarded water pumps (12) | 50.00 | 0.00 |
| | Electric pin insulators (45) | 71.11 | 0.00 |
| | Tyres (12) | 25.00 | 58.57 |
| | Waste container (40) | 7.50 | 45.00 |
| Semi-urban | Discarded earthen pots (32) | 9.37 | 62.50 |
| | Discarded coconut shells (47) | 4.25 | 57.44 |
| | Discarded glass bottles (21) | 7.52 | 49.61 |
| | Plantain leaf axils (36) | 0.00 | 25.00 |
| | Bamboo stump (46) | 0.00 | 56.52 |
| | Waste container (31) | 0.00 | 51.61 |
| | Discarded earthen pots (38) | 2.63 | 36.84 |
| Rural | Discarded coconut shells (57) | 0.00 | 42.10 |
| | Discarded glass bottles (11) | 0.00 | 36.36 |
| | Plantain leaf axils (65) | 0.00 | 32.30 |
| | Pineapple leaf axils (72) | 0.00 | 44.44 |
| | Colocasia leaf axils (62) | 0.00 | 43.54 |
| | Tree hole (9) | 0.00 | 44.44 |

N = Number of containers

CI = Container index (No. of containers +ve / total number of respective containers) *aegypti* and *Ae. albopictus* in different containers recorded in four different environmental settings. In industrial and urban settings, most of the containers were man-made solid wastes, where *Ae. aegypti* exhibited high container index values in comparison to that of *Ae. albopictus*. While in semi-urban and rural environments, the breeding habitats were found to be mostly of natural types (undomesticated) where the preponderance of *Ae. albopictus* over *Ae. aegypti* was more prominent as it showed high container index values. The solid-waste materials, viz. used tyres, discarded battery cases, discarded containers, etc., are generally found in urban environments, while cut bamboo stumps, tree holes, plant leaf axils, etc., are some of the natural breeding habitats of *Ae. albopictus* in peripheral and rural areas.

## Solid waste vis-à-vis breeding habitats of dengue vectors in urban and industrial towns

Solid waste, which is frequently dumped in urban and industrial areas, presents ideal mosquito breeding sources after accumulation of rainwater in these containers. In industrial towns, used-tyre dumps, empty and open

***Table 2:** Density patterns of immatures of Ae. aegypti and Ae. albopictus recorded from different solid waste containers in urban and industrial areas of townships*

| Solid waste containers (N) | CI | *Aedes* spp. detected | Larval density Mean ± SD | Pupal density Mean ± SD |
|---|---|---|---|---|
| Used tyres (80) | 83.75 | *Ae. aegypti*<br>*Ae. albopictus* | 89.62±17.87<br>8.12±2.83 | 25.94±10.38<br>1.60±1.33 |
| Used battery boxes (72) | 100.00 | *Ae. aegypti*<br>*Ae. albopictus* | 9.80±3.52<br>91.59±31.11 | 3.48±2.56<br>25.87±4.20 |
| Discarded coal tar drums (18) | 61.11 | *Ae. aegypti*<br>*Ae. albopictus* | 68.00±32.50<br>12.20±4.26 | 16.20±9.38<br>6.80±4.23 |
| Discarded water pumps (12) | 50.00 | *Ae. aegypti*<br>*Ae. albopictus* | 53.20±12.48<br>0.00 | 6.30±4.87<br>0.00 |
| Electric pin insulators dumped (45) | 71.11 | *Ae. aegypti*<br>*Ae. albopictus* | 9.50±2.11<br>0.00 | 3.58±1.60<br>0.00 |
| Waste tin/iron containers (68) | 47.05 | *Ae. aegypti*<br>*Ae. albopictus* | 8.50±3.54<br>2.30 ±1.64 | 3.70±1.50<br>1.70 ±0.54 |
| Discarded earthenware (32) | 56.25 | *Ae. aegypti*<br>*Ae. albopictus* | 7.25±1.54<br>2.20±0.80 | 1.88±0.65<br>2.56±1.00 |
| Discarded paper cups/ plastic pots (87) | 58.62 | *Ae. aegypti*<br>*Ae. albopictus* | 4.58±1.88<br>2.00±1.50 | 2.30±1.48<br>1.80±0.50 |
| Discarded glass bottles/ pots (24) | 66.66 | *Ae. aegypti*<br>*Ae. albopictus* | 5.89±3.56<br>1.68±0.80 | 3.60±1.88<br>1.00±0.65 |

CI=Container index value (% container positive for immature of *Aedes* mosquito)

N=Total numbers of respective containers searched battery boxes, iron scrap materials, electrical items, discarded pump sets, empty coal-tar drums, etc., are common solid wastes, whereas in urban areas, used tyres at tyre repair shops, discarded open battery cases, iron materials, paper and plastic cups, broken bottle/glass pots etc., are found as solid waste conducive for *Aedes* breeding. The breeding density patterns of dengue vector species in such containers was recorded (Table 2). The breeding potential of *Ae. aegypti*, the primary vector, was more pronounced showing a high larval breeding density in all types of solid-waste containers than *Ae. albopictus*. However, used tyres (average density 89.62 per container) were found to be the habitat of choice for the breeding of *Ae. aegypti*. *Ae. Albopictus*, on the other hand, was found to breed in selective habitat types showing predominance in used open battery boxes, the larval density on an average being 91.6 per container in both urban and industrial situations* (Figures 2 and 3).

The results of the entomological survey of used tyres in some townships covering seven north-eastern states revealed that these townships were infested with potential dengue vector mosquitoes as 63.6% of the used tyres out of the 747 surveyed were found positive for *Aedes* larvae. Both the vector species were detected to breed in waste tyres. The preponderance of *Ae. aegypti* was much higher than that of *Ae. albopictus* and the CI value for

* A follow-up study on the physio-chemical factors and plankton microbes growth in these two types of habitats, i.e. used tyres and open battery boxes, will be worthwhile – **Editor**

Figure 2: ***Solid waste – habitat of Aedes breeding***

*Figure 3:* ***Tyre dumps – habitat of choice of Aedes aegypti breeding***

*Ae. aegypti* was recorded in the range of 35.7 to 63.6, whereas the CI value of *Ae. albopictus* was in the range of 4.2 to 32.6 (Table 3).

## Dengue viral activity in the region based on point study

In a serological survey for arthropod-borne viral diseases conducted during February–May, 1963 in Arunachal Pradesh and the northern region of the Assam valley by the then Virus Research Centre, Pune, revealed DENV activity in Lohit district of Arunachal Pradesh and Darrang district of Assam.[5] It was also noted that the dengue activity in Lohit district was in the rural/sylvan environment.

Yet in another viral sero-surveillance study by the Regional Medical Research Centre (ICMR), Dibrugarh, Assam, since 1992, dengue virus antibody had been detected from Dibrugarh, north Lakhimpur, Dhemaji and Golaghat districts of Assam and from Dimapur in Nagaland. In 1992, out of the 84 sera tested, five cases (5.95%) showed positivity for DENV-2. Subsequently, 130 sera samples were examined during 1993 and 47 (36.15%) cases were found positive for DENV-2 antibody. It was observed that the positive samples were evenly distributed in four districts of Assam, i.e. Dibrugarh (20%), north Lakhimpur (34%), Dhemaji (30%), Golaghat (40%) and one district in Nagaland, i.e. Kohima (25%). However, during 1994, DENV-4 activity was also detected in 25 sera samples (71.42%) out of the 35 cases studied in the Medziphema area of Nagaland, and in this episode, nine cases (36%) out of the positives showed dengue haemorrhagic manifestations. Out of the 12 deaths recorded in this outbreak, the detailed clinical records of eight cases could be collected, and this information revealed that all these eight death cases had acute fever, body ache, pain abdomen, respiratory distress, hepatomegaly and haematemesis or melaena prior to death.[6,7] In

***Table 3.*** *Record of potential dengue vector mosquito breeding in used tyre dumps in major townships of seven different states of NE region*

| State | Township | Tyres searched | | | CI for *Ae. aegypti* (%) | CI for *Ae. albopictus* (%) |
|---|---|---|---|---|---|---|
| | | Total tyres | Wet tyres | +ve for larvae | | |
| Assam | Tinsukia | **56** | 48 | 27 | 52.0 | 4.2 |
| | Dibrugarh | 60 | 49 | 30 | 53.0 | 8.2 |
| | Jorhat | 46 | 30 | 18 | 50.0 | 10.0 |
| | Nagaon | 30 | 22 | 16 | 63.6 | 9.1 |
| | Guwahati | 65 | 52 | 35 | 57.6 | 9.7 |
| | Tezpur | 39 | 31 | 16 | 41.9 | 9.7 |
| | Dhubri | 42 | 36 | 21 | 50.0 | 8.3 |
| Arunachal Pradesh | Khonsa | 26 | 22 | 10 | 40.9 | 4.5 |
| | Itanagar | 32 | 25 | 16 | 56.0 | 8.0 |
| | Joyrampur | 29 | 18 | 13 | 61.1 | 11.1 |
| | Bhalukpung | 30 | 18 | 15 | 50.0 | 33.3 |
| Meghalaya | Byrnihut | 60 | 45 | 32 | 62.3 | 8.8 |
| | Shillong | 48 | 42 | 18 | 38.0 | 4.8 |
| | Jowai | 40 | 35 | 18 | 40.0 | 11.4 |
| | Tura | 26 | 22 | 12 | 50.0 | 4.5 |
| | Williamnagar | 12 | 12 | 7 | 41.6 | 16.7 |
| Manipur | Imphal | 40 | 34 | 18 | 47.1 | 5.8 |
| | Churachandpur | 24 | 18 | 12 | 50.0 | 16.6 |
| | Moreh | 20 | 16 | 14 | 56.3 | 31.2 |
| Mizoram | Aizawl | 20 | 16 | 11 | 57.1 | 11.6 |
| | Kolashib | 25 | 17 | 16 | 62.5 | 32.6 |
| | Thenzawal | 15 | 14 | 8 | 35.7 | 22.7 |
| Nagaland | Dimapur | 42 | 35 | 22 | 57.1 | 5.7 |
| | Kohima | 25 | 16 | 11 | 50.0 | 18.7 |
| | Mukokchung | 20 | 14 | 10 | 50.0 | 21.4 |
| | Tuli | 22 | 16 | 12 | 62.5 | 12.5 |
| Tripura | Agartala | 40 | 18 | 14 | 55.5 | 22.2 |
| | Dharmanagar | 20 | 14 | 10 | 57.2 | 14.2 |
| | Churaibari | 12 | 12 | 10 | 50.0 | 33.3 |

CI=Container index value

the present study during 2004–2005 in Dibrugarh district of Upper Assam, about 200 sera samples were screened for Japanese encephalitis/dengue, and out of these, five sera (2.5%) exhibited detectable antibody to dengue.

## Discussion

The present study revealed abundance of both dengue vectors, viz. *Ae. aegypti* and *Ae. albopictus*, in all the states of the north-eastern region of India, irrespective of the fact whether a township is situated in the plains, foothills or hilly areas (altitudes ranging from 100–1500 m above mean sea level). In earlier surveys, *Ae. aegypti* was not recorded in Mizoram, Nagaland and Tripura,[8] but in the present study, this species was detected in these three states, signifying the introduction of *Ae. aegypti* in these areas. The adaptability of *Ae. aegypti* to urban environment seems to be higher than that of *Ae. albopictus*, which is still thought to be a mosquito of the semi-urban area. Urbanization and urban human ecology have been the key factors in the displacement of *Ae. albopictus*.[9]

Entomological studies carried out in Nagaland at two different points of time, i.e. 1994 and 2004, indicated a Breteau index (BI) for *Ae. albopictus* as 85.0 and 72.72 for 1994 and 2004 respectively, while similar data for *Ae. aegypti* was estimated as 4.9 and 31.81. The authors had pointed out that the region had increasingly become vulnerable to dengue outbreaks.[10] This prediction proved true when Phuentsholing town of Bhutan, on the borders of West Bengal/Assam, reported its first-ever outbreak of dengue in 2004, where *Ae. aegypti* was found to infest urban areas in high densities.[11]

## Conclusion

Developmental activities, especially urban development associated with rapid growth of new townships, have accentuated the problem of vector-borne diseases, specially dengue, which is basically an urban disease. In regard to dengue vector proliferation, human ecology is responsible for the creation of a mosquito-genic environment. Man is directly or indirectly creating such situations. The greatest resource available to combat this problem is the human resource, which has to be brought into play for their own sake. Although the idea of self-help has been around for a long time, there is a new awareness to mobilize the poor rural and urban communities themselves. Many of the top-down solutions in vector control have failed or have become obsolete because of economic, logistics, social and other constraints. Now, the top-down strategy is being replaced by building activities at the bottom, for which the key is local action.[12,13]

Thus, community participation has become the rallying point for the success of the integrated vector control programme. This involves using acceptable technologies, which the community can afford, and also using appropriate education to develop the ability of communities to participate in the programme. Since communities are not homogeneous, the goal is to enlighten individuals to encourage them to work towards a common cause. Simple source-reduction methods through community efforts may result in effective elimination of the vector population. This constitutes actions like emptying of water containers periodically, scrubbing and cleaning them where possible, use of temephos treatment with sand granules of containers, or to apply a drop of kerosene oil or one teaspoonful of common salt (NaCl) to small breeding containers placed indoors, refrain from throwing any used or unused containers which can store rain water, proper disposal of solid wastes like used tyres or any metallic industrial wastes, disposing of unused tyres and other containers in a proper way but not out in the open. Simultaneously, concerned administrative authorities in urban areas and industrial townships should be made aware about these man-made environmental hazards and persuaded to arrange for safe disposal or proper storage of solid waste materials and, if possible, to include this matter in the model civic by-laws which are presently being followed under the Malaria Action Programme (NMEP, Delhi, 1995)[14] for urban malaria control. This small act will go a long way in preventing the occurrence of DF/DHF outbreaks.

## References


[1] Anonymous. Epidemic preparedness – dengue fever, DHF and DSS. CD Alert Monthly Newsletter. Delhi: National Institute of Communicable Diseases, Delhi. June 2001, 5(16).

[2] Gratz NG. Critical review of the vector status of *Aedes albopictus*. Med Vet Entomol 2004 Sep;18(3):215-27.

[3] Ilkal MA, Dhanda V, Hassan MM, Mavale M, Mahadev PV, Shetty PS, Guttikar SN, Banerjee K. Entomological investigations during outbreaks of dengue fever in certain villages in Maharashtra state. Indian J Med Res 1991 May;93:174-8.

[4] Clarke DH and Casals J. Techniques for hemagglutination and hemagglutination-inhibition with arthropod-borne viruses. Am J Trop Med Hyg 1958 Sep;7(5):561-73.

[5] Rodrigues FM, Dandawate CN. Arthropod-borne viruses in north-eastern India: a serological survey of Arunachal Pradesh and northern Assam. Indian J Med Res 1977 Apr;65(4):453-65.

[6] Barua HC, Mahanta J. Serological evidence of DEN-2 activity in Assam and Nagaland. J Commun Dis 1996 Mar;28(1):56-8.

[7] Baruah HC, Mohapatra PK, Kire M, Pegu DK, Mahanta J. Haemorrhagic manifestations associated with dengue virus infection in Nagaland. J Commun Dis 1996 Dec;28(4):301-3.

[8] Malhotra PR, Mahanta HC. Checklist of mosquitoes of Northeast India (Diptera: Culicidae). Oriental Insect 1994 28:125-149.

[9] Bang YH, Shah NK. Human ecology related to urban mosquito-borne diseases in countries of South East Asia region. J Commun Dis 1988 Mar;20(1):1-17.

[10] Dutta P, Khan SA, Khan AM, Sharma CK, Mahanta J. 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 2004 Apr;25(2):209-12.

[11] WHO. Report of the WHO mission for control of dengue outbreak in Phuentsholing, Bhutan, 5-19 August 2004. New Delhi: Regional Office for South-East Asia, World Health Organization (unpublished).

[12] Tonn Robert JE. Establishing a framework for management of community participation in disease vector control. In: Community participation for disease vector control – Proceedings of the ICMR/WHO workshop (3-9 February, 1986) to review research results. New Delhi: Malaria Research Centre (ICMR). 1986. p. 37-44.

[13] Renganathan E, Parks W, Lloyd L, Nathan MB, Hosein E, Odugleh A, Clark GG, Gubler DJ, Prasittisuk C, Palmer K, San Martín J-L. Towards sustaining behavioural impact in dengue prevention and control. Dengue Bulletin 2003;27:6-12.

[14] National Malaria Eradication Programme. Operational manual for malaria action programme (MAP). Ministry of Health & Family Welfare, Govt. of India, Delhi. 1995;122.