Sporadic Prevalence of DF/DHF in the Nilgiri and Cardamom Hills of Western Ghats in South India: Is it a Seeding from Sylvatic Dengue Cycle - A Hypothesis

Nand Lal Kalra* and Chusak Prasittisuk**

* A-38, Swasthaya Vihar, Vikas Marg, Delhi - 110 092
** Regional Office for South-East Asia, World Health Organization, New Delhi, India

Abstract
The Western Ghats of south India, encompassing the Nilgiri and Cardamom hills, are the wettest region of the country. Hills rising up to 3,000 metres receive over 200 cm of rainfall from both the south-west monsoon (June to September) and north-eastern monsoon (October to January). The eastern slopes of the Nilgiri Hills (200-500 metres) are bounded by Coimbatore and Erode districts of Tamil Nadu, whereas the western slopes of the Nilgiri and Cardamom hills are in the state of Kerala. The countryside has rich forests of teak and sandalwood, interspersed by groves of coconut, rubber, pepper, cardamom and banana plantations. Apart from the rich flora, monkeys (Macaca radiata) maintain a strong association in orchards with humans competing for food.

The emergence of DF/DHF in this hilly region is a recent occurrence. An epidemiological team from the National Institute of Communicable Diseases (NICD) investigated the first-ever reported outbreak in Coimbatore in 1998. In all, 20 serological positive (IgM) cases were recorded by the city corporation. Five cases came from urban towns and 15 cases from rural areas of the two districts of Coimbatore and Erode. Rural cases were scattered in distantly located villages. Pyramid characterization and clustering of cases was conspicuously absent. No attempt was made to link urban cases to central/peripheral wards, nor the history of movement of patients two weeks prior to the onset of fever was investigated. No increase in fever rate was observed. DF cases did not show any relationship with presence/absence of Aedes breeding. Aedes aegypti detected in urban centres failed to amplify the infection.

Kerala state also reported 116 cases in 1997, from Kottayam district. Out of these, 14 cases were confirmed serologically. After a lull of 4 years, 70 probable cases out of 877 were reported from the four districts famous for rubber plantations. Entomological investigations recorded only Aedes albopictus in these areas. Considering the high experimental susceptibility of both species of monkeys, viz. Macaca mulatta and Macaca radiata to yellow fever virus, detection of dengue antigen in field collected Aedes albopictus in Kozhikode (Kerala) and the evidence of transovarian transmission in Aedes albopictus reared from soils of tree holes at Jodhpur – Rajasthan (western India) lend support to the hypothesis that DF in the Western Ghats of South India exists as enzootic monkey – Aedes albopictus – monkey cycle and causes epizootics among rural human population either during periodic amplification of the enzootic cycle or as occupational hazards to the people working in orchards.

Keywords: DF/DHF, sporadic cases, Macaca radiata, dengue antigen in Aedes albopictus, transovarial transmission, sylvatic cycle, Nilgiri and Cardamom hills, south India.

* E-mail: chusakp@whosea.org
Introduction

The Western Ghats of south India encompass two southern states i.e. Tamil Nadu and Kerala (Figure). The crests of the Nilgiri and Cardamom Hills (rising up to 3,000 metres altitude) separate these two states. The eastern slopes of the Nilgiri Hills have a gentle slope and include two important district towns of Tamil Nadu, viz. Erode and Coimbatore, situated at an altitude varying between 200 to 500 metres; each with over one million population. This part of the region receives rains from both the south-west and north-east monsoon. The south-west monsoons become weak, being on the leeward side of the hills, but maximum rains come from the north-east monsoon, the total being <100 cm. The forests are tropical monsoon, which are famous for teak and sandalwood, with patches of arecanut palms\(^1\).

The western side of the Cardamom hills encompasses the state of Kerala. Strong winds of the south-west monsoon lead to the formation of heavy sand dunes in coastal areas and the rain water coming from the steep hills results in formation of shallow lagoons, all along the coast, at places connected to the sea. These lagoons are connected by canals. These backwaters are the characteristics of Kerala state. The banks of these backwaters and sand dunes are dotted with coconut trees\(^1\).

The Region receives heavy rains (> 200 cm) during the south-west monsoon. Hence, the whole region is very wet and supports luxuriant growth. Large tracts of forests have been cleared for raising cash crops, viz. arecanut palms, rubber, banana, pepper and cardamom plantations\(^1\).

Dengue transmission cycles

Transmission of dengue viruses occurs in two cycles, viz. enzootic and epidemic cycles. The enzootic cycle is a primitive sylvatic cycle maintained by lower primates (monkeys) and canopy dwelling Aedes mosquitoes, as reported from South-Asia\(^2\), Africa\(^3\) and Sri
A Suspected Sylvatic Cycle in the Nilgiri and Cardamom Hills in South India

Lanka[4]. Current epidemiological evidence suggests that these viruses do not regularly move out of the forests to urban centres but at times are involved in an epidemic cycle in small rural villages or islands[3]. A number of Aedes species may act as reservoirs[2].

The epidemic cycle is confined to large urban centres. The viruses are maintained in the Aedes aegypti – human – Aedes aegypti cycles with periodic/cyclic epidemics. Generally all serotypes circulate and give rise to hyperendemicity. Virus is maintained either transovarially by the vectors or by continuous low-grade transmission in susceptible hosts added to the population. DF/DHF in urban cycles is characterized by ‘ iceberg’ or ‘ pyramid’ phenomenon. At the base most of the cases are symptom-less, followed in increasing rarity, by undifferentiated fever, DF, DHF or DSS[5]. Occurrence of multiple cases in a single household or clustering of cases in a locality is yet another characteristic of this disease[2].

DF/DHF in India

In recent years the first outbreak of DF/DHF was reported from Kolkata (earlier known as Calcutta) in 1963[6]. Since then, more than 60 outbreaks have been reported from all over the country[7]. Aedes aegypti, invariably has been found to be associated with these epidemics. All the four serotypes, DEN-1, 2, 3 and 4, are now circulating in the country.

DF/DHF in Nilgiri/Cardamom hilly areas of south India

Since 1996-97, there have been reports of sporadic occurrence of DF/DHF cases in Tamil Nadu and Kerala.

DF in hilly regions of Tamil Nadu

During 1998, a team from the National Institute of Communicable Diseases (NICD), Delhi, investigated the first-ever reported outbreak in Coimbatore[8], a town situated at an altitude varying from 300 to 500 metres on the eastern slopes of the Nilgiri Hills. The epidemiological characteristics of the outbreak are summed up below:

• In all, 20 serologically positive and compatible to DF/DHF cases were reported. Eighty percent (16/20) were children below 10 years and two patients aged 16 and 5 died of DHF.
• Fourteen cases were males.
• Seventeen cases came from Coimbatore district and three cases from rural areas of adjoining Erode district.
• Only five cases came from urban Coimbatore town and the rest (12 cases) were from rural areas of Coimbatore district.
• Rural cases were scattered in distantly located villages. Clustering of cases and pyramid phenomenon was conspicuously absent. No attempt was made to link urban cases to central or peripheral wards/ zones nor the movement history of patients two weeks prior to the onset of fever was investigated.
• No relationship could be established between outbreak and increased fever rate.
• Eighty-nine percent of blood samples from healthy contact persons from urban and rural areas showed dengue virus IgG antibodies.
• Entomological investigation recorded *Aedes aegypti* in all areas surveyed in urban and rural areas, but failed to amplify the infection.

• During the 2003 outbreak in Coimbatore town 23 cases of DF were recorded. Distribution once again followed the same pattern, i.e. 5 cases from urban towns and 18 cases from rural areas (Source: VBDC, New Delhi)

### DF in Kerala

#### Epidemiological data

As per investigations undertaken by the Centre for Research in Medical Entomology (CRME)[9], the state of Kerala started reporting DF for the first time in 1997. Distribution of DF cases are included in Table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of suspected cases</th>
<th>No. serologically positive</th>
<th>Deaths</th>
<th>Districts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>116</td>
<td>14</td>
<td>4</td>
<td>Kottayam</td>
</tr>
<tr>
<td>1998</td>
<td>67</td>
<td>0</td>
<td>13</td>
<td>Kottayam</td>
</tr>
<tr>
<td>1999</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Kottayam</td>
</tr>
<tr>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Kottayam</td>
</tr>
<tr>
<td>2001</td>
<td>877</td>
<td>70</td>
<td>1</td>
<td>4 districts*</td>
</tr>
</tbody>
</table>

* Four districts included Kottayam, Idukki, Ernakulam and Thiruvananthapuram- famous for rubber plantations

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of district</th>
<th>House index</th>
<th>Container index</th>
<th>Breteau index</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Alappuzha</td>
<td>150 40 26.7</td>
<td>201 63 31.3</td>
<td>42.0</td>
<td>Types of containers and sites of detection of <em>Aedes</em> breeding, viz. domestic/peri-domestic; extradomestic not mentioned</td>
</tr>
<tr>
<td>2.</td>
<td>Ernakulam</td>
<td>24 10 41.7</td>
<td>54 41 75.9</td>
<td>170.8</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Kottayam</td>
<td>70 24 34.2</td>
<td>125 29 23.2</td>
<td>41.4</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Kozhikode</td>
<td>3,311 895</td>
<td>17,912 1,077</td>
<td>31.57</td>
<td></td>
</tr>
</tbody>
</table>

*Pool rearing of larval breeding collected from all localities indicated *Aedes albopictus* as the major species.*

*Aedes aegypti* was encountered in very few places and in scanty numbers (Source: NICD, Delhi, 2004)
Entomological data

Entomological investigation initiated by a CRME team in 2 localities of Kottayam district yielded only Aedes albopictus, and Aedes aegypti was not detected. Sylvan environment of rubber plantations was detected as the unique habitat of the Aedes albopictus\[10,11\].

Results of yet another entomological study carried out by the National Institute of Communicable Diseases (NICD) field station located at Kozhikode, in DF affected districts during 2001-2003, are included in Table 2.

Antigen detection of dengue virus

During May 2004, a pool of landing collection of Aedes albopictus (dessicated), collected from the fringe of forested villages, 600 metres away from Kozhikode (earlier known as Calicut) International Airport, yielded dengue antigen (processed at CRME, Madurai)\[12\].

Vertical transmission by Aedes albopictus

A recent study has been carried out at the Desert Medicine Research Centre (DMRC), Jodhpur (Rajasthan), an institution under the Indian Council of Medical Research, on possible existence of Aedes albopictus – monkey – Aedes albopictus cycle. The highlights of the study included that:

• In a desert ecosystem, both Aedes aegypti and Aedes albopictus breed in tree holes in zoo and monumental parks, harbouring monkeys, outside the city limits.
• Viable eggs retrieved from the soil of tree holes were reared to adults. Aedes albopictus, when subjected to IFA test, showed the presence of dengue antigen, thereby confirming the transovarial cycle of the virus\[13\].

Hypothesis

Occurrence of DF cases in peripheral and rural areas of Coimbatore and Erode districts in Tamil Nadu and non-amplification of infection by Aedes aegypti and sporadic occurrence of DF cases in Kerala in the absence of Aedes aegypti points out to either spillover of enzootic foci of dengue during periodic amplification of the sylvatic cycles or occupational hazards in the presence of vertical transmission as evidenced by the Kozhikode and Jodhpur studies.

• Both the Nilgiri and Cardamom hills are infested with Macaca radiata, the bonnet monkeys. Enzootic cycle of simian malaria caused by Plasmodium cynomolgi and Plasmodium inui, transmitted by Anopheles elegans (Anopheles dirus group)\[14,15\], has been detected in the Nilgiri hills. Whereas in Kerala, a similar simian foci has been detected at Nilambur district of the western slope in Macaca radiata, while in Alappuzha (district in the central plains, earlier known as Alleppey) monkeys were found negative for lack of Anopheles elegans population\[16\].
• Both the monkey species, viz. Macaca mulatta and Macaca radiata have been found to be highly susceptible to yellow fever virus (flaviviruses) under experimental conditions\[17\]. This lends support to the susceptibility of these monkeys to dengue virus as well.
• Lack of vectorial competence of *Aedes albopictus* in the amplification of urban dengue epidemic has recently been demonstrated during the investigation of the first-ever DF outbreak at Phuentsholing, Bhutan in 2004[18]. Entomological investigations revealed that *Aedes aegypti* occupied domestic habitats breeding primarily in storage containers inside houses, while *Aedes albopictus* bred in tree holes, 55-gallon drums and used tyres in the extra-domestic habitats. The overlapping zone was the peridomestic areas where both species shared breeding in flower vases/trash. A large-scale source reduction/larvicidal campaign supported by deltamethrin fogging in residential areas largely eliminated *Aedes aegypti* and the cases came down to single digits within a month, while *Aedes albopictus* still maintained high larval indices.

• Rudnik and Lim[19], while working in Malaysia, isolated DEN-1, 2 and 3 viruses from monkeys and also proposed that the rural dengue vector – *Aedes albopictus*, may introduce sylvatic virus into the human population.

• Studies in Sri Lanka proved that dengue virus causes epizootics among macaques, rather than being enzootic as observed elsewhere[4].

• Gubler[20], proposed that at some point in the past, probably with the clearing of the forests and development of human settlements, dengue viruses moved out of the jungles and into a rural environment where they were, and still are transmitted to humans by peri-domestic mosquitoes such as *Aedes albopictus*.

In view of the aforesaid, the land use in the Nilgiri hills of Tamil Nadu and in the Cardamom hills in Kerala is under pressure of deforestation to be replaced with cash crops. This has brought monkey populations much closer to human settlements. Therefore, there is a need for indepth sero-epidemiological and entomological studies with backup of virology support using molecular tools for genomic sequencing of viruses obtained from simian and human sources. Validation of the hypothesis is of great epidemiological significance as it would require radical changes in developing vector control strategies for *Aedes albopictus*-transmitted DF.

Acknowledgements

The author gratefully acknowledges Dr. Duane J. Gubler for critically reviewing the manuscript.

References


