Prevalence of *Aedes aegypti* and *Aedes albopictus*– Vectors of Dengue and Dengue haemorrhagic fever in North, North-East and Central India*

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Abstract

The *Aedes aegypti* mosquito vector was found to be prevalent in the western, northern, Indo-Gangetic and eastern plains, Assam valley and the coastal areas of Orissa state in India. The species was non-existent in the Himalayan region. In north-central highlands, the species showed low-to-moderate prevalence, while in south-central highlands, the mountainous areas were largely free but high populations of the vector were encountered in the valleys. Similarly, the eastern plateau, including the eastern *ghats* were comparatively free of the vector except large towns in the Mahanadi basin. The Satpura ranges of north Deccan were also found to be free of *Ae. aegypti.*

The elevation, type of relief, terrain, density of population, water storage practices in drought-prone regions and high rainfall leading to formation of secondary foci had direct relationship with the prevalence of the species. Altitudes above 1000 metres were found to be unfavourable for the species.

Being hygroscopic, the species depicted a phenomenon of 'annual pulsation'. It tends to move to 'mother foci' in the central parts of cities which are humid during the dry season and spreads out during the wet season.

Aedes albopictus was encountered in the peripheral areas of towns where it replaced the *Ae. aegypti* populations. However, in the eastern plateau, the species penetrated upto the central parts, probably due to lack of intra-species competition from *aegypti* which is very scanty in the region.

The information proved to be of immense value in delimiting areas which were prone to DF/DHF epidemics. The internal dynamics provided useful information for developing control strategies.

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Introduction

Dengue epidemics have been known to occur over the last two centuries in tropical and subtropical areas of the world. However, the role of the mosquito *Aedes aegypti* as the vector of this arbivirus has been known only during the past 70 years[1]. In 1953-54 a new disease syndrome associated with dengue appeared in the Philippines, which later spread throughout south-east Asia and the Western and South Pacific. Unlike classical dengue which causes only morbidity, this disease entity affected young children and caused severe illness with haemorrhage and shock, resulting in high mortality, and earning a name for itself as dengue haemorrhagic fever/ dengue shock syndrome or DHF/DSS.

In India, the association of haemorrhagic manifestations were noticed for the first time in an outbreak in Calcutta in 1963. In this outbreak both the viruses, i.e. dengue and Chikungunya, were found to be circulating together[2]. Since then the country has reported several dengue outbreaks in different parts of the country with manifestations of haemorrhagic symptoms in varying degrees. To assess the receptivity of different geographical areas of the country to this infection, an attempt was made to determine the distribution of *Aedes aegypti* in 1968, based upon the museum collection of the National Institute of Communicable Diseases[3]. Since this collection was not represen-tative of the whole country, a compre-hensive study was launched in 1969 to assess the extent and intensity of the prevalence of *Aedes aegypti*, the known vector of DF/DHF, and its associated species *Aedes albopictus*, the suspected vector in the country. This paper high-lights the results of five years of inquiry.

Study areas

The study covered ten physiographical regions of India, viz. (i) Himalayan region; (ii) Western plains; (iii) Northern plains; (iv) Indo-Gangetic plains; (v) Eastern plains; (vi) Central highlands; (vii) North Deccan; (viii) Eastern plateau; (ix) Coastal plains of Orissa, and (x) Assam valley and the states of Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana, Chandigarh, Rajasthan, Uttar Pradesh, Madhya Pradesh, Bihar, Orissa, and West Bengal (Fig.1).

Material and methods

In the present study the conventional methods of *Aedes* survey as adopted by the National Institute of Communicable Diseases (NICD) for outbreak studies were followed[4]. As the scope of the study was limited to determining the distribution of the species, the information was collected on the following aspects:

(i) Occurrence (as evinced by indigenous breeding), and

(ii) Intensity of infestation (No. of houses found positive per ward)

House (premises) Index :

$$\frac{\text{No. of houses positive for Aedes larvae}}{\text{No. of houses examined}} \times 100$$

Figure 1. Pysiographical Regions of India Surveyed for *Aedes aegypti* and *Aedes albopictus*

For information collection, 10 to 40 towns, depending on size and population, were selected in each region. Towns/cities were divided into wards/ localities and 50 houses selected at random were examined in each ward. Wherever the *aegypti* population reached the peripheral limit, the searches were extended to the adjoining rural areas as well. Each region was surveyed twice corresponding to dry season (March to June) and wet season (July to October).

Searches were carried out in domestic, peridomestic and extra-domestic habitats. Tree holes were the principal habitats examined under extra-domestic situations.

Observations

During the period 1969-1973, a total of 203 towns/cities covering ten physiographical regions corresponding to dry and wet seasons were surveyed, except Assam, Kashmir valley and towns in West Bengal which were surveyed during the dry season only. The houses in towns/ cities investigated during dry and wet seasons for *Aedes aegypti* and *Aedes albopictus* are included in Inserts B and C. An analysis of the data indicated the following patterns of distribution.

1. Himalayan region

A total of 20 towns spread over south Kashmir Himalayas, Punjab Himalayas, Kumaon hills and eastern Himalayas were

investigated. The majority of the areas investigated had an elevation above 500 metres. The region was found to be completely free of *Aedes aegypti*. *Aedes albopictus* was found to be the predominant species in Punjab Himalayas, while in south Kashmir Himalayas and Kumaon hills, its prevalence was scanty.

2. Western plains

The area includes the arid zone of moving sand dunes commonly known as "Thar desert" situated between the Indus plain dunes on the west and Rajasthan upland in the south-east. The area is very thinly populated due to extreme scarcity of water.

The *Aedes aegypti* population seems to be fully entrenched in the area and shows perennial prevalence. In Sikar, it was found to infiltrate into rural areas during the wet season. Water scarcity and the resulting water storage practices were determined as the main factor for the high build-up of *Aedes* population.

Aedes albopictus was encountered both during dry and wet seasons in the peripheral areas of towns/cities.

3. Northern plains

The region includes the plains of Punjab and Haryana. Major rivers in the Punjab region are Sutlej and Beas, which have long mountainous courses and provide a large network of canals for irrigation purposes. The south-western parts of Haryana face an acute shortage of water. The whole area is densely populated and is one of the richest wheat-growing areas of the country.

The *Aedes aegypti* population depicted low-to-moderate rates of positivity, except in water-scarce areas of Haryana (Ambala, Panipat, Rewari and Rohtak), where a large population builds up particularly during the wet season.

4. Indo-Gangetic plains

The Indo-Gangetic plains comprise Ganga-Jamuna *doab* (which literally means area lying between two rivers), Rohilkhand plains and Avadh plains. Of the *doabs* of India, the Ganga-Jamuna *doab* is by far the largest and most fertile and densely populated area. The elevation and character of the flood plains change within the *doabs*. On the east are the low-lying Rohilkhand and Avadh plains. These plains are seamed with deserted rivers. The Ramganga and Sarda rivers meander through the Rohilkhand plains and lower reaches of Gomti and Ghaghra flow through the Avadh plains. On the north, these plains are bordered by the narrow waterless sandy belts of Bhabar and the swampy belt of alluvial soil (Terai), supporting vast expanses of marshy land with luxuriant growth of vegetation.

The *Aedes aegypti* population seems to have achieved ecological stability in the Ganga-Jamuna *doab* areas. Most of the towns were found to be positive both during dry and wet seasons, indicating a perennial prevalence of the species. Proximity of the towns near the two great rivers, which provide riverine routes for the dispersal of the species and high density of human population, seems to have

provided a foothold to the species in this region.

Both in Rohilkhand and Avadh plains, the *aegypti* population were detected in wet season only, except in some large towns (e.g. Lucknow and Jaunpur) or towns which are situated on the bank of the river Ganga (e.g. □aranasi). A gradual decline in the incidence of the species could be observed as one proceeded towards the swampy and marshy Terai and Bhabar regions in the north.

The *Aedes albopictus* populations were more pronounced in the Rohilkhand and Avadh plains than in Ganga-Jamuna doab. This may be due to the abundance of natural vegetation cover provided by the forested areas in the region.

5. Eastern plains

The eastern plains are further divided into north Bihar plains, south Bihar Plains, north Bengal plains and Bengal basin. The Ganga flows along the southern border of the north Bihar plains, receiving on its left bank three of the major Himalayan rivers - Ghaghra, Gandak and Kosi. A long line of marshy stretch extends from east of Chhapra to Khagaria. North Bengal plains extend from the foot of the eastern Himalayas to the northern limits of the Bengal basin. The region is drained by tributaries of the Ganga and the Brahmaputra. South of Duars, the plains are more flattish and get waterlogged. The Bengal basin embraces most of the alluvial plains of West Bengal and includes the great Ganga delta.

The *Aedes aegypti* populations showed a definite relationship with the terrain. These were found to be quite stable both in the south Bihar plains and the Bengal basin. Both the regions are vulnerable to repeated introduction of the species through the Ganga, which has a lot of riverine traffic. Both in north Bihar and north Bengal plains the species was either absent or had a scanty prevalence. This may be due to the terrain features which support exten-sive vegetation and lack navigational facilities in its river system.

Aedes albopictus was found in negligible numbers in peripheral areas of large towns.

6. Central highlands

The Central highlands is a wide belt of hilly country bordered on the west by the Aravalli range and on the south by the Satpura range. This physiographical region separates the Great Plains from peninsular plateaus. It is further divided into two divisions, namely, north-central highland, which includes the Aravalli range, east Rajasthan uplands, Madhya Bharat *pathar* and Bundelkhand uplands. The Aravalli range extends south-west for a distance of 800 km, in which Abu Hills (1722 m) is the highest peak. East Rajasthan uplands lie on the east of Aravalli, ranging in height from 250 to 500 metres. Madhya Bharat *pathar* is□□□□□□□□□ð□□□□□□□□□□□□□□□□□□□□□□□□□à□□□ط□□□□□□èÌÈê□ÂèÒÜÎ@æêäÌÂÆÊ\@¨ÐÊ@□ÐÂÚÄÂØ@ÐÂæ@Æêè@Â@ÈÊÊà@ÂÜÈ@îÒÈÊ@ìÂØØÊò@ÒÜ@èÐÒæ@ÂäÊÂ\@□êäèÐÊä@ÊÂæè@lie the Bundelkhand uplands.

The south-central highlands include the Malwa plateau, which is built of lava with rolling surface and flat-topped forested hills with a number of flowing rivers. East of the Malwa plateau is a series of plateaus at different levels collectively known as Vindhyan scarplands. On the south it is bordered by the Vindhya range. Skirting the roots of the Vindhya range and sandwiched between Vindhya and Satpura extends the Narmada valley from east to west.

Aedes aegypti depicts differential patterns of prevalence in the north-central and south-central highlands. In north-central highlands the species is fairly widespread particularly in the east Rajasthan uplands and Malwa plateau. Water scarcity and the resultant water storage practices seem to be the single most important factor promoting the stability of the species. It is less common in Madhya Bharat *pathar* because of the hilly and forested nature of the region.

South-central highlands are comparatively free of *A. aegypti* except in large towns situated in the Narmada valley (Jabalpur and Sagar), which showed year-round prevalence of the species. In other large towns of the region, the species was detected during the wet season only.

Aedes albopictus also depicted a similar pattern of distribution. It was much more pronounced in north-central highlands and was scanty in south-central highlands. The species was always encountered in peripheral areas.

7. North Deccan

North Deccan is part of the peninsular plateau which is one of the largest physiographical divisions of India. North Deccan comprises the Satpura range and the Maharashtra plateau. The Satpura broadens out considerably in the central part bordered on the north by the Mahadeo hills and on the south by the Gwalgarh hills.

Ae. aegypti was found to be completely absent in this region. This may be due to the hilly nature of the terrain, which has been observed to be inhospi-table for the species in India. However, *Ae. albopictus* was the common species encountered in the region during the wet season.

8. Eastern plateau

The Eastern plateau has a much more diversified topography than the Deccan plateau. It comprises the Chhota Nagpur plateau, Garhjat hills, the Mahanadi basin and the Dandakarnya area. The Chhota Nagpur plateau consists of perfect basin surrounded by hills rising from 600 to 1000 m. Dandakarnya is also a forested and hilly area.

The Eastern *ghats* are essentially a coastal range. This range exhibits its true mountain character between the Godavari and the Mahanadi.

Aedes aegypti are commonly unstable in this area. Low densities of the species were encountered in the industrial towns of Dhanbad and Jamshedpur in the Chhota Nagpur plateau. In other towns the species

seemed to infiltrate during the wet season from the adjoining south Bihar plains.

In the eastern plateau, the species was found restricted to towns situated in the Mahanadi basin only where it perhaps got introduced from the coastal plains. The eastern *ghats* were found to be free of *aegypti* population.

Aedes albopictus was the dominant species in the region, particularly in the eastern plateau. The species was found to invade practically entire towns during the wet season.

9. Coastal plains of Orissa

The eastern coastal plains of Orissa are much drier and wider than their counterpart in the west. These are also known as Utkal plains and include the Mahanadi delta.

Out of the ten towns surveyed in the region, five towns situated on the coast were found positive for *Aedes aegypti* both during dry and wet seasons. In the other five towns which had proximity to the hilly terrain of the eastern *ghat* and Gharjat hills were found negative for the species. *Aedes albopictus* continued to be the dominant species in this region and was encountered in both dry and wet seasons.

10. Assam valley

The valley, occupied by the middle course of the Brahmaputra, stretches for nearly 600 kms. The valley is linked with the Ganga plains by the plains of north Bihar. The upper Assam valley, because of its marshy nature, is sparsely populated, while the lower Assam valley is densely populated. The areas receive heavy rainfall from south-western monsoons.

The survey was carried out only during the dry season and it was observed that *Aedes aegypti* was endemic in the entire valley. House indices were observed to be quite high.

Aedes albopictus was the dominant species in the peripheral areas of towns and was detected in high densities.

Conclusions

The studies carried out in north and north-east India indicated that *Aedes aegypti* was endemic in the western plains (Thar desert), northern plains (Punjab and Haryana), Indo-Gangetic plains, eastern plains (Bihar and Bengal basin), Assam valley and the coastal areas of Orissa. The species was found to be completely non-existent in the Himalayan region. In north-central high-lands, the species showed a low-to-moderate prevalence, but in south-central highlands, the mountainous areas were largely free but high populations were recorded in the Narmada valley. The eastern plateau, including the eastern *ghats,* were comparatively free except some prevalence in the towns situated in the Mahanadi basin. The Satpura ranges of north Deccan were also found to be free of *Ae*. *Aegypti.*

The *Aedes aegypti* population in this region depicted a terrain-bound phenomenon as determined by Kalra et al [3].

The elevation, type of relief, terrain, population density and water storage practices were found to have a direct relationship with the prevalence of the species. The species depicted a high prevalence in areas up to an elevation of 500 metres. These included plains, coastal areas and river valleys.

In areas with the elevation ranging from 500 to 1000 metres, which included mountainous areas and plateaus, the species was found to be scanty. Elevation higher than 1000 metres seems to be the least attractive to it.

In the plains, the species was found to be widespread in densely populated towns while the rural areas were found to be completely free. Introduction of the species into rural areas is a recent phenomenon associated with rural water supply schemes.

The *Aedes aegypti* population depicted a phenomenon of 'annual pulsation'. The population showed a definite reduction during the dry season and expansion during the wet season due, respectively, to the drying up and availability of breeding sites.

Both drought conditions and high rainfall were found to encourage a high build-up of *Ae. aegypti* population. In the former case, water storage practices due to water scarcity, and in the latter case, abundant availability of secondary foci in domestic and peridomestic areas promoted growth of high vector populations.

A complete absence of breeding was observed in extra-domestic habitats, including tree holes, in this region. This showed continued dependence of the species on man for food and shelter and complete absence of any sign of ecological adaptation towards feral situation which increases its epidemiological potential.

Aedes albopictus was encountered in the peripheral areas of towns where it replaced the *aegypti* population. However, in the eastern plateaus, the species was found to be endemic which had penetrated into the central parts of towns/ cities. This may be partly due to the absence of intra-species competition from *Ae. Aegypti,* which is very scanty in this region.

Utility of the information collected

The data collected under the inquiry helped in delimiting the areas prone to *Aedes*-borne epidemics. The information was also supplied to concerned state governments to enable them to take preventive measures against dengue outbreaks. The dengue outbreaks in Ajmer (1969)[5], and Gwalior (1970)[6] are classical examples. The information broadly holds good even today.

Besides, the data provided useful information on the bio-ecology of the species for planning future studies.

Acknowledgement

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Reference

1. Gratz NG and Knudsen AB. The rise and spread of dengue, dengue haemorrhagic fever and its vectors. WHO, Geneva, 1996, CTD/FIL (DEN) 96-7:1-197.

2. Sarkar JK. Calcutta experience and findings in haemorrhagic fever and Chikungunia fever epidemics. Jap. J. Med. Sci. Biol. 1967, 20 (suppl):88-90.

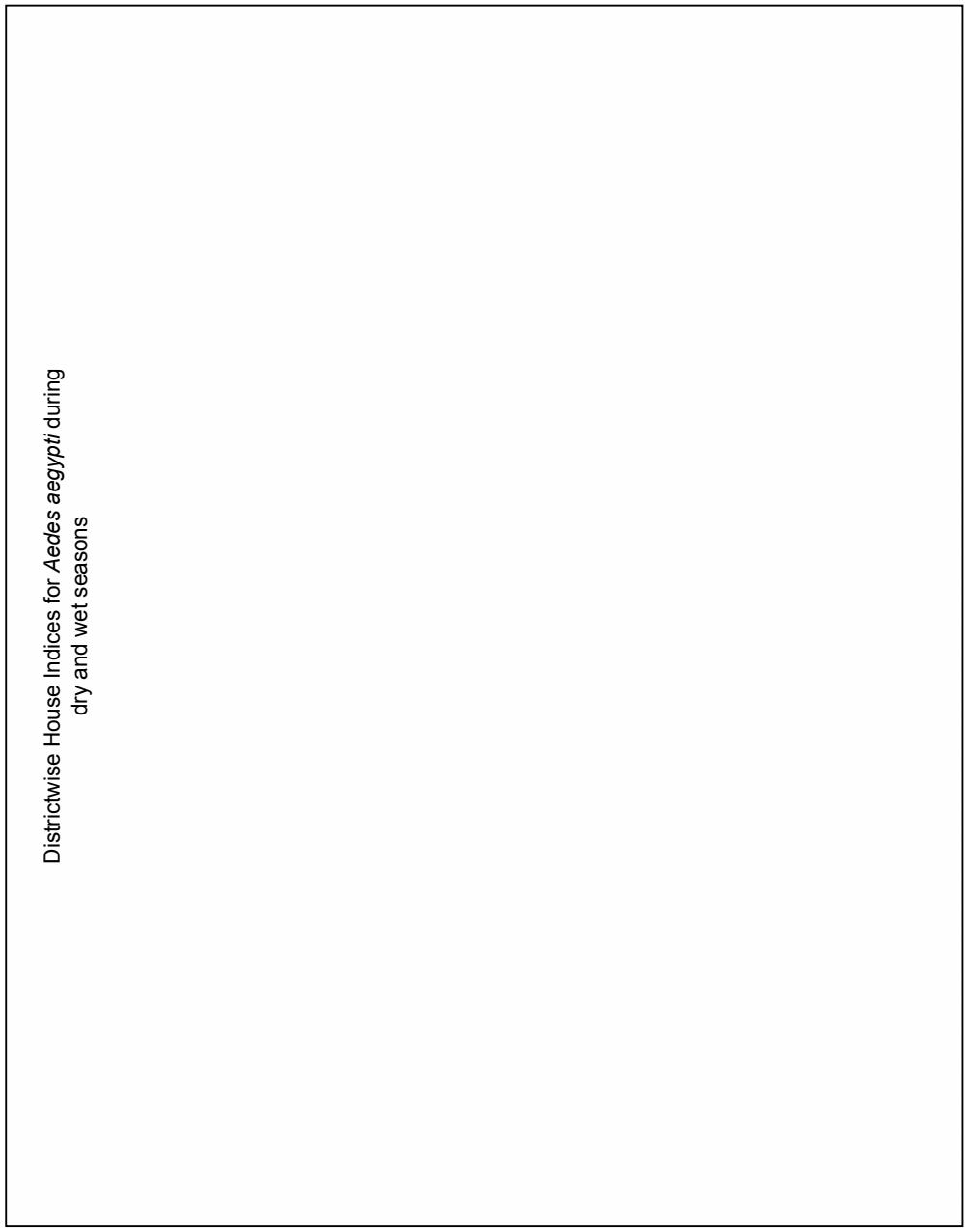
3. Kalra NL, Wattal BL and Raghvan NGS. Distribution patterns of *Aedes* (Stegomyia) *aegypti* in India. Some ecological considerations. Bull. Ind. Soc. Mal. Com. Dis. 1968, 5:307-34.

4. Kalra NL. *Aedes* survey of Vishakhapatnam following an epidemic of febrile illness in 1964. Bull. Ind. Soc. Mal. Com. Dis. 1965, 2:33.

5. Kalra NL et al. Epidemiological and entomological study of an outbreak of dengue fever in Ajmer, Rajasthan, in 1969. J. Com. Dis. 1976, 8:261-279.

6. Arora DD et al. Epidemic of Dengue fever (DEN-3) at Gwalior. J.Com. Dis. 1973, 5:11.

Insert B


Districtwise House Indices for *Aedes aegypti* during
dry and wet seasons

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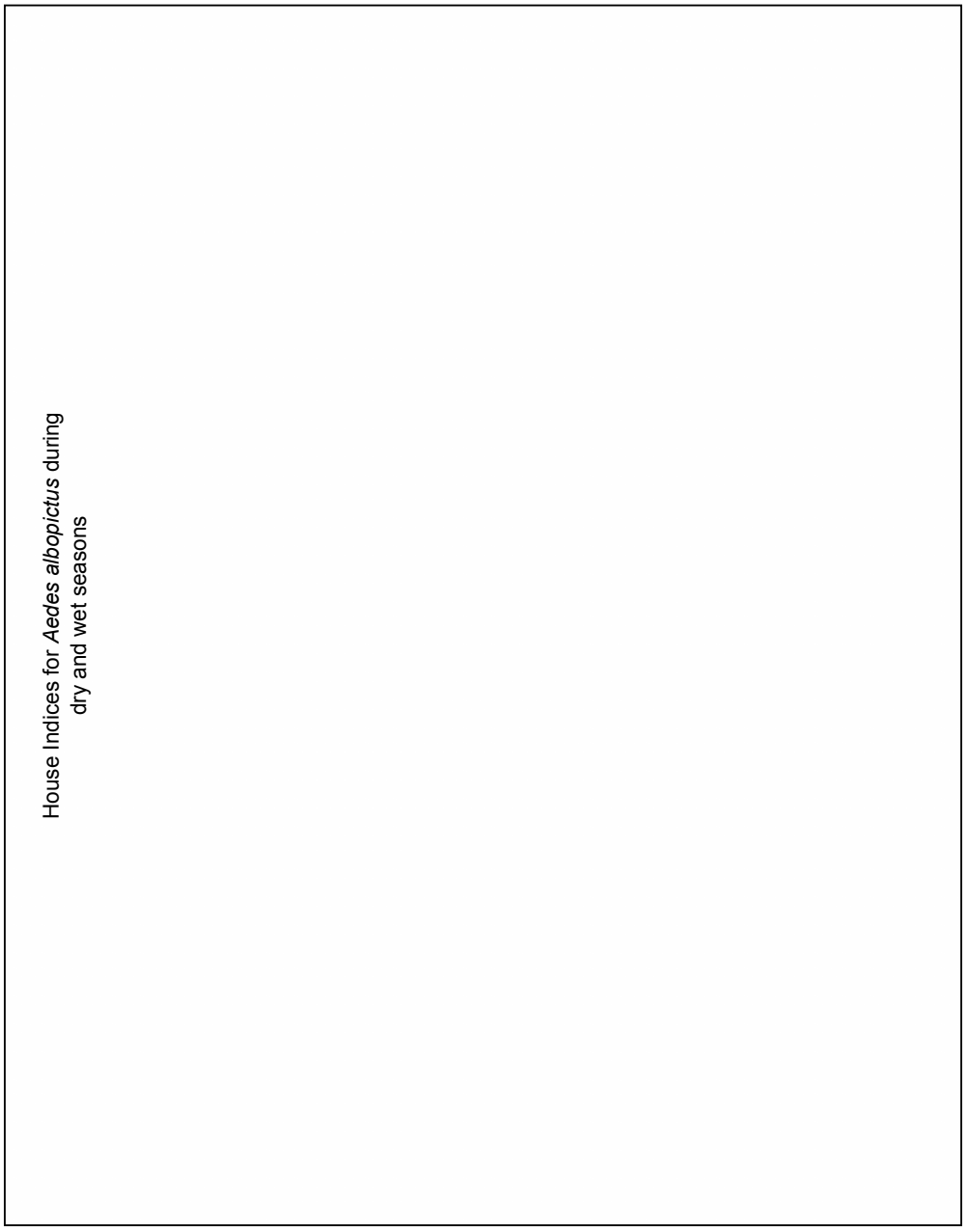
House Indices for *Aedes albopictus* during
dry and wet seasons