ACTIVITY OF DENGUE-2 VIRUS AND PREVALANCE OF *AEDES AEGYPTI* IN THE CHIRIMIRI COLLIERY AREA, MADHYA PRADESH, INDIA

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Abstract. Repeated outbreaks of a suspected viral fever in Chirimiri colliery area, Madhya Pradesh were reported since 1990. The area consists of an agglomeration of sprawling settlements at varying altitudes of 816 to 890 m and it has partial sylvan cover. During a 1992 outbreak 25 patients' sera were tested, of which 13 showed seropositivity to dengue (DEN) by MAC-ELISA test; DEN-2 was isolated from *Aedes aegypti* collected from two of the eight settlements of the area. The principal vector, *Ae. aegypti*, was prevalent in all the settlements studied; Breteau indices (BI) varied between 2.5 and 125.0; adult house indices (AHI) between 0 and 60.0%; *Ae. albopictus* and *Ae. vittatus* occurred in considerable numbers; *Ae. aegypti* bred in more containers with nonpotable water than those with potable water; the breeding of this species was noted in a maximum number of cement tanks while mud pots were predominant among the available containers. Paired comparisons between relative prevalence indices showed significant correlation and regression coefficients. Significant association of *Ae. aegypti* breeding with the households having tap water supply was noted, the relative risk declining with the people's use of well water either exclusively or in combination with other sources of water supply. It was also collected in the nonresidential areas. The role of ecological factors in the maintenance and spread of *Ae. aegypti* and dengue in these settlements is discussed.

INTRODUCTION

Several epidemics of dengue were reported from urban areas in India (Mohan Rao, 1987) and in rural areas of Kerala in 1983 (unpublished data), Maharashtra in 1986 (Ilkal *et al*, 1991) and Gujarat in 1988 (Mahadev *et al*, 1993b). Among these were the epidemics from Gwalior, Jabalpur and Saugar cities in Madhya Pradesh (MP) (Mohan Rao, 1987). Although the role of urbanization in dengue epidemiology and its mosquito vector *Aedes aegypti* has been documented, impacts of the ecological changes underway are not predictable. Ecological factors considered important for the maintenance and spread of *Ae. aegypti* are: a) urbanization, b) altitude, c) transportation and d) vegetation (Pant *et al*, 1973).

Following an outbreak of disease in the Chirimiri area of Sarguja district, Madhya Pradesh (MP) in 1990, dengue infection in patients was indicated serologically and etiology was confirmed by dengue virus type 2 (DEN 2) isolations from patients (unpublished data). During June and July 1992 a further outbreak of dengue was reported in this area with similar clinical presentation. Serological studies on these patients and the results of the entomological follow-up conducted in August 1992 are presented here.

MATERIALS AND METHODS

Study area

Chirimiri area (23° .05'N; 82° .15'E) is situated in Vindhya mountain ranges within the Vindhyachal-Baghelkhand region (altitudes between 150 and 1,200 m) which in turn is flanked by the Gangetic plains in the north and the Narmada-Son river trough in the south (Singh, 1971). The terrain is rugged and has forests largely of the following trees: *Shorea robusta, Tectona grandis, Pterocarpus marsupium* and *Bassia latifolia.* The sylvan cover is seen only along the western aspect of the present study area which has altitudes varying between 816-890 m.

Climate

The average climate of Sarguja district is moist throughout the year, with at least one rainy day in every month; rainfall normal is 149.32 cm, over 72.5 rainy days (Meteorology Department, Pune, 1981). Average rainfall of Chirimiri area varied between 97.15 (in 1987) to 171.25 cm (in 1990) during five years prior to this study. During 1992, rainfall upto the end of July was below average; but a precipitation of 28.35 cm in July and 15.83 cm upto mid August of 1992 was also within the usual limits (20.4 - 35.25 cm) for these months. Mean maximum temperatures vary between 23.9°C to 39.6°C and mean minimum 8.0° to 24.8°C.

Demography

Chirimiri area (Fig 1) is comprised of 28 settlements distributed in seven blocks. This area consists of Kurasia urban agglomeration (KUA) [which includes Kurasia, Chirimiri, North Chirimiri, New Chirimiri Pondering Hill (NCPH) and Doman Hill], Korea block and West Chirimiri block (Table 1) (Nanda, 1992). The 1991 census showed that the KUA had an overall 35.26% decadal growth; Korea and West Chirimiri together had 34.56% decadal growth, but within KUA area it varied between 1.5% (North Chirimiri) and 99.75% (Doman Hill). The whole area consists of sprawling coal miners slummy settlements situated adjoining the respective open cast coal mines or mining tunnels. With the growth of the mining industry there is an influx of a work-force from outside the otherwise tribal district (Anonymous, 1908).

Sources of water

The sources of residential water as recorded during this study varied from settlement to settlement. At the "G.M. Complex" (West Chirimiri), Godripada (Kurasia) and Korea the potable water supply (drinking and cooking) was predominantly from the household taps; residents in Chirimiri and NCPH fetched it from springs; at North Chirimiri and Doman Hill it was being supplied from wells by tankers. In some parts of West Chirimiri and in the slums of Gadabuda the drinking water supply was effected by street taps, while most parts of the West Chirimiri have residential tap water supplies.

In addition, the residents at Chirimiri, NCPH, North Chirimiri and Doman Hill received copius

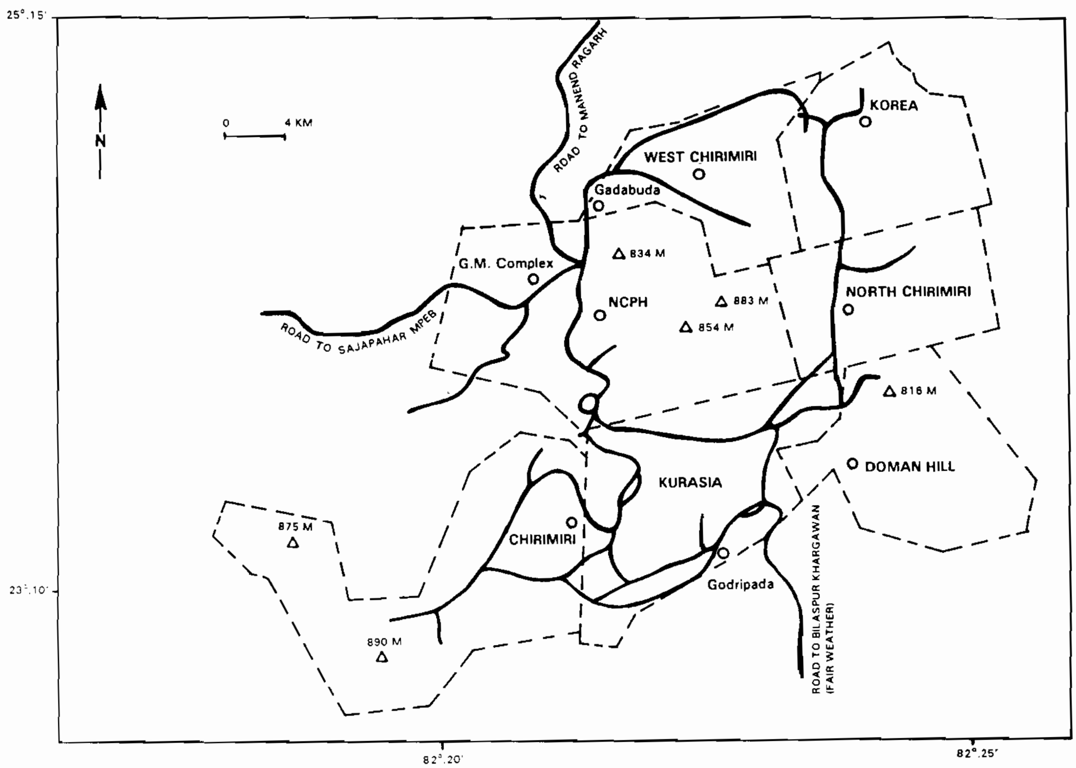

Fig 1 –Surface plan of Chirimiri area.

Table 1

Description of the localities visited in each settlement in Chirimiri area.

Colliery (township class)	Population (1991 census)	Locality visited	Household Water Sources				
			Well	Taps	Tap & Well	Tap & Spring	Unrecorded
Kurasia (class II urban agglomeration)							
Doman hill	14,706	Slum and Cheep quarters opposite dispensary	-	26	4	-	-
Chirimiri	15,861	New and old miners quarters	-	8	-	32	-
North Chirimiri (Gelhapani)	4,931	Ghode daphai School daphai	-	-	40	-	-
NCPH	16,205	Lower Bhaisa Daphai R6 colliery, Teena & officer daphai	-	-	-	40	-
"	"	GM Complex (Double storey buildings)	-	11	-	-	-
Kurasia	15,898	(Godripada) New miners Qrs near regional hospital	-	20	-	-	-
West Chirimiri (Class V town)	8,889	Survey # 5 near new GM qrs, class II & III qrs etc	-	4	26	10	-
"		Gadabuda (Prem Nagar and Dharmnagar)	-	11	14	-	15
Korea (Class V town)	8,863	Railway quarters and Bazaarpara	6	24	5	-	5

but interrupted ground water supply by the household taps. Being hard, this water was used for non-potable purposes (washing and bathing). While these were gross variations, 52.49% houses had dual water supplies, 42.52% had a single supply while the supplies to 4.98% of houses were unrecorded owing to lack of information on the dual water supplies in the area, *a priori* (Table 1). Consequently the recording of the detailed sources water commenced.

Patients

Serum samples of selected cases among those reporting at the regional hospital, Godripada, KUA, were referred to the National Institute of Virology, Pune. The cases had a history of fever, normal hematologic picture, absence of malarial parasites and Widal negative reaction; their sera were tested in IgM-antibody capture ELISA (MAC-ELISA) for the evidence of recent viral infection and hemagglutination inhibition (HI) tests on paired sera if there was any rise in the serum antibody titers against Japanese encephalitis (JE), West Nile (WN) and dengue (DEN) virus antigens (Burke *et al*, 1982; Gadkari and Shaikh, 1987; Clarke and Casals, 1958).

Mosquito collections and virus isolations

The adult mosquitos caught in wild or those reared from field collected larvae were transported alive to Pune. Isolation of the virus was attempted from the bodies of individual females whose head squashes were tested DEN positive by indirect immunofluorescent antibody technique (IIFT) (Mahadev *et al*, 1993b). After successive passages in reared *Ae. aegypti* females and Swiss albino mice, the isolates were characterized by the complement fixation test (CF) (Pavri and Shaikh, 1966).

Field sampling

The sampling was conducted in 40 households from a point in a settlement where a recent DEN like illness was reported. One-larva/pupa-per container method was used to assess the relative prevalences of *Aedes* spp (Sheppard *et al*, 1969) which were given by Breteau index (BI = the numbers of containers with *Ae. aegypti* per 100 houses visited), house index (HI = % houses with *Ae. aegypti*) and container index (CI = % containers infested with *Ae. aegypti*) (Chan, 1985; Mahadev *et al*, 1993b). The HI was prefixed in this study by A/L to denote adults or larvae respectively. The breeding preference ratio (BPR) was given by the proportion of an exploited container type for *Ae. aegypti* breeding to the proportion of that container type among the total available containers with water; preference is indicated if BPR > 1 (Mahadev *et al*, 1993a).

The nonresidential areas visited for mosquito collections were a tyre-dump in Chirimiri and a mine in NCPH.

Data analysis

The distribution of *Ae. aegypti* was presented settlement-wise; the water container distribution data from all the settlements was pooled for statistical analyses. Association of the water storage practices or the sources of water with *Ae. aegypti* breeding were analysed using 2 × 2 chi-squared (x^2) tests (Bailey, 1959) and the relative risk of *Ae. aegypti* breeding by water sources was estimated (MacMahon and Pugh, 1970). The linear regression analyses amongst AHI, LHI, CI and BI were made on arithmatic scale, upon arc-sin or Freeman and Tukey's tranformations of proportions. Freeman and Tukey's transformation was given by: $1/2 \{\text{Sin}^{-1} (r/n + 1) + \text{Sin}^{-1} [(r + 1) / (n + 1)]\}$ (Snedecor and Cochron, 1969; Freeman and Tukey, 1950).

RESULTS

Serology

Among 25 sera tested, 24 were from Doman Hill and one from Chirimiri. The MAC ELISA tests indicated DEN positivity in 13 cases (Table 2); one each among the positives were reactive to JE and WN viruses. The lone serum sample from Chirimiri colliery was negative. The positive sera were of 2(n = 3) male childern, 7(n = 15) men and 4 (n = 7) women. The HI tests conducted on paired sera did not provide conclusive evidence since 16 (64%) of these were reactive to more than one virus; DEN antibody titers of ≤40 were noted in 6 sera (considered negative), 80-320 in 11 sera (+ve), and 640 - ≥1280 in 8 (32%) sera (suggestive of secondary infections).

***Ae. aegypti* prevalence**

A total of 301 houses were visited in nine residential localities where BI of *Ae. aegypti* varied between 2.5 and 125.00 and the AHI varied between 5% and 60.0%. The overall *Ae. aegypti* positivity was noted in 86 (28.57%), the adults in 19.6% houses and the larvae in 17.28% houses. Among other species breeding of *Ae. albopictus* and *Ae. vittatus* was considerable (Table 3).

Virus isolations

None out of 21 males and 5 of 89 females of *Ae. aegypti* from the residential areas showed the presence of DEN virus antigen by IIFT (Table 4). DEN 2 virus was isolated successfully from two of the 5 females processed individually and both these isolates were obtained from the NCPH area.

Ae. aegypti (1F) and *Ae. albopictus* (2F) collected at the mine in NCPH, a nonresidential area, were found to be negative for DEN by IIFT.

***Ae. aegypti* breeding in water storage containers**

The water containers with *Ae. aegypti* breeding were significantly more in outdoor sites than indoors ($x^2 = 23.65$; $p < 0.001$) and in water containers for non-potable than those for potable purposes ($x^2 = 48.889$; $p < 0.001$). The number of indoor water containers differed by the purposes (potable or nonpotable) of storage ($x^2 = 33.196$; $p < 0.001$); but such outdoor containers had nonsignificant differences ($x^2 = 3.454$; $p > 0.05$). The number of water containers for potable purposes did not differ by indoor or outdoor locations ($x^2 = 0.002$; $p > 0.09$); nor did the non-potable water containers located indoors or outdoors differ ($x^2 = 0.191$; $p > 0.6$) (Table 5).

Table 2

The results of MAC-ELISA tests on the patient sera recieved from Chirimiri area during an outbreak during 1992.

Type of sera tested	No. of sera tested					
	DEN	JE + DEN	WN + DEN	Flavivirus	-ve	Total
Single	1	-	1	2	6	10
Paired	10	1	-	1	3	15

Table 3

Relative prevalence of *Aedes* species in Chirimiri area, 1992.

Colliery	No. of houses visited	No. of containers per 100 houses with			
		Ae. aegypti	*Ae. albopictus*	*Ae. vittatus*	Others
Doman hill	30	60.00	-	3.33	16.67
Chirimiri	40	22.50	5.00	10.00	2.50
West Chirimiri	40	2.50	5.00	17.50	15.00
Gadabuda	40	2.50	17.50	10.00	7.50
GM Complex	11	9.09	36.36	100.00	0.00
North Chirimiri	40	27.50	15.00	10.00	30.00
Korea	40	7.50	-	5.00	22.50
NCPH	40	22.50	27.50	5.00	7.50
Godripada	20	125.00	-	5.00	25.00

Table 4

Detection of DEN antigen in *Aedes aegypti* in Chirimiri area.

Locality	Nos. +ve/Nos. tested		
	Male	Female	Total
Doman hill	-	0/5	0/5
Chirimiri	-	0/2	0/2
N. Chirimiri	-	2/10	2/10
Korea	-	0/2	0/2
NCPH	0/16	3/28	3/44
Godripada	0/5	0/42	0/47
Total	0/21	5/89	5/110

The distribution of water containers as given by mode and mean differed from settlement to settlement, be it for potable purposes or not (Table 6). The mean ± SD of total containers examined was maximal at Godripada and the mode was highest at Gadabuda; the minima were noted in the settlements of Chirimiri and Korea.

For the purposes of anlaysis of frequency distributions ('n'-households) the data from all the settlements was combined and plotted against the number of containers present (= examined) in a house -'x' (Fig 2 a to c). A mode of 5 was observed in 18.6% households for total number of containers per house; it was 2 for potable water storage in 37.87% households and 1 for nonpotable water storage in 26.25% houses. The frequency of house-

Table 5

Presence/absence analysis of *Ae. aegypti* breeding by site and purpose of water storage in Chirimiri area.

Site	Outdoor		Indoor		Combined	
	+ve	Total	+ve	Total	+ve	Total
Potable	1	58	4	561	5	619
Nonpotable	55	542	20	227	75	769
Total	56	600	24	788	80	1,388

Table 6

Localitywise distribution of containers examined in Chirimiri area.

Colliery	No. of houses visited	No. of containers examined			Potable		Non-potable	
		Total	Mode	Mean ± SD	Mode	Mean ± SD	Mode	Mean ± SD
Doman hill	30	171	3&6	5.7 ± 3.13	4	2.67 ± 1.97	3	3.63 ± 2.13
Chirimiri	40	175	3&4	4.38 ± 1.86	3	1.93 ± 1.23	1&2	2.25 ± 1.46
West Chirimiri	40	193	4&5	4.83 ± 2.68	2	2.05 ± 1.48	2	2.7 ± 2.23
Gadabuda	40	163	8	4.075 ± 2.48	1&2	1.7 ± 0.82	3	2.38 ± 2.05
GM Complex	11	44	5	4.89 ± 2.37	0	0.45 ± 0.6	5	3.55 ± 2.88
North Chirimiri	40	176	5	4.33 ± 1.47	2	2.18 ± 0.93	1	2.325 ± 1.53
Korea	40	152	4	3.89 ± 1.52	2	1.7 ± 0.91	1	2.1 ± 1.28
NCPH	40	186	5	4.65 ± 2.11	1,2	2 ± 1.18	1	2.65 ± 1.76
Godripada	20	127	5-7	6.35 ± 2.62	3,4	3.5 ± 1.64	2&3	2.90 ± 2.22

holds with *Ae. aegypti* breeding (n^+) showed a significant correlation with those examined (n v. n^+; r = 0.7288, df = 13, $p < 0.01$); similar significant correlation was noted among the frequencies of nonpotable water containers (n_{np} v. n^+_{np}; r = 0.8411, df = 9, $p < 0.01$) and that of potable ones was nonsignificant (n_p v. n^+_p; r = 0.5814, df = 6; $p > 0.05$). There was no significant correlation between the LHI of *Ae. aegypti* and the water container classes of both nonpotable storage (r = 0.4918; d.f. = 9; $p > 0.05$) and the potable storage (r = 0.4123; d.f. = 6; $p > 0.05$), but their addition showed significant correlation (r = 0.6897, df = 13, $p < 0.01$). Thus there was an increase in the number of houses with *Ae. aegypti* as a function of the number of houses examined but not as a function of the number of containers per house examined either in 'n' or 'n^+'.

Association of *Ae. aegypti* breeding with water sources

The LHI of the households with single source (27.2%) was significantly more than those with dual source (16.56%; x^2 = 4.09; $p < 0.05$). Even among the households with single source of supply, households with tap water supply had more LHI (30.56%) than those with wells exclusively and the other categories (14.51%; x^2 = 3.9344; $p < 0.05$). The relative risk of the breeding of *Ae. aegypti* in a house with tap water supply (exclusively) was highest followed by taps + spring, taps+ wells and wells respectively; the drop in the relative risks of "Taps"

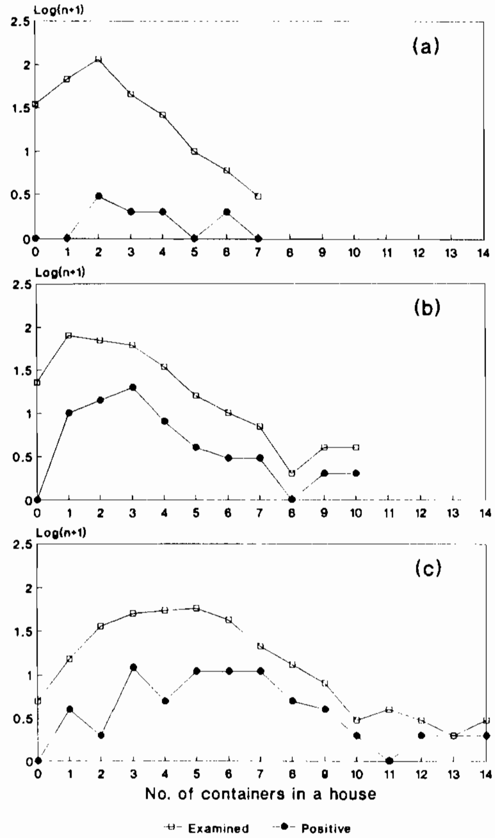

Fig 2 –Frequency polygon of households (n) in relation to (a) Potable water storage (b) Non-potable water storage and (c) Total water storage containers examined and those positive (n^+) for *Aedes aegypti*

was by 0.51 and 0.39 times when combined with springs and wells respectively (Table 7).

Type of larval habitats

The distribution of available water storage containers (*ie* wet containers) and those with *Ae. aegypti* are classified into 6 types according to the material by which they are made of and the purpose of water storage (Table 7). While the mud pots ranked 1st among available containers the cement tanks did so among the *Ae. aegypti* positive ones. Highest BPR was noted in iron drums followed by cement, tires, and the mud-pots with nonpotable water storage. In the remaining containers BPR for *Ae. aegypti* was <1, thus indicating no preference. Only a small but variable number of mud pots for potable purposes were observed to have become empty owing to routine water usage; but, no effort was made to enumarate these empty containers.

Comparison of indices

Significant linear relationship was observed when AHI *vs* BI and LHI *vs* BI were compared on arithmatic scale as well as on transformed scales. The r-squared values were significant ($p < 0.001$) when : a) BI *vs* LHI were regressed on arithmatic scale; b) Freeman-Tukey's transformed AHI *vs* LHI were compared; c) BI *vs* CI for total containers (T) as well as those for nonpotable containers (np) were also compared (Table 8). Slope value however was more for the BI *vs* CI (np) curve than that for BI *vs* CI (T). This was expected in view of the elimination of the poorly productive water contain-

Table 7

Association of the type of water supply and the presence of *Ae. aegypti* larvae (+ve) in Chirimiri area.

Type of water supply	No. of households			Relative risk
	Examined	+ve	LHI	
Well	17	1	5.88*	**
Taps	108	33	30.56	7.04
Wells & Taps	75	11	14.67*	2.75
Spring & Taps	82	15	18.92*	3.58
Unrecorded	19	1	5.26*	1.13

* Comparisons LHI with a common sign showed nonsignificant difference ($p > 0.05$) from each other.

** Absence of taps in these houses is considered as control for calculating the relative risk.

Table 8

Breeding preference ratios (BPR) of container types in Chirimiri area.

Type of containers examined	Containers examined with				BPR
	Ae. aegypti		Water		
	No.	X%	No.	Y%	
Iron drums	3	3.75	13	0.94	3.99
Metal (Potable)	0	-	160	11.53	0.00
" (Nonpotable)	6	7.50	171	12.32	0.61
Mud pots (Potable)	5	6.25	459	33.07	0.19
" (Nonpotable)	16	20.00	145	10.45	1.91
" (Partly buried)	0	-	2	0.14	0.00
Cement tank	45	56.25	350	25.22	2.23
Tires	1	1.25	8	0.50	2.16
Miscillaneous	4	5.00	80	5.76	0.87

ers for potable purposes which accounted for 44.6% of the available (Table 4).

DISCUSSION

The isolation of DEN type-2 from *Ae. aegypti* in this study, two isolations of DEN type-2 from patients in 1990 (unpublished data), and the serological evidence of recent DEN infections in 35.45% (n = 189) patients reporting at the regional hospital during 1990 to 1993 indicate a recurrent activity of DEN in the area (unpublished data). Further among these DEN seropositives ~42% had HI titers >1,280 thus indicating presence of secondary infection by DEN or other flaviviruses prevalent in the area. DEN activity in the proximity of a sylvan setting is of concern owing to the possible emergence of endemic dengue in the subcontinent. Further, vegetation is present in the Chirimiri area which is known to support the populations of *Ae. albopictus* and *Ae. vittatus* (Pant *et al* 1973). Their potential in DEN transmission is being documented in recent years (Metsellaar *et al,* 1980; Mavale *et al,* 1992).

During 1990, DEN 2 activity in DHF cases was noted in Calcutta, West Bengal (Bhattacharjee *et al,* 1993); which was often visited by some residents of Chirimiri. The activity of DEN-1, 2 and 3 were also observed in the adjoining states of Bihar, Uttar Pradesh, Rajasthan, Maharashtra and Gujarat (Mohan Rao, 1987; Chouhan *et al,* 1987; Ilkal *et al,* 1991; Mahadev *et al,* 1993b; Padbidri *et al,* 1995) whence other types of DEN could spread due to peoples movements.

Among the ecological aspects outlined by Pant *et al* (1973), the vegetation (as mentioned above) and the urbanization appeared to be more relevent in the context of dengue in Chirimiri area than the road transportation which is poorly developed and the altitude. Little significance of spread can be ascribed to a few tires in a private transport's tire dump with *Ae. aegypti* breeding in Haldibaldi area of Chirimiri township. There are some householders at Gadabuda who use tires to avoid their roofs being wind blown. Some of these tires harbored *Ae. vittatus* larvae. The range altitudes noted in this area were similar to those in Bangalore (850m - 925m) which had circannual activity of *Ae. aegypti* and DEN 1 and 2 (Soman, 1976; George and Soman, 1975).

Chirimiri area has a history of urbanization for ~40 years. KUA was formed in the census in 1981. Chirimiri area represents a case of despersed urbanization which is commonly observed in Madhya Pradesh. This contrasts with Maharashtra and Gujarat which showed concentrated growth (Premi, 1991). The decadal growth within Chirimiri area seems to owe to natural growth except at Doman Hill where it was >90% by 1991 perhaps due to people's in-migrations. The temporary movements

Table 9

Linear regression analysis between BI, AHI and LHI in Chirimiri
[y = a+bx (n = 9; df = 7)].

Comparison X	*vs* Y	a	byx	r^2	Sig p
AHI%	LHI%	1.5714	1.1721	0.7774	< 0.01
LHI%	AHI%	8.4142	0.6632	0.7774	< 0.01
BI	AHI	0.0446	0.4542	0.8105	< 0.01
BI	LHI	0.0285	0.6575	0.9610	< 0.001
BI%	CI(T)%	1.1812	0.1514	0.991	< 0.001
BI%	CI(np)%	1.0821	0.3128	0.9922	< 0.001
Sin^{-1} LHI	Sin^{-1} AHI	2.1171	0.6196	0.7918	< 0.01
Sin^{-1} AHI	Sin^{-1} LHI	0.3234	1.2778	0.7918	< 0.01
LHI-TUK	AHI-TUK	5.3124	0.7080	0.8140	< 0.001
AHI-TUK	LHI-TUK	-0.9861	1.1497	0.8140	< 0.001
BI	AHI-TUK	15.7189	0.2880	0.7091	< 0.01
BI	LHI-TUK	14.5819	0.4104	0.8869	< 0.01

BI-Breteau index; AHI-Adult House Index; LHI-Larval House Index; Sin^{-1} - Arcsin transformation; TUK = Freeman & Tukeys transformation; a - intercept; b - slope; r^2 = correlation coefficient; CI(np) - Container index in nonpotable containers; CI(T) - Container index in total containers.

of workers to home-towns/villages seem to have contributed to the import of recent DEN infections and the prevalent vectors in the area to sustain local transmission.

While in the large cities recurrent DEN outbreaks and DHF were reported (Kabra *et al,* 1992; Bhattacharjee *et al,* 1993) in the rural areas they were selflimiting, insular and spanned short durations (Newton and Reiter, 1992; Norman *et al,* 1991). Thus DEN-2 episodes in Chirimiri area since 1990 are akin to the urban outbreaks.

The people's water utilizations from diverse sources as noted in the present study was also observed in Ahmedabad city (Gujarat) and Ratnagiri (Maharashtra) (Mahadev 1985; Mahadev *et al,* 1993a). However the association of *Ae. aegypti* breeding with the tap water was noted only at Ratnagiri and the present study. The absence of significant association in Ahmedabad owed to the absence of representative sample in the data. It is significant that there was a reduction in the relative risk of *Ae. aegypti* breeding with dual water supplies. In Venezuella too an association of tap water supplies and the household positivity for *Ae. aegypti* breeding was observed (Barrera *et al,* 1993). But in Chirimiri area the statistical significances need to be interpreted considering the peoples' water utilization practises. In some of these settlements tap water was used exclusively for nonpotable purposes and in others for mixed (= potable and nonpotable) purposes.

As the present study coincided with monsoon showers, consequent highly humid climate supported prolonged survival of mosquitos. In addition there was a high frequency of wet cement tanks which offered stable breeding habitats for *Aedes* spp. These factors contributed to the significant correlations and linear relationships amongst the relative prevalence indices of *Ae. aegypti.* Among these indices the LHI *vs* adult densities showed positive correlation in the coastal towns of Tamil Nadu (Reuben and Soman, 1979). On the other hand in Nigeria the paired data used for such comparisons came from protracted studies and the statistics r and b differed from village to village (Bang *et al,* 1981); in Honduras a large number of poorly productive breeding containers (Gil-Bellorin, 1991) and the adulticidal applications for a break in DEN transmission in Ahmedabad (Mahadev *et al,* 1993a) contributed to the lack of association among these indices.

The essential outcome of the single-larva surveys is the positive attribute of the larval habitat of *Ae. aegypti* and CI represents the proportionality whose binomial expectation is given by $1\text{-}q^x$, where q = non positive habitat, x = the number of containers scored (Bang *et al,* 1981). BI values calculated from the binomial expectations of CI values observed in Chirimiri area matched closely with the observed BI (data not given). This owed to the total containers examined in a household as against a sampling program of a limited containers examined in the Nigerian study (Bang *et al,* 1981). In view of the presence of *Ae. albopictus* and *Ae. vittatus* present deductions reflect on the species frequencies. Therefore an estimate of actual container frequencies with *Aedes* sp will be essential for embarking on their control.

The workers choice determined the classification of containers examined *eg* Moore (1983) differentiated them by the fabric or the way they were filled, Focks *et al* (1981) by the shape and size of the containers. This study classified them as : a) nominal categories : outdoor/indoor sites, potable/ nonpotable purposes of water storage and 6 types by their fabric; b) the numerical classes of the number of containers per house which were further sorted for potability. Since there are multiple ways by which water containers were classified, the sumtotal outcome of this endeavor is a case of pooled probability as indicated by Moore (1983). By quantitative estimation of potable water storage and *Ae. aegypti* breeding in them an estimate of residual populations of the vectors can be made that following a larval control program in the nonpotable water storages. A prudent domestic management of the potable storages could bear benifits by minimizing the *Aedes* breeding as well as waterborne infections (Jonnalagadda and Bhat, 1995). Thus such inputs have bearing on the health in transdisease areas.

The container breeding of *Ae. aegypti* in Chirimiri was consistent with the deductions made from the data of Gujarat and Maharashtra on all the types of container classifications addressed except for the types of containers examined *viz*, a combined category of partly buried mud pot and cement tanks were predominant in Maharashtra, as were cement tanks in Gujarat (Mahadev, 1985; Mahadev *et al,* 1993a,b). The predominant containers with *Ae. aegypti* in Chirimiri were the cement tanks of various descriptions. They were situated below the ground level, on the ground level, inside and/or on the roofs of the residences.

Comprehensive epidemiological and ecological model building for DEN natural history and control demands systems approach of analysing various elements based on numerical data. Such an outlook is opposite to the normal reductionist scientific process (Focks *et al,* 1995). Various analyses conducted on the container breeding *Aedes* spp data of Chirimiri, is consistent with this approach. But the emphasis was laid on the qualitative aspects of those elements. Hereforth two courses of action will be open for follow up. On the onehand representative and quantitative data will be necessary for operationalization of the container infesting mosquito control. For this purpose scrupulous coverage of the nonresidential areas will also be needed taking into account the water utilization therein (Hofkes, 1983) and its contribution to container infestations by *Aedes* spp. Alternatively, present data should serve as basis for monitoring the impact of environmental changes brought about by the continued urban expansion or the displacement of the settlements due to the altered sites of coal mining.

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