Community-centred approach for the control of *Aedes* spp. in a peri-urban zone in the Andaman and Nicobar Islands using temephos

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ABSTRACT

**Background.** Chikungunya fever struck the Andaman and Nicobar Islands in July 2006. From the entomological point of view, dengue and chikungunya are hard to control due to the high prevalence of *Aedes aegypti* in both urban and rural areas. Mobilizing communities for the control of *Aedes aegypti* has not been attempted in India.

**Methods.** We did a prospective observational feasibility study in one peri-urban locality (Brookshabad) to assess the *Aedes* spp. infestation and subsequently test the efficacy of a community-based approach to control *Aedes aegypti*. An *Aedes* infestation larval survey was done with the assistance of community volunteers using the single larval survey (SLS) technique. House index, container index and Breteau index reflecting the relative prevalence and infestation levels were estimated. Various information, education and communication (IEC) campaign tools were developed to disseminate information about the prevalent situation. Several talks were organized to sensitize and motivate the people to realize the problem and participate in solving it. A two-pronged strategy, viz. environmental management through source reduction and anti-larval campaign using temephos was adopted to combat *Aedes* infestation through community involvement.

**Results.** A total of 533 water-holding containers were searched for *Aedes* larvae, both indoors (188/533, 35.3%) and outdoors (345/533, 64.7%) from 104 (104/235, 44.3%) premises. Of these, 109 containers (95% CI 17.19%–24.03%) were found to support *Aedes* spp. larval breeding (20.45%). The Breteau index was 104.8%. *Aedes aegypti* predominated followed by *Aedes albopictus*. The most abundant water-holding containers supporting *Aedes* breeding were plastic, metal drums and cement tanks. These water-holding containers were targeted for temephos application by the community volunteers. Forty rounds of temephos applications were carried out during the study period. The number of containers supporting *Aedes aegypti* breeding reduced significantly within 1 month post-intervention by community volunteers. As a result the Breteau and house indices dropped from 104.8% to 2.7% and 44.23% to 2.6%, respectively. Thereafter, the indices remained at zero level till completion of the study.

**Conclusion.** Larval indices indicate that *Aedes aegypti* is well established in peri-urban Brookshabad. Predominance of this mosquito species indicates infiltration into the peri-urban locality and beginning of displacement of *Aedes albopictus*. Epidemiologically, 3 categories of water-holding containers, viz. plastic, metal drums and cement tanks facilitate breeding of *Aedes aegypti*. Consequently, targeted source reduction as one way of selectively attacking the most important types of containers with temephos is feasible. Community involvement and networking with the residents allowed for a community-centred approach to combat *Aedes aegypti* infestation. As an outcome of this approach, the larval indices reduced significantly and remained low. We suggest that a control strategy emphasizing the use of temephos through a community-centred approach should be considered for these islands. However, close monitoring of this approach is warranted for long term sustainability.


INTRODUCTION

Dengue, dengue haemorrhagic fever and chikungunya are mosquito-borne viral diseases that occur in over 100 countries, placing two-thirds of the world’s population at risk.1,2 Unpublished WHO data indicate that there are 30–60 million cases each year, including thousands of deaths from dengue haemorrhagic fever (particularly among children). India is endemic for dengue fever/ dengue haemorrhagic fever.1,3 Epidemic outbreaks have been reported from time to time4,5 and many states have recorded clinical cases of dengue and chikungunya.1,4

In 1993, the World Health Assembly1 prioritized dengue control and prevention, and in 1995, a global strategy was drafted that combined the use of new surveillance and control tools, intersectoral involvement, improved training and community
involvement. However, success was limited due to the lack of effective methods to control the principal vector, *Aedes aegypti* (L.), an urban mosquito that breeds in water-storage containers as well as discarded containers that collect rainwater. *Ae. aegypti* almost disappeared from many countries 3 decades ago, when dichlorodiphenyltrichloroethane (DDT) was widely used, but it became widespread again after the use of DDT decreased. The occurrence of *Ae. aegypti* in the Andaman archipelago was reported in 1983. During the past decade, rapid urbanization in Port Blair has led to the proliferation of *Ae. aegypti* breeding sites resulting in an increase in prevalence and high infestation levels. The lack of infrastructure such as piped water and intermittent water supply necessitates storage of water in containers, and inadequate solid waste management has led to an accumulation of discarded containers. *Ae. aegypti* is also showing signs of infiltration into rural areas adjoining urban Port Blair. On the other hand, sero-epidemiological studies have shown evidence of antibodies to dengue and chikungunya.

Chikungunya occurred in many parts of the Indian Ocean islands, Southeast Asia and spread to peninsular India by the end of 2005 and to the Andaman Islands by July 2006. The majority of cases were reported from urban Port Blair where one-third of the population resides. The chikungunya outbreak in the Andaman Islands and the threat of dengue provided us an opportunity to involve the community in controlling the mosquito vector. We aimed to generate baseline estimates of *Aedes* spp. between August 2006 and October 2007.

**METHODS**

**Study site**

The community approach to control *Aedes* spp. was done in a peri-urban rural area, viz. Brookshabad, under Ward 17 of Port Blair Municipal Council. Ward 17 is headed by an elected councillor. In Brookshabad, there are 235 premises with a population of 1718 spanning over a surface area of 4 sq. km. Unlike urban Port Blair, households in Brookshabad are spaced out in a sylvatic setting. There is also a subcentre to cater to the healthcare needs of the local community. Numerous health delivery activities are coordinated through volunteers by health officers from the Primary Health Centre (PHC). For the purpose of comparison, a similar area, viz. Adampahad, was selected but no intervention was carried out.

**Identifying and sensitizing volunteers**

We identified volunteers through Seva Bharathi, a non-governmental organization. We explained the problem and sought their willingness to help us with this work. Subsequently, they were trained to conduct the survey and identify *Aedes* larvae.

**Baseline survey**

We aimed to generate baseline estimates of *Aedes* infestation and identify major breeding sources for targeting source-reduction measures. An intensive *Aedes* larval infestation survey was done with the assistance of community volunteers. Premises were inspected randomly. Inspection was conducted both indoors and outdoors within a 15-metre perimeter of a premise.

**Larval sampling**

The basic sampling unit was a house, which was systematically searched for water-holding containers. The single larval survey (SLS) technique was adopted with a slight modification, i.e. if there were both *Aedes* and *non-Aedes* larvae, *Aedes* larvae were deliberately selected to assess the infestation and prevalence. The immatures from different habitats were collected with the help of ladders with long handles and glass pipettes were used where ladders could not enter. Three indices, viz. the house index (HI), container index (CI) and Breteau index (BI), commonly used to assess relative prevalence and monitor *Ae. aegypti* infestation levels, were computed as follows:

- **House index (HI)**: is the percentage of houses infested with larvae and/or pupae and is expressed as
  \[ HI = \frac{\text{No. of houses infested}}{\text{No. of houses inspected}} \times 100 \]

- **Container index (CI)**: is the percentage of water-holding containers infested with larvae or pupae and is expressed as
  \[ CI = \frac{\text{No. of positive containers}}{\text{No. of containers inspected}} \times 100 \]

- **Breteau index (BI)**: is the number of positive containers per 100 houses inspected which is expressed as
  \[ BI = \frac{\text{No. of positive containers}}{\text{No. of houses inspected}} \times 100 \]

**Identification of species**

The immatures sampled from different habitats were transferred to plastic containers and brought to the centre’s laboratory and reared individually in plastic vials to adulthood. The adults were identified following standard keys.

**Sensitizing the community and social mobilization**

To disseminate information to the community about the magnitude of the problem, various information, education and communication (IEC) campaign tools were developed. Slide shows were organized to highlight the prevailing situation in the locality. Community volunteers were motivated to make charts/posters depicting the scenario and the remedial action to be taken by the residents. In addition, several talks were organized to highlight the extent of the problem and motivate people to participate in solving it. Eventually, a process of continuous dialogue was set in motion with community volunteers and residents. When asked whether they would control the larvae by themselves or not, they said they would do it if they were provided with temephos.

**The strategy**

We adopted a twin strategy to combat the *Aedes* problem—environmental management through source reduction and antilarval campaign using temephos. Through the volunteers, the residents were asked to periodically empty smaller water receptacles and inspect their immediate surroundings regularly for any such water containers. They were also asked to dispose of smaller containers, coconut shells, etc. and burn them periodically. Through community volunteers, the residents of Brookshabad were educated about the elimination of breeding foci.

Temephos 50% emulsifiable concentrate (EC) is the larvicide of choice, which is advocated routinely for public health purposes by the National Vector Borne Diseases Control Programme (NVBDCP), New Delhi. As per WHO recommendations, it is absolutely safe @ 1 mg/L (=1 part per million) level even in potable water. The application procedure is 2.5 ml of 50% EC diluted in 10 L of water. This dilute served as the stock for field application; 20 ml of this dilute was applied to the target source per one square metre surface area. Temephos was procured from...
the Directorate of Health Services, Andaman and Nicobar administration and made available to the community. The application procedure and calculation of surface area of the breeding sources was imparted to the community volunteers. The community volunteers were asked to apply temephos at weekly intervals and were advised to restrict the application to only those water sources which were not used for drinking and cooking.

Monitoring and evaluation
While volunteers carried out the above measures, we closely monitored and evaluated this approach. For this purpose a sample of 150 premises was surveyed randomly at monthly intervals for a period of 1 year covering all seasons, including those of the comparison area.

Statistical analysis
The 95% confidence limit for the proportion of containers supporting *Aedes* spp. breeding was estimated. The significance of difference in the proportion of containers supporting breeding indoors and outdoors was tested using chi-square test. The percentage value of the 3 indices for the experimental as well as the comparison area were transformed to arcsine values as dependent variables and analysis of variance (ANOVA) was done to normalize the data and analysis of variance (ANOVA) was done by taking transformed arcsine values as dependant variables and months (13) as factors. Comparison of group means of percentage reduction was done using the Student–Newman Keuls (SNK) test.\(^2\)

**RESULTS**

**Larval prevalence and species composition**

In all, 104 (104/235, 44.3%) premises were searched randomly for assessing the prevalence of *Aedes* spp. infestation. As many as 533 (mean: 5.13 containers per premise) water-holding containers were searched for *Aedes* larvae, both indoors (188/533, 35.3%) and outdoors (345/533, 64.7%); 109 containers (95% CI 17.2%–24.0%) were found to support *Aedes* spp. larval breeding (20.5%). The number of containers supporting breeding was significantly higher among containers located outdoors than indoors ($C^2=40.86$, $p<0.001$). The BI was 104.8%. From the 111 mosquito immatures, *Ae. aegypti* (74/111, 66.7%) predominated followed by *Ae. albopictus* (35/111, 31.5%). The other mosquito species were *Armigeres subalbatus* and *Culex quinquefasciatus*, and accounted for only 0.9% of the total immatures collected. The HI for *Ae. aegypti* and *Ae. albopictus* were 44.2% and 22.1%, respectively (Table 1).

**Water-holding containers supporting breeding of *Ae. aegypti* and *Ae. albopictus**

The most common water-holding containers supporting breeding were plastic and metal drums (Table II). The primary positive containers for *Ae. aegypti* breeding were cement tanks, metal drums and plastic drums. Secondary containers supporting this species included flower vases, plastic buckets, etc. The primary containers supporting *Ae. albopictus* breeding were discarded tyres, flower vases and others. Metal drums, plastic drums, plastic buckets were of secondary importance.

**Containers targeted for temephos application**

During the study period, 40 rounds of temephos application were carried out by the community volunteers. The number of plastic drums that were targeted ranged between 172 and 232. Likewise, metal drums and cement tanks ranged from 122 to 200 and 29 to 51, respectively (Fig. 1).

**Effect of temephos on larval indices**

The larval indices recorded in different months in the experimental community-based and comparison area (no intervention) are shown in Fig. 2. The number of containers supporting *Ae. aegypti* breeding decreased significantly within a month. As a result, the BI and HI dropped from 104.8% to 2.7% and 44.2% to 2.6% in 1 month. In January there was a spurt in all these indices. Thereafter, the indices declined in the month of February and remained at zero levels during the entire study period. ANOVA indicated that the reduction in the larval indices during different months of the study period, post-temephos application through community participation differed significantly (BI: $F=44.062$, df=25, $p<0.001$; CI: $F=55.877$, df=25, $p<0.001$; PI: $F=69.686$, df=25, $p<0.001$).

**DISCUSSION**

Effective *Ae. aegypti* control can be achieved by adopting an integrated approach that targets mosquito larvae. This species was eliminated from most countries in tropical America during the 1950s and 1960s, effectively preventing both epidemic dengue and yellow fever. Unfortunately, these programmes were terminated in the early 1970s. This was followed by the rapid re-invasion by *Ae. aegypti* of most tropical American countries, putting them at high risk for epidemic dengue. With the possible exception of Cuba, Singapore and Viet Nam are the only countries that have recorded successful control of *Ae. aegypti*.
Why was it successful in these countries? A combination of the ‘top down–bottom up’ approach worked in Cuba and Singapore, while successful exploitation of *Mesocyclops* in Viet Nam controlled the species. In all these countries, community involvement played a pivotal role in the control of this mosquito species. To the best of our knowledge, there is no documentation of the use of a community-based approach to control *Ae. aegypti* in India. Our study generated information on the prevalence and infestation levels of both the potential vectors of dengue and chikungunya, viz. *Ae. aegypti* and *Ae. albopictus* in a peri-urban area of Port Blair, in addition to the earlier record of *Ae. aegypti* and its widespread distribution within urban Port Blair. With very high larval prevalence indices, it is evident that *Ae. aegypti* is well established in the peri-urban area of Brookshabad. The preponderance of *Ae. aegypti* in comparison to *Ae. albopictus* in the sylvatic peri-urban Brookshabad probably indicates the infiltration of the former and beginning of displacement of the latter species, which hitherto could have been infested predominantly with *Ae. albopictus*. In peri-urban/semi-urban areas, *Ae. aegypti* co-exists with *Ae. albopictus* or other species of *Aedes*. Rapid urbanization tends to increase the habitats suitable for *Ae. Aegypti*, while *Ae. Albopictus* thrives in semi-urban, rural and sylvan ecosystems. Urbanization is gradually taking place in peri-urban Brookshabad, and therefore, we observed a co-existence of both species. Further, *Ae. aegypti* is expanding its niche to hitherto unknown peri-urban areas adjoining the urban agglomeration of Port Blair. A similar phenomenon has been previously observed in peri-urban areas adjoining Port Blair in South Andaman, northeastern India and elsewhere.

In Brookshabad, epidemiologically we identified 3 categories of water-holding containers—plastic drums, metal drums and cement tanks in and around people’s homes which provide the ideal habitat for *Ae. aegypti* larvae, while discarded tyres, flower vases and discarded containers support the breeding of *Ae. albopictus*. This allowed us to adopt targeted source reduction as one way of selectively attacking the most important types of containers with temephos. Evidently, the community volunteers consistently covered the key categories of water-holding containers for temephos application. Diligent community volunteers and networking with the residents of Brookshabad accomplished a focal point for a community centred approach to combat *Ae. Aegypti*. Environmental management through source reduction and an anti-larval campaign using temephos to combat *Ae. Aegypti* reduced the number of containers supporting *Aedes* breeding. As a result, there was a reduction in the larval indices during the entire study period. Elsewhere, temephos applied only during the rainy season, significantly brought down the larval indices and number of dengue cases. Complete reliance on temephos as the primary tool of a control programme,
could potentially create a false sense of security that it is sufficient to prevent dengue and chikungunya, leading residents to forego activities such as container management and cleaning the surroundings by discarding containers. Our study indicates that judicious application of temephos to only epidemiologically important categories of water-holding containers coupled with source reduction measures could achieve prolonged control of *Ae. aegypti* and *Ae. albopictus*.

From the entomological point of view, dengue and chikungunya are hard to control due to the high prevalence of *Ae. aegypti* in both urban and rural areas throughout India. Larviciding with 96%–98% coverage is a promising control measure but it is labour-intensive. The other method for *Ae. aegypti* control could be ultra-low volume (ULV) application of insecticides, which targets adult mosquitoes. Lack of efficacy of the ULV approach led to its re-evaluation and resulted in the development and widespread use of community-based, integrated approaches to *Ae. aegypti* control. With many of the top-down solutions in vector control having failed or becoming obsolete, there has been a paradigm shift towards building up activities from the grassroots. Community participation or local action is central to this approach. Since humans have contributed to the breeding of the *Ae. aegypti* mosquito, the most economical way is to develop mechanisms for people to delegate their responsibilities, authority and resources in the control of this mosquito species through source reduction.

We feel that the residents of peri-urban Brookshabad would not change their behaviour all of a sudden and remain ‘changed’. We believe that the residents are moving through subtle stages: from becoming cognizant, to becoming educated and convinced, deciding to take action, taking action, repeating that action, and finally maintaining the action. To that end, we have managed to educate and convince the residents. Currently, we feel the people are in the transient phase and the real challenge ahead is to lead them to the next paradigm by suggesting an effective and feasible new behaviour, which would prompt them to take the necessary steps towards adopting and maintaining the new behaviour. Close monitoring of this approach keeping long term sustainability in perspective is warranted. Since there is no regular vector surveillance or a control programme in place in these islands for the control of dengue and chikungunya, continued risk of dengue and chikungunya infection in Port Blair and its adjoining areas cannot be ignored. This approach could be extended further to urban Port Blair and similar settings elsewhere.

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