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Chennai (Tamil Nadu)

Chennai City contributes 60–70% malaria of Tamil Nadu. Simple techniques of mosquito proofing of water storage tanks were applied and simultaneous entomological and epidemiological indices were collected. It was shown that mosquito proofing can successfully control malaria in towns. Field operations were highly cost-effective and sustainable. The following additional contributions were made:

- Rainwater harvesting is creating a large number of mosquito breeding habitats that may become an important source of mosquito production, particularly the vectors of malaria and dengue. This finding should be seen in the background of increasing trend of rainwater harvesting and epidemic situations created by the spread of Dengue fever and Chikungunya virus
- Municipal bye-laws were amended and made more stringent

Background

Chennai City reports about two-thirds of all malaria cases of the entire Tamil Nadu state. To understand the dynamics of malaria transmission and mosquitogenic conditions in an urban setting and demonstrate the feasibility of using integrated method for malaria control, a field unit was opened in Chennai City in 1986. *Plasmodium vivax* was the predominant malaria parasite species and the annual parasite incidence was >10 per 1,000 population. *Anopheles stephensi* in the city and *An. culicifacies* in peri-urban areas were the main malaria vectors.

Activities, Progress and Achievements

Integrated vector control in Chennai City

Six highly malarious corporation divisions (No. 86, 87 and 88) in Chintadripet and Sowcarpet (No. 53, 54 and 55) were selected for demonstrating the feasibility of bioenvironmental methods in malaria control. The study was carried out from 1987 to 1992. The main breeding sites of *An. stephensi* were overhead water storage tanks and both unused and used wells. The intervention methods applied were: (i) introduction of larvivorous fish, *G. affinis,* in open wells and overhead tanks, (ii) introduction of expanded polystyrene beads in unused wells and unapproachable overhead tanks, (iii) mosquito proofing of overhead tanks that were difficult to check periodically and, (iv) demolition of defunct overhead tanks. With the implementation of this strategy, the proportion of overhead tanks with breeding of *Anopheles* declined from a pre-intervention status of 35.2 to 2.06% during the first year of intervention and was maintained below 4.06% during the later part of the study (Fig. 1). In wells, the habitat positivity declined from 26.5% to less than 1% (Fig. 2) (Chandrahas and Venkataramanaiah, 1994). Habitat positivity in OHTs and wells in control area was above 20% and ranged between 0.5 and 59.3%. The mean annual density of *An. stephensi* based on collections from cattle sheds ranged between 1.17 and 5.41per man hour in the experimental area and 7.29 to 18.24 in the control area. Thus the man hour densities in the experimental area were 2.8 to 6.6 times lower than the mean densities in corresponding months in the control area indicating reduction in vector densities due to effective interventions. However, in Sowcarpet area, though there was a reduction from 2.25 in 1987 to 1.07 in 1989, during subsequent years the slide falciparum rate (SFR) was slightly higher—3.17%. The SFR in Chintadripet area was 0.41 in 1991 and 1992. Though

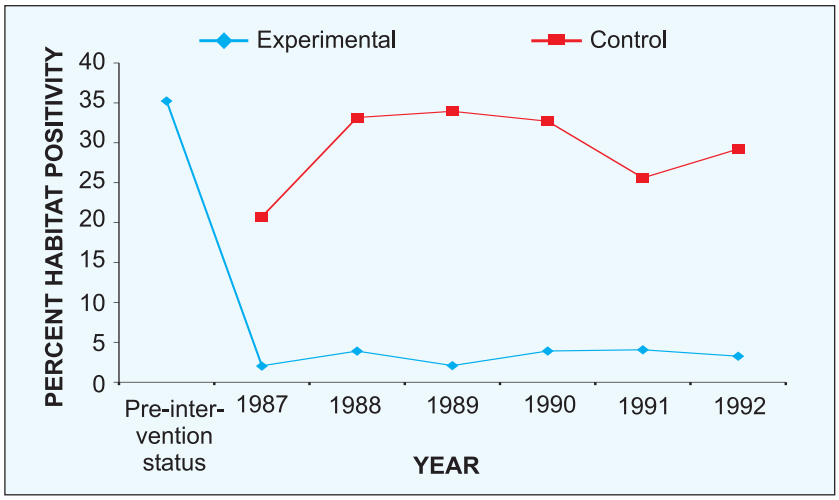


Fig. 1: Reduction of *Anopheles* breeding in overhead tanks after fish introduction

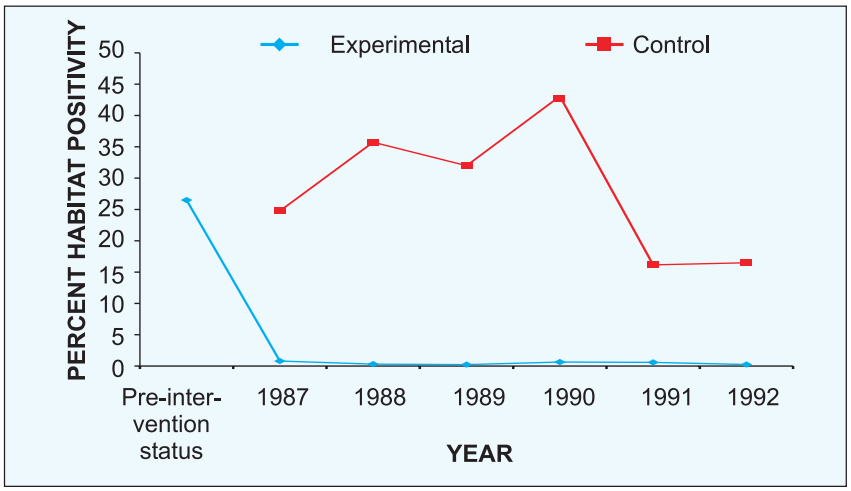


Fig. 2: Reduction of anopheline breeding in wells after fish introduction

the reduction in SFR may appear marginal, the desegregation of malaria cases registered on incorrect addresses, and exclusion of imported cases indicated a good impact on the control of malaria (Chandrahas *et al*., 1993).

Seven point action plan for control of malaria in Chennai

An action plan was prepared for integrated control of malaria in 6 municipal corporation divisions in Chennai. The action plan was submitted to the Govt. of Tamil Nadu in 1991. Highlights of the 7-point action plan are as follows.

Action by the Government

An appropriate Government order should be issued to all involved in building construction and maintenance to mosquito proof overhead tanks, wells and cisterns, providing proper drainage facilities and to use standard design to cover the same. Orders are also to be issued to nominate an official/person in each building/organisation with required budget for interaction, inspection and vector control activities. Government should provide technology and materials and facilitate provision of loans through banks/corporation with recovery in easy installments for mosquito proofing of breeding sources, identify sources for supply of larvivorous fishes, expanded polystyrene beads and mosquito larvicidal oil to public for procurement and use. Health department should identify mosquito-breeding habitats and prepare action plan for mosquito control. Technical guidance should be provided to different agencies/organisations involved in vector control activities. Health department should strengthen case detection and treatment.

Inter- and intra-departmental coordination

Health department of Corporation should solicit from their own and other departments, active participation in preventive and corrective aspects of mosquito control. Certain Governmental departments such as water supply, horticulture and fisheries should be involved directly in mosquito control programme by preventing any water logging in their areas of activity. Health department should also elicit people's, participation and involvement through educational programmes. School/college students and voluntary agencies should be involved in preventing mosquito breeding.

Legislative measures

Municipal byelaws should be implemented rigidly. For effective enforcement of Public Health Act and Madras City Municipal Corporation Act, Entomological Assistants should be empowered to issue notice to defaulters with prior approval of concerned Senior Entomologist. Fine to be imposed on defaulters should double up every time with non-compliance. The Government of Tamil Nadu in this respect should bring suitable amendment to the act.

Clearance from Health Department

New construction activity should be carried out only after clearance/permission from the Health Department of Corporation. All involved in new constructions should deposit towards expenditure on vector control activity. Health Department should decide on the amount based upon the number of sources created and duration of water storage.

Tropical aggregation of labour

It was observed that aggregation of labour for construction related activities had resulted in focal outbreaks of malaria in the city. To avoid this, the Health Department of the Corporation should ensure regular and aggressive antilarval measures using available tools such as larvicides, MLO, fishes, etc. in and around the construction site. All labourers at the camp should be screened for malaria regularly and promptly treated if found with malaria. In large populations of construction workers, one time screening and radical treatment to malaria patients should be undertaken.

Implementation mechanism

A three-phase implementation programme was proposed. During the first phase, mapping of breeding sources, implementation of byelaws, issue of Government orders, development of fish hatcheries and provision for availability of EPS beads, mosquito larvicidal oil and mosquito proofing devices were to be made. During the second phase, implementation of the strategy was suggested in all high malaria incidence areas (> API 20). In the third phase, all the other divisions of the city were suggested to be brought under the programme.

Constitution of committees

In order to oversee the implementation of the strategy, two committees namely a Steering Committee and a Project Committee were proposed. Steering Committee would be responsible for ensuring governmental and political support while the Project Committee was to oversee the implementation and monitor the progress.

Malariogenic stratification of Dindigul town

In Dindigul town (Tamil Nadu) malaria cases exceeded 10,000 in 1993 with API and SPR being 54.29 and 31.19, respectively. For a population of 1.87 lakhs, the numbers of malaria cases recorded were very high. The Directorate of Public Health and Preventive Medicine, Govt. of Tamil Nadu requested Malaria Research Centre to help in analysing the serious malaria situation, develop an action plan for the control of malaria and assist local authorities to prevent transmission of malaria in the town. The Chennai field unit carried out a house-to-house survey in all the 44 municipal wards during 1994–95. All potential *Anopheles* and other mosquito breeding places were identified (Table 1). The survey indicated overhead tanks, wells, cisterns and tap pits as the main breeding habitats of *An. stephensi* (Kar *et al*., 1996). During the malariogenic survey of Dindigul town, major factors responsible for transmission of malaria were identified. An action plan was prepared and submitted to the local health authorities for sustainable control of the malaria vector, *An. stephensi*. Intensive intervention activity by the local health department resulted in the reduction of malaria cases in Dindigul Municipality. A Geographical Information System (GIS) based module was prepared using data on house-to-house survey, anopheline and other mosquito breeding habitats, location of houses with population, etc. (Srivastava *et al.,* 2003). The output is available for use in updating GR for preventive vector control.

Table 1: *Anopheles* breeding habitats in Dindigul Municipal area

Breeding sources	Total No.	No. open	Breeding area (m^2)
Overhead tanks	3,809	3,257	10,011.5
Wells	1,642	1,622	12,848.3
Underground tanks	1,939	1,522	3,762.7
Tap pits	1,526	1,515	1,533.5
Inside tanks (P)	2,401	2,401	1,658.0
Outside tanks (P)	5,083	5,083	5,950.0
Inside tanks (T)	3,700	3,700	2,422.1
Outside tanks (T)	24,181	24,181	4,717.4
Barrels	5,315	5,315	1,225.4

P—Permanent; T—Temporary.

Mosquito breeding associated with rainwater harvesting

A field study on the implication of various rainwater harvesting structures on mosquito breeding was undertaken in Chennai. Rain water harvesting (RWH) in open wells, recharge wells, trenches, percolation trenches, percolation and junction pits and RWH underground tanks were identified as potential sources of mosquito breeding. Fortnightly surveys were carried out for mosquito breeding. RWH in open wells supported extensive breeding of *Culex* and *Aedes* mosquitoes. Larval positivity for *Culex*, *Aedes* and *Anopheles* in various habitats ranged from 3.6 to 18.8%, 4 to 11% and 3.6 to 6.3%, respectively (Figs. 3 a and b). *Culex* and *Aedes* mosquitoes were commonly observed breeding in trenches and larval positivity ranged between 7.7 and 100%. In Junction pits, intense breeding of mosquitoes was observed. Larvae of *Anopheles* and *Aedes* were found in 3.4 to 33.3% habitats and *Culex* larvae were found in 5.6 to 33.3% habitats. *An. stephensi, Cx. quinquefasciatus* and *Ae. aegypti* were the mosquito species observed breeding in the RWH structures. A brochure on "Rain water harvesting and ways to mitigate mosquito breeding" was prepared. Safe rainwater harvesting is essential to prevent the breeding of disease vectors, and it should be seen in the background of the rising trend of dengue and chikungunya.

Biology of *Anopheles stephensi* and *An. culicifacies*

Studies on bioecology of *An. stephensi* and its ecological variants revealed that all the three variants namely type form, intermediate and var. *mysorensis* occur in the city in high, moderate and low malarious areas. Intermediate form was the most prevalent form (96.6%), followed by type form (2.3%) and *mysorensis* (1.1%). Laboratory experiments on the susceptibility of the variants of *An. stephensi* to *P. vivax* infection indicated that all the three variants were susceptible, however, delayed sporogony was observed in var. *mysorensis.*

A detailed cytogentic analysis of *An. culicifacies* collected from Rameswaram Island for sibling species composition revealed that within species B there are two Y-chromosome variants- acrocentric and submetacentric in this population (Subbarao *et al.,* 1993). Later, the two Y-chromosome polymorphic forms were given species status following vector incrimination. Population with acrocentric Y-chromosome was designated as species B and that with sub-metacentric Y-chromosome as species E. Sibling species E is a vector while species B is a non-vector (Kar *et al.*, 1999). This study established that in Rameswaram Island, *An. culicifacies* is a mixture of sibling species B and E.

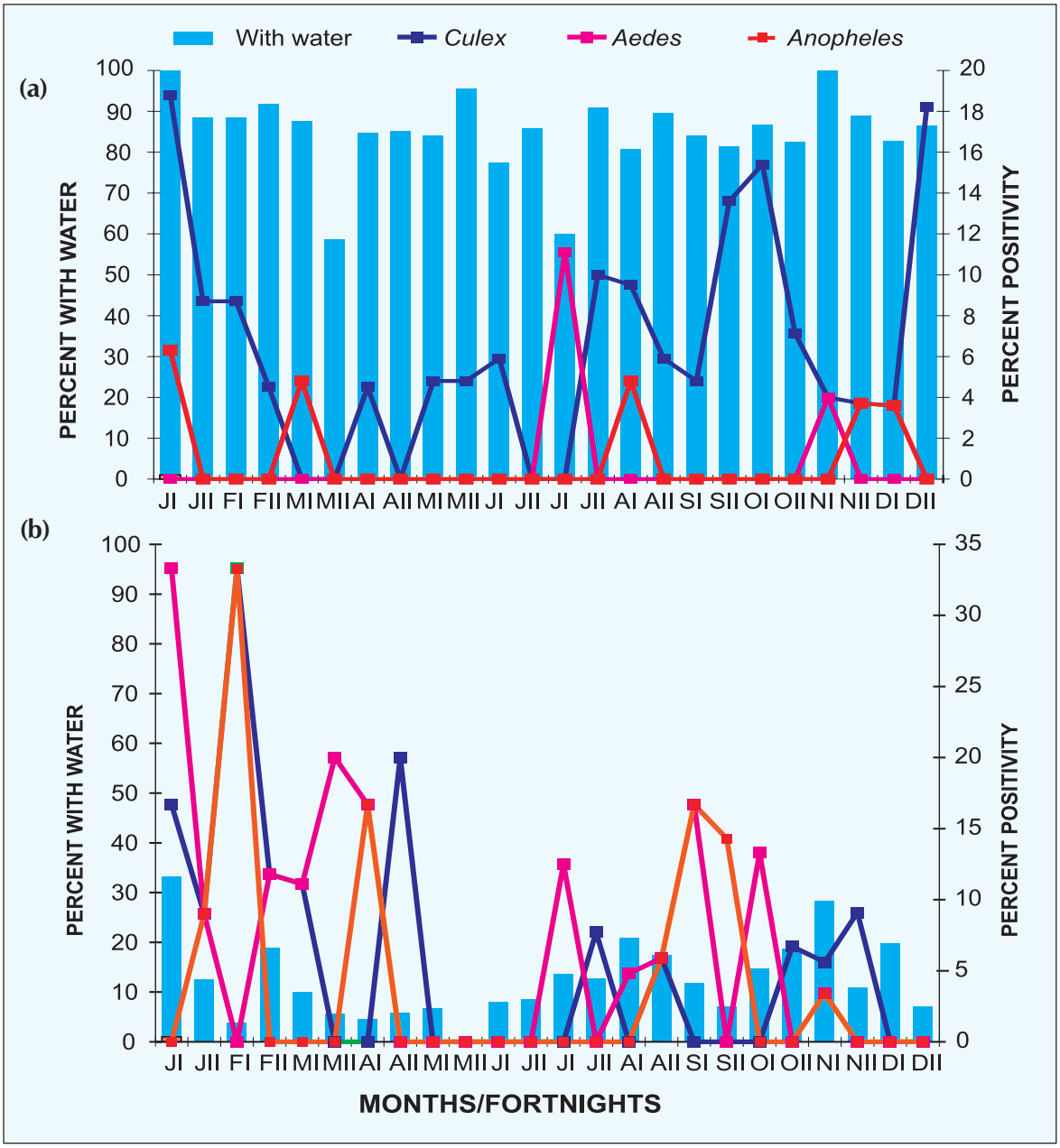
Evaluation of larvicides

Evaluation of biolarvicides

Large-scale trials of biolarvicides namely *B. sphaericus* and *B. thuringiensis* var *israelensis* were carried out against *Cx. quinquefasciatus* in Coovum river and Otteri nullah during 1993–94. Fortnightly application @ 1 g/m^2 of *B. sphaericus* caused larval reduction between 84 and 98% (Fig. 4), whereas the reduction ranged from 84 to 100% with *B.t.i.* (Fig. 5) (Kar *et al*., 1997). Based on the results, Govt. of Tamil Nadu had issued a circular approving the use of biocides as one of the intervention tools for vector control in the state.

Evaluation of an IGR compound

The larvicidal efficacy of an insect growth regulating compound, Hilmilin (Diflubenzuron- 25% WP) applied at the rate of 0.04 and 0.1 ppm/m^2 was evaluated against *Cx. quinquefasciatus* in domestic wells. The pre-treatment densities per dip recorded in control wells, and wells treated with 0.04 and 0.1 ppm/m^2 diflubenzuron were 66.8, 66.3 and 71.7 respectively. Reductions of more than 60% were obtained with 0.04



Figs. 3 a & b: Mosquito breeding in (a) rain water harvesting wells, and (b) junction pits

and 0.1 ppm respectively after 11 days post-treatment in trials with *Anopheles* (Fig. 6). Field evaluation of diflubenzuron in rice fields indicated that anophelines were more susceptible to this compound than culicines.

Field evaluation of Temephos

Field evaluation of larvicidal activity of Temeguard (Temephos 50% EC) against immatures of *An. stephensi* and *Ae. aegypti* was undertaken in overhead tanks and cisterns. The larval mortality obtained at an application rate of 5 ppm was 63–99% (Fig. 7). In cisterns, the percent mortality was 90.4 to 99.3 at 2.5 ppm dose. Against *Ae. aegypti*, trials were carried out @ 2.5 ppm in barrels (Fig. 8). Overall mortality recorded was 89.5% in the firtst trial and100% in the second and third trials.

Field evaluation of VectoBac tablets

Field evaluation of Vectobac tablets, a formulation of *B. thruingiensis* var. *israelensis,* was carried out against immatures of *Cx. quinquefasciatus* in fountain

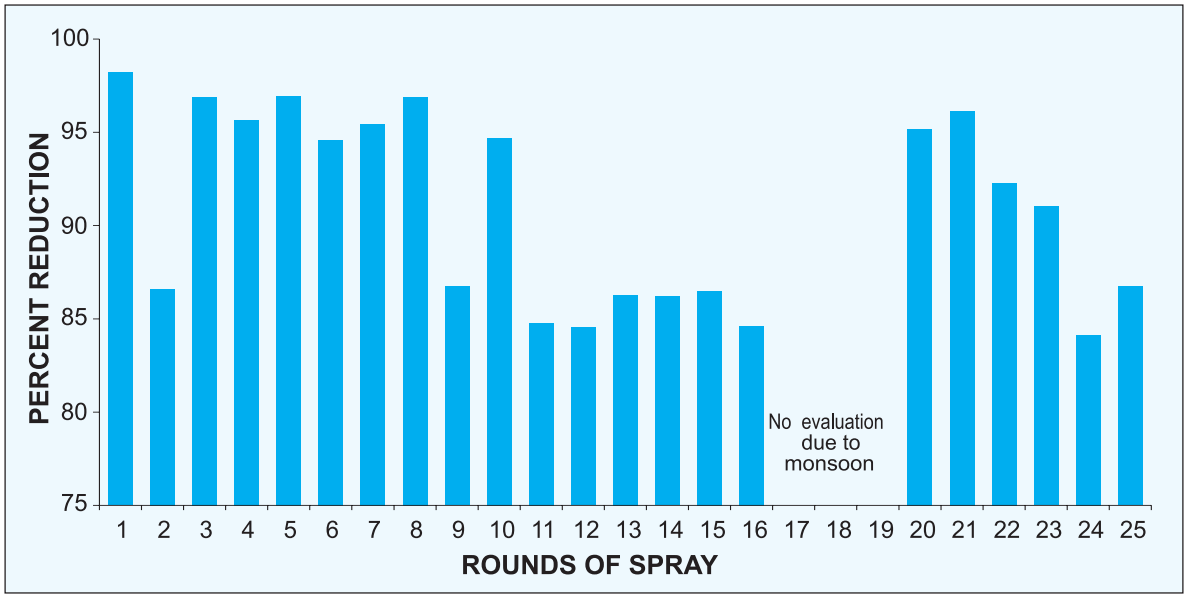


Fig. 4: Effect of *B. sphaericus* on III and IV instar larvae of *Cx. quinquefasciatus*

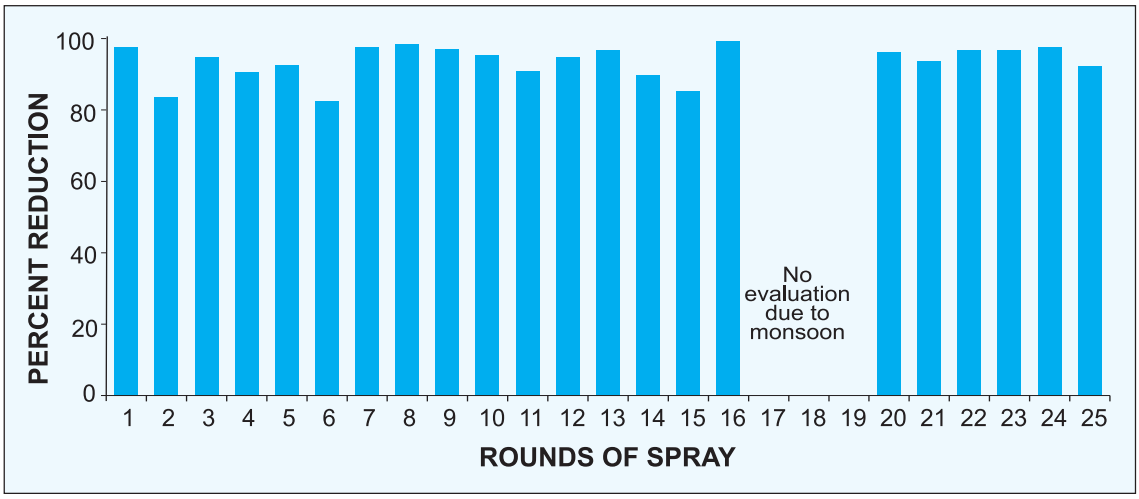


Fig. 5: Effect of bactoculicide on the larvae of *Cx. quinquefasciatus*

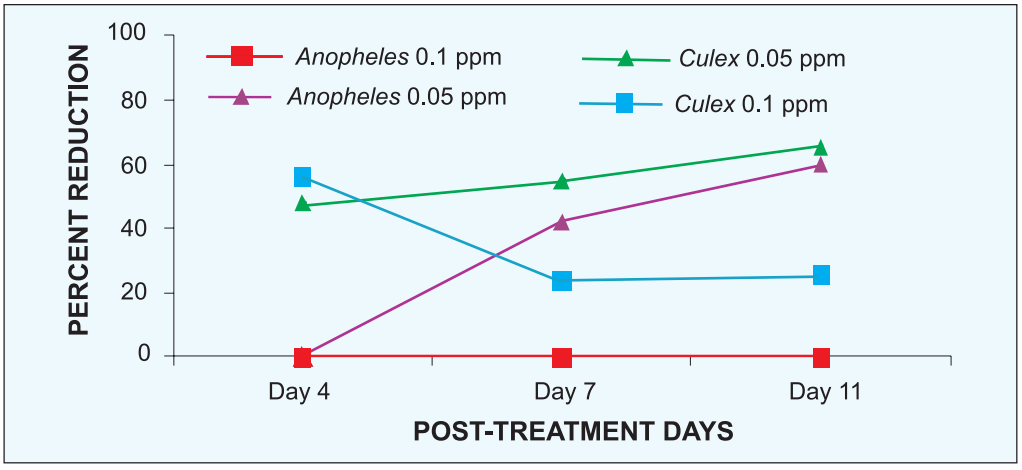


Fig. 6: Effect of Hilmilin on immatures' density of *Cx. quinquefasciatus*

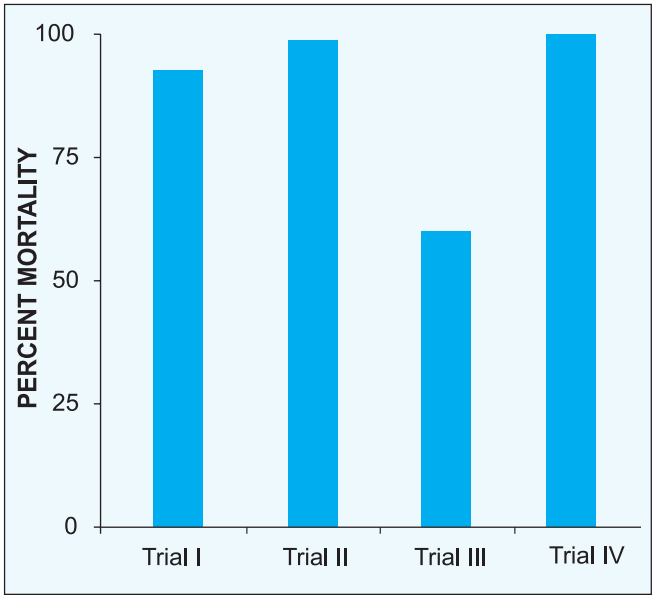


Fig. 7: Mortality of immatures of *An. stephensi* in overhead tanks treated with temeguard

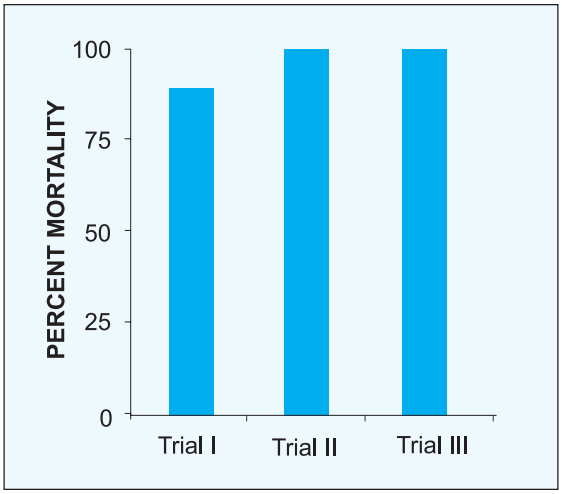


Fig. 8: Percent mortality of immatures of *Ae. aegypti* in barrels treated with temeguard @20 cc/m²

tanks and *An. stephensi* in unused overhead tanks. Application dose was 1/2 tablet (0.19 g) per 50 L against *Cx. quinquefasciatus* and 1 and 2 tablets per 50 L against *An. stephensi*. In fountain tanks, 92.7% reduction occurred in the density of *Cx. quinquefasciatus* larvae. In overhead tanks, there was 100% reduction in the density of *An. stephensi* larvae at the application of 1 or 2 tablets (Figs. 9 and 10).

Therapeutic efficacy of chloroquine

Therapeutic efficacy of chloroquine against vivax malaria using the standard WHO protocol was evaluated in Chennai. Results of 143 enrolled cases revealed 96.5% clearance of parasites by Day 3 and complete clearance within a week. The parasitaemia on Day 0 ranged between 352/µl and 39,680/µl. No recurrence of parasitaemia was observed on any day within 28 days after treatment. Good clinical response without any recurrence of fever indicated adequate clinical and parasitological response to chloroquine treatment. In another study in Rameswaram Island, 46 *P. falciparum* and 21 *P. vivax* cases were enrolled in the study. Follow-up on Days 2, 3, 7, 14, 21, 28 and on any other day when the patient reported with fever revealed 58.1% *Pf* patients with late treatment failure (Fig. 11). No recurrence of parasitaemia was observed on any day within the stipulated 28 days after treatment in all 21 *Pv* cases indicating adequate clinical and parasitological response.

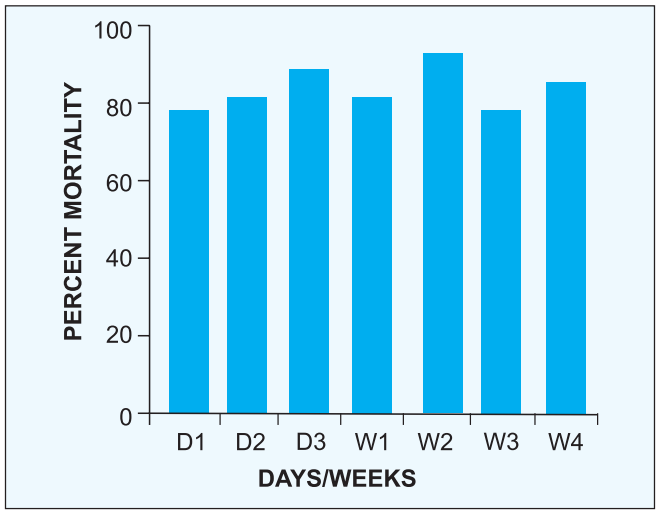


Fig. 9: Efficacy of VectoBac tablets against *Cx. quinquefasciatus* in fountain tanks

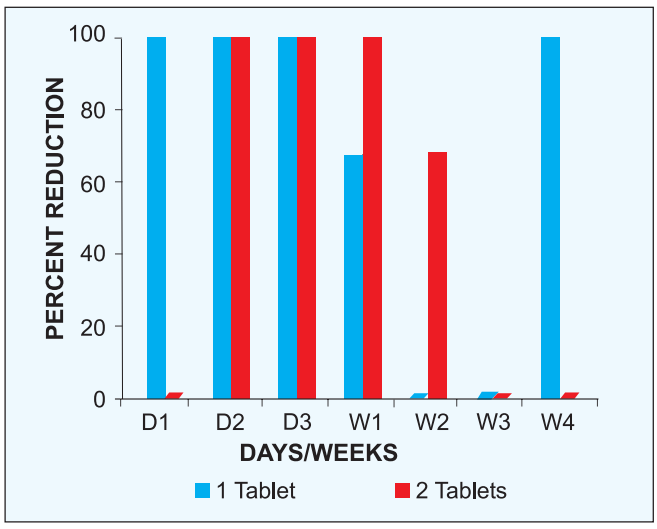


Fig. 10: Efficacy of VectoBac tablets against *An. stephensi* in overhead tanks

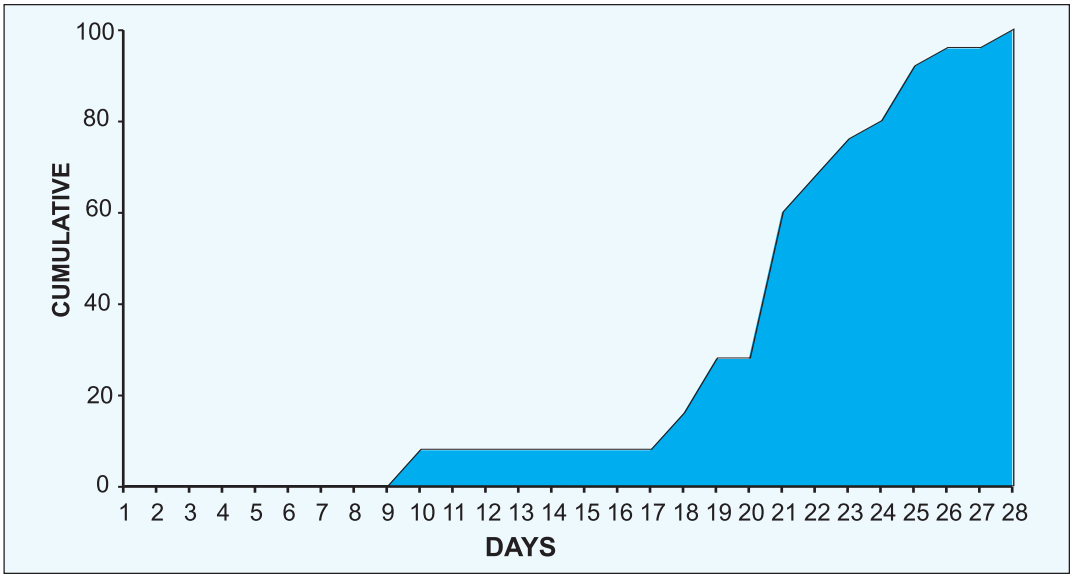


Fig. 11: Day-wise recurrent malaria episode in *Pf* patients after chloroquine therapy

Evaluation of rapid diagnostic tests for malaria

Efficacy of ParaSight®-F was evaluated for diagnosis of *P. falciparum* malaria in Chennai. The test performed on 93 febrile patients indicated 100% sensitivity and specificity for the detection of *P. falciparum* infection (Kar *et al*., 1999). Efficacy of ICT Malaria *Pf/Pv* immunochromatographic test kit (AMRAD-ICT) was also evaluated. A total of 268 cases were enrolled in the study including 10 and 44 falciparum and vivax cases, respectively. The sensitivity and specificity for *P. vivax* were 68.18 and 100%, whereas for *P. falciparum,* these were 100 and 89.9%, respectively (Valecha *et al*., 2002).

Malaria situation analysis

In Tamil Nadu, malaria situation analysis was undertaken in Tuticorin Municipality in July 1998. The study highlighted the potential breeding habitats of malaria vector and identified hardcore malaria areas in the town/municipality. Methods to control vector breeding and malaria control with reference to seven point action plan in an urban area was suggested in the form of a report and submitted to the Directorate of Public Health and Preventive Medicine, Govt. of Tamil Nadu. A close watch on the fishermen communities in the coastal areas and strengthening of surveillance activities were also suggested.

Situation analysis of malaria was undertaken in Rayagada and Malkangiri districts of Orissa state in September and October 2002 on a request of the Directorate of NVBDCP, Delhi. Kashipur and Gudari PHCs in Rayagada district and Korokanda and Kalimela PHCs in Malkangiri district were visited for the purpose. Dangosil (PHC-Kashipur) and Kodama (PHC-Gudari) sub-centres were also visited for a first hand assessment. The situational analysis undertaken was mainly to observe the functioning of malaria activities in these areas. The analysis observed deficiencies in the functioning of the laboratory in CHC/PHC and at sub-centre level, improper maintenance of MF 7, 8 and 9, unacceptable time lag between blood smear collection and examination, inadequate stock/supply of antimalarials, partial coverage of spray activities, inadequate manpower with respect to staff available and sanctioned, etc. A detailed report of was submitted to NVBDCP.

Malaria clinic

The malaria clinic functioning at the field unit receives patients from all over the city but mainly from Anna Nagar (East and West), Mogappair (East and West), Ambattur, Villivakkam, Koyambedu, Kilpauk, Nolampur and Virugambakkam. The examination of fever patients reporting at malaria clinic revealed that there is a gradual reduction in slide positivity rate (SPR) and proportion of *P. falciparum* cases. The SPR was high in late 1980s, which has been gradually coming down, and in 2004 it was 5.3% (Table 2).

Health education and training activities

Health education, particularly on the importance of

Table 2: Data of malaria clinic at IDVC field unit Annanagar, Chennai

YEAR	BSE	Cases	*Pf*	SPR	SFR	*Pf* %
1987	983	349	61	35.1	6.3	18.1
1988	2,384	991	100	41.6	4.2	10.1
1989	3,947	1,374	58	34.8	1.5	4.4
1990	3,720	1,508	31	40.5	0.9	2.1
1991	2,785	1,098	43	39.2	1.5	3.9
1992	1,945	491	20	25.2	1.0	4.1
1993	2,292	676	43	29.5	1.9	6.4
1994	2,708	864	32	31.9	1.3	3.9
1995	3,389	1,125	64	33.2	1.9	3.1
1996	4,986	1,520	147	30.5	2.9	9.8
1997	5,175	1,726	167	33.4	3.3	9.9
1998	8,312	2,471	221	29.7	2.7	9.1
1999	8,242	1,987	52	24.1	0.6	2.6
2000	7,924	1,319	81	16.6	1.1	6.4
2001	5,408	423	33	7.8	0.6	8.0
2002	3,327	112	5	3.7	0.1	4.5
2003	3,338	94	4	2.8	0.1	4.3
2004	2,501	126	8	5.3	0.3	6.3
2005	1.942	100	0	5.21	0	0

bioenvironmental control of malaria and the need for mosquito proofing of overhead tanks and wells, was highlighted in all the programmes organised independently by MRC and in collaboration with other voluntary organisations like YASS, Probus Club, Civic Exnora and other Associations like Mogappair, Ambattur Associations etc. A large number of health awareness programmes were organised. In addition, three important workshops were organised, one for Engineers and other two for administrators of various governmental departments like PWD, Telephones, Highways Department, Slum Clearance Board, Chennai Metro Water Supply and Drainage Board, etc. including senior level engineers (Chennai and Dindigul). The role of various departments in the creation of mosquitogenic conditions and necessary actions/precautions to be taken to prevent such conditions were highlighted to the participants.

Documents produced

1. Seven Point Action Plan for Malaria Control in Madras City. MRC Technical Information Series No. 003/92.

2. Seven Point Action Plan for Malaria Control in Urban Areas. MRC Technical Information Series No. 003/96.

3. Rain water harvesting and ways to mitigate mosquito breeding (Brochure).

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