

Nadiad (Gujarat)

First field unit to demonstrate the bioenvironmental malaria control, mass production and release of larvivorous fishes, and composite fish culture. The following additional field research programmes contributed to malaria control in Gujarat and other states.

- Health Impact Assessment and incorporation of remedial measures in development projects
- Ahmedabad City: In-depth studies on urban malaria and its control
- Malaria epidemic investigations and preventive interventions in earthquake-affected areas of Gujarat
- Field evaluation of new insecticides

Background

Several parts of Kheda district in Gujarat were badly affected by an epidemic of malaria in 1981 and there were reports of deaths due to malaria from some villages. Despite the implementation of a modified plan of operation by the NMEP in 1977, malaria incidence had remained high in several parts of the country including Gujarat state. In 1981, malaria incidence was high in Kheda district (API—27.7/1000 population). In Kheda district, malaria API during 1978 to 1982 ranged from 11.6/1000 to 27.7/1000 and Nadiad taluka was the most affected.

Use of chemical insecticides for indoor residual spraying to control malaria did not yield desired results and malaria control was proving to be difficult in this area. With this background, the Government of Gujarat requested the Indian Council of Medical Research, New Delhi to undertake applied field research on malaria using alternative methods of control. Thus, a field unit of MRC was established in Nadiad in March 1983 to demonstrate the feasibility of bioenvironmental control of malaria using alternative methods such as biological control, environmental management, health education, inter-sectoral coordination, and community participation. In 1985, the field unit initiated the IDVC Project for the first time.

Activities, Progress and Achievements

Bioenvironmental control of malaria

The first demonstration-cum-feasibility project on bioenvironmental control of rural malaria was launched in Kheda district in 1983 with the main objectives to: (i) demonstrate the impact of bioenvironmental approach on malaria; and (ii) develop a cost-effective model for extension to other similar areas. The main components of the project were reduction of mosquito breeding by environmental management and use of



Fig. 1: Application of EPS beads in an abandoned well



Fig. 2: Introduction of larvivorous fish for mosquito control

expanded polystyrene (EPS) beads (Fig. 1), biological control of mosquito breeding using mosquito larvivorous fishes (Fig. 2), health education, community participation, improved case detection and treatment, environmental improvement and inter-sectoral coordination.

The project was initially launched in 7 villages with a population of about 26,000 and later expanded to cover entire Nadiad (pop. 3.5 lakh, 100 villages) and Kapadwanj (pop. 3.4 lakh, 151 villages) talukas including Kapadwanj town. The project activities brought down the incidence of malaria and paediatric spleen rate markedly (Table 1).

Urban malaria epidemiology and control

Ahmedabad City: Malaria burden estimation and bioenvironmental control

The true burden of malaria in urban areas of India is currently not known. A retrospective epidemiological study was carried out in Ahmedabad City with over three million population to estimate the burden of malaria (Yadav *et al.*, 2003). Malaria incidence data for

the period from 1965 to 1998 collected through routine surveillance programme were analysed. *P. vivax* was the predominant malaria species followed by *P. falciparum*. Malaria incidence increased from 1967 to 1976, followed by the waves of low and high incidence. The study also reported that *P. falciparum* proportion was gradually increasing in the city since 1983 and the most probable cause was resistance to chloroquine, which has remained the first line antimalarial drug. To estimate malaria burden, malaria surveillance data and health records of the major public and private health facilities in the city were also analysed for the period between 1991 and 1998 (Table 2).

During this period the antimalaria programme reported an average of 4,119 cases (1.3 cases/1000 population/year). As against this, the malaria incidence was estimated to be nine times higher (37,431 cases, representing a mean annual incidence of 12.2 cases/1000). Similarly, the annual malaria-attributable mortality (22 deaths/million) was found to be much higher than that officially notified (0.3 deaths/million). The results of the retrospective analysis not only provide a more accurate baseline estimate of the burden of malaria in an urban area of India but also clearly indicate the need for a much more efficient health information system, for recording and managing malaria in such a setting (Yadav *et al.*, 2003).

Nadiad unit has been promoting bioenvironmental strategy to control malaria in other parts of Gujarat state. A detailed geographical reconnaissance of vector habitats in Ahmedabad was undertaken between 1996 and 1998. During the years 1999 to 2000, a project was undertaken to demonstrate feasibility of control of urban malaria with biological control, environmental management, improved malaria surveillance system and information, education and communication (IEC) in two municipal wards. Several larvivorous fish hatcheries in existing textile-mill tanks and ornamental tanks were set up. For comparison, entomological monitoring and malaria surveillance were carried out in 4 wards in which malaria control activities were being carried out under the urban malaria scheme of the NAMP. To test sustainability, all activities were implemented by Ahmedabad Municipal Corporation staff except for entomological monitoring, examination of blood smears and support in IEC. During the year 2000, 248 group meetings and nine lecture demonstrations in schools were organised in the wards where bioenvironmental approach was applied. Over 1,75,000 fish were released in different

Table 1: Malaria incidence in the area under the Kheda project (1983–1987)

| Year | Population | Malaria cases | API | Spleen rate % |
|------|------------|---------------|------|---------------|
| 1983 | 26,000 | 411 | 15.8 | 8.3 |
| 1984 | 26,000 | 141 | 5.6 | 4.9 |
| 1985 | 58,719 | 154 | 2.6 | 2.0 |
| 1986 | 3,47,906 | 626 | 1.8 | – |
| 1987 | 6,85,976 | 1,938 | 2.8 | – |

Table 2: Incidence of malaria cases, *P. falciparum* (Pf) cases and deaths attributable to *P. falciparum* in Ahmedabad City

| Year | Actual cases reported by Urban Malaria Scheme | | | Additional data retrieved from hospitals | | | | | | Total malaria cases | Deaths due to Pf reported by hospitals |
|------|---|-----------------|---------------------|--|---------------|---------------------|---|------------------------|-------------------------|---------------------|--|
| | | | | With malaria diagnostic facility | | | With only clinical examination facility | | | | |
| | Blood slides examined | Malaria cases | % blood slide (+)ve | Blood slides examined | Malaria cases | % blood slide (+)ve | Fever cases reported | Clinical malaria cases | Estimated malaria cases | | |
| a | b | c = (b x 100)/a | d | e | f | g | h | i = (f x g)/ 100 | b+e+i | | |
| 1991 | 150,373 | 9,932 | 6.6 | 45,364 | 5,196 | 11.5 | 269,000 | 147,234 | 30,811 | 45,939 | 102 |
| 1992 | 135,000 | 4,857 | 3.6 | 68,052 | 6,750 | 9.9 | 279,000 | 141,379 | 27,674 | 39,281 | 99 |
| 1993 | 115,697 | 3,887 | 3.4 | 71,606 | 7,677 | 10.7 | 291,000 | 172,792 | 31,199 | 42,763 | 59 |
| 1994 | 127,989 | 3,909 | 3.1 | 84,121 | 9,429 | 11.2 | 280,000 | 140,378 | 31,385 | 44,723 | 99 |
| 1995 | 120,864 | 3,366 | 2.8 | 83,363 | 7,159 | 8.6 | 258,000 | 126,045 | 22,156 | 32,681 | 45 |
| 1996 | 142,019 | 2,386 | 1.7 | 75,067 | 5,871 | 7.8 | 246,000 | 118,614 | 19,240 | 27,497 | 50 |
| 1997 | 164,482 | 2,353 | 1.4 | 73,292 | 7,270 | 9.9 | 244,000 | 104,886 | 24,203 | 33,826 | 63 |
| 1998 | 142,851 | 2,264 | 1.6 | 64,223 | 6,318 | 9.8 | 219,000 | 112,223 | 21,544 | 30,126 | 48 |
| Mean | 137,409 | 4,119 | 3.0 | 70,636 | 6,959 | 9.9 | 260,750 | 132,944 | 25,688 | 36,766 [§] | 71 [†] |

[§]Estimated number of malaria cases were 9 times (36,766/4,119) more than the reported cases; [†]Average of 2 malaria deaths per 1,00,000 population/yr.

mosquito breeding habitats including large domestic water storage practices. A system to stock and distribute fish was developed by establishing small cemented tanks at several ward-level offices. Minor engineering works and source reduction activities like filling-up of sluice valve chambers with earth at pumping stations, repair of water supply leakages, cleaning of storm water drains, filling-up of puddles, etc. were undertaken.

During the baseline period indoor resting densities of *Anopheles stephensi* and *Aedes aegypti* were comparable in both the groups of wards. Following the bioenvironmental activities, the densities were found lower than that in the wards under the Urban Malaria Scheme, or at the most comparable in lean months. Periodic surveys of intradomestic water storage practices were also undertaken. In the baseline month, 10.8% containers were found with larval breeding in bioenvironmental wards compared with 12.9% in routine control wards. In subsequent months, however, the container positivity rate ranged from 0.8–1.7% in the former areas compared with 2.9–9.1% in the lat-

ter, thereby showing marked impact of the alternative strategy on the larval breeding.

There was a significant impact on malaria incidence as well. The slide positivity rate (SPR) in the bioenvironmental wards declined from 8.02% in 1999 to 3.95% in 2000 in Paldi ward, and from 6.51 to 1.96% in Saraspur ward. During the corresponding years, malaria SPR in the wards under routine control increased from 3.86 to 5.24%. Thus, bioenvironmental measures were either more cost effective.

Surat City: Development of an integrated malaria control plan

A collaborative malaria control and research project was launched in Surat in 1999 with the assistance of Department for International Development-India through British High Commission, New Delhi. The project aimed to develop alternative, cost-effective and sustainable methods of malaria control for Surat, which could also fit into the ongoing antimalaria programme. Urban malaria research was one of the

important components of the project. At that time Nadiad field unit had been working on the epidemiology and control of malaria in Ahmedabad since January 1996 with the ultimate goal of preparing a comprehensive malaria action plan for the city. Based on this experience, MRC was identified to undertake vector bionomics study in Surat City in collaboration with the Surat Municipal Corporation (SMC). The project was launched with the major objectives to assist the development of an appropriate and efficient entomological monitoring unit to provide sustainable entomological support to the urban malaria control programme, to study the vector bionomics in Surat in order to understand malaria transmission dynamics, to evaluate vector susceptibility to insecticides and larvicides so as to rationalise their usage in the programme, to evaluate the sensitivity of *P. falciparum* and *P. vivax* to antimalarial drugs, and to assess the need for engineering and environmental methods of vector control.

A well-equipped entomological monitoring unit was established in the premises of the SMC as a part of the project objectives. Entomology staff of SMC were imparted training in various entomological techniques at Nadiad field unit. A detailed study on vector bionomics and larval ecology was conducted. Drug sensitivity study was done and insecticide susceptibility tests were conducted. An integrated plan for control of vector borne diseases was developed, which is being sustained now by the SMC. This has led to a rationale use of insecticides in the city.

Integrated control of malaria and dengue in northern Gujarat

The semi-arid area of Gujarat state is suitable for implementation of an integrated strategy for malaria and dengue control due to the reason that malaria is unstable and is mainly associated with excessive rainfall. Local and focal outbreaks of dengue are caused by increased prevalence of vector populations due to increased tendency of the people to store water during water scarcity periods. Spraying of residual insecticides for malaria control during the past several years has not yielded consistent results and the problem of malaria is once again on the rise in the entire north Gujarat. Development of resistance in vector mosquitoes to DDT and malathion, and prohibitive costs of pyrethroid insecticides have necessitated the implementation of an evidence-based integrated approach to disease and vector control, which may ultimately provide long-lasting benefits. Accordingly, a WHO supported study was conducted in north Gujarat from

2002 to 2004 with the aim to contribute to the development of rationale strategies and policies for the control of malaria and dengue. Major objectives of the study were: (i) to identify mosquito larval habitats by geographical reconnaissance to plan appropriate antilarval methods; (ii) to study vector bionomics and in particular the role of sibling species of main malaria vector(s) in malaria transmission; (iii) to evaluate vector susceptibility to insecticides used for indoor residual spraying; (iv) to suggest a rapid response mechanism for containment of disease outbreaks; (v) to assess training needs of the antimalaria programme; and (vi) to conduct training and inter-sectoral workshops at different levels.

Field work was carried out in 6 districts and based on the study outcome, an integrated control strategy was suggested for malaria and dengue control. Components of the strategy are listed below:

- Assessment of the risk of disease and stratification
- Development of a management information system and epidemic containment
- Increasing access and coverage to diagnosis and complete treatment
- Strengthening of laboratory and diagnostic services
- Drug supplies and drug resistance monitoring
- Dengue surveillance, diagnosis and treatment
- Vector management
 - Assessment of vector management needs
 - Vector management in high risk/epidemic-affected areas
 - Vector management in hypo- to meso-endemic areas/villages
- Advocacy
- Inter-sectoral cooperation
- Legislation for development works in rural areas
- Operational research
- Capacity strengthening
- Monitoring and evaluation

Epidemiological and parasitological studies

Malaria is unstable in Gujarat state and *P. vivax* is the predominant species (60–70%). Rainfall and its distribution, irrigation, paddy cultivation and migration of labourers from endemic districts influence malaria transmission. The main malaria transmission season extends from July to November corresponding with the monsoon season. Spring transmission is short. During summer *P. vivax* prevalence is mainly due to

relapses. In a longitudinal study, relapse rate within 8 months of primary attack was found to be around 40% in vivax cases not treated with primaquine compared with 2.6% within 1 year in patients treated with 5-day course of primaquine (Sharma *et al.*, 1990). In another study, relapse rates with chloroquine alone and in combination with pyrimethamine was found to be 28.3 and 27.7% respectively (Srivastava *et al.*, 1996).

Studies have also been carried out at the field unit on frequency of ABO blood groups, sickle-cell haemoglobin, G-6-PD deficiency and their relationship with malaria in Muslim and Christian communities, scheduled castes and scheduled tribes (Pant *et al.*, 1992), upper caste Hindus (Pant *et al.*, 1993) and other backward castes of Kheda district (Pant and Srivastava, 1997).

Gujarat state lies in the eco-epidemiological setting of semi-arid plains. In the semi-arid plains of western India, malaria is unstable and comes in 5–8 year 'troughs and crests' associated with rainfall variations. Analysis of the trend of malaria in Gujarat state over 1961–2005 shows that two major epidemic waves have occurred in the state with the first major peak incidence in 1976 and the second one in 1989 (Fig. 3).

Focal outbreaks of malaria have also occurred in certain high rainfall years. In normal years, the proportion of *P. vivax* in all cases remains around 80% and that of *P. falciparum* around 20%. During the epidemic

years, the ratio of *Pf* reaches up to 35%. Increase in *Pf* cases is likely to increase the proportion of severe and complicated cases and deaths due to malaria.

Malaria control activities are carried out through the primary health care system in Gujarat. Surveillance of past and present fever cases is carried out on fortnightly basis by the multi-purpose health workers. Blood slides are sent to the PHC for staining and examination. Staining is done mainly with the JSB stain. In a study it was found that there was no statistically significant difference in the results of Giemsa stain, difference in clarity of malaria parasites and leucocytes and the number of artefacts (Gautam *et al.*, 1992). A study found that 2% blood smears were misdiagnosed as positive and 6.7% blood smears as negative and misdiagnosis could cause no or improper treatment of a large number of patients (Gautam *et al.*, 1992). Poor or no surveillance, inadequate therapeutic measures and inadequate, ineffective and untimely vector control operations have resulted in enhanced malaria transmission (Srivastava *et al.*, 1995) and outbreaks in several parts of Gujarat state (Sharma and Gautam, 1990; Srivastava and Yadav, 2000) as well as in neighbouring states like Maharashtra and Rajasthan.

Health impact assessment of development projects

Nadiad unit is mandated to carry out studies on health impact assessment (HIA) of development projects. A

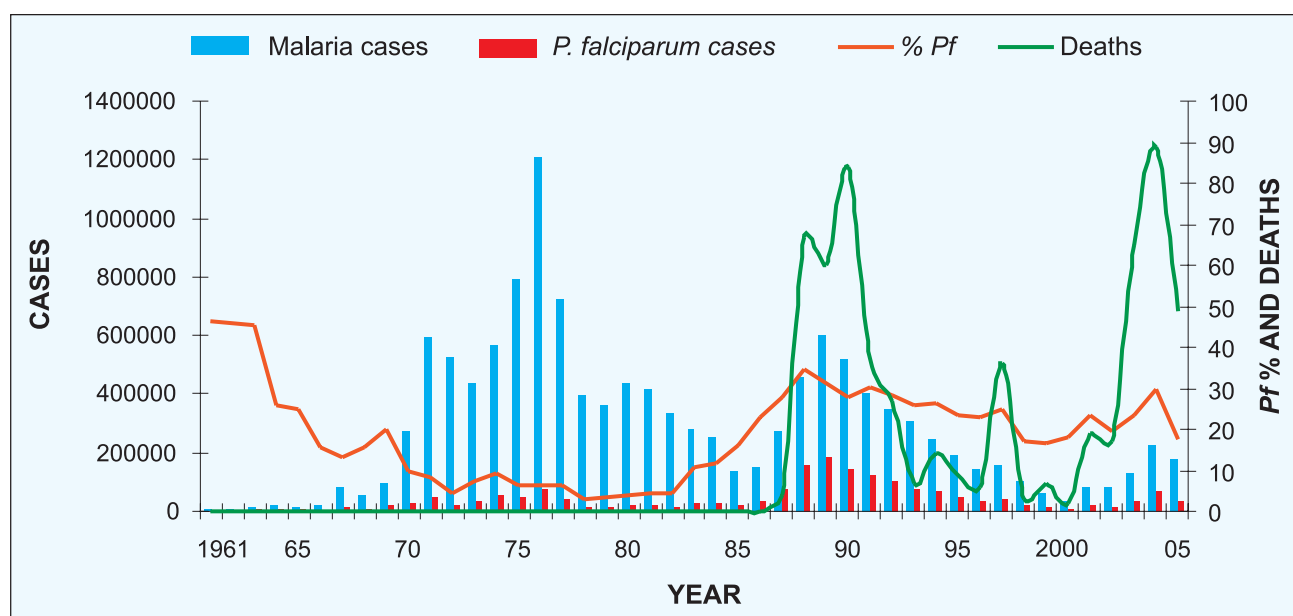


Fig. 3: Malaria situation in Gujarat

collaborative research project on the HIA of Sardar Sarovar Project with particular reference to communicable diseases was initiated in 2002 in collaboration and financial support of the health department of Government of Gujarat to assess environmental receptivity, community vulnerability and preparedness of health services at the project site, command area and rehabilitation sites. Apart from malaria, the study aims to assess impact on other communicable diseases such as filariasis, Japanese encephalitis, dengue and leishmaniasis.

Entomological monitoring was done in sentinel sites at the dam site labour colony, in the command area, non-command area and the rehabilitation and resettlement colonies of the project-affected people to study the vector bionomics and vectorial potential in the areas. Study of the vector ecology has shown breeding of malaria vector *An. culicifacies* and other mosquito species namely *Cx. vishnui*, *Cx. tritaeniorhynchus*, *Cx. quinquefasciatus* and *Ae. vittatus*. A geographical reconnaissance along 144 km of the main canal as well the canal network in Phase 1 districts of Narmada, Vadodara and Bharuch has been completed to locate new mosquito breeding habitats created. Preventive and remedial measures have been suggested.

Baseline malaria incidence survey during the pre-irrigation phase showed low incidence of malaria. Data on the prevalence of various vector-borne diseases are being collected from PHCs in all the districts in the command area. GIS-based malaria risk maps are being created each year to plan and suggest necessary remedial/control measures. A survey of Cyclops and snails has also been conducted and further work on the project is in progress.

Studies have also been carried out on malaria associated with the Mahi River ecosystem covering three different stretches of river like rocky, sandy and tidal areas. The study highlighted the importance of local riverine ecosystems in maintaining varied endemicity of malaria and impact of irrigation on malaria in the Mahi command area.

Evaluation of therapeutic efficacy of antimalarial drugs

A large number of malaria cases are imported by migratory labour and travellers, and contribute to a high proportion of chloroquine resistant *P. falciparum*

(Sharma and Sharma, 1988). Problem of chloroquine resistant *P. falciparum* has been observed in various districts of Gujarat as well as neighbouring states of Rajasthan and Maharashtra (Karmakar *et al.*, 1990), and in migrant labourers from various endemic parts of Gujarat as well as other states coming to Kheda, Surat City and Sardar Sarovar Project area (Srivastava and Sharma, 2000).

It has been observed that the proportion of falciparum malaria has been steadily rising in Gujarat during the past two decades. Chloroquine resistance is attributed to this rise (Yadav *et al* 2003). Following recent outbreaks of malaria in central Gujarat, a study to evaluate therapeutic efficacy of chloroquine against *P. vivax* and *P. falciparum* was conducted in Anand and Kheda districts using standard WHO procedures. About 1,377 patients were screened for malaria parasitaemia in Deva and Pansora PHCs in District Anand, and in Chaklasi PHC in District Kheda. In Pansora PHC of Anand district and Chaklasi PHC of Kheda district high proportion of treatment failure of falciparum malaria with chloroquine was found. Using the results of study, NVBDCP has advised Gujarat state to change the drug policy in these areas.

Evaluation of malaria rapid diagnostic tests

Some rapid diagnostic tests have been evaluated for diagnosis of malaria at the malaria clinic of the field unit and in villages. An immunochromatographic test (ICT malaria Pf) based on detection of *P. falciparum* HRP-II antigen was evaluated and compared with the examination of Giemsa stained thick blood films. The ICT test was 99% specific and 92% efficient (Yadav *et al.*, 1997). Another rapid diagnostic test, OptiMal[®] was found to have high sensitivity and specificity for diagnosis of *P. vivax* and *P. falciparum*. Sensitivity of Paracheck[®] for *P. falciparum* parasites was 93.3%, while that of OptiMal[®] was 93.3 and 83.3% for *P. vivax* and *P. falciparum*, respectively (Valecha *et al.*, 2003). Paracheck[®] test for diagnosis of *P. falciparum* supplied by NVBDCP was also evaluated.

Bionomics of anophelines

Various aspects of biology and ecology of mosquitoes particularly of malaria vectors have been studied in Kheda district and other parts of Gujarat state and neighbouring states of Maharashtra and Rajasthan. In Kheda district, 16 anopheline species were found, and

of these, eight have been recorded for the first time (Yadav *et al.*, 1989). *An. culicifacies*, the main malaria vector in the plains, is endophilic though a sizeable proportion also rests outdoors as revealed by collections from artificial pit shelters. Presence of all gonotrophic conditions proves its outdoor resting habit even in the absence of any insecticide pressure (Bhatt *et al.*, 1989). Among various mosquito sampling methods evaluated, animal bait collection method was found most productive of all and maximum number of species and highest number of anophelines per unit of collection effort were collected (Bhatt *et al.*, 1991).

Abundance of anophelines varies greatly with seasons in Kheda district. In the canal-irrigated areas, density of *An. culicifacies* shows increasing trend from February and attains peak during March coinciding with release of irrigation water for pre-monsoon paddy cultivation and thereafter showing a declining trend till July. The second rise in its density occurs during the monsoon months and stabilises during August to October again declining in December. In the non-canal irrigated areas too the density follows a similar pattern but at a low level, whereas in riverine villages high density of *An. culicifacies* has been observed from January to April and thereafter it remains moderate to low during rest of the year (Bhatt *et al.*, 1991). *An. culicifacies*, *An. stephensi* and *An. fluviatilis* are predominantly zoophilic species. Survival and expected infective life of all vectors remain high during the cold season (Bhatt *et al.*, 1994).

In areas with low cattle population, high values of human landing rate (17.4/man/night), anthropophilic index (12.3%, n = 2443) and the mean sporozoite rate (0.64%, 10/1568) have been observed which vary significantly between indoors and outdoors during the hot and rainy seasons, and also between different quarters of the night. Vectorial capacity estimates for different months show positive correlation with the malaria slide positivity rate in the population ($r = 0.09$, $p < 0.05$) in such areas. *An. culicifacies* exhibits bimodal biting rhythm and shows a seasonal shift in its peak biting activities. Biting activity has no correlation with the temperature and relative humidity during most parts of the year (Bhatt *et al.*, 1991). *An. stephensi*, *An. subpictus*, *An. vagus* and *An. varuna* species exhibit unimodal rhythm with most of the feeding occurring during the early part of the night with occasional increase during pre-dawn/dawn hours (Bhatt and Kohli, 1996).

An. culicifacies has been observed to be a ubiquitous

species breeding in all types of habitats available, whereas *An. fluviatilis* and *An. stephensi* have shown restricted breeding preferences (Yadav *et al.*, 1989, Bhatt *et al.*, 1996). Mosquito breeding preferences in tree holes (Srivastava, 1989), domestic water storage containers (Gupta *et al.*, 1992), ponds infested with water hyacinth (Rajnikant *et al.*, 1992), wells (Rajnikant *et al.*, 1993) and urban sewage system (Haq *et al.*, 1998) have been studied in detail. Among the anophelines breeding in various habitats in canal irrigated areas, breeding of *An. culicifacies* is associated with *An. annularis* in ponds, paddy fields and small pools, with *An. stephensi* in paddy fields and *An. subpictus* in domestic containers (Bhatt *et al.*, 1990). In non-canal irrigated areas, species diversity and homogeneity are highest in seepage drains. Inter-specific associations occurred most commonly in habitats representing the stable ecosystem (Bhatt *et al.*, 1993).

Evaluation of vector control agents

During the demonstration project on bioenvironmental control of malaria, several studies were carried out simultaneously at the field unit. These include field trials on the application of expanded polystyrene (EPS) beads in mosquito control (Sharma *et al.*, 1985), studies on the role of indigenous fish in the control of mosquito breeding (Sharma *et al.*, 1987), bioenvironmental control of malaria linked with edible fish production (Gupta *et al.*, 1989), isolation and evaluation of fungal and bacterial strains for mosquito control (Patel *et al.*, 1990; Gupta *et al.*, 1991) and sensitivity of mosquito-pathogenic bacterial strains to various antibiotics (Gupta *et al.*, 1992).

Evaluation of new insecticides and larvicides

In collaboration with WHO Pesticide Evaluation Scheme (WHOPES), Geneva and the Indian R&D industry, field evaluations of new insecticides or improved formulations of existing insecticides and larvicides have been carried out. During July 1999 to March 2000, bifenthrin 10% WP (synthetic pyrethroid) and fipronil 80% WDG were tested against *An. culicifacies* in collaboration with WHOPES in an area in central Gujarat where *An. culicifacies* is the major malaria vector species. Some parts of central Gujarat including Kheda district and the entire south Gujarat are triple resistant areas, i.e. *An. culicifacies* has developed resistance to three conventional insecticides—DDT, HCH and malathion. It is in these areas

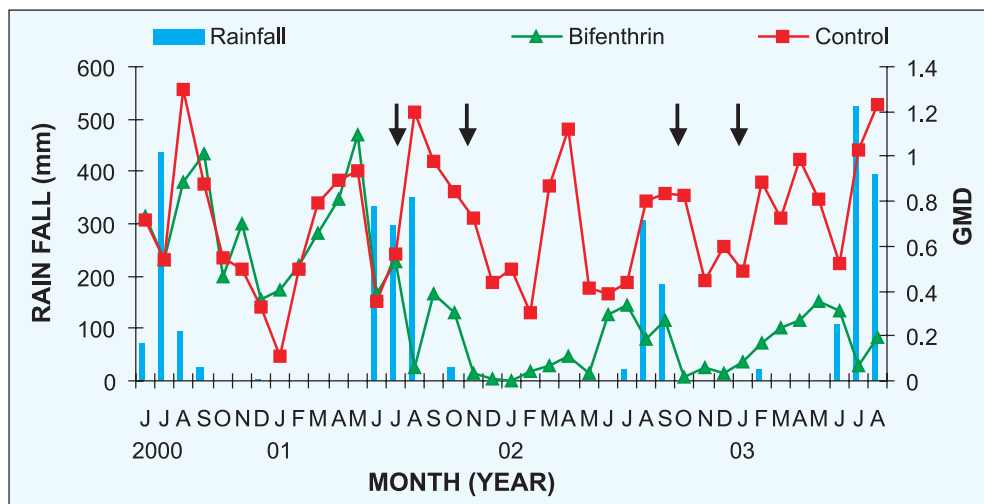


Fig. 4: Geometric mean densities (GMD) of *An. culicifacies* in intervention and control villages. Arrows indicate first and second round of spraying in the intervention villages

that there was a need for effective insecticides. Considering the significant insecticidal action of bifenthrin, the 25 mg dose was found to be the most superior among all the four doses evaluated (Yadav *et al.*, 2003). A village-scale (phase III) evaluation of bifenthrin 10% WP was carried out from June 2000 to August 2003 in collaboration with WHOPEs (Fig. 4). A 25% WG formulation of deltamethrin was also evaluated simultaneously for malaria vector control. Overall, the village-scale trial showed that bifenthrin and delta-methrin, sprayed indoors at 25 mg/m² and 20 mg/m² respectively were very effective in reducing vectorial potential of *An. culicifacies* and were safe to spraymen and local communities on relevant exposures. The study recommended two rounds of spraying of bifenthrin or deltamethrin three months apart for the control of malaria. A focal round of spraying is recommended in isolated villages with persistent transmission of malaria during the spring season.

Persistence, wash-resistance and shelf-life of mosquito nets treated with a water dispersible tablet formulation of deltamethrin (K-O Tab®) at 25 mg/m² dose was evaluated against malaria vectors (Fig. 5). During June 2001 treated and untreated polyester, nylon and cotton nets were separately distributed in three villages. Unwashed polyester nets, and those washed once one month post-treatment, produced 100% mortality in *An. culicifacies* for 6 months. A second wash at 3-month end marginally reduced the insecticidal action. *An. stephensi* was fully susceptible up to 4 months when exposed to unwashed nets but washing considerably reduced insecticidal action (65–78% after 2 washes). Treated nylon and cotton nets were effective for 4 months on both vectors. Treated nets



Fig. 5: Distribution of deltamethrin treated nets

kept on shelf retained 100% efficacy for 12 months. Overall, the treated nets gave a considerably long persistence of insecticidal action even after a single wash. Treated polyester nets were found most effective. Compared with our earlier experiences of using the liquid formulations, the tablet formulation is likely to have a better community acceptance in treating nets (Bhatt *et al.*, 2005).

A phase III evaluation of lambdacyhalothrin CS formulation for malaria vector control in rural areas in collaboration with WHOPEs has also been completed. Field trials have also been conducted of the formulation of biolarvicides (*B.t. israelensis* and *B. sphaericus*) and an IGR compound for mosquito control.

Technical support

The field unit staff have provided technical support to the health and non-health sectors in the following areas:

- Direct support in several malaria epidemic investigations and containment in Gujarat, Maharashtra and Rajasthan states
- Dengue outbreak investigation in Gujarat, Maharashtra and West Bengal
- Chikungunya outbreak investigation in Ahmedabad and other parts of Gujarat, and technical support in containment
- Participation in annual planning and review of vector borne disease control programme in Gujarat
- Monitoring of NVBDCP activities such as the ITN programme (Gujarat and Jharkhand states), larvivorous fish programme (Chhindwara district in Madhya Pradesh, Gujarat and Karnataka), malaria situation analysis (Gujarat) and mass drug administration programme for elimination of lymphatic filariasis in Gujarat
- Evaluation of malaria laboratory services in Gujarat
- Technical support in establishing larvivorous fish resources in urban and rural Gujarat including developing a manual on larvivorous fishes
- Support in scaling up of ITN programme
- Health education and observance of antimalaria month
- Technical support to WHO in the Southeast Asia and the Eastern Mediterranean Regions

Trainings

A number of training workshops and short courses were organised for development of capacity for vector borne disease control. These broadly included—

- Training on engineering and environmental management methods of malaria control for engineers of various departments including urban, rural and project area
- Malaria microscopy training for laboratory technicians
- Capsule training courses on malaria entomology for urban malaria staff
- Inter-sectoral training workshops
- Seminar on control of vector borne disease for School Principals
- Seminar on malaria for medical students
- Training workshop on use of larvivorous fish and biolarvicides for malaria control for the District Malaria Officers of Gujarat
- Training of trainers on the use of rapid diagnostic test for malaria
- Taluka level inter-sectoral training programmes on integrated control of malaria and dengue
- Training workshop for Epidemic Medical Officers on strategy for integrated control of vectors of malaria and dengue
- Training of Block Health Officers on indoor residual spraying

