Field Evaluation of Conventional and New Insecticides

Evaluation of new insecticides has been identified as a thrust area in order to guide the national antimalaria programme for selection of alternative insecticides in areas with double and multiple resistance in vector species and also to suggest ways and means to prolong the useful life of conventional insecticides. In consonance with this policy a large-scale field trial was carried out in District Ghaziabad to compare the relative efficacy of DDT and HCH at single and double doses against *An. culicifacies* which is responsible for about 70% malaria transmission in northern plain of rural India (Ansari *et al.*, 1986). Results revealed that DDT spraying @ 1 g/m^2 by increasing the spray coverage from 50 to 90% has interrupted the malaria transmission in predominant area of species A which was found completely susceptible to DDT. There was also no significant difference between 1 and 2 g/m^2 doses of DDT spraying against this species. *An. culicifacies* is mainly a zoophilic species and has inherent tendency to rest in cattlesheds and houses. The study revealed that house spraying alone with >80% room coverage produced the same impact as observed in an area where both houses and cattlesheds were sprayed with similar proportion of coverage.

In addition, several new insecticides were also evaluated to tackle increasing problem of resistance and fulminating outbreaks particularly in multi resistant areas. Salient finding of each trial is given below.

Field Evaluation of Deltamethrin against An. culicifacies in District Ghaziabad, Uttar Pradesh

Anopheles culicifacies, responsible for bulk of malaria transmission in rural areas, has become resistant to conventional insecticides—DDT, HCH and malathion in most parts of the country. To control double or triple resistant *An. culicifacies*, new insecticides namely synthetic pyrethroid have been introduced both in the form of indoor residual spray and also for treatment of mosquito nets. The first trial of a synthetic pyrethroid by indoor residual spraying was carried out in some villages of PHC Razapur of District Ghaziabad in U.P. Deltamethrin wettable powder formulation (2.5%) was sprayed in three doses—12.5 mg/m^2 (3 rounds), 20 and 25 mg/m^2 (2 rounds each). One section in Dadri PHC located at a distance of 22 km away from this area was held as control, where three rounds of HCH were sprayed @ 200 mg/m^2. Deltamethrin spraying was carried out for three years. Results revealed that spraying deltamethrin @ 25 mg/m^2 resulted in drastic reduction of DDT and HCH resistant *An. culicifacies* and other anophelines (Fig. 11) and caused interruption of malaria transmission (Fig. 12).

Trial of New Insecticides in Collaboration with WHO Pesticide Evaluation Scheme

Phase II Evaluation of Bifenthrin

In an area in Gujarat where *Anopheles culicifacies*, the main vector of rural malaria has developed

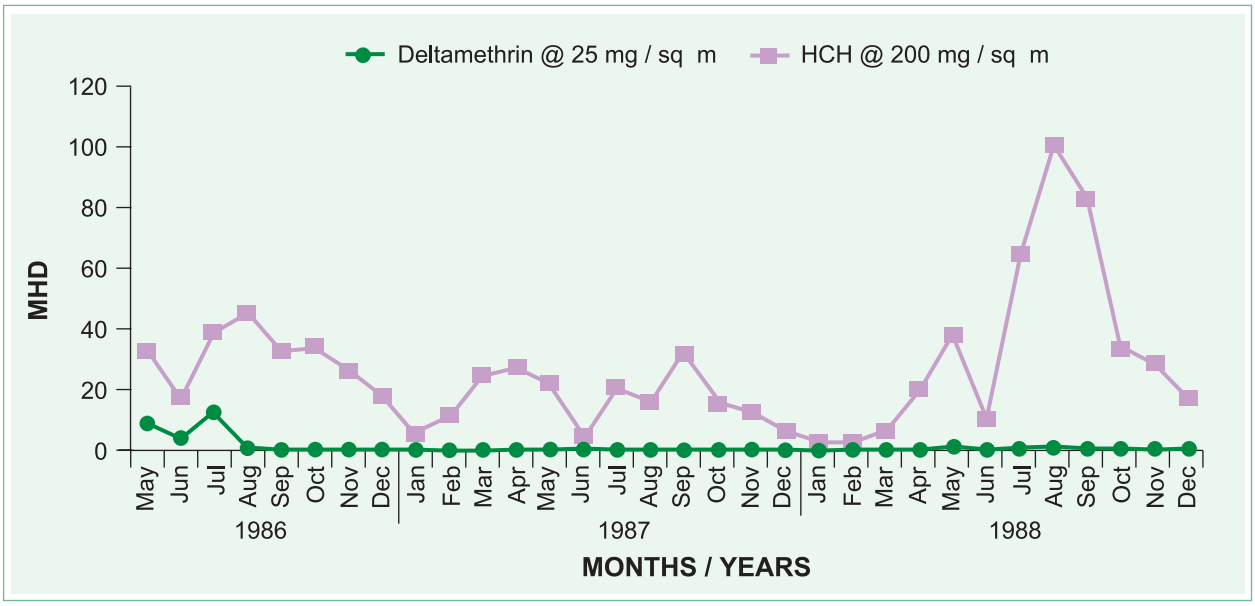

Fig. 11: **Impact of deltamethrin on indoor resting densities of *An. culicifacies***

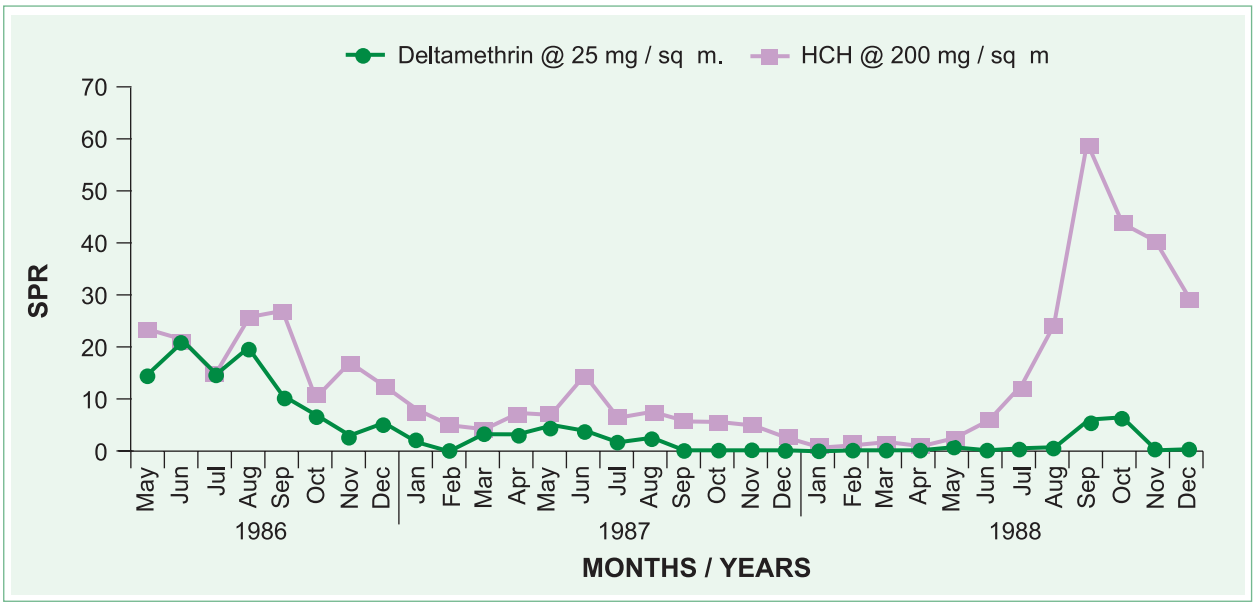

Fig. 12: **Impact of deltamethrin on slide positivity rate**

triple resistance to DDT, HCH and malathion, a randomized house-scale (phase II) trial of bifenthrin 10%WP was undertaken from July 1999 to March 2000. Baseline tests showed that *An. culicifacies* was 100% susceptible to bifenthrin (0.1% test papers) but only 57% to malathion (5% test papers). Entomological impact of four serial doses of bifenthrin (25, 50, 100 and 200 mg/m^2) sprayed in rooms in five villages was compared with malathion (2 g/m^2), and unsprayed control. In contact bioassays carried out on sprayed surfaces for 24 weeks, bifenthrin 100 and 200 mg doses caused ≥80% mortality in *An. culicifacies* till 24 weeks. The 50 mg dose caused ≥80% mortality on tin, wood and mud surfaces for 24 weeks, and on brick-walls for 16 weeks. Bifenthrin 25 mg dose produced ≥80% mortality for 24 weeks on tin, 20 weeks on mud-walls, 16 weeks on brick-walls, and 8 weeks on wood surfaces. Persistence of ≥80% mortality did not differ for 25 and 50 mg doses on any surface except on wood ($p < 0.05$). Malathion sprayed in three rounds of 6 weeks apart caused ≥80% mortality for 16 weeks on the brick and mud-walls, and for 20 weeks on the tin and wood surfaces. Bifenthrin 25 and 50 mg doses produced a similar impact on the densities of *An. culicifacies* and other mosquitoes but a

superior one than malathion or control. Bifenthrin 25 mg dose caused least excito-repellency. Overall, efficacy of bifenthrin was superior to malathion. Considering the duration of the persistence of significant insecticidal action of bifenthrin on the most common surfaces (mud and brick-walls), least excito-repellency and a relative impact on the mosquito densities, the 25 mg dose was found to be most superior among all the four doses evaluated. The trial recommended a further village-scale (phase III) evaluation of bifenthrin 10% WP at 25 mg/m^2 dose (Yadav *et al*., 2002).

Phase III Evaluation of Bifenthrin 10% WP and Deltamethrin 25% WG

In the phase III village-scale trial, bifenthrin 10% WP sprayed indoors at 25 mg/m^2 dose was evaluated in the Gujarat state during 2000–2002 to control *An. culicifacies*. An improved formulation of deltamethrin—Deltamethrin 25% wettable granules, was also evaluated by spraying indoors at 20 mg/m^2 during this period. Both deltamethrin and bifenthrin reduced the elements of vectorial capacity—vector densities (Figs. 13 and 14), survivorship, sporozoite rate and entomological inoculation rate significantly compared with these parameters in unsprayed control villages. A low excito-repellent action of bifenthrin caused a mass killing effect of the indoor resting population of vector mosquitoes. First round of spraying of insecticides was undertaken in mid July 2001. Bioassays on mud walls, which are most common surfaces, showed 100% knock-down effect up to next two months which declined markedly by the third month. The indoor resting densities of *An. culicifacies* declined significantly in sprayed villages in the month of August but increased in September though at a level much lower than in the control villages. Considering the built up of indoor resting densities, a second round of spraying was undertaken in October 2001—three months after the first round of spraying. The increasing trend of vector densities beginning February indicated that the impact of spraying of the second round of bifenthrin lasted for 3 months.

Based on the detection of sporozoites in *An. culicifacies* collected in early July during the study, main period of the incidence of malaria extends from July to January. In a riverside village sporozoites of *P. vivax* and *P. falciparum* were also detected in *An. culicifacies* in the month of April in spring season when the vector densities were ascending. Considering the persistence of insecticidal action determined through contact bioassays on sprayed surfaces and the length of malaria transmission in this area, two rounds of spraying with bifenthrin or deltamethrin three

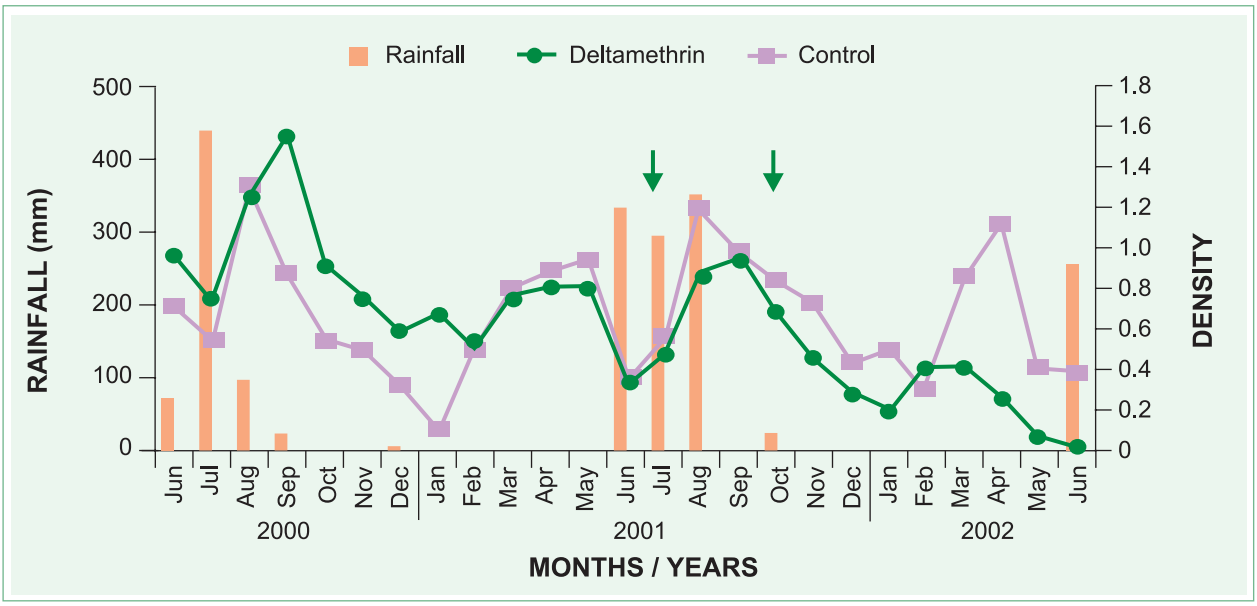

Fig. 13: **Geometric mean densities of *An. culicifacies* in intervention and control villages. Arrows indicate first and second round of spraying in the intervention villages**

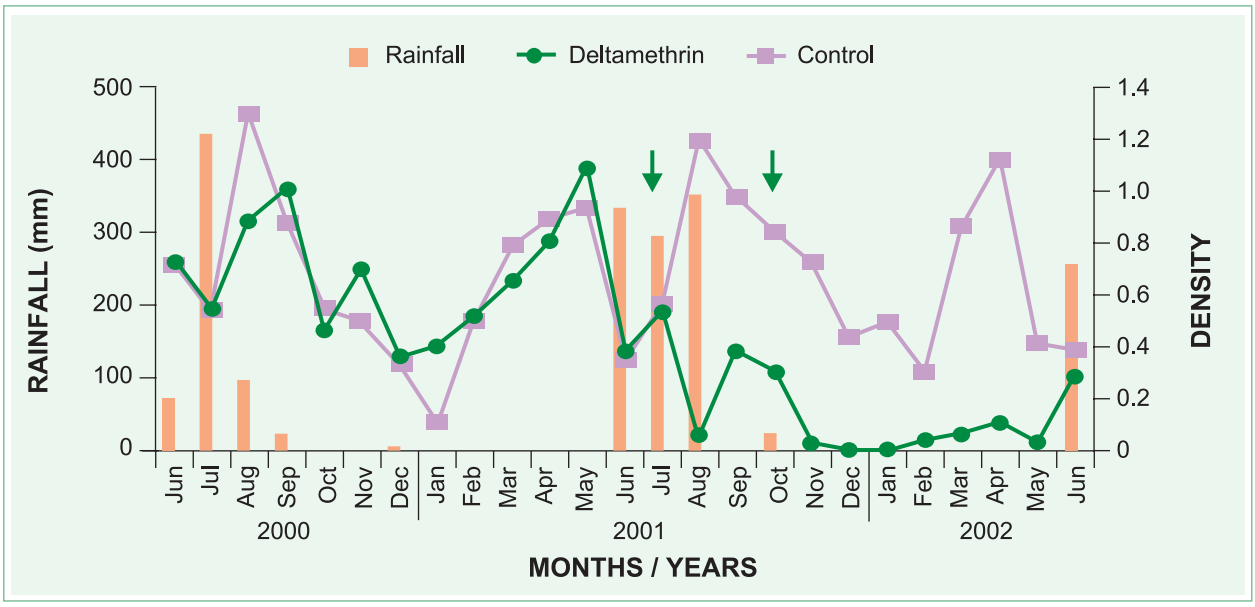

Fig. 14: **Geometric mean density of *An. culicifacies* in intervention and control villages. Arrows indicate first and second round of spraying in the intervention villages**

months apart would ensure an effective reduction in malaria transmission well over six months. It would be pertinent to undertake spraying in early June and complete the first round as early as possible, preferably by the end of June to interrupt the transmission of malaria. In isolated villages showing high potential of malaria transmission, focal spraying might be required to interrupt the persistent transmission of malaria during the spring. The householders did not report any adverse reaction to these insecticides. Clinical, haematological and urological examinations, and lung function and nerve conduction tests performed on volunteer spray-men showed no adverse effect on short-term relevant exposure during the trial.

Trials of Insecticide Treated Mosquito Nets and Curtains

Nets or curtains treated with various formulations of pyrethroids such as deltamethrin, cyfluthrin, lambdacyhalothrin and bifenthrin have been evaluated in laboratory and through field trials. The results are given elsewhere in this publication.

Trials in Progress

Field evaluation of new insecticide chlorpyriphos methyl 40% EC (Reldan), an organophosphorous compound and bendiocarb (carbamate) has been just completed. The indoor residual spraying of reldan @ 0.5 g/m^2 and bendiocarb @0.2 g/m^2 caused drastic reduction in vector population and malaria incidence. Insect growth regulators, biolarvicides and new larvicides are also being evaluated to find out safe and cost-effective vector control measures in urban areas. Similarly, extended field trials of bifenthrin 10%WP and deltamethrin 25% WG insecticides are also in progress for rural malaria control. n