15

Shahjahanpur (Uttar Pradesh)

Bioenvironmental malaria control and large-scale production of larvivorous fishes and composite culture were carried out by the field staff. Classical work on the demonstration of malaria and lymphatic filariasis by spraying *Bacillus thuringiensis israelensis* and *Bacillus sphaericus* was carried out in rural settings of Shahjahanpur. A short *in vivo* test method for monitoring resistance was developed and field tested in Shahjahanpur and published in the WHO Bulletin. The field unit has been closed and staff deployed to other IDVC field units.

Backgound

During 1982–85 many outbreaks of malaria were reported in Shahjahanpur and its adjoining districts. District authorities recorded 349 deaths due to malaria in Nigohi and Tilhar PHCs. Several focal outbreaks were also reported in Dadraul PHC. The situation was alarming and there was an urgent need to combat malaria in the district. Therefore, a field unit under IDVC project was established in January 1986 to understand the reasons of outbreaks, to evaluate suitable interventions such as the feasibility-cum-demonstration of an integrated approach to control malaria in Shahjahanpur district.

Activities, Progress and Achievements

Integrated vector control of malaria and filaria

Integrated disease vector control project was initially launched in 21 villages of Dadraul PHC and subsequently it was extended to all the 168 villages of the PHC covering a population of 1,00,423. The major components of the control strategy were: (i) mosquito control through environmental management and biological control; (ii) health education; (iii) early case detection and treatment; and (iv) inter-departmental coordination (Prasad and Sharma, 1994). The control villages were under insecticide spraying indoors. Malaria incidence in the experimental and control villages in 1986 is shown in Fig. 1.

During the entomological surveys in the study villages, 12 anopheline species— *An. culicifacies, An. stephensi, An. annularis, An. aconitus, An. barbirostris, An. subpictus, An. nigerrimus, An. pulcherrimus, An. tessellatus, An. splendidus, An. vagus* and *An. pallidus* were recorded. These species were found throughout the year with varying densities. A number of mosquito breeding sites such as ponds, pools, pits, ditches, rivers and river-bed pools, canals, irrigation channels, drains, intra-domestic breeding sites, rice-

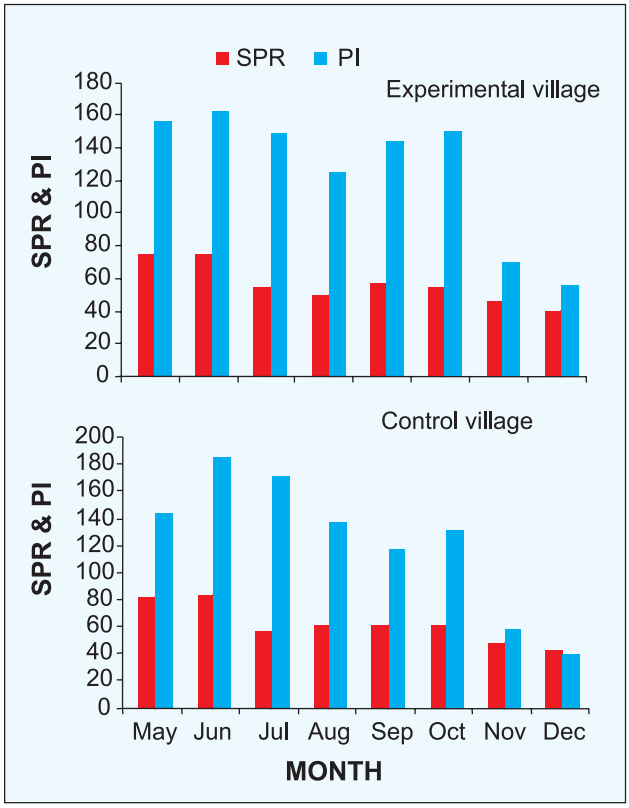

Fig. 1: Malaria incidence in experimental and control villages in Shahjahanpur in 1986

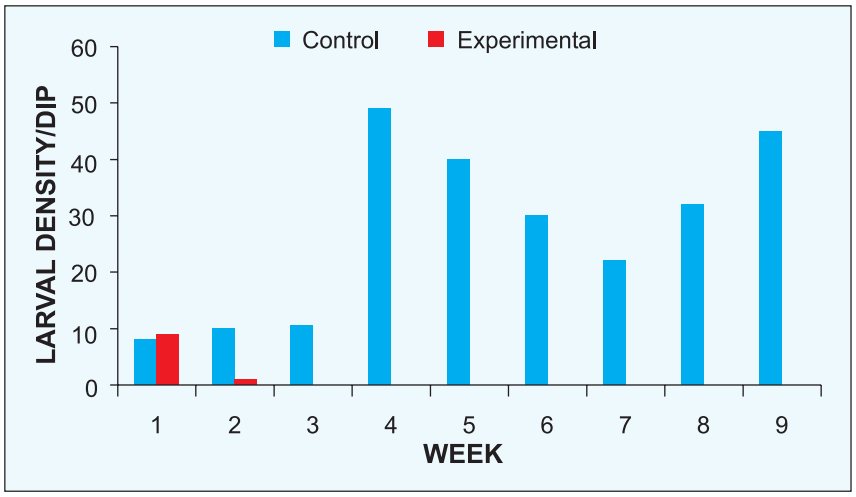

Fig. 2: Impact of introduction of *Gambusia* on anopheline larval density

fields, wells, tree-holes, factory effluents, etc. were found during the surveys.

Extensive earth work was carried out to eliminate the breeding sites by filling the low-lying areas in the experimental villages. Soakage pits were also constructed to eliminate water collection. Larvivorous fish (*G. affinis*) was used to control mosquito breeding in wells, ponds/pools, canals, rice-fields, etc. Stock ponds of *Gambusia* were maintained and the fish was introduced in various water bodies from time-to-time. Impact of *Gambusia* on larval positivity is shown in Fig. 2. By organising health camps and group meetings in the villages, the villagers were made aware about the malaria and other vector-borne diseases and various methods of their control. Encouraged by this activity, the villagers came forward to help the IDVC programme at various levels (Prasad *et al.*, 1993). Surveillance of fever cases was carried out on weekly basis. Presumptive treatment was given to fever cases and radical treatment was given to malaria positive cases within 24 hours. Nurseries of different types of plants were established in the study area to facilitate plantation of economic and fodder plants at marshy areas to check the mosquito breeding. As a part of holistic approach to the management of environment and malaria control, Non-conventional Energy Development Authority was persuaded to install smokeless *chulhas* and street lights, Vinoba Seva Ashram, a voluntary organisation was requested to help in educating the villagers regarding the IDVC programme.

All these activities resulted in the reduction of mosquito nuisance. *An. culicifacies* densities were reduced by 70–80% in 1990 (Fig. 3). Monitoring of parasitological indices showed gradual reduction in slide positivity rate (SPR) and annual parasite incidence (API). The SPR and API in 1986 was 57 and 1009.5 in experimental villages, while in control villages the same indicators were 63 and 983, respectively. After the implementation of bioenvironmental methods of

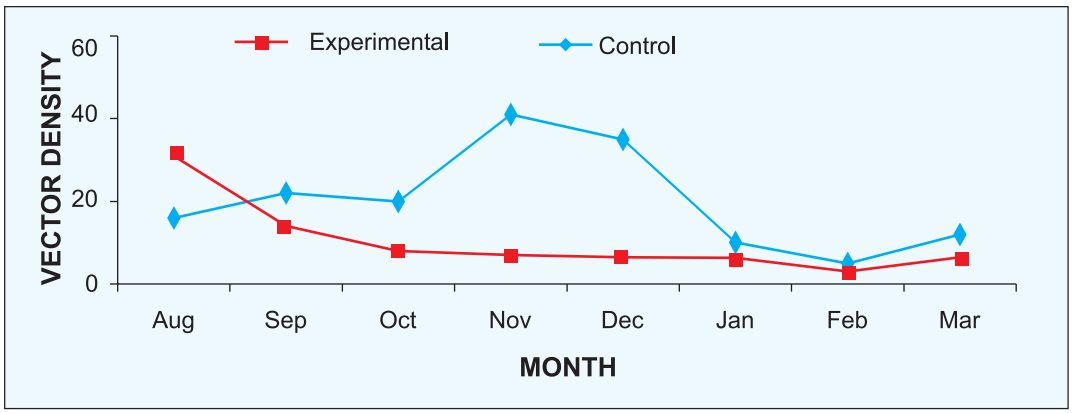

Fig. 3: Impact of *Gambusia* on vector density in Shahjahanpur in 1990

control, SPR declined to 2.5 and API to 6.7 in 1990, while in the control villages SPR was 18.1 and API was 20. Though there was a decline in all the parameters in control villages, these parameters were 3–4 fold lower in the experimental villages (Fig. 4).

Development of a simplified *in vivo* test system for determining chloroquine resistance in *P. falciparum*

Owing to high falciparum rate detected in the experimental villages, an effort was made to study the susceptibility status of *P. falciparum* to chloroquine. A simplified *in vivo* test system (7-day test) was developed for early detection and management of chloroquine resistant cases. Out of 47 cases studied with the standard dose of 1500 mg chloroquine phosphate, more than 50% cases showed resistance, 27.6% cases were of R-III level and the remaining were of RII level (Fig. 5). This *in vivo* method is a simple and useful test for early detection of chloroquine resistant falciparum infection and for management of the non-responding patients to chloroquine with alternate therapy (Prasad *et al.,* 1990).

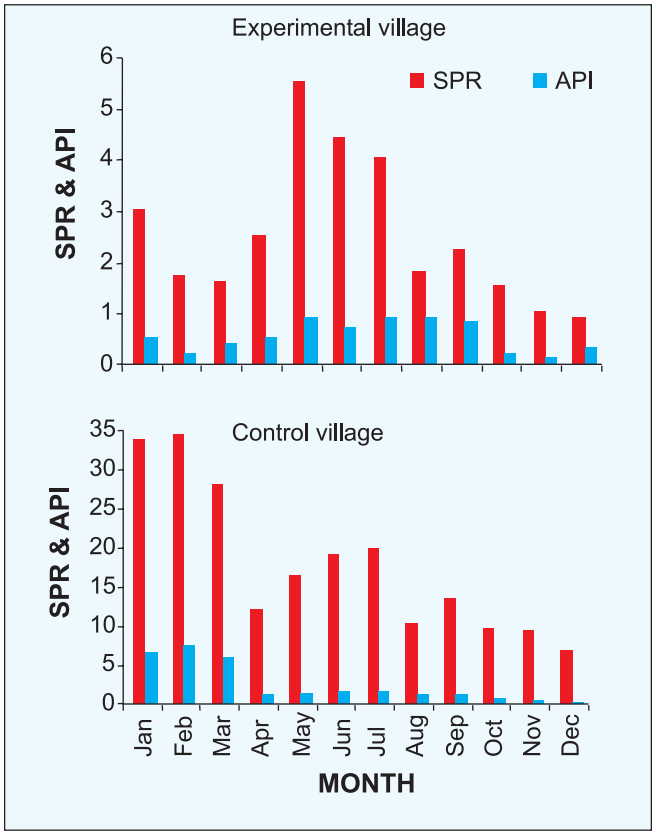

Fig. 4: Malaria incidence in experimental and control villages in Shahjahanpur in 1990

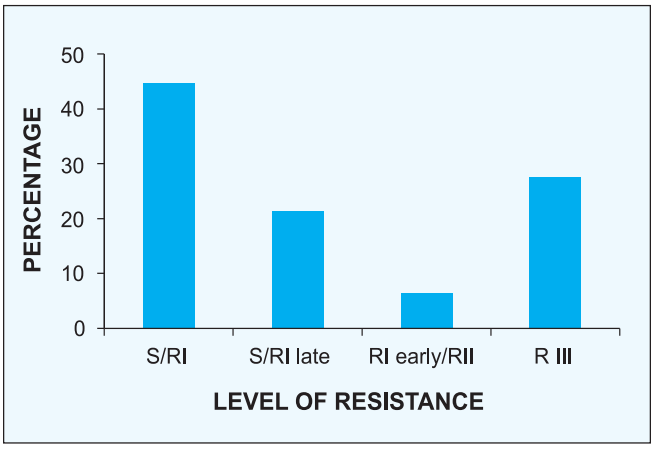

Fig. 5: Different levels of resistance to chloroquine in *P. falciparum*

Efficacy of 5-day course of primaquine against *P. vivax* relapses

A study was carried out to evaluate the efficacy of primaquine in the treatment of *P. vivax* cases (Virk *et al.*, 1994). *P. vivax* cases screened for the study were divided into two groups, one group was given five days treatment with 600 mg chloroquine and primaquine @ 15 mg per day and the second group was given only 600 mg chloroquine. The study revealed that 16.3% cases, who were treated with only chloroquine, showed reinfection/relapse after eight months and only 3.8% cases treated with both chloroquine and primaquine showed relapse/reinfection during the same period. The study showed that treatment of *P. vivax* cases for 5 days with primaquine is effective in significantly reducing relapses of *P. vivax* in District Shahjahanpur.

Establishment of larvivorous fish hatcheries and mass production of fish

Establishment of hatcheries

For biological control of mosquitoes, local fish fauna of the area was surveyed and experiments were carried out in the laboratory to find out the larvivorous capacity of indigenous fishes. A total of 30 fish species were selected to check their larvivorosity. Out of these, only three species namely, *Colisa fasciata*, *Chela bacaila* and *Esomus danricus* were found to be good larvivorous fish. They were introduced in a variety of habitats such as ponds, pools, wells, etc. to reduce larval density. The indigenous fish did not fulfill the requirement of a larvivorous fish due to their bigger

size, breeding habits, poor fecundity, popularity among people as food fish, etc.

In May 1988, about 10,000 *G. affinis* were brought from Haldwani field unit and were introduced into a few selected ponds for mass breeding. From these ponds, fishes were further introduced into ponds of other villages. In January 1989, *Gambusia* fish were available in the entire district. Later on, about 40 million *Gambusia* were maintained to supply fish to the entire Shahjahanpur district (Fig. 6). Volunteers from all over the district were trained and guided about the use of *Gambusia* and its introduction into mosquito breeding places.

Culture of *G. affinis* with food fishes

Culture of *G. affinis* along with food fish carps was undertaken in village ponds and it did not affect the production of food fish. Growth and survival of *Gambusia* were found to be good in most of the composite fish culture ponds. Composite culture was, therefore, recommended to get the villagers to dual benefit, fish for food and fish for the control of mosquito proliferation in village ponds (Haq *et al*., 1991).

Studies on the dispersal of fishes due to floods

During 1990, there were widespread floods in Shahjahanpur district due to that 70 *Gambusia* hatcheries were affected and fish were washed away in large numbers. This opportunity was utilised to study the natural dispersal and colonisation of *Gambusia* in different aquatic habitats. The study revealed that the

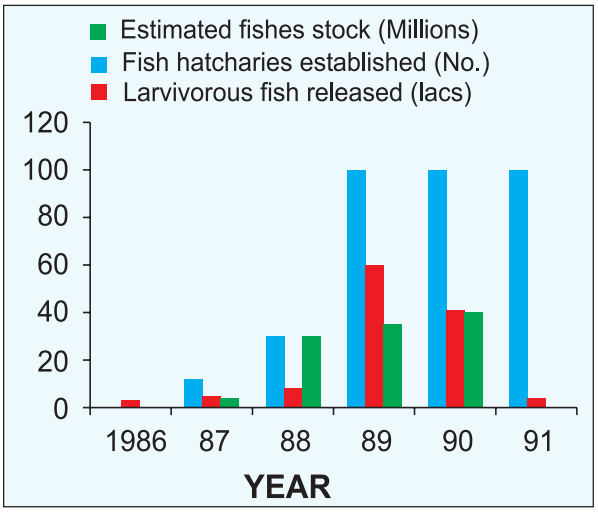

Fig. 6: Establishment of larvivorous fish hatcheries in Shahjahanpur

Gambusia did not eliminate the local fish fauna to become the dominant species. *G. affinis* is therefore, unlikely to pose any ecological hazard (Haq *et al*., 1992).

Control of mosquito breeding through *G. affinis* in rice-fields

Studies on mosquito breeding and its control through *G. affinis* in nursery and paddy-fields after transplantation of seedlings were carried in about 10 ha rice-field area. Six anopheline species— *An. culicifacies*, *An. annularis, An. subpictus*, *An. nigerrimus*, *An. barbirostris* and *An. aconitus*, and four culicine species— *Cx. tritaeniorhynchus*, *Cx. bitaeniorhynchus, Cx. quinquefasciatus* and *Aedes* spp. were found breeding in rice-fields. *G. affinis* was used to control mosquito breeding in these rice-fields (Fig. 7). The fish survived well in submerged rice-fields and provided 87.8% mosquito larval control (Prasad *et al*., 1993).

Malaria epidemic investigations

During 1988, following the request of the district health authority, a survey was carried out in four villages of Banda PHC of District Shahjahanpur (Prasad and Sharma, 1990). Surveys revealed that 47 deaths occurred in these villages were due to high fever/malaria. Entomological studies revealed a very high (2.89%) sporozoite rate in *An. culicifacies* indicating that this species was responsible for the focal outbreak of the disease (Fig. 8). It was also observed that the epidemic occurred due to misdiagnosis of cases leading to failure in treatment. The outbreak was controlled by mass drug administration by the MRC team and residual insecticide spraying by the state health programme. Focal outbreak of malaria was reported in the year 2002 in three PHCs of the District Shahjahanpur. Random fever surveys were carried out in these villages from where fever cases were reported to find out the malaria incidence.

During an epidemic of malaria in Khutar PHC, blood smears of 100 febrile patients from two villages (Chaltua and Sermau Uttari) were collected. Out of 74 blood smears examined from Chaltua, three were positive for *Pv* and four were positive for *Pf* (SFR–5.4; SPR–9.4). In Seramau Uttari none of the 26 smears examined was found positive formalaria.

Powayan PHC had the highest incidence of malaria. Blood smears were collected from seven villages—

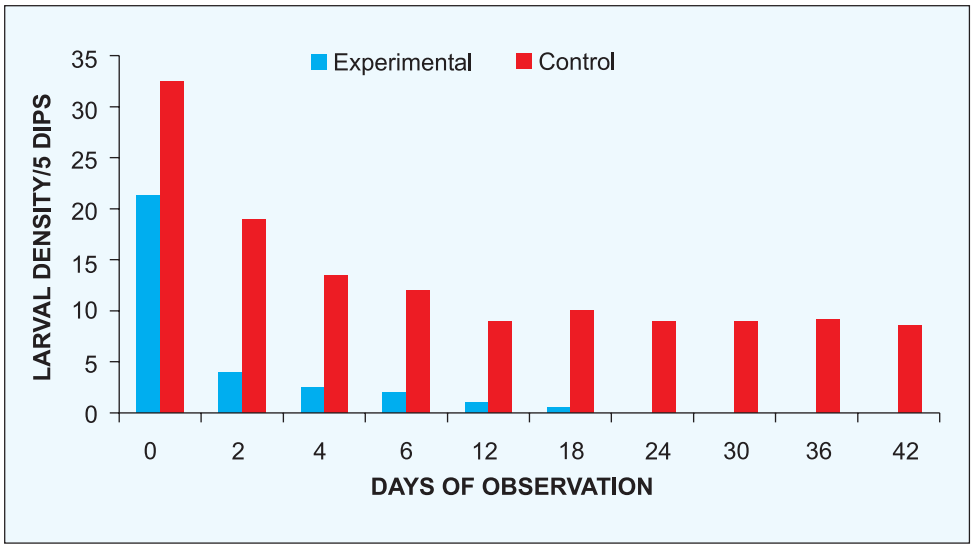

Fig. 7: Effect of *Gambusia* on larval density in rice-fields

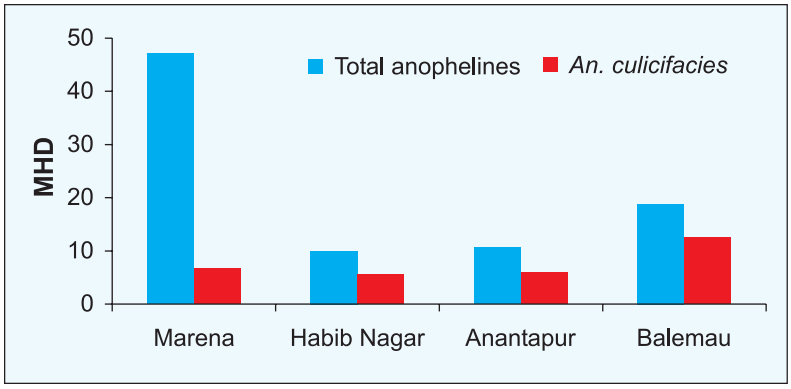

Fig. 8: Mosquito density in villages of Banda PHC in Shahjahanpur district

Mohamadpur Saijania, Aurangabad, Nahil, Gangsara, Kahimara, Umaria Kalyanpur and Gadadnia. Highest positivity was found in Mohamadpur Saijania and Aurangabad villages. Among 243 blood smears examined from Mohamadpur Saijania, 96 were positive (39.5%) for malaria and SFR was 38.3. In the Aurangabad village, 85 blood smears were examined, of that 33 were positive (38.8%) for malaria and SFR was 34%. Among 20 blood smears examined from Gangsara, 2 (10%) were positive for malaria and SFR was 10%. In the Nahil village, 69 blood smears were examined of that one was positive (1.4%) for malaria and SFR recorded was 1.4. In other villages, none of the 34 blood smears examined was found positive for malaria.

Following the report of a large number of fever cases from some villages of Tilhar PHC, a survey was carried out in the villages namely Jodhpur Navadia, Habibpur Barkhiria, Rata, Azmabad, Dhaneli Mahesh and Shivdaspur. Habibpur Barkhiria had the maximum number of malaria cases. Among 27 blood smears examined from this village, 9 (33.3%) were positive for malaria and SFR recorded was 25.9. In village Jodhpur Navadia, 105 blood smears were examined, of which 9 (8.6%) were positive for malaria and SFR recorded was 2.8%. In village Dhaneli Mahesh, out of 54 blood smears examined, 2 (3.7%) were positive for malaria.

During August to November, 1991 many deaths were recorded in Baniyani village of Talgram PHC of District Farrukhabad. Integrated measures like spraying of DDT and HCH, fogging with malathion and application of Baytex in mosquito breeding sites were being used by the Health Department of the U.P. Government to contain epidemic. Investigations carried out by MRC during November and December 1991 showed low mosquito densities and larval positivity but very high incidence of malaria in the village (Fig. 9). No

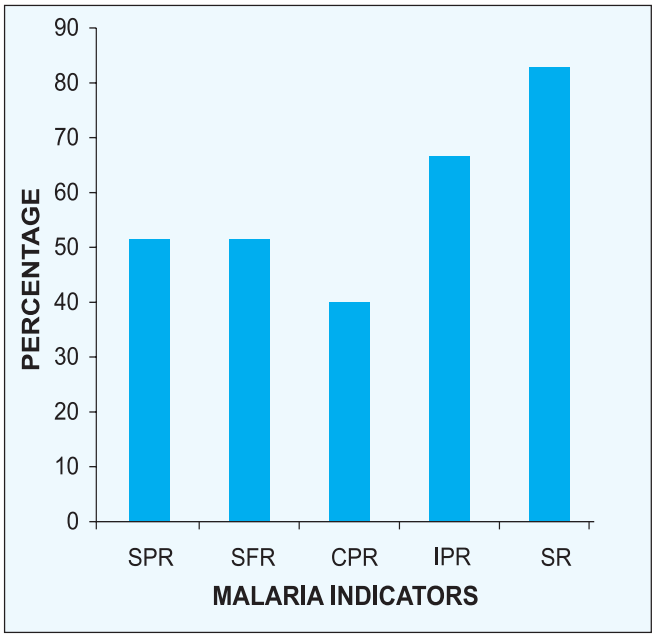

Fig. 9: Parasitological indicators in Baniyani village in Farrukhabad district

malaria case was recorded by the surveillance worker of the Health Department of the state government before the outbreak of the disease. However, high slide faciparum rate (51.57%), child parasite rate (40), infant parasite rate (66.66) and spleen rate (82.9) in the village during the outbreak clearly indicated high incidence of malaria in the area. It was concluded that deaths recorded in the village during the malaria transmission period probably were due to malaria. Major factors responsible for the deaths due to malaria in the village were poor surveillance, misdiagnosis, low literacy and socio-economic status of the villagers (Prasad *et al*., 1992).

Parasitological investigations

In a study carried out from January to December 1988, schizonts were detected in the peripheral blood smears in 21 *P. falciparum* cases (Prasad *et al.*, 1989). The occurrence of schizonts was more in females (62.9%) than in males (38.1%). The number of schizonts detected per mm^3 blood ranged between 4 and 760. Out of 3303 *P. vivax* cases examined, 84 showed multiple invasion of erythrocytes (Prasad *et al.*, 1990). In five cases, more than one schizont was present in a single erythrocyte and in 14 cases more than five rings were recorded in an erythrocyte. However, the maximum invasion of an erythrocyte was observed in a 50 year old male patient where a single erythrocyte was seen harboring 12 rings. Such variations are probably related to the *P. vivax* strain found in this area.

Concomitant occurrence of malaria and filarial parasites in patients

Microfilariae of *Wuchereria bancrofti* are generally not seen in the peripheral blood smear during day-time. But concomitant infection of malaria and filariasis was observed in 18 patients in District Shahjahanpur. The co-existence of filariasis was more with *P. vivax* (77.7%) than with *P. falciparum* (22.2%). It is clear that microfilariae can be found both during the day-time and in night blood collections (Prasad *et al.*, 1990).

Situation analysis of malaria in Shahjahanpur district

Transmission of malaria has three determinants—human, vector and parasite. During the implementation of IDVC project in Shahjahanpur district, these factors were studied and their role in the transmission of malaria was assessed. *An. culicifacies*, the main vector of malaria in this area, showed its presence throughout the year with varying density. The variation in the density was observed because of the ecological condition of the area as the villages of the district are either situated on the bank of rivers or canals or are away from rivers (non-riverine) (Fig 10). The two types of habitats — rivers and canals provided numerous additional breeding grounds for the vector mosquito resulting in the variation in density and malaria incidence. At the same time, *An. culicifacies* has developed resistance to DDT and HCH in this area. Due to poor response of people at the time of insecticidal spraying of houses, only 27.2% houses could be sprayed completely, 61.2% were sprayed partially and 11.4% houses were unsprayed respectively leading to continued vector prevalence. The densities were high enough to transmit malaria.

Studies carried out to determine the sensitivity of *P. falciparum* indicated 50% resistance against 1500 mg dose of chloroquine (WHO recommended dose). The study clearly indicated the failure of chloroquine in the treatment of *P. falciparum* cases in the community.

To assess the role of human population in malaria transmission some important aspects—parasitological, community response at the time of spraying houses with insecticides, housing and clothing pattern and movement of population were studied in District Shahjahanpur. The parasitological observation reflects that 14.5% malaria patients showed behavioural indifference and ignorance towards the treatment of

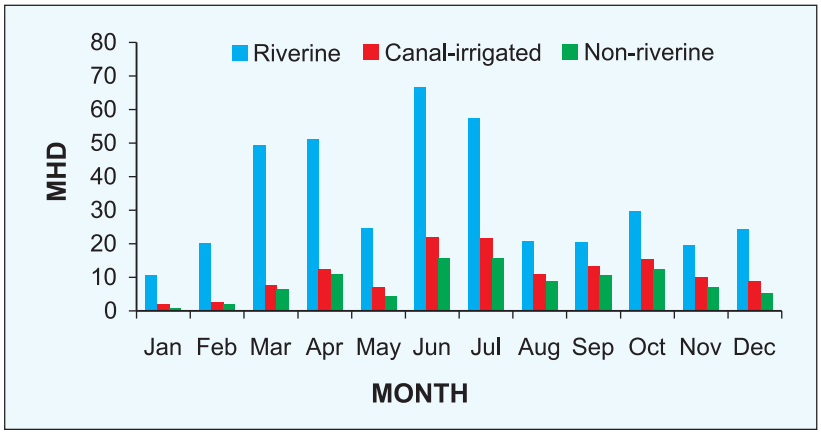

Fig. 10: Average monthly Man hour density of *An. culicifacies*

malaria (Prasad *et al*., 1990). Such patients either took improper/delayed treatment, which resulted in persistence of malaria in the community.

The type of houses and their association with cattle-sheds were also found to influence malaria. The risk of acquiring malaria in thatched houses was found 16% as compared to 10.5% in *pucca* houses. It was further observed that the risk of malaria was found higher (13.8%) in human dwellings as compared to mixed dwellings (6.8%). Clothing and covering of the body were also found to play an important role in malaria transmission. Males were found more exposed to mosquito bites as compared to females. The combination of all these factors enhanced the risk of malaria transmission and thus the villages of Shahjahanpur district continued to be endemic for malaria.

Studies on vector bionomics

Out of nine major and minor vectors of malaria in India, *An. culicifacies* has been reported as the main vector, which transmits 65–70% malaria in most of the rural areas of plains and peri urban areas in the country. *An. culicifacies* was found throughout the year in the study area with varying densities (Figs. 10, 11 and 12). The variation in the density was mainly due to difference in type and availability of breeding sites. The density of *An. culicifacies* exhibited two seasonal peaks, the first one was during pre-monsoon period— in the month of March/April, and second peak was in post-monsoon period— in the month of June/July. The species was primarily endophilic.

The species was found breeding in a variety of habitats such as river-bed pools, canals, rice-fields, ponds/pools, etc. However, it was not found breeding in intradomestic pits and containers, water collection near hand pumps, street drains/pits, effluents from factories, etc. *An. culicifacies* was found breeding in association with six other anopheline species— *An. annularis*, *An. stephensi*, *An. subpictus*, *An. barbirostris*, *An. nigerrimus* and *An. aconitus*. The biting activity of the species was recorded maximum before mid-night during colder months and at late night in the

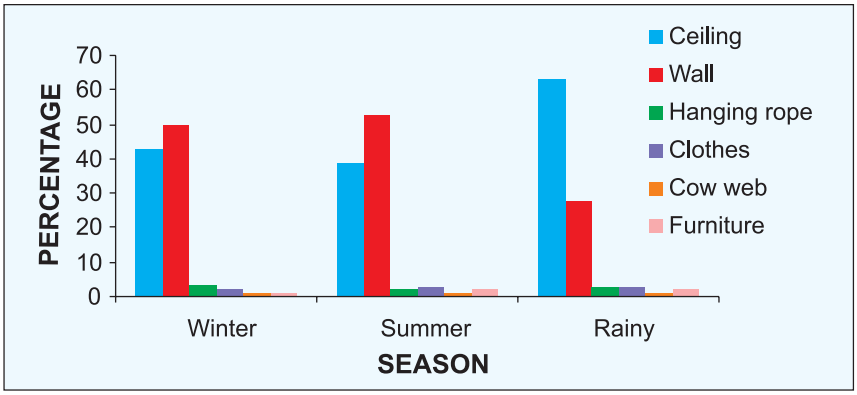

Fig. 11: Average percentage collection of *An. culicifacies* in human dwellings during 1989–91

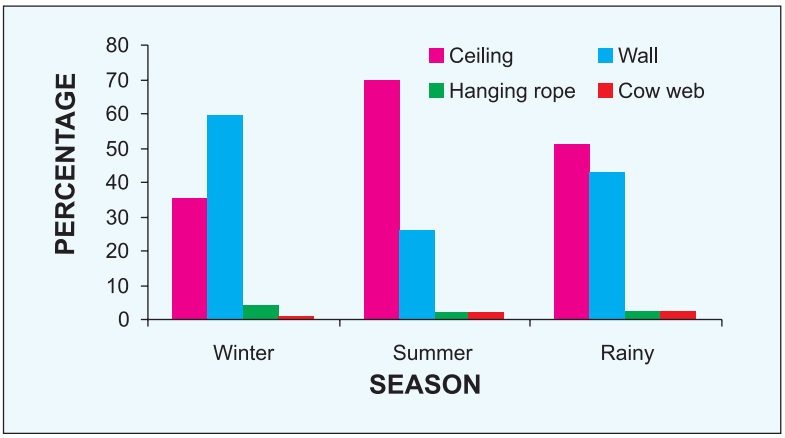

Fig. 12: Average percentage collection of *An. culicifacies* in cattlesheds during 1989–91

warmer months. Studies carried out to identify sibling species in Shahjahanpur revealed the presence of species A and B with predominance of species A.

To know the susceptibility status of *An. culicifacies* to insecticides, susceptibility tests were conducted in September 1991. Blood-fed, wild caught *An. culicifacies* were tested against 4% DDT impregnated papers using WHO technique. The percentage mortality of *An. culicifacies* varied from 4.6 to 6% only. This indicated high resistance status of *An. culicifacies* to DDT in this area.

Evaluation of biolarvicides

Two larvicide formulations—*Bacillus sphaericus* and *B. thuringiensis israelensis* were applied @ 1 and 0.5 g/m^2 respectively for controlling breeding of malaria vector *An. culicifacies*) in different types of habitats in 38 villages of Farrukhabad district. Impact of spray was assessed on immature and adult densities, and malaria incidence. Results of both the larvicides revealed low anopheline and culicine densities in the experimental villages as compared to those in the control villages (Figs. 13–15). *B. thuringiensis* in comparison to *B. sphaericus* had high killing effect on Day 1 after application. But on Day 5, the impact was similar with both the formulations. Reappearance of III and IV instar larval densities in treated habitats within a week indicated absence of recycling of biolarvicides. Spray impact was less in grassy habitats and extensive seepage collection due to tube-well irrigation system (Sharma *et al.*, 1998).

In another study, *B. sphaericus* was applied @ 1 g/m^2 for controlling breeding of filaria vector *Cx. quinque-*

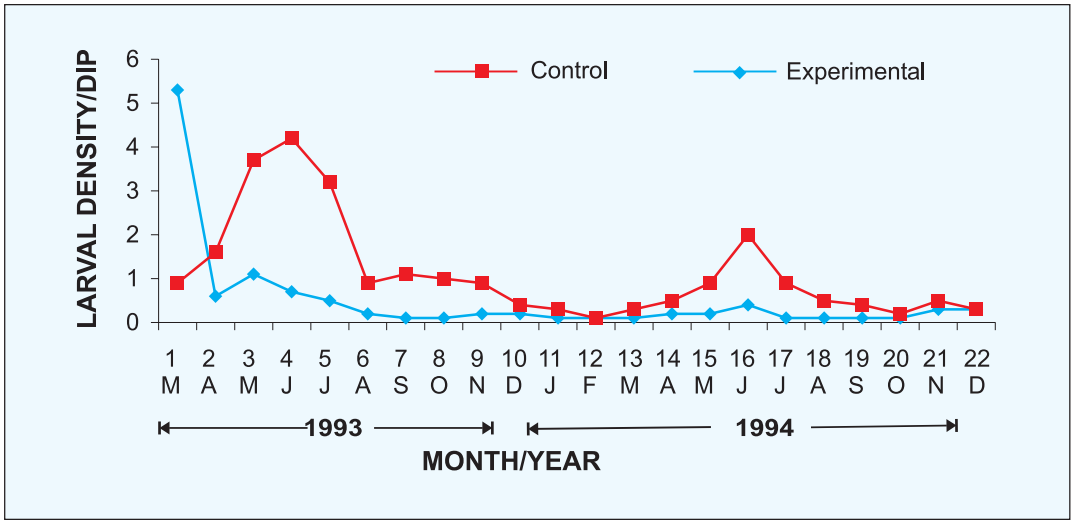

Fig. 13: Impact of *B. sphaericus* on anopheline larvae

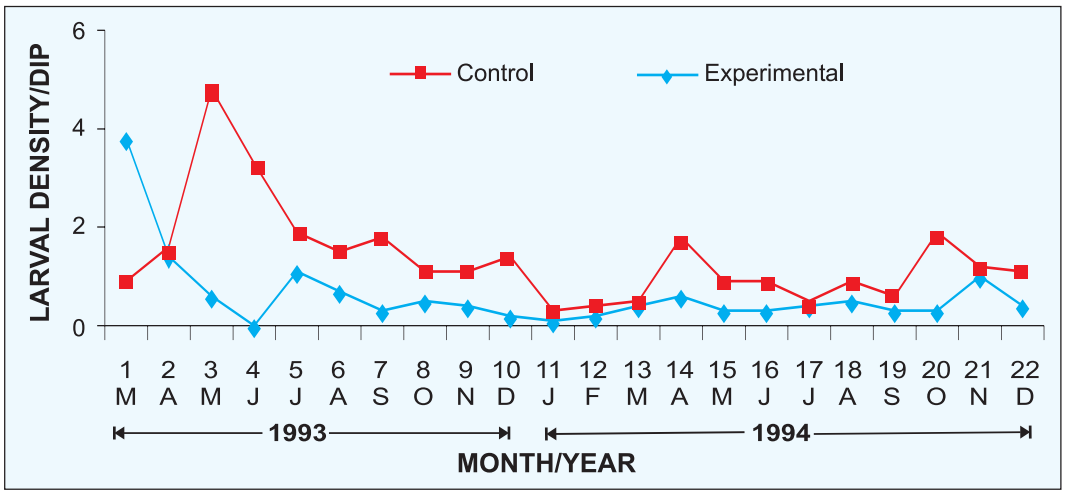

Fig. 14: Impact of *B.t. israelensis* on anopheline larvae

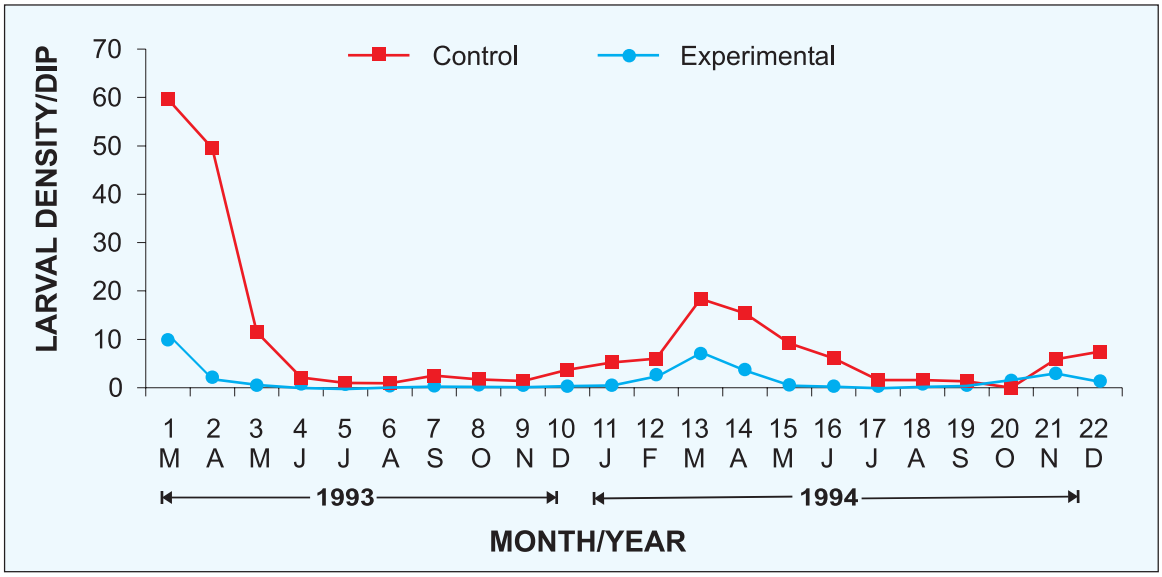

Fig. 15: Impact of *B.t. israelensis* on culicine larvae

fasciatus in different types of habitats in 10 villages of Powayan PHC of the District Shahjahanpur. Impact of biolarvicide was assessed on densities of immatures and adults, and microfilariae rate. The biolarvicide was found highly effective against culicine larvae as 98.9% mortality was recorded on 3rd day after application in all the treated habitats (Fig. 16). Biolarvicide could check larval density till 21 days. Spray impact was less in grassy habitats. The microfilariae rate was found to be lower in the experimental villages (0.4%) than that in the control (0.8%) after one year of the study.

Evaluation of pyriproxyfen

Field trials of pyriproxyfen (0.5 G), an IGR compound, was carried out in various mosquito breeding habitats of District Shahjahanpur. The compound was applied in three dosages—2, 4 and 10 g/m^3 of water capacity of breeding sites. The compound was tested against mosquito immatures of *Cx. quinquefasciatus* and *An. culicifacies*. High inhibition of adult emergence was obtained in various mosquito breeding sites. The effect was more pronounced on the larvae to pupal metamorphosis.

Small-scale trials of notonectid bug (*Anisops bouveri*) for the control of mosquito larvae

A small-scale field trial using 5 bugs/m^2 and 10 bugs/m^2 were carried out from October to December 1989 for the control of mosquito larvae in roadside borrow

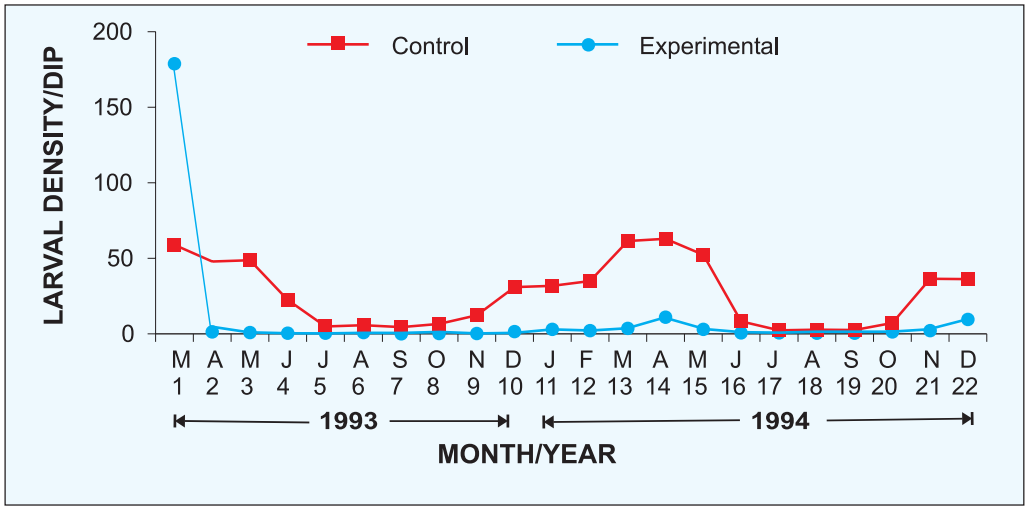

Fig. 16: Impact of *B. sphaericus* on culicine larvae

pits. Observations were made up to 42 Days. With the introduction of 5 bugs/m^2, hundred percent reduction of III and IV instar larvae was observed on Day 35 but a slight decrease (97.7%) in reduction was recorded on Day 42. However, 100% mortality in culicine larvae (III and IV instar) was recorded from Day 28 to 42 after applying 10 bugs/m^2. In a similar type of habitat, impact of notonectids was observed on anopheline larvae. On Day 42, 90.2 and 95.5% reduction of above anopheline larvae were recorded after applying 5 bugs/m^2 and 10 bugs/m^2 respectively. The above study thus showed that notonectid bugs could act as an effective biological agent for controlling mosquito breeding in field.

Geographical reconnaissance and survey of malaria in urban areas of District Shahjahanpur

Geographical reconnaissance carried out in the urban areas of Shahjahanpur district revealed that the area was highly mosquitogenic. *Culex* larvae were reported from peri-domestic breeding sites, while *Aedes* larvae were reported from intra-domestic breeding sites. Random fever surveys carried out in different PHCs of the district from time-to-time revealed low incidence of malaria in the area. Presumptive treatment was given to all the fever cases. Malaria positive cases were referred to the DMO for radical treatment.

Prevalence of filariasis in rural areas of Shahjahanpur

Night blood surveys carried out in different PHCs of District Shahjahanpur showed microfilariae, filaria disease and filarial endemicity rates of 10.1, 11.4 and 18.8%, respectively. Entomological survey revealed increased prevalence of *Cx. quinquefasciatus* (Prasad *et al.,* 1993).

Studies on dengue haemorrhagic fever

Many deaths occurred in the city zone of District Shahjahanpur during August to October 1992. A detailed investigation was carried out. National Institute of Virology, Pune was contacted and serological studies were carried out which confirmed the outbreak of dengue haemorrhagic fever. *Ae. aegypti* was found to be vector of the disease. Necessary control measures were suggested to the health department of the district.

Trainings imparted

The staff of various agencies working in the district were trained in bio-environmental malaria control methods. The training dealt with the life-cycles of the mosquitoes, their common breeding habitats, salient features of the biology vectors, life-cycle of the malaria parasite, brief information on the other vector-borne diseases, principles of mosquito and malaria control with emphasis on control methods which could be practiced by the individual, communities and by various agencies working in the area. The trained staff of these agencies were very helpful in training others and promoting vector control in their areas. There was general awareness in the community and people with fever started visiting malaria clinics resulting in high

blood slide collection.

A large number of training camps were organised mainly in collaboration with Vinobha Sewa Ashram, Mahila Mangal Dal, Bharat Yuvak Sewak Samaj and Nehru Yuva Kendra in Shahjahanpur district. In these camps, over 5,500 volunteers attended the training. Subsequently, the voluntary agencies in their programmes also incorporated training programmes for housewives and children on simple methods to control mosquito breeding and plan of action in fever cases. This has now become an important part of overall training activities of these agencies in their teaching and training programmes on weaving, tailoring, adult education, cottage industries, etc.

❑