## Rourkela (Orissa)

This area was selected to study malaria epidemiology in forest and mining areas. Initially bioenvironmental malaria control was evaluated in forest villages. Insecticide-treated mosquito net programme was launched in forested villages and for mining population and the technology was passed on to the Steel Authority of India in Rourkela and NVBDCP. The field unit developed special expertise in the following areas:

- A field site is being developed for malaria vaccine trials in addition to the Jabalpur field unit
- Epidemiological investigations have been undertaken in forested areas and vector bionomics has been studied
- Collaboration with the Ispat General Hospital resulted in developing special expertise on antimalaria drug trials, e.g. $\alpha-\beta$ arteether and bulaquine studies

### Background

The Orissa state is regarded as one of the most hard-core malarious areas with perennial transmission. The malaria endemic areas are forested hills inhabited with aboriginal tribes. During 1985–87, API was in the range of 25–57/1000 with *P. falciparum* incidence in the range of 81–86%. The strategy to control malaria used indoor residual spraying with DDT, active malaria surveillance at fortnightly interval and passive case detection and treatment at PHC level. This strategy had very little impact on malaria and the disease continued to be a major cause of morbidity and mortality. In 1988, a field unit of NIMR was established at Rourkela to undertake a number of applied and field operational studies to find out malaria transmission risk factors in tribal population and evaluate effective alternative interventions. Studies were initiated in tribal hard-core malarious area of Bisra block in Sundargarh district.

### Activities, Progress and Achievements

#### Integrated control of malaria

A study on the feasibility of bioenvironmental control of malaria was conducted from 1988 to 1991 covering a population of 38,664 in 39 villages of Bisra PHC, which was meso- to hyper-endemic to malaria. The area was characterised by the presence of forested hills, rocks, streams, rivers, stone quarries and vast areas of rice-fields. The houses were clustered in hamlets, some of which are located in deep forested area. For the convenience of the study, the area was divided in two groups—forested villages (Complex-A) with a population of 6,732 with high malaria incidence and non-forested villages (Complex-B) with a population of 31,932 with comparatively low malaria incidence. As a part of the integrated control strategy, various control measures such as breeding source reduction, use of biological agents like fishes in breeding sites, active surveillance and early treatment, environmental improvement, health education and community participation were adopted in the experimental villages (Yadav and Sampath, 1993). In the control villages DDT was sprayed routinely.

Entomological assessment of the impact was studied by monitoring the mosquito densities on fortnightly basis from the sentinel villages. Throughout the period of study, the man hour density of *An. culicifacies* was lower in the experimental area than that in the control area (Fig. 1) of both the complexes (Complex-A : Experimental (E)–7.1 to 76.8, Control (C)–10 to 154; and Complex B: E–3.5 to 97.1, C–5.4 to 223.4). The proportion of ponds, wells and intra-domestic contain-
ers with larvae was also low in the experimental area compared to that in the control area.

Epidemiological monitoring was done through weekly surveillance in experimental villages but in control villages it was done fortnightly by the programme. There was a significant reduction in malaria incidence in the experimental area. Parasite incidence reduced from 45 in October 1989 to 5.7 in June 1991. On the contrary, malaria incidence increased or remained steady in remaining rural areas of Bisra PHC and other parts of the district under DDT spray operation. Results of the point prevalence surveys also indicated that malaria prevalence in the study area was significantly lower than that of the control area. *P. falciparum* prevalence was 75–80% of all cases followed by *P. vivax* (15–20%), mixed infection (1–2%) and *P. malariae* around 1%. There was a marked improvement in the awareness of people, more significantly of the schoolchildren about the mosquito borne diseases and their control (Yadav et al., 1993). The local communities also contributed to a considerable extent for the success of the programme.

**Evaluation of insecticide-treated bednets**

Most of the malaria in rural plains of India is transmitted by *An. culicifacies* and in hill forests of Orissa by *An. fluviatilis*. In view of the intense transmission of malaria in forest areas, which were not amenable to bioenvironmental control due to inaccessibility and myriad of larval habitats, it was imperative to test efficacy of insecticide treated nets (ITNs) in areas where these species were the main malaria vectors. Hence, two trials were carried out between 1989 and 1993 in Sundargarh district in northern Orissa where above mentioned two species were the main malaria vectors. In tribal villages in Kuarmunda PHC, nylon nets treated with deltamethrin SC or lambdacyhalothrin EC at 25 mg/m² reduced indoor densities of both the malaria vectors, their biting rate and the malaria incidence significantly (Figs. 2 and 3) (Sampath et al., 1998; Yadav et al., 1998, 2001).

In the mining areas, where malaria caused a tremendous economic loss in work days (Yadav et al., 1991), use of nylon nets treated at 50 mg/m² of cyfluthrin EW
resulted in a high reduction in the densities and human biting of *An. fluviatilis*, as well as a significant reduction in the incidence of malaria (Figs. 4 and 5), anaemia and spleen rates in children (Sharma and Yadav, 1995). Hospital occupancy due to malaria in two mining hospitals decreased. Miners accepted ITNs very well and perceived that ITNs reduce mosquitoes as well as other household insect pests. Human toxicity studies revealed that the treated nets were safe to impregnators and bednet users (Yadav *et al*., 1996; Satpathy *et al*., 1997).

**Evaluation of community financing of insecticide-treated nets**

A collaborative field project was conducted in a tribal area of Jhangira sector in Keonjhar district (Sharma, 1997; Yadav, 1997; Sharma *et al*., 1999). The project was financed by the Orissa Health Projects Office of the British Council Division with funds from the Overseas Development Agency of the United Kingdom. The objectives of the study were to explore whether the communities with poor socio-economic status living in malaria endemic areas can finance and sustain ITN usage and to assess epidemiological impact of ITNs.

The duration of the project was from June 1994 to March 1997. The generation of demand for mosquito nets and their subsequent distribution through social marketing at a subsidized price of Rs. 50.00 per ITN was undertaken by CARE-India, while MRC took up the responsibility of providing technical support and monitoring the epidemiological impact of the interven-
Fig. 5: Impact of ITN’s (cyfluthrin 50 mg/m²) on malaria incidence in the mining area of Sundargarh district

Fig. 6: Impact of deltamethrin-treated mosquito nets on the vector density in Keonjhar district

tion. Distribution of deltamethrin-treated nets (dosage: 25 mg/m²) commenced from May 1995 in all the 55 villages (population–29,000) falling under seven sections of Jhangira sector. In all 7,799 nets were sold, covering approximately 81% of the total population. The nets were re-treated at six month interval under the supervision of MRC.

For epidemiological evaluation, entomological and parasitological monitoring was carried out and for comparison a control area of about 22,000 population in the adjoining Jirang sector was selected. The impact was measured on vector densities (Fig. 6), human biting rate, malaria incidence (Fig. 7) and infant mortality rate. The study indicated that ITNs provide full protection from the bites of mosquitoes and there was 50% reduction in malaria incidence and 34% reduction in infant mortality in the ITN villages. The ITN use rate ranged from 45 to 60% in different seasons. The ITN use was well-accepted by the people and there was better awareness among the communities to fight malaria.

Evaluation of nets treated with deltamethrin tablet formulation

The study was conducted during 2002–03 in three villages under Bisra PHC of Sundargarh district (Sharma et al., 2005). These villages were Birkera (Pop. 506) which was the trial village, while San Pokhari (Pop. 367) and Dudarta (Pop. 271) were control villages. Based on entomological and parasitological parameters, the impact of mosquito nets treated with the tablet formulation of deltamethrin was assessed. The bioefficacy studies showed 100% mortality in An. fluviatilis and 80–100% mortality in An. culicifacies up to six months. The density of malaria vectors, An. culicifacies and An. fluviatilis in houses with treated nets was significantly low as compared to houses with plain nets and no nets. There was overall reduction in entry rate of mosquitoes into the houses with treated nets compared to others with plain nets and without nets. There was 39.6% immediate mortality in mosquitoes coming in contact with treated nets and 43.3% of mosquitoes succumbed to lethal
dose within 24 h. The low feeding success rate of mosquitoes in the trial village in comparison to villages with plain nets and without nets also confirm high protective efficacy of tablet formulation of deltamethrin. The tablet formulation was found to have low excito-repellency rate for both the vector species, which is likely to result a better mass killing effect on the mosquito population. There was significant reduction in malaria incidence in the trial village in comparison to control villages with plain nets or without nets.

Cross-sectional malaria prevalence data collected during pre-intervention and intervention period also showed that there was 65.2% reduction in malaria parasite rate (Fig. 8) in population using treated nets, which is significantly higher in comparison to population using plain nets (35.4%) and without nets (7.5%). The study showed that in areas with persistent malaria throughout the year, such as Sundargarh district, two treatments of mosquito nets at an interval of six months would provide effective protection against malaria.

Evaluation of bioefficacy of Olyset® nets against malaria vectors

Another project on the evaluation of bioefficacy of Olyset®, a long-lasting insecticide treated net (LLIN) impregnated with permethrin 2%, was initiated during 2004 in two villages—Jharbeda and Barsuan in Bisra PHC characterised by *An. fluviatilis* and *An. culicifacies* respectively. Cone bioassay tests were performed on *An. culicifacies* and *An. fluviatilis* and bioavailability of the insecticide after repeated washing of the nets was determined. Olyset nets were 100% effective against *An. fluviatilis* even after 20 washes (Table 1). Use of Olyset net resulted in reduction of man hour density of *An. culicifacies* and *An. fluviatilis* considerably (Fig. 9a & b). Olyset® nets were also 100% effective against nuisance species such as *Culex*, head lice, houseflies and cockroaches but caused only 40% mortality in bed-bugs.
### Table 1: Impact of washing of Olyset® net on its bioefficacy against malaria vectors

<table>
<thead>
<tr>
<th>No. of washings</th>
<th>% mortality (3 min exposure) An. culicifacies</th>
<th>An. fluviatilis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–11</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>12–13</td>
<td>95</td>
<td>100</td>
</tr>
<tr>
<td>14–17</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>18 –19</td>
<td>85</td>
<td>100</td>
</tr>
<tr>
<td>20</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>

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**Evaluation of biolarvicides for mosquito control**

A field trial to evaluate the efficacy of two biolarvicides, *B. sphaericus*, strain B101, serotype H-5a, 5b and *B. thuringiensis israelensis* H-14 was conducted from June 1993 to October 1994 in two separate localities of Rourkela City (Fig. 10). A concurrent comparison area was included where the municipality continued anti-larval measures under urban malaria scheme. *B. sphaericus* and *B.t. israelensis* were sprayed @1g/m² and 0.5 g/m² respectively in all the habitats except septic tanks @ 4 g/m². Larval densities were monitored on weekly basis and habitats were resprayed on appearance of III/IV instar larvae. Reaplication intervals were 1 to 4 weeks for *B. sphaericus* and 2 to 8 weeks for *B.t. israelensis* in different habitats. Densities of adult mosquitoes were also monitored on fortnightly basis.

There was a significant reduction in larval density after the spraying of *B. sphaericus* in drains (15 to 100%), waste water pools (95 to 100%), cement tanks (60 to 100%) and rice-fields (8 to 100%) in comparison with the control area. The positivity rates for the occurrence of anopheline and culicine pupae in drains were 2.2 and 11.2%, respectively in the experimental area. In the control area these were 20 and 72.8%. The corresponding figures for wastewater pools and paddy-fields were lower in the experimental area (range *Anopheles*: 1.1 to 2%; *Culex*: 3.7 to 9.8%) than that of the control area (range *Anopheles*: 14.4 to...
58.5%; *Culex*: 20.5 to 65.7%). The impact of *B. sphaericus* on *Armigeres* spp breeding in septic tanks was less prominent at the dose of 1 g/m², hence the dose was increased to 4 g/m² which caused remarkable reduction in larval density (Yadav et al., 1997).

Application of *B.t. israelensis* also caused notable reduction in larval density in all habitats—drains (50–100%), wastewater pools (90–100%), masonry tanks (35–100%), sluice valve chambers (98–100%) and rice-fields (25–100%) as compared to that in the control area. In the beginning of the study, 58.3% of habitats were positive for mosquito breeding in the experimental area and 54.4% in the control area. Larval breeding positivity decreased significantly after spraying in the experimental area (range 7.7 to 26.2%) compared with that of the control area (range 55.5 to 84.2%). Pupal positivity rates in different habitats were also lower in the experimental area (range *Anopheles*: 0.3 to 1.8%; *Culex*: 5.7 to 15%) than the control area (range *Anopheles*: 5 to 20.1%; *Culex*: 14.5 to 57.5%). Both *B. sphaericus* and *B.t. israelensis* caused marked reduction in the densities of total mosquitoes, total anophelines and *Cx. quinquefasciatus* (Figs. 10 and 11).

**Larvivorous fish fauna surveys**

A fish fauna survey was carried out in Sundargarh district during 1988–90 to identify and evaluate indigenous larvivorous fishes for mosquito control. In all, 57 species belonging to 19 families under six orders were
found. Out of 58 species studied, 20 were found to be most or moderately suitable for mosquito control. The fish species were divided into three categories. Group one comprising of four fishes — *O. melastigma*, *A. panchax*, *G. affinis* and *P. reticulata* which were surface feeders with superior mouth opening, smaller size and high breeding potential can be considered as most suitable for biological control (Yadav et al., 1992). These fishes had high predatory index (No. of mosquito larvae consumed per day per gram body weight) which ranged from 176.9 to 600 for *Anopheles* and 64.8 to 428.6 for *Culex* larvae (Table 2).

Three fishes—*D. rerio*, *E. danricus* and *O. mossambicus* were considered good in terms of their high breeding potential, smaller size and ability to withstand stress (Chand and Yadav, 1994; Yadav and Das, 1994). However, because of their terminal mouth the predatory index of these fishes ranged from 381.9 to 475.6 for *Anopheles* and 19.9 to 188.5 for *Culex* (Table 2). The remainder 13 fishes—*Barilius barila*, *B. bendelisis*, *Chela laubuca*, *C. cachius*, *Danio dangila*, *D. aequipinnatus*, *Puntius ticto*, *P. sophore*, *P. gelius*, *P. amphibias*, *Rasbora daniconius*, *Salmostoma bacaila* and *Chanda nama* had certain characteristics similar to that of II category. However, because of their limited breeding potential these species were placed in category III.

Reproductive biology of *P. reticulata* was studied in laboratory to generate information for use in developing strategy for its mass multiplication. Various biological parameters were studied by providing both natural and commercial food (Padhan et al., 1995).

### Study on the mosquito breeding associated with rice agro-ecosystem

The study was launched in July 1992 in four distinct ecosystems, one each in forest area, broken forest area without irrigation facility, broken forest area with irrigation facility and in peri-urban area where drain water is used for irrigation. Only *kharif* crop was grown in the areas without irrigation facility and both *kharif* and *rabi* crops were grown in other areas. Thirty-four species of mosquitoes emerged from the larval samples collected from paddy-fields which included 16 anopheline and 18 culicine species (Table 3).

In the forest areas, *An. fluviatilis* accounted for 1.6%, *An. culicifacies* 1 to 2.7% and *An. annularis* 1.1 to 4.6% of the total mosquitoes emerged in samples collected from rice-fields. The breeding of *An. fluviatilis* and *An. culicifacies* in pools, that were formed inside the paddy-fields due to terraced cultivation, ranged from 0.7 to 11.2% and 2.1 to 43%, respectively. *An. culicifacies* was found to breed only in the beginning, while *An. fluviatilis* and *An. annularis* throughout the crop season. In broken forest area, *An. culicifacies* accounted for 0.6 to 2.3% and *An. annularis* around 2% of the total mosquitoes, while *An. fluviatilis* was completely absent.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Species</th>
<th>Predatory index*</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Anopheles</td>
<td>Culex</td>
</tr>
<tr>
<td>Category–I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td><em>Gambusia affinis</em> (Exotic)</td>
<td>193.5</td>
<td>80.4</td>
</tr>
<tr>
<td>2.</td>
<td><em>Poecilia reticulata</em> (Exotic)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>3.</td>
<td><em>Aplocheilus panchax</em> (Indigenous)</td>
<td>176.9</td>
<td>64.8</td>
</tr>
<tr>
<td>4.</td>
<td><em>Oryzias melastigma</em> (Indigenous)</td>
<td>600.0</td>
<td>428.6</td>
</tr>
<tr>
<td>Category–II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td><em>Danio rerio</em> (Indigenous)</td>
<td>384.0</td>
<td>104.0</td>
</tr>
<tr>
<td>6.</td>
<td><em>Esomus danricus</em> (Indigenous)</td>
<td>381.9</td>
<td>19.9</td>
</tr>
<tr>
<td>7.</td>
<td><em>Oreochromis mossambicus</em> (Exotic)</td>
<td>475.6</td>
<td>188.5</td>
</tr>
</tbody>
</table>

*No. of larvae consumed per gram body weight of fish per day.*

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**Table 2: Suitable larvivorous fishes for Sundargarh district**
The *vishnui* group of mosquitoes were 40–50% of all mosquitoes, while non-vector anophelines and culicines accounted for 33.3–39.4% and 8.8–23.9%, respectively. In canal irrigated area, *An. culicifacies* had low density—0.2 to 1.7% of the total mosquitoes in nurseries and rice-fields both during *kharif* and *rabi* crops. The proportion of *An. annularis* ranged from 0.4–4.8%. *An. culicifacies* was found to breed more profusely in canals/channels which ranged from 0.7 to 34.7%. In the peri-urban area, the composition of *An. culicifacies* in both rice-fields and nurseries was higher (0.5 to 5.5%) than that of other areas, which was probably due to absence of other preferred breeding habitats such as streams, canals, etc. The proportion of *An. annularis* was also higher (0.7 to 6.6%). In this area, breeding of filariasis vector, *Cx. quinquefasciatus* was observed in low intensity.

In all the four areas, the density of mosquito larvae was higher in the beginning, which declined gradually and increased again towards the end of the crop season. Fewer number of mosquito species were found breeding in the beginning of the crop seasons, which became more diversified as the crop progressed.

### Vectors of malaria in Orissa

Due to varied ecological conditions prevailing in the entire Orissa state, the dynamics of malaria transmission also vary from area to area due to differential role played by different vector species. The entire Orissa state is under the influence of *An. culicifacies* and *An. fluviatilis*. Over the years, Orissa has witnessed vast changes as a result of industrialisation, urban development, deforestation and irrigation. Considering all these factors, studies were carried out on bioecology of malaria vectors (mosquito fauna and their distribution in Orissa, species-specific breeding preferences of mosquitoes and biology of the vectors—feeding and resting behaviour and vector incrimination). Surveys in nine districts of Orissa representing coastal, plain and hilly areas were conducted. In all 17,276 mosquito specimens belonging to 38 mosquito species falling under six genera were recorded, out of which anophelines were predominant with 21 species. Maximum prevalence of malaria vector species — *An. fluviatilis* and *An. culicifacies* was recorded from hill area, followed by plain and coastal area. Man biting rate of *An. culicifacies* and *An. fluviatilis* varied from

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Species</th>
<th>Non-irrigated (Forest)</th>
<th>Irrigated (Broken forest)</th>
<th>Non-irrigated (Broken forest)</th>
<th>Irrigated (Peri-urban)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>An. culicifacies</em></td>
<td>1.8</td>
<td>0.5</td>
<td>1.4</td>
<td>2.0</td>
</tr>
<tr>
<td>2.</td>
<td><em>An. fluviatilis</em></td>
<td>1.6</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3.</td>
<td><em>Cx. tritaeniorhynchus</em></td>
<td>22.0</td>
<td>26.0</td>
<td>35.2</td>
<td>27.2</td>
</tr>
<tr>
<td>4.</td>
<td><em>Cx. vishnui</em></td>
<td>10.4</td>
<td>13.2</td>
<td>7.6</td>
<td>10.4</td>
</tr>
</tbody>
</table>

**Table 3: Percent emergence of anophelines from different ecosystems**

![Fig. 12: Indoor resting density of *An. culicifacies* in Sundargarh district, Orissa](image-url)
one district to another and correspondingly the malaria was more prevalent in hill area followed by plain and coastal areas. The density of *An. culicifacies* in Sundargarh district ranged between 2.8 and 10.5 during the year with two peaks, each during spring (March–April) and monsoon seasons (July) and lowest during January and February (Fig. 12). Two biting peaks were observed during the whole night collections. The peak biting activity was observed between 2200 and 2400 hrs and the second biting peak was from 0300–0400 hrs (Fig. 13). *An. fluviatilis* is restricted to the foothill forested areas in Sundargarh district with highest prevalence during post-monsoon months (Fig. 14). The biting activity of this species starts between 1900 and 2000 hrs and continued throughout night with peak biting between 2200 and 2300 hrs (Fig. 15).

*An. fluviatilis* is an efficient vector of malaria, particularly in the hills and foothills of India. It is widely distributed in India although its role in malaria transmission varies from place to place. Keeping in view these facts, studies were conducted to understand the bionomics of *An. fluviatilis* in two distinct ecological conditions—forest and broken-forest areas of Sundargarh district characterised by persistent malaria transmission. The study revealed that forest ecotype support heavy breeding of this vector species because of abundance of slow running streams, whereas in broken forest the breeding potential of this species is very low because of absence of preferred breeding places. The density as well as human biting rate of this species is high in forest area, particularly during post-monsoon months as compared to broken forest area. The species prefers biting human than cattle, and indoor biting is more...


An. fluviatilis, An. annularis, An. subpictus, An. vagus, An. pallidus, An. aconitus, An. splendidus and An. nigerrimus—were found resting outdoors in tree holes, bushes, pit shelters, under culverts, river/stream side cavities. The density of all these species ranged between 0.7 and 1.9 per man hour. Most of the species were found resting outdoors in both the ecotypes but An. culicifacies and An. fluviatilis were found resting outdoors only in the forest area near river or stream. In all, 14 anopheline species were recorded from indoor resting collections from both type of villages, but the number of streamside villages was more as compared to riverside villages (Chand et al., 1993). However, density of anophelines was more in riverside villages than that in streamside villages. The study showed that major proportion of anopheline species prefer to rest indoors, however, a small proportion of anopheline species do rest outdoors as well, which may be of epidemiological significance. Studies on mosquito breeding and resting in tree-holes in forest area of Sundargarh district were also conducted (Yadav et al., 1997).

Insecticide susceptibility of malaria vectors

Insecticide susceptibility of wild caught adult An. culicifacies and An. fluviatilis against the discriminating dosages of DDT (4%), malathion (5%) and deltamethrin (0.05%) was determined as per standard WHO procedure in eight districts of Orissa (Chand and Yadav, 1991; Sharma et al., 2004). All these districts are predominantly inhabited by the tribal population and are hyper-endemic for malaria. The results showed that An. culicifacies is resistant to DDT in all
the eight districts, and to malathion in Mayurbhanj, Bolangir and Nuapada districts. The data showed indication of development of multiple resistance to DDT, malathion and deltamethrin in Bolangir and Nuapada districts (Table 4). An. fluviatilis was found susceptible to DDT, malathion and deltamethrin in all the districts except Mayurbhanj where 95 and 87.5% mortality was observed against DDT and malathion, respectively (Table 5). Based on these findings, appropriate changes in the indoor residual spray strategy were suggested to achieve effective vector control.

**Breeding potential of Ae. aegypti in the Rourkela township**

Prompted by report of large number of dengue cases in a township of Rourkela steel plant during 1998, entomological surveys were carried out to know the distribution and extent of Aedes breeding in and around the dengue fever affected areas (Sharma et al., 2001). Out of 2,062 water containers searched, 819 were positive for Aedes larvae. The house index, container index and breteau index were 53.4, 39.7 and 118.5 respectively. About 27.9% of the houses had single breeding habitat. The breteau index of single storey houses and double storey buildings was 149.8 and 54.6, respectively, showing that the single storey houses have more potential for Aedes breeding. The breeding preference was highest for plastic containers. Ae. aegypti was found breeding in coolers, cement tanks, tyres and miscellaneous containers with a prevalence rate of 13.2%. The role of entomological surveillance and health education is very important for the control of the disease through community participation.

**Malaria transmission dynamics in forest ecotype**

About one-third of the geographical area of Sundargarh district is covered by dense forest. Studies have revealed great variability in malaria endemicity in forested and broken forest villages (Nanda et al. 2000). Studies were carried out on the seasonal prevalence of two major malaria vectors—An. culicifacies and An. fluviatilis. The density of An. fluviatilis starts increasing from August and reaches to peak in December. Thereafter, from January it starts declining and reaches to a low level during May to July. On the contrary, density of An. culicifacies was low during November to February and high from March to September with a peak in March–April. Results revealed that the densities of two vectors pulsate alternatively and maintain perennial transmission in forested villages.

Malaria transmission is perennial with P. falciparum accounting for >80% of malaria cases. Transmission intensity varies with season— high transmission after the monsoon rains in autumn and winter, low transmission in summer, and intermediate transmission in spring. The anthropophagic mosquito, An. fluviatilis was identified as the main vector for malaria transmission. Based on observation of spleen rates and supported by data on malaria parasite prevalence and malaria incidence, forest area can be classified as a hyper-endemic area for P. falciparum malaria.

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**Table 4: Susceptibility of An. culicifacies to DDT, malathion and deltamethrin in some districts of Orissa**

<table>
<thead>
<tr>
<th>District</th>
<th>Corrected percent mortality</th>
<th>DDT (4%)</th>
<th>Malathion (5%)</th>
<th>Deltamethrin (0.05%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sundargarh</td>
<td></td>
<td>12.0 (100)</td>
<td>100.0 (100)</td>
<td>100.0 (100)</td>
</tr>
<tr>
<td>Keonjhar</td>
<td></td>
<td>14.0 (50)</td>
<td>NP</td>
<td>100.0 (80)</td>
</tr>
<tr>
<td>Mayurbhanj</td>
<td></td>
<td>62.5 (40)</td>
<td>50.0 (40)</td>
<td>100.0 (100)</td>
</tr>
<tr>
<td>Bolangir</td>
<td></td>
<td>23.3 (60)</td>
<td>68.3 (60)</td>
<td>95.0 (60)</td>
</tr>
<tr>
<td>Nuapada</td>
<td></td>
<td>8.3 (60)</td>
<td>75.0 (60)</td>
<td>81.7 (60)</td>
</tr>
<tr>
<td>Kalahandi</td>
<td></td>
<td>12.0 (60)</td>
<td>88.3 (60)</td>
<td>96.7 (60)</td>
</tr>
<tr>
<td>Rayagada</td>
<td></td>
<td>15.0 (60)</td>
<td>100.0 (60)</td>
<td>100.0 (60)</td>
</tr>
<tr>
<td>Phulbani</td>
<td></td>
<td>20.0 (60)</td>
<td>100.0 (60)</td>
<td>100.0 (60)</td>
</tr>
</tbody>
</table>

Figures in parentheses indicate number of mosquitoes exposed; NP— Test not performed.

**Table 5: Susceptibility of An. fluviatilis to DDT, malathion and deltamethrin in some districts of Orissa**

<table>
<thead>
<tr>
<th>District</th>
<th>Corrected percent mortality</th>
<th>DDT (4%)</th>
<th>Malathion (5%)</th>
<th>Deltamethrin (0.05%)</th>
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<td>Sundargarh</td>
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<td>100.0 (60)</td>
<td>100.0 (100)</td>
</tr>
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<td>100.0 (40)</td>
<td>100.0 (120)</td>
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<td>87.5 (40)</td>
<td>100.0 (40)</td>
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<td>100.0 (60)</td>
<td>100.0 (40)</td>
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</table>

Figures in parentheses indicate number of mosquitoes exposed.
Parasite prevalence and malaria incidence rates decrease with age, suggesting that residents of forest area develop immunity to malaria (Sharma et al., 2004). A number of immunological and molecular studies also support existence of premonition in the adult population in the forest area (Kabilan et al., 1994; Biswas et al., 1995; Roy et al., 2001; Chattopadhyay et al., 2003). The studies on sporozoite rate and entomological inoculation rate (EIR) also demonstrate high transmission load in the tribal communities living in the forest ecotype. The EIR during high and low transmission seasons was 0.48 and 0.08 infective bites per person per night, which are comparable to those found in many parts of Africa. Major transmission risk factors in forest area are as follows:

(i) High parasite load in the tribal communities due to poor case detection and treatment.
(ii) Predominantly P. falciparum malaria.
(iii) Presence of two primary malaria vectors—An. culicifacies and An. fluviatilis of which An. fluviatilis is highly efficient vector due to high anthropophilic index.
(iv) The two vector species complement each other in malaria transmission thereby ensuring year round transmission.
(v) Low socio-economic conditions, and socio-cultural practices.
(vi) Drug resistant P. falciparum foci in certain areas.

Development of field site for malaria vaccine trial

This is a collaborative project with International Centre for Genetic Engineering and Biotechnology, New Delhi, being funded by the Department of Biotechnology. The studies are being carried out to understand the epidemiology of malaria in Sundargarh district, Orissa which will facilitate the future field trials for malaria vaccines through collection of clinical, entomological and molecular epidemiological/immunological indicators from the study site. The project was initiated during August 2000 and was initially up to July 2002 but has been extended for the tenth Five Year Plan (2002–07). Longitudinal and cross-sectional epidemiological studies are being continued in two sets of villages in forest and plain areas characterised by

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Fig. 16: Study area: District Sundargarh showing villages in two PHCs—Gurundia and Birkera
hyper- and meso-endemic malaria situations respectively. Initially there were 13 study villages with a total population of 4,473. During 2003, the study population was increased to 15,525 with the addition of 23 villages (Fig. 16). Now there are 35 study villages (forest 23, plain 12).

Parasitological studies include monitoring of malaria incidence and attack rate of \( P. falciparum \) in different age groups, age-wise distribution of parasite rates during different transmission seasons, level of parasitaemia and clinical manifestation, splenomegaly in children and adults, prevalence of asymptomatic cases, and collection of biological samples for immunological and molecular studies. Malaria prevalence in the study population during different transmission seasons is being measured through cross-sectional point prevalence surveys in all the study villages during March, June and November characterised by moderate, low and high malaria transmission seasons respectively. About 40% of the houses are selected randomly and all occupants of these houses are examined for malaria parasites.

In forest area villages, malaria transmission is perennial and \( P. falciparum \) accounts for 82% of a total of 3,247 malaria cases recorded during the study period. Malaria transmission is also perennial in plain area villages although the incidence of malaria is markedly low compared to forest villages. On an average the number of \( P. falciparum \) cases in forest and plain villages was 284.1/1000/yr and 31.2/1000/yr, respectively (Fig. 17). In cross-sectional surveys, the average parasite rate in forest and plain ecotypes was 14 and 1.7% respectively.

The malaria transmission intensity varies with seasons, with high transmission after monsoon rains in autumn and winter (October–January), low transmission in summer (April–June) and intermediate transmission during rest of the year. In the forest area, clinical malaria occurs more frequently in children than in adults, whereas in the plain area all age groups are equally affected. In forest villages, the parasite rate is also highest in children aged 0–5 year and declines gradually with increasing age (Sharma et al., 2004). There was a negative correlation between age and number of clinical malaria episodes per person per year (Fig. 18) as well between age and spleen rates suggesting the development of protective immunity with repeated exposure (Sharma et al., 2004).

The forest area is under the influence of two primary malaria vectors—\( An. fluvialis \) sibling species S and \( An. culicifacies \) sibling species C, the former breeds in fresh water streams, is highly anthropophagic and responsible for intense transmission of malaria during post-monsoon months and is complemented by \( An. culicifacies \) sibling species C during other seasons of the year thereby ensuring perennial transmission. In the plain area, \( An. culicifacies \) sibling species C is responsible for malaria transmission. The month-wise
Fig. 18: Age-wise distribution of malaria cases and *P. falciparum* proportion in forest and plain area villages (Data generated through weekly surveillance); PI (F)—Parasite incidence in the forest area; PI (P)—Parasite incidence in the plain area.

man hour density of *An. culicifacies* in forest and plain areas is shown in Fig. 19. *An. fluviatilis*, that is found only in the forest area showed highest prevalence during post-monsoon months (Fig. 20).

The entomological inoculation rate (EIR) in the forest area during low, intermediate and high transmission season was 0.007, 0.279 and 0.546 infective bites/person/night respectively, which is comparable to many areas of high malaria intensity in Africa, whereas in the plain area, EIR was 0, 0.025 and 0.003 infective bites/person/night respectively. The study showed that these villages may be classified as hyper- and meso-endemic respectively.

Assessment of therapeutic efficacy of antimalarials

Sensitivity of *P. falciparum* to chloroquine, amodiaquine, quinine, mefloquine and sulphadoxine-pyrimethamine was evaluated during 1990–91 in the tribal population of Sundargarh district (Ghosh *et al.*, 1992; Yadav *et al.*, 1995). Subsequently, with the revision of protocol by WHO, therapeutic response of chloroquine and sulphadoxine-pyrimethamine was studied in uncomplicated falciparum malaria patients at Keonjhar (Biswas *et al.*, 2003). In 2003–04, 113 falciparum cases in PHCs Bisra and Kuarmunda of Sundargarh district were included and followed-up for...
28 days as per standard WHO protocol. In case of chloroquine, the early treatment failure in Bisra and Kuarmunda was found in 1.8 and 3.4%. The late treatment failure was in 42.9 and 42.4% cases, respectively, while 55.4 and 54.2% cases showed adequate clinical and parasitological response, respectively. All these cases responded well to sulphadoxine-pyrimethamine. On the basis of this study, NVBDCP has changed the drug policy in these two PHCs. Sulphadoxine-pyrimethamine is now the first line drug for the treatment of uncomplicated falciparum malaria.

**Radical curative efficacy of 5-day regimen of primaquine for the treatment of *P. vivax* malaria**

The antimalaria programme of India is using a 5-day primaquine regimen as an anti-relapse therapy to treat *P. vivax* malaria for over four decades now. In view of the conflicting reports on the effectiveness of this regimen in the Indian sub-continent, and varying *P. vivax* prevalence in various ecosystems in India, anti-relapse efficacy of this regimen was evaluated in Orissa, a malaria endemic state in eastern India where *P. falciparum* predominates. In 723 *P. vivax* infections treated with chloroquine alone and followed-up weekly for 1 year, the prevalence of recurrence of parasitaemia with fever was 8.6%. Among another 759 *P. vivax* cases treated with chloroquine and a 5-day regimen of primaquine at 15 mg/day (adult dose), there were 6.5% recurrences of infections. The difference in recurrence was not significant ($p = 0.53$). It is important to note that a great majority of *P. vivax* infections did not recur even without treating with primaquine in this area (Yadav and Ghosh, 2002). This finding that the use of 5-day primaquine regimen with chloroquine had no significant advantage over chloroquine alone, undermines the rationale of using primaquine as an anti-relapse drug in forested areas with a high prevalence of *P. falciparum*.

**Renal involvement in quartan malaria**

Sundargarh district is characterised by the prevalence of quartan malaria caused by *P. malariae* that constitutes about 1% of the total malaria infections (Yadav et al., 1990). Although quartan malaria does not seem to cause concern but when undetected, prolonged course of infection may develop nephritic syndrome. Reports from African studies revealed that *P. malariae* infection caused nephritic syndrome in children as a result of deposition of circulating immune complexes on the capillary walls of renal glomeruli. A study was conducted in collaboration with Ispat General Hospital, Rourkela to examine whether nephritic syndrome will develop in children. In all 70 *P. malariae* cases were followed for six months and urine samples were analysed for protein, creatinine, RBC, WBC and casts. In 62% cases the ratio of urine protein to creatinine was >0.2. A total of 26 children were followed-up after one year of initial screening. Blood samples were tested for cholesterol, urea, creatinine, total protein and albumin while urine samples were analysed for creatinine and albumin. In all the cases the parameters were within normal range except in two patients where urine sample showed hyperalbuminuria. The study showed that quartan malaria does not present etiology of nephritic syndrome in this area.

**Role of nutrition in malaria**

It was reported elsewhere that malnourished children get natural protection from malaria—children with low haemoglobin content suffer less from malaria. A collaborative study with Ispat General Hospital, Rourkela was carried out during 1990–91. The children up to
nine years of age from endemic area of Bisra PHC were included in the study for estimation of haemoglobin by Cyanmethaemoglobin method and malaria. A total of 330 children were followed. Haemoglobin was estimated at the time of malaria infection and then within a month after clinical cure. Studies indicated no significant association of parasitaemia and malaria incidence in children with varying degrees of anaemia (Ghosh *et al*., 1995).

**Malaria in pregnancy and children**

A collaborative operational research study to assess malaria prevalence among children of 12–24 months age group and pregnant women was conducted by MRC/CARE, Orissa in 36 Anganwadi villages of Harichandanpur block in Keonjhar district during 1997–98. The study was a part of anaemia control project with the objective to control the incidence of malaria, which in conjunction with iron supplementation can control the prevalence of anaemia. Malaria prevalence among the pregnant women and children in the age group of 12–24 months was carried out through mass blood survey among the target population before supplementation of iron. Thick and thin blood smears were made and after microscopic examination all malaria positive cases were given radical treatment as per the national drug policy. Subsequently, all children and pregnant women were kept on prophylactic dose of chloroquine. The baseline survey revealed that among the pregnant women and children in the age group of 12–24 months was carried out through mass blood survey among the target population before supplementation of iron. Thick and thin blood smears were made and after microscopic examination all malaria positive cases were given radical treatment as per the national drug policy. Subsequently, all children and pregnant women were kept on prophylactic dose of chloroquine. The baseline survey revealed that among the pregnant women the slide positivity rate (SPR) and slide falciparum rate (SFR) were 4.6 and 3.9 respectively and Pf% was 84.2. Most of the cases were asymptomatic. Among children, the SPR and SFR was 5.9 and 4.7 with a Pf% of 79.4. The endline survey after an interval of one year showed no significant improvement in the malaria prevalence rate though there was marginal improvement in the haemoglobin levels.

**Clinical drug trials**

**α-β Arteether**

A synthetic derivative of artemisinin derived from a Chinese herb (qinghaosu) developed by the Central Drug Research Institute, Lucknow was found highly effective in treating uncomplicated *P. falciparum* cases admitted in Ispat General Hospital by giving one single dose (150 mg deep i.m.) daily for three days in an ethically cleared phase II trial. *In vivo* study in two patients indicated that in one patient (M/30 years) *P. falciparum* parasitaemia dropped from an initial 5200/µl to 400/µl at 12 h and to zero by 24 h interval. In another patient (F/26 years) parasitaemia dropped from an initial 94000/µl to 400/µl at 12 h and sustained up to 24 h and became zero by Day 2. Both patients recovered clinically.

**Gametocytocidal effect of 80/53 compound**

A prospective study to determine gametocytocidal effect of 80/53 compound in uncomplicated *P. falciparum* malaria cases was undertaken. A total of 27 patients with gametocytes in the peripheral blood smears were administered with 80/53 drug @ 75 mg single dose on D-3 after chloroquine therapy. The laboratory reared *An. stephensi* were membrane-fed on the heparinised blood of these patients on D-0 and D-4. The mosquitoes were dissected on Day 7 and Day 10 to see the development of oocysts and sporozoites respectively. The sporogony was inhibited in all the cases except in one of the total 27 cases treated with 80/53 compound, thereby showing gametocytocidal action of the drug.

**Field evaluation of ICT Pf rapid diagnostic kit and quantitative buffy coat (QBC) vs. conventional microscopy**

A rapid immunodiagnostic test, ICT, for the diagnosis of *P. falciparum* in the peripheral blood was evaluated in the field for its sensitivity, specificity and efficacy in comparison to the microscopic examination (Sharma *et al*., 1999). The results showed that the test’s sensitivity, specificity and efficacy were 98.2, 96.9 and 97.5% respectively. The positive and negative predictive values of the test were 96.4 and 98.4% respectively. The test, when compared to the conventional microscopy, did not show any statistically significant difference suggesting that the two diagnostic methods are equally good. The test performed did not show cross-reactions with other parasite species. It is a simple and rapid field diagnostic method, which does not require any expensive laboratory equipment or skilled personnel. A comparative study on malaria diagnosis by QBC and conventional microscopy was carried out. The results showed that QBC method’s sensitivity, specificity and efficacy were 80.1, 93.5 and 83.8% respectively (Singh *et al*., 2001).

**Genetic markers and malaria**

Blood samples collected from different tribal communities in Sundargarh district were screened for G-6-PD deficiency by filter paper spot test. In 362 out of 1990
(18.2%) samples were found to have G-6-PD deficiency, 16.4% population was found having sickle-cell trait, while 767 blood samples from forest area villages and 379 from plain area villages were tested for haemoglobin by Hemocue machine and 10.8 and 7.4% children in the age group of 1–5 year in forest and plain areas respectively were found having haemoglobin in the range of 7–10 g/dl in both the areas respectively. Only 2% children in the forest area and 5% in the plain area were found having normal haemoglobin above 11 g/dl. Malaria may be one of the major causes of low haemoglobin (Sharma et al., 2004).

**Malaria outbreak investigations**

Epidemiological and entomological investigations were carried out during the months of May and June 1995 in some villages under two malaria affected PHCs of Bikaner district. The area is a part of the Thar desert and characterised by small sandy hillocks experiencing extremely high temperature during summer and low rainfall of 150 to 200 mm per year. Only western part of the district is irrigated by Indira Gandhi Canal. Malaria incidence was low up to 1991 (API< 2) but increased manifold during 1992 and 1994 (API 5 to 11) reaching to an epidemic situation in the district. The two PHCs, Napasar and Kolaiyat were worst affected during 1994. The possible reasons for high incidence of malaria were poor surveillance (annual blood examination rate 5.3%); poor house spray coverage (11 to 27%) and high rainfall during 1994 (350 mm). The entomological studies revealed that An. stephensi was dominant (53.4%) followed by An. culicifacies (14.7%). An. stephensi was found to breed in cemented tanks and ponds, whereas An. culicifacies was found breeding in the seepage water of canal in the fields. On the basis of survey, the following recommendations were suggested:

(a) EDPT strengthening.
(b) Training of laboratory technicians in malaria microscopy.
(c) Improvement in spray quality and percentage coverage.
(d) Control of breeding of An. stephensi in intra-domestic containers.
(e) Use of insecticide-treated nets

During May–June 1999, a serious malaria outbreak with deaths occurred in the Paderu Division of Visakhapatnam district, Andhra Pradesh affecting a population of about 5.5 lacs, which were mostly tribals. On the request of the state government, an investigation was carried out on the causes of malaria outbreak (Dhiman et al., 2001). The slide positivity rate was 70% in spite of intensive surveillance and fever radical treatment in the affected areas. An. culicifacies was found resistant to DDT, but susceptible to mala-thion and deltamethrin. However, the finding of An. culicifacies in only four villages out of 12 tribal villages surveyed, and that too with highest density of 13.3, indicated that DDT was still having some impact. In a small sample, P. falciparum parasite was found resis-tant to chloroquine. The possible reasons of outbreak were: lack of surveillance and expertise in detection of malaria parasite; (ii) ineffective radical treatment as indicated by resistance in P. falciparum; and (iii) im-proper coverage of indoor residual DDT spraying in 1998. Advanced rains in the month of May 1999 also added to the hindrance in surveillance and control measures in the hilly terrain of the affected area. A report was submitted to the state government for taking follow-up actions.

**Community awareness in controlling mosquito-borne diseases**

Health education has been recognised as an important tool for human resource development. During the course of implementation of an integrated malaria control project in a tribal area of Orissa state, a health education programme involving demonstration camps, group meetings, documentary films on malaria and filariasis, wall slogans, student rallies in villages, inter-school debates and children exhibition were organised from July 1988 to December 1991. Apart from these, village health committees including the village heads, religious leaders, teachers, Mahila Mandalis and Yuvak Sanghs were also organised to make the programme successful. To assess the impact of health education on the level of awareness a survey was conducted at the completion of the study taking 6 villages of Bisra PHC where the integrated control strategy was launched and six villages of neighboring Birkera PHC where spray and fortnightly malaria surveillance was being carried out. Two hundred fifteen people were interviewed in each area. The results obtained through a questionnaire survey were analysed, which showed an overall statistically significant improvement in the knowledge of high schoolchildren, and adults (Yadav et al., 1993). Among the mosquito-borne diseases, knowledge about malaria was significantly higher in experiment-al villages (68.3%) than in the control (5.7%). More than 96% of the children in the intervention area knew
that mosquito breeding took place in water compared to 30.8% in the latter and 90.4% of children of intervention area recognised the mosquito larvae and pupae as compared to the 6.7% in control. Among mosquito control and personal protection methods knowledge about bioenvironmental methods and use of bednet was present in higher proportion in intervention group (71.2%) than in control (3.8%).

People of both the areas knew equally well about the presence of malaria in their areas reflecting malaria as a major health problem. Nevertheless, the actual cause of malaria was known better to intervention group (64.2%) than to the control (26%). There was a significant improvement in the knowledge in intervention area (74.4%) than in control (19.5%). Over 60% of the people in intervention area recognised the mosquito immature as compared to less than 9% in control. When asked about the source of acquiring information, children attributed it largely to the project activities (87.2%).

Socioeconomic factors of malaria in tribal area

Malaria was found to have high prevalence and caused serious economic loss in the mining areas (Yadav, 1991; Yadav et al., 1991). Another study on the socioeconomic factors and human behaviour in a cross-section of tribal communities in Sundargarh district, Orissa revealed that poor socio-economic status and sociocultural factors play important role in maintaining high degree of malaria transmission (Sharma et al., 2001). Human behaviour such as location of hamlets, types of housing, sleeping habits, outdoor activities after dusk, poor knowledge about the disease and treatment seeking behaviour are of great significance as determinants of malaria transmission. All these factors need to be considered before planning a community health programme. Estimation of economic loss due to malaria showed an average loss of 8.96 man days per malaria patient with an average loss of 3.84 man days to other family members. Mean total loss per malaria episode comes to Rs. 334.91. The study showed that malaria is one of the major diseases affecting the tribals and putting a lot of burden on the economic upliftment of these communities.

Situational analysis of malaria

Problematic districts were identified jointly by IDVC field unit and NVBDCP for detailed study with the objectives to assess the malaria situation and status of programme implementation in the districts and to provide technical assistance to the district/state health authorities. Surveys were carried out in three districts of Bolangir, Nuapada and Kalahandi of Orissa during 2002. Data from district headquarters and PHCs were collected as per proforma provided by NVBDCP. Besides collection of data and spot observations, the team also carried out vector susceptibility studies, rapid fever surveys and cross-examination of blood slides collected from different PHC’s.

Assessment of the operational feasibility of the introduction of rapid diagnostic kits and blister packs

Blister packs for the radical treatment (RT) of adult patients (15 year and above) who constitute nearly 60% of all cases of malaria were introduced for the first time in the national programme to improve acceptance of antimalarial drugs and compliance of the full course of radical treatment. The advantage of these blister packs is that less number of tablets has to be consumed for each dose. Such blister packs have been used in Maharashtra for about seven years and have been found to be effective and well accepted. Since there is a time-lag between collection of blood slide and diagnosis, all fever cases are given presumptive or presumptive radical treatment. The latter has been recommended for high-risk areas during transmission season. Conventional presumptive treatment (600 mg chloroquine) is an incomplete treatment, it acts as an antipyretic and may prevent complications. The full dose of 1500 mg chloroquine + 45 mg primaquine has advantage of complete treatment but majority of patients without Pf also get exposed to high dose of chloroquine and primaquine. Therefore, if rapid test for Pf is conducted, only positive cases can be treated with FRT while the rest can either be treated after microscopic diagnosis or can be given chloroquine since these will be either vivax cases or negative for malaria. IDVC field unit, Rourkela carried out independent assessment of the operational feasibility of rapid diagnostic kits and Blister packs in two states under Enhanced Malaria Control Project in Orissa and Chhattisgarh as per terms of reference given by NVBDCP and detailed report was submitted.

Evaluation of ITN programme

Insecticide-treated mosquito nets is one of the impor-
tant components of integrated vector control. The use of insecticide-treated mosquito nets is promoted under the NVBDCP as a cost-effective vector control measure. A pilot project in 14 districts was started in May 2003 to document operational aspects of the treatment of the mosquito nets and to assess the inputs required to make the above exercise feasible at the field level on a sustainable basis in the above pilot districts. IDVC field unit, Rourkela carried out concurrent evaluation to document the operational aspects of the treatment of the mosquito nets in Visakhapatnam (Andhra Pradesh), Purulia (West Bengal) and Nayagarh (Orissa) during March–April 2004 and the detailed report was submitted to NVBDCP.

Studies on the prevalence of bancroftian filariasis in Sundargarh district, Orissa

All the blood smears collected through active surveillance in PHC Bisra during day-time were also examined for the presence of microfilariae. In 1988–89 the mf rate was 0.76, whereas it came down to 0.55 and 0.28 during 1990 and 1991 respectively. Night mass blood surveys conducted in the study area indicated high prevalence rate of 5.9, 5.8 and 10.5 during 1989, 1990 and 1991 respectively. The study indicates that lymphatic filaria caused by Wuchereria bancrofti is endemic in the area (Ghosh & Yadav, 1995). The concomitant infections of filarial with P. vivax, P. falciparum and P. malariae were also recorded.

Malaria clinic

Malaria clinic of the field unit provided free referral services to medical practitioners and general public for diagnosis and treatment of malaria. Every year, on average 7,000 to 13,000 persons are examined for malaria and those found with malaria are given free treatment as per national drug policy (Table 6). Malaria clinic data provided indication for malaria trend as well as useful information for delimiting of transmission foci in and around Rourkela. Data also helped in identifying sentinel sites for various field efficacy trials of newer intervention tools.

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