# Persistence of malaria transmission in a tribal area in Maharashtra, India

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**In recent years the incidence of malaria in most of the districts of Maharashtra has reduced but the problem in Gadchiroli district was still persisting in spite of implementation of the main tools of intervention, i.e. indoor residual spray (IRS) by deltamethrin and fever radical treatment (FRT) to all fever cases. A study was made to find out the reasons for persistence of malaria in Gadchiroli district during November 2002. The coverage of two rounds of IRS by synthetic pyrethroids was around 85%. Detailed parasitological survey revealed that slide positivity rate ranged from 3.22 to 42.8 and *P. falciparum* was sensitive to chloroquine in majority of the subjects (92.6%). Twenty-five per cent of positive cases detected were having gametocyte stage of *P. falciparum* parasite, indicating that compliance to FRT was not satisfactory. Entomological findings revealed that the main vector, *Anopheles culicifacies* was resting indoor and was 100% sensitive to deltamethrin. Results of cone bioassay indicated that on the wall surface sprayed before nine days, mortality of *An. culicifacies* was around 67.8%, while the mortality was only 13% on the surface sprayed before one month, indicating unsatisfactory quality of spray. An insight into the reasons for persistence of malaria revealed that the intervention measures were being affected by the social factors. The findings emphasize the importance of health education to community and their involvement in malaria control for achieving best results.**

THERE has been a decline in malaria incidence in most of the districts of Maharashtra but a few districts in Nagpur division were still having problem of malaria with deaths.

The Gadchiroli district is mainly hilly forested and inhabited by the Gond tribal population and is under the Enhanced Malaria Control Programme. Details of topography, health infrastructure, etc. of the district are given in Table 1. The majority of houses have mud-plastered walls with thatched/tiled roofs. The number of rooms per family is usually 2–4 and cattle sheds are attached with human dwellings. In winter season, smoldering of wood in the compound of houses is common during nights. Pyrethroids are in use as indoor residual spray (IRS) since 1998 and two rounds of IRS are undertaken. In 2002, the first round of IRS was made in July using Fendona (α cypermethrin) and the second round of deltamethrin 2.5% wp (@ 20 mg/m$^2$) in October/November 2002.

In condensed fever treatment (CRT), similar to fever radical treatment (FRT) as per criterion of NAMP[1], all fever cases in high risk areas are given adult dose of presumptive treatment of 1500 mg chloroquine in three divided daily doses, i.e. 600 mg on 1st day, 600 mg on 2nd day and 300 mg on 3rd day with a single dose of 45 mg Primaquine on 1st day. If the fever cases are found positive for *P. falciparum*, no radical treatment is given. However, in *P. vivax* infection, Primaquine @ 15 mg daily for five days is given for radical treatment. The chloroquine-resistant cases of *P. falciparum* are given second line of treatment of Sulphalene/Sulphadoxine 1500 mg + Pyremethamine 75 mg as single adult dose and thereafter 45 mg Primaquine. In spite of this, annual parasite incidence (API) in 2001 was 15.20 with five deaths and in 2002 API was 7.94 with three microsocopically confirmed deaths (Table 2). Deaths were reported to be due to late health-seeking behaviour and not adhering to radical treatment. Therefore, a field visit was undertaken in November 2002 (peak transmission month of malaria) to investigate the reasons for persistence of malaria in Gadchiroli district.

The Primary Health Centre (PHC) wise epidemiological data for the last five years, i.e. from 1997 to 2001 were collected from the office of District Malaria Officer, Gadchiroli.

Based on the incidence of malaria in 2001 and 2002, four PHCs namely Dhanaura, Muramgaon, Etapalli and Gatta were selected as representative of high malaria. To know the situation in low-malarious areas, the Chamorshi PHC was selected. Entomological surveys for collection of anopheline mosquitoes for availability of malaria vectors, adult mosquito collection from human dwellings and cattle sheds for determining man hour density (MHD), insecticide susceptibility of *An. culicifacies* to insecticides used for IRS and cone bioassay for determining the quality of IRS

**Table 1.** District profile of Gadchiroli

| Parameter | | Information |
|---|---|---|
| Created in | : | 1982 from Chandrapur district |
| Area | : | 14412 km$^2$ |
| Population | : | 994292 (urban, 49000; rural, 945292) |
| Tribal population | : | 987217 |
| Tribes | : | Madia, Gond and Gowari |
| Rivers | : | 10 |
| Altitude | : | Max 967 m |
| Topography | : | 77.9% hilly forested |
| Temperature and rainfall | : | 6–45°C and 2133 mm |
| PHCs | : | 46 |
| Tribal PHCs | : | 44 |
| High risk PHCs | : | 17 |
| Ashram schools | : | 86 |
| Anganwadi | : | 1285 |
| Drug distribution centres | : | 2057 |
| Fever treatment depots | : | 542 |
| Pada workers | : | 1598 |

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**Table 2.** Epidemiological data of malaria in Gadchiroli district (1997–2002)

| Year | Population | Blood slide collected/examined | Positive | *P. vivax* | *P. falciparum* + mixed | ABER | API | SPR | *Pf* % | Death |
|---|---|---|---|---|---|---|---|---|---|---|
| 1997 | 887000 | 595794 | 15286 | 7406 | 7880 | 67.17 | 17.23 | 2.57 | 51.55 | 8 |
| 1998 | 897000 | 631737 | 17206 | 6274 | 10932 | 70.43 | 19.18 | 2.72 | 63.54 | 1 |
| 1999 | 912000 | 633387 | 15896 | 6596 | 9300 | 69.45 | 17.43 | 2.51 | 58.51 | 3 |
| 2000 | 919000 | 662808 | 17865 | 6038 | 11827 | 72.12 | 19.44 | 2.70 | 66.20 | 5 |
| 2001 | 942000 | 887390 | 14321 | 5448 | 8873 | 94.20 | 15.20 | 1.61 | 61.96 | 5 |
| 2002 | 994292 | 588185 | 7703 | 2548 | 5155 | 60.70 | 7.94 | 1.30 | 62.95 | 3 |

Source: Office of District Malaria Office, Gadchiroli.

were made in selected villages according to standard methods[2,3]. The insecticide papers used for tests were supplied by WHO and used afresh. Outdoor collections were made by searching tree holes, bushes, ditches, etc. and by installing CDC light trap outdoors from 1800 to 0600 h. *An. culicifacies* collected indoors were cytologically identified to sibling species following Subbarao[4]. The mosquitoes used for determining insecticide-susceptibility status of *An. culicifacies* were collected from IRS-sprayed villages while for cone bioassay, mosquitoes were collected from unsprayed village. Fever surveys were made by door-to-door visit for collection of blood smear from fever cases and blood slides were examined in the field itself and radical treatment was given[1]. For determining the sensitivity of *P. falciparum* to chloroquine, patients were recruited for *in vivo* drug sensitivity following Prasad *et al.*[5] and WHO[6].

The analysis of epidemiological data from 1997 to 2002 revealed that API ranged from 7.94 to 19.44 (Table 2). *P. vivax* and *P. falciparum* are the species of malaria parasites recorded from the area and the proportion of *P. falciparum* cases ranged from 51 to 66% during 1997–2002. Annual blood examination rate was high, ranging from 60.7 to 94.20, indicating capture of all possible fever cases and possibility of repeated blood slide collection from the same subjects. Slide positivity rate recorded was less than 3 during 1997–2002. The main disease transmission period is from July to December, with highest in November and lowest in May–June.

In the present study, overall 20 villages in five PHCs were surveyed for point prevalence of malaria in the community. Slide positivity rate (SPR) ranged from 3.22 to 42.8 (Table 3). The percentage of *P. falciparum* ranged from 60 to 100. Students of Ashram schools (residential) run by the state government for tribal population, showed more positivity for malaria. The age group of malaria-positive subjects indicated indigenously ongoing transmission of malaria as evidenced by 12.5% positivity of infants. Subjects up to 14 years of age constituted about 70% of malaria-positive cases. The 25% of subjects found with gametocyte stage of parasite indicated that FRT was not satisfactory. *P. malariae* was detected in one person from Godalwahi village, Dhanaura PHC.

The results of *in vivo* sensitivity of *P. falciparum* to chloroquine (till 14 days) on 27 subjects revealed that except two children from Gatta and Chavela villages (4 and 5 years) with scanty ring stages of parasite on days 7 and 14, all were cleared of parasites by day 7 indicating efficacy of the treatment.

Streams, rivulets and ponds in villages were major breeding habitats of anophelines. Of nine villages under high-risk area, *An. culicifacies* was collected from eight villages in deltamethrin-sprayed human dwellings and cattle sheds and MHD ranged from 1 to 52. *An. annularis*, *An. splendidus*, *An. subpictus* and *An. barbirostris* were collected in low numbers. In low-malarious villages, *An. culicifacies* MHD was 34.5 and 90. There was no evidence of outdoor resting of *An. culicifacies* except in one village Chavela under Dhanaura PHC, where the vector was found in a tree hole in the vicinity of human dwellings.

*An. culicifacies* could not be collected in light trap collections made during the survey. Cytotaxonomy of *An. culicifacies* specimens revealed the prevalence of species B and C. Of 64 samples examined, 54 (84.3%) were species C, an established vector of malaria in India; while 10 (15.6%) were species B, a non-vector. *An. fluviatilis* though in very low density (0.3 per man hour) was also encountered from Jharewada village, the role of which needs to be determined.

The results of insecticide susceptibility status of *An. culicifacies* indicated (Table 4) that the vector was fully susceptible to deltamethrin (0.05%), 92.9% susceptible with Malathion (5%) and 51% susceptible to 4% DDT when exposed for one hour.

Cone bioassays were also conducted on wall surfaces sprayed with deltamethrin one month before and nine days before the date of bioassay conducted in Etapalli and Gatta villages respectively (Table 4). The results revealed that on the wall surface sprayed with deltamethrin before one month (29 days), 12.9% mortality was observed in *An. culicifacies*, while on the surfaces sprayed nine days before, the mortality was 67.8%. It indicates that the quality of insecticide spraying was unsatisfactory.

Analysis of the data of second round of deltamethrin spray in 48 villages under Dhanuara PHC from 8 to 31 October 2002 revealed that 16.2% of houses were not covered fully, while 2.59% houses were found closed. 9.8% of rooms could not be covered under IRS. It is primarily due to lack of knowledge and cooperation of local inhabitants

**Table 3.** Results of fever survey undertaken in Gadchiroli district (Nov. 2002)

| PHC | Locality | Population | BSC/BSE* | +ve | *Pv* | *Pf* | *Pm* | *Pf* % | SPR |
|---|---|---|---|---|---|---|---|---|---|
| Dhanaura | Malanda | 460 | 9 | 1 | 0 | 1 | 0 | 100 | 11.1 |
| | Chavela | 631 | 7 | 3 | 0 | 3 | 0 | 100 | 42.8 |
| | Godalwahi | 1027 | 33 | 5 | 1 | 3 | 1 | 60 | 15.1 |
| | Katchkar | 144 | 31 | 1 | 0 | 1 | 0 | 100 | 3.22 |
| | Japtalai | 450 | 43 | 6 | 0 | 6 | 0 | 100 | 13.9 |
| Muramgaon | Kulbhatti | 800 | 56 | 4 | 0 | 4 | 0 | 100 | 7.14 |
| | Muramgaon + ashram school | 1500 | 105 | 6 | 0 | 6 | 0 | 100 | 5.71 |
| Etapalli | Todsa | 1987 | 12 | 1 | 1 | 0 | 0 | 0 | 8.33 |
| | Jharewada | 180 | 2 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | Petha | 384 | 5 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | Maveli | 185 | 4 | 1 | 0 | 1 | 0 | 100 | 25.0 |
| | Burgi ashram school | | 26 | 6 | 1 | 5 | 0 | 83.3 | 23.0 |
| | Udera ashram school | | 5 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | Pandewahi ashram school | | 5 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Gatta | Jambia + ashram school | 375 + 300 | 27 | 5 | 0 | 5 | 0 | 100 | 18.5 |
| | Hedri ashram school | 21 | 5 | 0 | 5 | 0 | 100 | 23.8 | |
| | Gatta | 920 | 5 | 2 | 0 | 2 | 0 | 100 | 40.0 |
| | Basewada | 265 | 7 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| Chamorshi | Kurud | 1500 | 8 | 2 | 0 | 2 | 0 | 100 | 25.0 |
| (low risk PHC) | Markanda Dev | 550 | 3 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| | | Total | 414 | 48 | 3 | 44 | 1 | 91.6 | 11.5 |

*Blood slide collected/examined.

**Table 4.** Results of insecticide susceptibility tests and cone bioassay conducted on adult *An. culicifacies*

| Insecticide paper used | Locality | No. of mosquitoes exposed | | Mortality after 24 h | | Corrected % mortality |
|---|---|---|---|---|---|---|
| | | Expt. | Control | Expt. | Control | |
| Insecticide susceptibility test | | | | | | |
| DDT (4%) | Malanda (Dhanaura) | 45 (3) | 15 (1) | 23 | 0.0 | 51 |
| Deltamethrin (0.05%) | Chavela (Dhanaura) | 60 (3) | 25 (1) | 60 | 0.0 | 100 |
| Malathion (5%) | Maveli (Etapalli) | 33 (3) | 15 (1) | 31 | 13.3 | 92.9 |
| Cone bioaassay | | | | | | |
| | Todsa[a] (Etapalli) | 31 (2) | 15 (1) | 4 | 0 | 12.9 |
| | Gatta[b] (Gatta) | 30 (2) | 15 (1) | 21 | 1 | 67.8 |

[a]Test conducted after 29 days of deltamethrin spray; [b]After nine days of deltamethrin spray.
Figures in parentheses indicate the number of replicates.

who leave their houses early in the morning and do not allow spray in kitchen and worship rooms. It was also noticed that second round of IRS was undertaken in October, i.e. just before Diwali festival. On the occasion of Diwali, the inhabitants smeared/white-washed their houses, thus nullifying the effect of spray.

Vacancies of surveillance staff in some PHCs like Gatta were also found as one of the major reasons for persistence of malaria.

The results reveal that in spite of FRT to all positive malaria cases, about 85% coverage of houses by deltamethrin (to which the vector species, *An. culicifacies* is fully susceptible), highly satisfactory surveillance leading to ABER from 60 to 94.20, malaria was still refractory to intervention measures. The finding of 25% of *P. falciparum*-positive subjects with gametocytes indicates that compliance to treatment was not satisfactory and the efforts of local health authorities in giving FRT are thwarted by the attitude of local population who are under the influence of quacks. The vector species was fully susceptible to deltamethrin, the insecticide used for indoor residual spray in the study area. But the results of cone bioassay

revealed that the indoor wall surfaces were not having residual effect of the sprayed insecticide. It can be explained primarily to the quality of spray and smearing of houses with white-wash on the occasion of festivals. The high fever rate with low SPR warrants further investigation to find out the cause of fever other than malaria.

The study shows that the efforts of local malaria control operations are thwarted by the attitude of local population by not adhering to complete treatment, smearing of houses after indoor residual spray and not realizing the importance of IRS (as they do not allow spray in all rooms). Socio-cultural aspects of tribal inhabitants responsible for maintaining high degree of malaria have been well documented[7–9] from intense malarious regions of Assam, Orissa and Madhya Pradesh. Inaccessibility due to difficult terrain and non-compliance to treatment by inhabitants are the prime reasons resulting in outbreaks of malaria in tribal areas[10–13].

There is need to impart health education to tribal communities by audiovisuals (i) showing the benefits of adhering to radical treatment to avoid deaths, (ii) to educate them not to smear the sprayed surfaces and ensure complete coverage of houses and rooms, (iii) promotion of insecticide-treated bed nets in Ashram schools, and (iv) introduction of blister packs for specific age groups of fever/malaria cases for more effective radical treatment. The finding of *P. malariae* necessitates the importance of careful blood slide examination to know the actual prevalence of parasite species requiring specific treatment strategy. There is also need to monitor drug resistance in *P. falciparum* to chloroquine in different areas and to ensure whether two rounds of IRS are sufficient to exert vector control in an area with transmission window open for around eight months.


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# Nitrous oxide fluxes in a tropical shallow urban pond under influencing factors

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**Fluxes of nitrous oxide ($N_2O$) were measured *in situ* monthly for two years from a tropical shallow urban pond, receiving influx of agricultural run-off from the surrounding water shade and domestic sewage, located in Ujjain city, Madhya Pradesh. Results revealed that the shallow pond is a continuous source of $N_2O$ with relatively low efflux value (0.00 to 0.51 mg $m^{-2}$ $d^{-1}$) and maximum emission generally occurred during the hot seasons (77% of annual emission), with annual mean of 1.0 kg $N_2O$ $ha^{-1}$ $yr^{-1}$. Several influencing factors like pH, temperature, total nitrogen, inorganic nitrogen stock and organic carbon were studied concomitantly with $N_2O$ gas flux measurement. $N_2O$ emissions were positively and significantly correlated with sediment total nitrogen and surface water temperature. The study concludes that the shallow tropical water body is a source of $N_2O$ flux, but does not have significant efflux compared to the terrestrial habitats.**

AQUATIC ecosystems are considered to be significant sources of nitrous oxide ($N_2O$), a stable trace gas contributing to the

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