ISSN 0377-4910

ICMR BULLETIN

Vol.39, No.4-6 April-June, 2009

INTEGRATED DISEASE VECTOR CONTROL OF MALARIA: A SUCCESS STORY BASED IN ASSAM, NORTHEASTERN INDIA

Integrated Disease Vector Control (IDVC) project had its beginning in Kheda district of Gujarat way back in 1983. With the demonstrated success of malaria control using environmental approaches in select villages of Nadiad Taluka, the project jointly funded by the Indian Council of Medical Research and Ministry of Health and Family Welfare was expanded in mission mode to field test this strategy in different epidemiological situations. The criteria for site selection were high transmission of malaria not responding to residual spraying of the given insecticide(s), prevalence of high proportions of *Plasmodium falciparum* and reported death cases, variations in ecological settings involving different malaria transmitting vector species, and other epidemiological determinants influencing malaria transmission, *viz.*, tribal belts, forest coverage, industrial establishments, rainfall, rural and urban settings, *etc*. It was a general consensus that field testing and study outcome of various emerging technologies in these varied ecological settings would result in the implementation of the control programme for malaria transmission reduction. Among the different study locations in the country, the Sonapur Primary Health Centre (Dimoria block) in Kamrup district of Assam was selected for the northeastern states as prototype foothill location reporting majority cases and malaria-attributable deaths annually. The state of Assam ($24^{0}44'$ - $27^{0}45'$ N latitude; $89^{0}41'$ - $96^{0}02'$ longitude) is the most populous (29.65 million, population as per census 2007) and is the gateway to the northeast for economic activities. The region is highly receptive to malaria transmission and accounts for >50% of reported cases of malaria in the northeastern region. Here malaria transmission is perennial and persistent with seasonal peak during April - September corresponding to months of rainfall. *P. falciparum* and *P. vivax* both occur in abundance but *P. falciparum* is the predominant parasite (>60%). Focal disease outbreaks were recurring characterized by high rise in cases and deaths attributed to *P. falciparum* malaria. The problem of chloroquine resistance first detected in Assam was spreading and intensifying. The available methods of malaria control which included chemotherapy (anti-parasite) and DDT spraying operations (anti-vector) were not producing desired levels of transmission reduction threatening equitable socio-economic development of the region. The northeastern region of the country is of strategic importance with international borders with China to North, Bangladesh to the South, Myanmar to East and Bhutan to the West, and poses several challenges in malaria control contributing to the hapless malaria situation. Inter-alia these included heavy rainfall and recurrent floods, inaccessible terrain, civic unrest, poverty and illiteracy, poor health infrastructure in the periphery, population migration and deforestation. To contain the disease severity, there was imperative need for alternative interventions which are operationally feasible, cost-effective, community-based and sustainable. Given the mandate, ever since the establishment of the field station in Assam in 1986, besides the in-depth study of malaria epidemiology and vector bionomics, number of technologies that were subject to field evaluation and subsequent implementation in the control programme, are reviewed in the present write-up.

Vector Bionomics and Disease Relationships

In the state of Assam, rainfall is heavy and most part of the year is hot (22-33^{0}C) and humid (60-90% RH) that is conducive for mosquito proliferation and longevity. Mosquito fauna of the state is rich and breeding habitats are numerous and diverse[1,2]. Contrary to the common belief that *Anopheles minimus* had disappeared implicating the role of *An. philippinensis* as vector, *An. minimus* were recorded to be prevalent and incriminated by detection of sporozoites in its salivary glands practically for all months of the year, and proven unequivocally to be a predominant efficient malaria carrying mosquito in most districts of the Brahmaputra valley of Assam[3]. Their relative abundance, as well as breeding, biting and other behavioral characteristics of *An. minimus* were established which helped formulate species specific intervention strategies. Tools based on geographical information system (GIS) were field tested for establishing distribution of vector species and targeting interventions for effective control, and saving costs[4]. Other proven vector species, *i.e.*, *An. dirus* (renamed as *An. baimaii*) was also recorded but was found to be of seasonal importance (monsoon months) with patchy distribution restricted to forest fringe villages. Its numbers (erstwhile predominant species) were recorded to be dwindling owing to large scale deforestation, changing agricultural practices and population migration. In addition, *An. fluviatilis* were also observed to be prevalent in winter season only but population density was dismal low. Collaborative research efforts revealed that *An. fluviatilis* population in Assam is indeed only a variant form of *An. minimus* that was confirmed using molecular assays (O.P. Singh, personal communication). Similarly, *An. philippinensis* that is abundant were cytogenetically characterized as *An. nivipes*[5]. However, with the fast urbanization and population explosion, there was an imperative need to study the mosquito fauna and vector bionomics in the changing ecological context and climatic determinants for effective vector control. The available data on prevalent vector species helped design and field test insecticide-treated netting materials against malaria specific to northeast region.

Malaria Parasite Load and Transmission Dynamics

A malaria clinic was established in the Sonapur Primary Health Care Centre (Kamrup district) as passive cases detection agency to ascertain disease burden, parasite formula and transmission trends. Malaria was found to be perennial and persistent evidenced by infant parasite rate for all months of the year[6]. Parasitic infections were recorded in both febrile (34%) and afebrile (12%) individuals suggestive of herd immunity and asymptomatic carriers in the communities[7]. *P. falciparum* was the predominant species and constituted >60% of cases confirmed positive by microscopic examination. The only other malaria parasite infection was *P. vivax* barring few sporadic cases of *P. malariae*[8]. Mixed infections of *P. falciparum* and *P. vivax* constituted <1% of malaria cases representative of low-to-moderate transmission intensities. Malaria cases were recorded across all age groups of both sexes, but parasite prevalence rates were significantly higher in <15 years age group than ≥15 years ($P < 0.0001$). Individuals with gametocytes were recorded for all months but proportions of carries were significantly higher in dry months compared to wet season ($P < 0.01$) underlining inadequate treatment/ drug failure. Monthly distribution of cases revealed that there was shift in parasite formula in favor of *P. falciparum* in April - June corresponding to months of rainfall. There were consistently far more cases of *P. falciparum* in wet season (April - September) compared to dry season (October-March), but the transmission intensities varied significantly between years ($P<0.0001$). Nevertheless, correlation between annual rainfall and number of reported cases was not significant ($P = 1$)[9]. Based on data for the period 1991- 2007, transmission trends were clearly declining which could be attributed to multiple interventions including use of insecticide treated nets (ITNs), artemisinin-based combination therapy and increased awareness regarding disease prevention and control (Figure)[10]. The disease transmission profiles are changing in relation to interventions in force, urbanization, ecological changes and climatic determinants which warrant periodic situational analyses for appropriate policy in place.

Insecticide Treated Netting Materials for Vector Control

In Assam, vector populations of *An. minimus* are highly susceptible to DDT which continues to be used for indoor

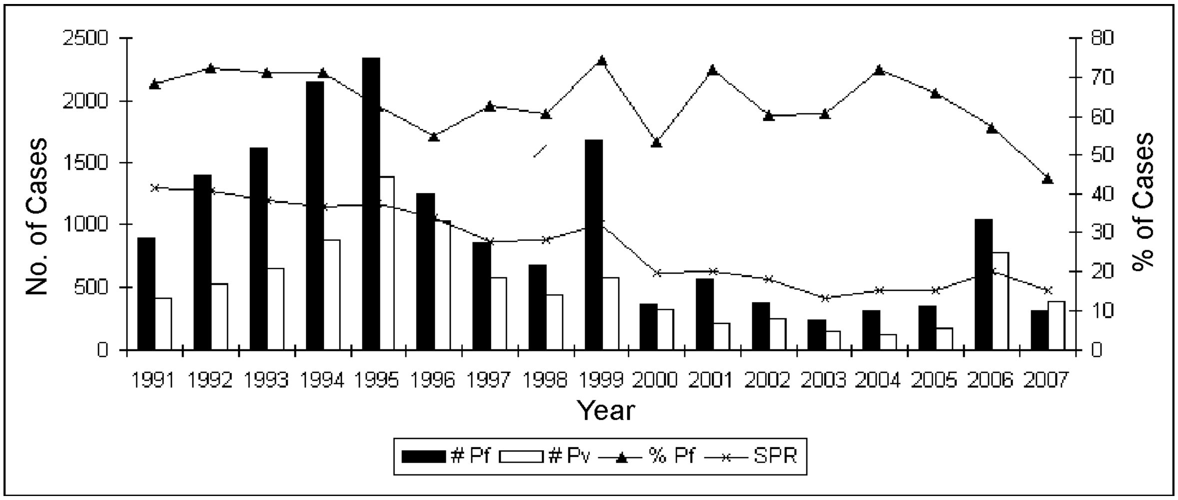

Fig. Malaria transmission trends and parasite species composition in the Sonapur Primary Health Centre, Kamrup district, Assam, India for the years (1991 - 2007) for data based on passive detection agency (Pf = *Plasmodium falciparum;* Pv = *Plasmodium vivax*; SPR = slide positivity rate)

residual spraying in high-risk areas reporting high proportions of *P. falciparum* and death cases[11]. However, for decades of attempted control using DDT, malaria transmission remained uninterrupted largely due to operational constraints including high refusal rates, recurrent floods and difficult terrain limiting access to outreach population groups where it is needed most. Return of focal disease outbreaks have also been reported. As an alternative strategy to DDT spraying, village scale field trials were conducted with insecticide-treated nets (the first time in India) in malaria endemic pocket of Assam during 1988-1990. These trials were evaluated to be a success story by the Technical Advisory Committee of the National Vector Borne Disease Control Programme (NVBDCP) of Government of India[12-13]. Based on the research findings, a pilot project was undertaken under centrally sponsored scheme to assess the operational feasibility and sustainability of this intervention through primary healthcare services in the northeast sector for which National Institute of Malaria Research (formerly Malaria Research Centre) served as the nodal agency for technology transfer which involved demonstration and training of health workers of entire northeastern states and participating NGOs. Under this scheme, one hundred thousand insecticide-treated nets were distributed gratis beginning 1996 in communities living below poverty line that were identified by the respective state health directorate of seven states of the northeast. For reporting states of Assam, Meghalaya and Arunachal Pradesh for which data were analyzed, the results were found to be promising in reducing disease transmission, and public responses were forthcoming (Table)[14-16]. The communities clearly preferred ITNs against DDT spraying

Table. Implementation and impact assessment of Insecticide treated nets on malaria transmission in northeastern states of India[a]

State	Population	Time Period[b]	No. blood-smears examined	No. +ve for malaria parasite	% of blood-smears +ve for malaria parasite	No. of malaria cases per 1000 population
Assam	31467	Jan–Dec 1995	12713	2215	17.41	70.39
	32732	Jan–Dec 1996	2715	178	6.55	5.34
Meghalaya	8946	Jan–Dec 1995	4424	609	13.76	60.00
	10270	Jan–Dec 1996	4494	274	6.09	26.67
Arunachal Pradesh	9404	Jan–Dec 1995	6431	828	12.87	88.05
	9710	Jan–Dec 1996	5567	86	1.54	8.86

[a]Source: Data collected by the respective State Health Directorate through primary healthcare services (for other northeastern states, the distribution of nets was irregular and patchy, thus data could not be evaluated). The re-treatment of nets was not conducted as scheduled, thus data of the subsequent years could not be considered.

[b]Data for January - December 1995 is the baseline malaria incidence. Mosquito nets treated with deltamethrin (2.5% flow) were introduced in January 1996.

and reported collateral benefits for decreased nuisance due to other household insect pests. Based on the resounding success, the ITNs distribution programme was extended to malaria endemic states of Orissa and Madhya Pradesh, and results were reproducible. Since then provision of ITNs is a continuing activity under Global Fund against AIDS, Tuberculosis and Malaria (GFATM) including impregnation of community-owned nets. With the advent of long-lasting insecticidal nets (LLINs) that are ready-to-use pre-treated nets not requiring re-treatment for 4 to 5 years, varieties of LLINs are currently subject to follow up for field evaluation against *An. minimus* transmitted malaria. These LLINs are wash-resistant, and assessed to be operationally feasible community-based intervention for sustainable management of disease vectors against malaria. Community compliance and acceptance have been reported high, and users reported decreased nuisance due to biting mosquitoes. Large scale introduction of LLINs is proposed beginning with high-risk population groups living under impoverished conditions.

Rapid Diagnostic Test Kits

As per requirement of the control programme, popular brands of rapid diagnostic kits collectively termed as dipsticks were subject to field evaluation for their comparative malaria sensitivity and specificity in relation to gold standard method of microscopic examination. Dipsticks based on *P. falciparum* specific histidine-rich protein (Pf HRP-2) antigen capture assay revealed 100% sensitivity and high specificity varying from 94-100%, thus concluded to be reliable tool for confirmed diagnosis in field situations[17-19]. However, Pf-HRP-2 based kits continued to show positive results up to day 7 after parasite clearance on account of persistent circulating antigen. Yet another kit based on parasite-specific lactate dehydrogenase (pLDH) enzyme that was subject to assessment revealed high sensitivity (81-89%) and specificity (100%) for both falciparum and non-falciparum malaria. It was concluded that the rational use of these kits would accord health benefits in providing early diagnosis and treatment in the periphery where microscope facility is non-existent. Accordingly, use of these kits have been incorporated in the existing healthcare services that would help saving many lives (State Health Directorate : Unpublished data).

Therapeutic Efficacy of Anti-malarials and Drug Policy

Drug-resistance in *P. falciparum* malaria was first detected in Karbi Anglong district of Assam in 1976, and presently stands widespread for which northeastern India is considered hotbed for malaira proliferation and dissemination. The problem is more acute in marginalized populations living in impoverished conditions along inter-state and inter-country border areas with little access to healthcare services. To serve the needs of the malaria control programme, therapeutic efficacies of commonly used antimalarial drugs for treatment of *P. falciparum* malaria were investigated in districts reporting majority cases and malaria-attributable deaths. *In vivo* follow up revealed that not only the efficacy of chloroquine in the treatment of *P. falciparum* malaria is declining but also some local strains have become multi-drug resistant[20, 21]. For the treatment of multi-drug resistant cases, field evaluation of artemisinin derivatives alone resulted in good treatment success reporting rapid parasite clearance[22,23]. However, taking cognizance of the problem that the use of artemisinin monotherapy may be short lived, beginning 2007, it has been replaced with artemisinin-based combination therapy (artesunate + sulfadoxine-pyrimethamine) for the treatment of every confirmed case of *P. falciparum* in select district of the northeast sector. Currently, different artemisinin based combination therapies are being evaluated in chloroquine-resistant pockets of northeast to arrest the development and spread of multi-drug resistant strains (Neena Valecha, Personal communication). The initial results are promising with cure rate of >95%, which could help the control programme formulating drug treatment policy that is evidence-based. In addition, in search for alternative treatment regimens, newer molecules with demonstrated antimalarial activity alone and in combinations with chloroquine were subject to therapeutic assessment for the treatment of *P. falciparum* and *P. vivax* malaria[24,25].

Larvivorous Fish for Biological Control

Besides regular interventions based on indoor residual DDT spraying and insecticide-treated nets, other environmental management methods and application of biological control agents such as larvivorous fishes are being revived world over[26,27]. Both *Poecilia reticulata* (Guppy) and *Gambusia affinis* (Mosquito fish) have been demonstrated to be effective against *An. culicifacies* transmitted malaria in the Karnataka state[28,29]. Based on the Karnataka role model, larvivorous fishes are being presently field evaluated for operational feasibility in Assam against *An. minimus* transmitted malaria in select districts with varied topography for which NIMR has been identified as partcipating agency for technology transfer and monitoring[30]. Mother hatcheries for both varieties of larvivorous fishes have been established and their large scale introduction and distribution is currently in progress to check mosquito breeding. Based on the study outcome, this method of intervention is slated for incorporation as an integral part of the control programme in other malaria endemic districts of northeastern states. It is strongly argued that the existing tools when combined with bio-environmental approaches would yield good dividends in achieving appreciable transmission reduction.

Technical Support to the Control Programme

Besides basic understanding of disease epidemiology and research inputs, the NIMR Field Station of northeast provided consultancies for preparing malaria action plan, delimiting high-risk areas for prioritizing interventions[31], coordinating inter-border meeting for coordinated vector control operations, World Bank sponsored situational analyses of high-risk districts for epidemic control preparedness, malaria outbreak investigations and containment[32], and served as resource centre for the ITN programme in the northeast sector. Programme support was also provided to other major industries *viz.* tea industry[33,34] and other major establishments, *e.g.*, defense services, *etc.*in providing guidelines for epidemic control[35,36].

Information, Education and Communication and Human Resource Development

With vast majority of communities living below poverty line (>30%), information, education and communication (IEC) activities were taken up as part of the integrated disease vector control strategy for increased awareness and much needed community compliance. The IEC campaigns were intensified each year during the anti-malaria month (June of each year) in close coordination with state/district health authorities. Over the years, media coverage were organised and booklets, web pasting, video films, TV spots were developed on malaria and its prevention for public circulation/ dissemination particularly during high transmission season in national and regional languages. Group meetings and health camps were routinely arranged in partnership with community representatives, NGOs, civic societies and state health functionaries. The community responses were overwhelming resulting in increased mosquito net ownership in malaria ridden communities which helped in declining disease trends. In addition, for capacity building exercises, technical expertise was provided to state technicians, NGOs, medical colleges, tea garden hospitals for malaria microscopy and preventive measures using insecticide-treated nets and making provision for supply of larvivorous fishes. In Roll Back Malaria initiative this compoent may prove extremely useful and help to meet the malaria challenge.

Research Opportunities

Besides field based research support in malariology, basic research has also been carried out on malaria vectors[37-39] and parasite biology[40-42] in collaboration with leading national laboratries. Northeast is rich in bio-resources and offers challenging opportunities for young scholars for advanced research. The Field Unit in Assam is well equipped for providing logistics and technical support to collaborating agencies for carrying out research in malariology.

Future Challenges

Given the malaria scenario in the country, there is need to strengthen and upgrade the health infrastructure at the periphery for early diagnosis and effective treatment of cases. Communities must be empowered by increased awareness and disease prevention that is eco-friendly and affordable. Health information system needs to be robust for accurate case detection and reporting to formulate situation-specific interventions in place and time averting impending disease outbreaks, and saving lives. Community participation should be sought at all levels of planning and control operations for easy access to healthcare services for those most at stake. There is a clear need for malaria stratification to demarcate high-risk areas for prioritizing interventions ensuring equitable socio-economic development, and to check the spread of drug-resistant malaria. Malaria control should, in large part rely on insecticide-treated nets preferably the long-lasting insecticidal nets (LLINs) in combination with other bio-environmental approaches that are self-sustainable, *e.g.*, use of larvivorous fishes. In the face of rapid population increase, there is need for increased allocation of resources for control interventions beginning with the below poverty line families/ high-risk population groups. Training and re-orientation exercises should be continuing activiies for human resources development in keeping with the latest developments in service to the communities at stake. For strengthening laboratory services, adequate provisions should be made for rapid diagnostic kits for on-the-spot diagnosis particularly in the remote inaccessible pockets. For every single confirmed case of *P. falciparum*, monotherapy with artemisinin derivatives should be replaced by artemisinin-based combination therapy in accordance with the WHO guidelines for treatment of drug-resistant malaria. Therapeutic efficacy of anti-malarials in use should be monitored periodically and drug-policy should be upgraded to check drug-resistant malaria. There is need to identify early warning indicators for possible malaria outbreaks at the local level and have rapid response teams to meet the logistic needs in complex emergencies. Due priority should be accorded for coordinated action along inter-state and international borders that are believed to be the hotspots for multi-drug resistant malaria. Mechanism should be in place for detection and treatment of cases at every checkpoint to prevent introduction of new parasite strains particularity in labor-intensive industries, congregation and development projects. Lastly, it is the intersectoral convergence particularly the NGOs which have vital role to play in reaching the outreach population groups by increased awareness on disease prevention and control.

Conclusions

The demonstrated success of various interventions against malaria in Assam resulted in implementation of control programme that benefited number of agencies including health directorates of the northeastern states, tea industry, small scale industrial units, Oil and Natural Gas Commission, hydro-electric projects, defense services, the Railways and NGOs. Integrated bio-environmental approaches are being revived world over. These when combined with the tools available today would yield rich dividends in making rolling back malaria a reality[43]. The need of the hour is the commitment for continued increased allocation of resources and its judicious application in time and place ensuring equity in healthcare services. It is advocated that control interventions should be targeted in high-risk population groups (estimated to be ~40% of the population that contribute >60% of cases) which will help in saving costs. Concerted efforts should be made for strengthening heath infrastructure at the periphery for case management to avert the spread of drug-resistant malaria, and saving lives.

References

1. Dev, V. . Breeding habitats of anopheline mosquitoes in Assam. *Indian J Malariol 31:* 31, 1954.
2. Dev, V. *Anopheles minimus*: Its bionomics and role in the transmission of malaria in Assam, India. *Bull World Health Organ 74:* 6, 1966.
3. Dev, V., Phookan, S., Sharma, V.P. and Anand, S.P. Physiographic and entomologic risk factors of malaria in Assam, India. *Am J Trop Med Hyg 71:* 451, 2004.
4. Srivastava, A., Nagpal, B.N., Sexena, R., Dev, R. and Subbarao, S.K. Prediction of *Anopheles minimus* habitat in India - A tool for malaria management. *Int J Geograp Inform Science 19:* 91, 2005.
5. Subbarao, S.K., Vasantha, K. N., Nanda, N., Nagpal, B.N., Dev, V. and Sharma, V.P. Cytotaxonomic evidence for the presence of *Anopheles nivipes* In India. *J Am Mosq Contr Assoc 16:* 71, 2000.
6. Dev, V. and Sharma, V.P. Persistent transmission of malaria in Sonapur PHC, Kamrup district, Assam. *J Parasit Dis 19:* 1995.
7. Dev, V., Phookan, S., Sharma, V.P., Dash, V.P. and Anand, S.P. Malaria parasite burden and treatment seeking behavior in ethnic communities of Assam, Northeastern India. *J Infect 52:* 131, 2006.
8. Dev, V. *Plasmodium malariae,* A case of quartan malaria in Assam. *J Commun Dis 32:* 149, 2000.
9. Dev, V. and Dash, A.P. Rainfall and malaria transmission in north-eastern India. *Ann Trop Med Parasitol 101:* 457, 2007.
10. Dev, V., Doley, G.C. and Dash, A.P. Rolling back malaria is possible. *Indian J Med Res 128:* 2008.
11. Dev, V., Bhattacharyya, P.C. and Talukdar, R. Transmission of malaria and its control in the Northeastern region of India. *J Assoc Physicians India 51:* 1073, 2003.
12. Dev, V. Insecticide impregnated mosquito nets: An alternative strategy for malaria control. *Curr Sci 74:* 5, 1998.
13. Jana-Kara, B.R., Jihullah, W.A., Shahi, B., Dev, V., Curtis, C.F. and Sharma, V.P. Deltamethrin impregnated bed

nets against *Anopheles minimus t*ransmitted malaria in Assam, India. *J Trop Med Hyg 98:* 73,1995.

14. Dev, V. and Dash, A.P. Insecticide-treated nets, the key element for rolling back malaria in north-eastern India: policy and practice. *Open Entomol J 2:* 14, 2008.

15. Dev, V. Operational aspects of insecticide treated nets for malaria control in Assam. *J Commun Dis 33:* 147, 2001.

16. Dev, V. and Borgohain, B.K. Insecticide treated nets for malaria control, an eco-friendly technology for the northeastern States of India. *J Northeastern Council 21:* 37, 2001.

17. Valecha, N., Singh, N., Yadav, R.S., Dev, V. Aggarwal, A. and Subbarao, S.K. Field evaluation of optimal 48 rapid malaria diagnostic test in India. *Acta Parasitol 48:* 232, 2003.

18. Dev, V. Relative utility of dipsticks for diagnosis of malaria in mesoendemic area for *Plasmodium falciparum* and *P. vivax* in Northeastern India. *J Vect Borne and Zoon Dis 4:* 123, 2004.

19. Dev, V. Field evaluation of HRP - 2-antigen detection test kit for *Plasmodium falciparum* malaria. *Curr Sci 77:* 17,1999.

20. Dev, V., Phookan, S. and Barman, K. Therapeutic efficacies of antimalarial drugs in the treatment of uncomplicated *Plasmodium falciparum* malaria in Assam, northeastern India. *Ann Trop Med Parasitol 97:* 783.

21. Dua, V.K., Dev, V. Phookan, S., Gupta, N.C., Sharma, V.P. and Subbarao,S.K. Multi-drug resistant *Plasmodium falciparum* malaria in Assam, India: Timing of recurrence and antimalarial drug concentrations in whole blood. *Am J Trop Med Hyg 69:* 555, 1998.

22. Dev, V., Nayak, N.C., Mahapatra, K.M., Choudhury, B., Phookan, S., Srivastava, J.S., Asthana, O.P. and Sharma, V.P. Alpha/ beta arteether, a new anti-malarial. *Curr Sci 75:* 758,1998.

23. Asthana, O.P., Srivastava, J.S., Kamboj, V.P., Valecha, N., Sharma, V.P., Gupta, S., Pande, T.K., Viswanathan, K.A., Mohapatra, K.M., Nayak, N.C., Mahapatra, P.K., Mahanta, J., Srivastava, V.K., Dev, V., Singh, N., Sukla, M.M., Balsara, A.B., Mishra, S.K., Satpathy, S.K., Mohanty, S. and Dash, B. A multicentric study with arteether in patient with uncomplicated falciparum malaria. *J Assoc Physicians India 49:* 692, 2001.

24. Dunne, M.W., Singh, N., Shukla, M., Valecha, N., Bhattacharyya, P.C., Dev, V., Patel, K., Mohapatra, M.K., Lakhani, J., Benner, R., Lele, C. and Patki, K. A multicenter study of azithromycin alone and in combination with chloroquine for the treatment of acute uncomplicated *Plasmodium falciparum* malaria in India. *J Infect Dis 191:* 1582, 2005.

25. Dunne, M., Singh, N., Shukla, M., Valecha, N., Bhattacharyya, P.C., Patel, K., Mohapatra, M.K., Lakhani, J., Devi, C.U., Adak, T., Dev, V., Yadav, R.S., Lele, C. and Patki, K. A double blind, randomized study of azithromycin compared to chloroquine for the treatment of *Plasmodium vivax* malaria in India. *Am J Trop Med Hyg 73:* 1108, 2005.

26. Shiff, C. Integrated approach to malaria control. *Clin Microbiol Rev 15:* 278, 2002.

27. Beier, J.C., Keating, J., Githure, J.I., Macdonald, M.B., Impoinvil, D.E. and Novak, R.J. Integrated vector management for malaria control. *Malaria J 7(Suppl 1):* S4 doi:10.1186/1475-2875-7-S1-S4, 2008.

28. Ghosh, S.K. and Dash, A.P. Larvivorous fish against malaria vectors: a new outlook. *Trans R Soc Trop Med Hyg 101:* 1063, 2007.

29. Ghosh, S.K., Tewari, S.N., Sathyanarayan, T.S., Sampath, T.R., Sharma, V.P., Nanda, N., Joshi, H., Adak, T. and Subbarao, S.K. Larvivorous fishes in well target the malaria vector sibling species of the *Anopheles culicifacies* complex in villages of Karnataka, India. *Trans R Soc Trop Med Hyg 99:* 101, 2005.

30. Dev, V., Dash, A.P. and Hozai, D. Fishing out malaria in Assam, northeastern India: hope or hype? *Trans R Soc Trop Med. Hyg 102:* 839, 2008.

31. Dev, V., Dash, A.P. and Khound, K. High-risk areas of malaria and prioritizing interventions in Assam. *Curr Sci 90:* 32, 2006.

32. Dev, V., Ansari, M.A., Hira, C.R. and Barman. K. An outbreak of *P. falciparum* malaria due to *Anopheles minimus* in Central Assam. *Indian J Malariol 38:* 32, 2001.

33 Dev, V. Malaria survey in Tarajulie tea estate and adjoining hamlets in Sonitpur district, Assam. *Indian J Malariol 33:* 21,1996.

34. Dev, V. and Phookan, S. Malaria prevalence in tea estates of Brahmaputra valley of Assam, India. *J Parasit Dis 20:* 189,1996.

35. Patra, S.S. and Dev, V. Malaria related morbidity in Central Reserve Police Force personal located in the North-Eastern states of India. *J Hum Ecol 15:* 255, 2004.

36 Dev, V. Malaria surveys in outposts of Assam Rifles: An investigation report. I*MA Calling 6(3)*: 6, 2007.

37. Alam, M.T., Das, M.T., Dev, V., Ansari, M.A. and Sharma, Y.D. PCR-RFLP method for the identification of four members of the *Anopheles annularis* group of mosquitoes (Diptera: Culicidae). *Trans R Soc Trop Med Hyg 101:* 239, 2007.

38. O'loughlin, S.M., Okabayashi, T., Honda, M., Kitazoe, Y., Kishino, H., Somboon, P., Sochantha, T., nambanya, S., Saikia, P.K., Dev, V. and Walton, C. Complex population history of two *Anopheles dirus* mosquito species in Southeast Asia suggests the influence of pleistocene climate rather than human-mediated effects. *J Evolution Biol 21:* 1555, 2008.

39. Vinayak, S., Biswas, S., Dev, V., Kumar, A., Ansari, M.A. and Sharma, Y.D. Prevalence to the K 76T mutation with *pfcrt* gene of *P. falciparum* among chloroquine responders in India. *Acta Tropica 87:* 287, 2003.

40. Ahmed, A., Bararia, D., Vinayak, S., Yameen, M., Biswas, S., Dev, V., Kumar, A., Ansari, M.A. and Sharma, Y.D. *Plasmodium falciparum* isolates in India exhibit a progressive increase in mutations associated with sulfadoxine-pyrimethamine resistance. *Antimicrob Agents Chemother 48:* 879, 2004.

41. Mittra, P., Vinayak, S., Chandawat, H., Das, M.K., Singh, N., Biswas, S., Dev, V., Kumar, A., Ansari, M.A. and Sharma, Y.D. Progressive increase in point mutations associated with chloroquine resistance in *Plasmodium falciparum* isolates from India. *J Infect Dis 193:* 1304, 2006.

42. Joshi, H., Valecha, N., Verma, A., Kaul, A., Mallick, P.K., Shalini, S., Prajapati, S.K., Sharma, S.K., Dev, V., Biswas, S., Nanda, N., Malhotra, M.S., Subbarao, S.K. and Dash, A.P. Genetic structure of *Plasmodium falciparum* field isolates in eastern and north-eastern India. *Malaria J 6:* 60 (doi:10.1186/1475-2875-6-60)

43. Dev, V. Rolling back malaria initiative in India. *Trans R Soc Trop Med Hyg 103:* 210, 2009.

This write-up has been contributed by Dr. Vas Dev, Scientist E and Officer-in-Charge, National Institute of Malaria Research Field Station, Chachal, Guwahati - 781 022, Assam, India

ICMR NEWS

The following meetings of various technical committees/ groups of the Council were held:

Meetings of Expert Groups (EGs)/Task Forces (TFs)/Core Committee/Steering Committee/and Other Meetings held at New Delhi

TF on Laboratory Containment of Polioviruses	March 6, 2009
EG on Virology Network Initiative	March 16, 2009
EG on Genomic Analysis of MHC Genes (HLA) in Type-1 Diabetes in the Indian Population	March 16, 2009
Core Committee on Neurosciences	March 17, 2009
EG on Recent Outbreak of Meningococcal Disease in Tripura and Its Control	March 24, 2009
Steering Committee of National Cancer Registry Programme	April 29, 2009
TF on Immunology	May 12, 2009
Meeting of Centre for Advanced Research in Medical Mycology	May 14, 2009
TF on Association of Oral Pre Cancers with Use of Pan Masala	May 15, 2009
TF on Leprosy	May 22, 2009
Meeting of Centre for Advanced Research on Genomics of Type 2 Diabetes Mellitus	May 26, 2009

Meetings of Project Review Committees (PRCs) held at New Delhi

PRC on Microbial Diseases	March 17, 2009
PRC on Oncology	March 18-19, 2009
PRC on Environmental Hygiene and Occupational Health	March 19, 2009
PRC on Mental Health and Biomedical Engineering	March 26, 2009
PRC on Experimental Medicine and Surgery	April 16, 2009

Participation of ICMR Scientists in Scientific Events

Dr. N Selvakumar, Scientist F, Tuberculosis Research Centre (TRC), Chennai, participated in the WHO Workshop for TB Laboratory Technicians at Male (March 1-5, 2009).

Dr. Soumya Swaminathan, Scientist F, TRC, Chennai, participated in the Biovision 2009 - The World Life Sciences Forum at Lyon (March 8-11, 2009).

Dr. Dipika Sur, Scientist E, National Institute of Cholera and Enteric Diseases (NICED), Kolkata, participated in the Meeting on Typhoid Fever Vaccination in Asia Pacific Region at Bangkok (March 10-11, 2009).

Dr. R.R. Gangakhedkar, Scientist E, National AIDS Research Institute (NARI), Pune, participated in the XI Meeting of the WHO Regional Advisory Panel for Asia and the Pacific at Bali (March 11-13, 2009).

Dr. B.K. Tyagi, Scientist F and Officer-in-Charge, Centre for Research in Medical Entomology (CRME), Madurai, participated in the XLV Annual Scientific Seminar of the Malaysian Society of Parasitology and Tropical Medicine at Kuala Lumpur (March 18-19, 2009).

Dr. V.A. Arankalle, Scientist F, National Institute of Virology (NIV), Pune, participated in the Forum on Challenges and Insights towards Understanding the Reemergence of Chikungunya at Singapore (March 20-21, 2009).

Dr. Sekhar Chakrabarty, Scientist F, National Institute of Cholera and Enteric Diseases (NICED), Kolkata, participated in the Keystone Symposium on Prevention of HIV/AIDS (X3) at Kolorado (March 22-27, 2009).

Dr. Soumya Swaminathan, Scientist F, TRC, Chennai, participated in the Consultant's Meeting on Nutrition and Malaria, Tuberculosis and Other Infectious Diseases in Infants and Children at Vienna (March 23-25, 2009).

Dr. V. Kumaraswami, Scientist F and Officer-in-Charge, TRC, Chennai, participated in the VI Meeting of WHO Regional Programme Review Group for Elimination of Lymphatic Filariasis at Dhaka (March 24-25, 2009).

Dr. J.M. Deshpande, Director, Enterovirus Research Centre, Mumbai, participated in the Meeting of Ad-hoc Working Group for Discussion on the Development and Evaluation of Diagnostic Reagents for Use in the WHO Global Polio Laboratory Network Bilthoven (March 24-26, 2009).

Dr. A.C. Mishra, Director, NIV, Pune, participated in the (i) Meeting of WHO Collaborative Centres on Influenza, H5 Reference Laboratories and Regional Influenza Laboratories in Africa and Middle East, and (ii) International Symposium on Viral Respiratory Disease Surveillance at Seville (March 24 and 25-27, 2009 respectively).

Dr. G.B. Nair, Director, NICED, Kolkata, participated in the WHO/IHR Informal Consultation on Concept and Design of Laboratory Networks at Bangkok (March 26-28, 2009). Dr. Nair and Dr. Dipika Sur, Scientist E, NICED, Kolkata, participated in the Meeting on Neglected Tropical Infections at Annecy (March 14-17, 2009).

Dr. Narendra Kumar, Scientist E, Rajendra Memorial Research Institute of Medical Sciences, Patna, participated in the Visceral Leishmaniasis Case Detection and Management Meeting at Kathmandu (April 10-11, 2009).

Dr. K. Raghavendra, Scientist E, National Institute of Malaria Research (NIMR), Delhi, participated in the Steering Committee Meeting on Insecticide Resistance at Geneva (April 15-16, 2009).

Dr. M.V. Murhekar, Scientist F, National Institute of Epidemiology, Chennai, participated in the LVIII Annual Epidemic Intelligence Service Conference at Atlanta (April 20 -24, 2009).

Dr. Arvind Pandey, Director, National Institute of Medical Statistics, New Delhi, participated in 2009 Population Association of America Annual Meeting at Detroit (April 29 - May 2, 2009). He also visited the Department of Biostatistics and Carolina Population Centre (May 4-8, 2009).

Dr. T. Ramamurthy, Scientist F, NICED, Kolkata, participated in the IX International Advanced Course on Vaccinology in Asia Pacific Region at Seoul (May 11-16, 2009). He also participated in the XII Asian Conference on Diarrhoeal Diseases and Nutrition at Yogyakarta (May 25-27, 2009).

Dr. A.C. Mishra, Director, NIV, Pune, participated in the Resumed WHO IGM/PIP Meeting at Geneva (May 13-16, 2009).

Dr. S.P. Tripathy, Scientist F, NARI, Pune, participated in the Bi-Regional Workshop on Prevention and Surveillance of HIV Drug Resistance at Bangkok (May 20-22, 2009).

Dr. R.S. Paranjape, Director, NARI, Pune, participated in the Evidence for Action Consortium Partners Meeting at Kampala (May 27-29, 2009).

Training

Dr. K. Raghavendra, Scientist E, NIMR, Delhi, underwent training on Laboratory Procedures for Testing Public Health Insecticides in Phases According to WHOPES Guidelines at WHO Collaborating Centre, LIN, IRD, Montepellier (March 2-12, 2009).

Dr. D. Raghunatha Rao, Scientist D, National Institute of Nutrition (NIN), Hyderabad, availed Netherlands Fellowship to participate in Food and Nutrition Security 2009 at Wageningon International, Netherlands (March 30-June 12, 2009).

Dr. K. Rajender Rao, Scientist B, NIN, Hyderabad, proceeded to work in the Laboratory of Dr. Jeffrey M. Friedman on the Indo-US Project entitled Localization and Cloning of Obesity Genes in WNIN Mutant Rats for 3 months at New York (w.e.f. April 15, 2009).

ICMR PUBLICATIONS

Non-periodicals	Price	
	Indian	Foreign*
Nutritive Value of Indian Foods by C. Gopalan, B.V. Rama Sastri and S.C. Balasubramanian, Revised & Updated (1989) by B.S. Narasinga Rao, Y.G. Deosthale & K.C. Pant (Reprinted 2007)	40.00	120.00
Low Cost Nutritious Supplements (Second Edition 1975, Reprinted 2000)	7.00	21.00
Menus for Low-Cost Balanced Diets and School-Lunch Programmes (Suitable for North India) (Second Edition 1977, Reprinted 2004)	10.00	30.00
Menus for Low-Cost Balanced Diets and School-Lunch Programmes (Suitable for South India) (Fourth Edition 1996, Reprinted 2002)	8.00	24.00
Some Common Indian Recipes and their Nutritive Value (Fourth Edition 1977, Reprinted 2006) by Swaran Pasricha & L.M. Rebello	30.00	90.00
Nutrition for Mother & Child (Fifth Edition 2002, Reprinted 2004) by P.S. Venkatachalam & L.M. Rebello	25.00	75.00
Japanese Encephalitis in India (Revised Edition 1980)	5.00	15.00
Some Therapeutic Diets (Fifth Edition 1996, Reprinted 2004) by Swaran Pasricha	12.00	36.00
Nutrient Requirements & Recommended Dietary Allowances for Indians (1990, Reprinted 2004)	25.00	75.00
Fruits (Second Edition 1996, Reprinted 2004) by Indira Gopalan & M. Mohan Ram	20.00	60.00

Count What You Eat (1989, Reprinted 2004) by Swaran Pasricha	25.00	75.00
Depressive Disease (1986) by A. Venkoba Rao	58.00	$14.00
*Medicinal Plants of India Vol.2 (1987)	136.00	$33.00
Diet & Diabetes (Second Edition 1993, Reprinted 2007) by T.C. Raghuram, Swaran Pasricha & R.D. Sharma	20.00	60.00
Dietary Tips for the Elderly (1992, Reprinted 2005) by Swaran Pasricha & B.V.S. Thimmayamma	10.00	30.00
Diet and Heart Disease (1994, Reprinted 2004) by Ghafoorunissa and Kamala Krishnaswamy	30.00	90.00
Dietary Guidelines for Indians – A Manual (1998, Reprinted 2007)	30.00	90.00
Dietary Guidelines for Indians (1998, Reprinted 1999)	10.00	30.00
A Manual of Laboratory Techniques (Second Edition 2003) by N. Raghuramulu, K. Madhavan Nair & S. Kalyanasundaram	110.00	330.00
Perspectives of Indian Medicinal Plants in the Management of Liver Disorders (2008)	500.00	$40.00
Ethical Guidelines for Biomedical Research on Human Participants (2006, Reprinted 2008)	250.00	750.00
Clinical Manual for Inborn Errors of Metabolism (2008)	250.00	750.00

Quality Standards of Indian Medicinal Plants

(Vol.I) (2003)	600.00	$40.00
(Vol.2) (2004)	600.00	$40.00
(Vol.3) (2005)	890.00	$65.00
(Vol.4) (2006)	700.00	$50.00
(Vol.5) (2008)	500.00	$40.00
(Vol.6) (2008)	600.00	$45.00
(Vol.7) (2008)	600.00	$45.00

Reviews on Indian Medicinal Plants

Vol.1 (Abe - Alle)	620.00	$40.00
Vol.2 (Alli - Ard)	620.00	$40.00
Vol.3 (Are - Azi)	620.00	$40.00
Vol.4 (Ba-By)	620.00	$40.00
Vol.5 (Ca-Ce)	900.00	$70.00
Vol.6 (Ch-Ci)	900.00	$63.00
Vol.7 (Cl-Co)	1000.00	$70.00
Vol.9(Da-Dy)	1000.00	$70.00

*25 per cent discount allowed to individuals.

These publications are available on prepayment of cost by cheque, bank draft or postal order (bank and postal charges will be extra) in favour of the Director-General, Indian Council of Medical Research, New Delhi. ***Money orders are not acceptable.*** All correspondence in this regard should be addressed to the Head, Division of Publication and Information, Indian Council of Medical Research, Ansari Nagar, New Delhi-110029 (India).

Printed and Published by Shri J.N. Mathur for the Indian Council of Medical Research, New Delhi
at the ICMR Offset Press, New Delhi-110 029

R.N. 21813/71