INDIAN COUNCIL OF MEDICAL RESEARCH

Division of Epidemiology & Communicable Diseases

Minutes of the Brainstorming Meeting of the Vector Science Forum held on 4th& 5th October 2011 at Hotel Clark Greens, Dwarka New Delhi

Agenda & list of participants: Annexed

Dr. Rashmi Arora opened the meeting and welcomed the members of the Vector Science Forum and the invitees to the meeting. While highlighting the need and importance of ICMR's initiative with regard to Vector Science Forum she informed the Group that the Secretary DHR and DG ICMR has formulated a Vector Science Forum in order to promote research on vectors and to develop a common platform for all vector biologists, entomologists, programme people and experts embarking upon common issues. The Council had conducted the first meeting of **Vector Science Forum** on 13th September 2010. She mentioned that in that meeting, researchers/institutes working on vectors/vector borne diseases shared their research activities, success stories, difficulties faced in the field research on vectors and vector borne diseases and operational problems experienced to bring the available tools to the field with officials of the National Vector Borne Disease Control Programme. Talking about the progress made by the Forum during the year she mentioned that As per the Terms of References of Forum (i) priority areas in basic and applied research in vector borne disease and early warning systems were identified and accordingly, a call for proposals on ICMR website was displayed and a total of 82 concept proposals were received which have been reviewed and decision will shortly be communicated to all PI's ,(ii) additionally, in a view to develop human resource, NIMR (New Delhi), VCRC (Puducherry), CRME (Madurai) and RMRC (Dibrugarh) together are in the process of developing a course curriculum and organising training programmes (short and long term) for hands on experience training in entomology, and (iii) the forum also suggested to hold annual Brain Storming Meetings and hence this meeting has been organized. She then requested Dr. V.P. Sharma to chair the meeting and conduct the proceedings.

Dr. Rashmi Arora then requested Dr. V.P Sharma, former Director, and NIMR & ICMR Chair in Public Health Research to give his key note address on "Elimination of Malaria".

Dr. Sharma presented malaria risk map of the world, and provided definitions for 'malaria elimination' and 'malaria eradication' and highlighted the salient features that differ between the two strategies. He mentioned that after a lapse of almost 40 years, malaria eradication is back on the global health agenda which has been inspired by the Gates Malaria Forum in October 2007. Showing the Country-wise distribution of *P. falciparum* and *P. vivax* cases, the burden of malaria disease, issues related to malaria elimination, and policies regarding diagnosis and treatment, he mentioned that scaling up the use of existing tools, for instance, blanketing the population with insecticide-treated bed nets and ensuring fast and free access to malaria drugs could have a huge payoff and showed that how several countries such as Zambia and Rwanda, have slashed cases by more than 50%. He also discussed declining trends of malaria in the Gambia, and in the island of Bioko in equilateral Guinea, and in Saotome and Principe, the island nation in the Gulf of Guinea, which are on the brink of elimination after three years of effective anti malarial measures. Discussing the efforts being

made towards elimination he mentioned that, thirty-nine countries across the world are making progress toward malaria elimination, some for nationwide elimination, while others are pursuing spatially progressive elimination within their borders**.** Of the 39 countries in the world embarking on elimination, ten countries located in the Asia Pacific Region are—Bhutan, China, Democratic People's Republic of Korea, Indonesia, Malaysia, Philippines, Republic of Korea, the Solomon Islands, Sri Lanka, and Vanuatu. Addressing the question whether malaria elimination and eradication can be achieved without a vaccine, Dr V P Sharma's opinion was that it is unlikely that malaria can be eliminated without a vaccine or another transformative tool that can be used in areas of intrinsically high malaria transmission and it is entirely feasible to eliminate malaria from countries and regions where the intensity of transmission is low to moderate, and where health systems are strong.

Session on Malaria vectors:

A session on malaria vectors was then chaired by Dr. V.P. Sharma and Dr. Sarala Subbarao, former director, NIMR, Delhi & INSA scientist. In this session speakers presented biology and bionomics of vectors and highlighted the characters that are posing challenges in controlling these vectors successfully, identified areas of research that are required and made recommendations/suggestions based on the available information.

Major Vectors of North-East – *Anopheles baimaii & An. minimus*):

Dr. Sarala Subbarao (in place of Dr. Anil Prakash from RMRC, Dibrugarh) who spoke on *An. baimaii*, Dr. O. P. Singh, NIMR, Delhi (in place of Dr. Vas Dev, NIMR, Assam) on *An. minimus* and Dr. K.S. Gill, NVBDCP who presented on both the species, were the speakers, and Dr. K. Gunasekaran from VCRC Puducherry was the rapporteur. Highlights from the presentations and the discussions are given below:

An. baimaii

An. baimaii is a hygrophilic species and distributes in clusters. *An. baimaii* is a major malaria vector in north-east India. Except in Sikkim, it is found in all other North Eastern (NE) states. This species is a member of the *An. dirus* complex. There are seven members in this complex, and *An. elegans* is another member of this complex found in India in Shimoga district of Karnataka state. *An. baimaii* breeding is found in deep forest and is a monsoon species showing peak abundance during July and August. It is exclusively exophilic, rests during day time on tree trunks / creepers in forests. It bites outdoors and indoors. In indoors it briefly rests on walls for about 20mts before biting. It bites all night with a peak biting time during 22.00-23.00 hours. Landing starts early. Compared to other quarters of the night a smaller proportion bites in the first quarter, and maximum biting is in the first half of the night. Transmission site is both indoors and outdoors. Post-monsoon period records a very high man biting rate and the chances of getting an infective bite by *An. baimaii* during this time is 3.7 times more as compared to that in monsoon season. It is susceptible to DDT and pyrethroids.

Challenges:

- Almost exclusively exophilic with only a small proportion entering indoors and exophagy is also observed.
- Transmission site for this vector species is both indoors and outdoors and a sizable transmission (about 21% of overall EIR) was found during the first quarter of the night i.e. prior to people retiring to bed.
- Only a small proportion of the population that enters indoors rests on the walls for a short time (about 20 min.) before biting
- There are people living in the forest, who are not easily accessible for providing vector control measures or treatment.
- Also people temporarily go to forest for collection of produce and spend nights there.

Areas of Research Identified:

- Distribution of species X, a new species found recently in Assam, in NE and its role in malaria transmission
- Estimation of indoor and outdoor biting populations using CDC light trap and man-landing collections
- Estimation of areas under the exclusive influence of *An. baimaii*
- Contribution of *An. baimaii* to the malaria incidence in NE
- Monitoring of the impact of large scale ITNs use on behavioural changes
- Monitoring of resistance to DDT and pyrethroids
- Novel strategies need to be developed for the complete control of *An. baimaii*

Suggestions:

- As its breeding sites are in deep forests and is exophilic, its area of influence is only up to 250 mts from the forest fringes, villages which are about half to one km distance from the forest under the predominant influence of *An. baimaii* need not be sprayed
- Villagers who spend nights in the forest may be provided with treated hammocks
- Develop sustainable strategies for distribution and use of treated materials/nets

An. minimus

*An. minimus*is a complex of 3 sibling species, in India only one species is found, *An. minimus s. s.* (*An. minimus* A). Because of overlapping morphological characters with other species of Myzomyia group, *An .minimus* is misidentified. *An. minimus* is misidentified as *An. fluviatilis* in Assam, and *An. varuna* as *An. minimus* in Vietnam. Furthermore, *An. minimus* and members of the *An. fluviatilis* complex are closely related, and there is no single molecular assay available which can identify all the species of the two complexes.

Distribution of this species is found in North-eastern states (Arunachal Pradesh, Assam, Meghalaya and Nagaland), Singhbhum hills and many other areas in Odisha state and Jalpaiguri district of West Bengal. It is found in forested foothill regions. Breeding is found mainly in clear-water canals and streams with grassy margins and slow moving current. It is basically indoor resting and indoor feeding species. Biting starts after22.00 hrs and continues all night with bimodal rhythm, one peak at 23.00 hrs to 00.00 hrs and the second peak from 01.00-03.00 hrs. Highest man biting rates are in June with about 15 bites/person /night. It is

highly anthropophagic, and in Assam AI was 93%. It is highly efficient vector, and as high as 8.5% sporozoite rate was observed in Assam. In post monsoon months (July to November) infection rates are high. Susceptible to DDT, Malathion and pyrethroids. Knockdown resistance (*kdr*) was not found. LLINs were found very effective in the control of this species.

Areas of Research Identified:

- As members of *An. fluviatilis* complex and of *An. minimus* are morphologically close, robust molecular identification techniques are to be developed which can distinguish all the members.
- Reasons why DDT spraying is not effective when the species is susceptible to DDT and is predominantly indoor resting. There are reports of reduced susceptibility of this species to DDT (80% mortality was reported from Keonjhar district of Odisha state), which needs to be verified.
- Estimation of the extent of endophily and exophily and also exophagy exhibited by this vector species
- Behavioural studies to examine excito-repellancy/avoidance in response to insecticide sprays

Suggestions:

- In areas where both *An. baimaii* and *An. minimus* are transmitting, LLINs will be very effective in controlling the transmission.
- A GIS map delineating the areas with predominant vectors transmitting malaria would facilitate in choosing appropriate vector control tool(s).

Major vector in hilly-forested areas – *Anopheles fluviatilis*:

The speakers in this session were Dr. P. Jambulingam, VCRC, Puducherry, Dr. M. M. Pradhan, NVBDCP, Odisha and Dr. Prasada Rao, NVBDCP, Vishakhapatnam (Andhra Pradesh). Dr. Nutan Nanda, NIMR, Delhi was the rapporteur. Highlights from the presentations and the discussions are given below:

It is found in hilly forested and foot hill areas where slow moving streams are found. This is a complex of three sibling species, species S, species T, species U, which vary in their distribution pattern and biological characteristics. Breeding is found in slow moving streams, terraced rice fields and irrigation canals. It is found in monsoon, post monsoon and cold seasons. Species S is indoor resting predominantly in human dwellings, highly anthropophagic and an efficient vector of malaria. Species T is primarily zoophagic and rests indoors/ outdoors and predominantly in cattle sheds. Biting of Species S was found both indoors and outdoors and peak biting was from 21.00 to 03.00 hrs. It is susceptible to all insecticides including DDT (in Chattisgarh it was found less susceptible to DDT, which needs to be verified). LLINs provided protection against malaria when used by pregnant women. Coverage of about 70% population by LLINs reduced the API by 50%.

Research Areas Identified:

- Delimitation of areas under the sole influence of *An. fluviatilis* in Orissa, Chattisgarh, Madhya Pradesh, Jharkhand and Andhra Pradesh., and areas where it is playing a role along with *An. culicifacies.*
- Mapping of spatial and temporal distribution in relation to changing landscape and climatic variation.
- Due to a variety of breeding habitats and ecotypes of malaria vectors (*An. fluviatilis and An. culicifacies*) in Andhra Pradesh, extensive entomological surveys are needed to generate information on vector prevalence and their bionomics especially in endemic districts like Visakhapatnam, Srikakulam, Vijayanagaram, and Khammam in Andhra Pradesh.
- Improved collection methods are to be developed, to overcome the low numbers collected by the conventional methods, for effective monitoring and evaluation.
- Site of transmission is to be established in areas where both indoor and outdoor resting is found, and extra domiciliary transmission if present needs to be quantified.
- Studies to monitor on behavioural (resting and feeding) changes in response to residual spraying using pyrethroids and use of LLINs.
- Innovative control methods/measures to be developed.

Suggestions:

- One round of good quality IRS with good coverage instead of two rounds in forest areas would be more cost effective in reducing transmission in areas where *An. fluviatilis* is the only vector present.
- Peak biting period of the vector varies in different seasons so seasonal shift is to be taken into consideration for implementing LLINs.
- LLINs given to tribals are not used due to limited room space and sometimes these are sold. LLINs suitable for the dwellings in tribal areas have to be designed.
- Source reduction and application of fished would have limited role in forest settings.

Major Vector in Plains – *Anopheles culicifacies*:

Dr. Neeru Singh, RMRCT, Jabalpur; Dr. J. C. Paliwal, NVBDCP, Madhya Pradesh; Dr. Narhari, NVBDCP, Andhra Pradesh and Dr. Ramesh Chander, Lucknow, Uttar Pradesh were the speakers in this session. Dr. T. Adak, NIMR, Delhi was the rapporteur. Highlights from the presentations and the discussions are given below:

An. culicifacies is a major vector responsible for 65-70 % malaria in India. It is a complex of 5 sibling species. In Madhya Pradesh Species C is predominant (69%) followed by Species D (24.2%), and species B (~6%). A small proportion of species A is also found in this state. It is predominantly a zoophagic species. Densities of *An. culicifacies* are very high (can be >100 per man hour) in tribal areas, and peak densities are found during monsoon and post-monsoon months (July to October). This species is found both in villages in forests and in villages outside the forest. It is found both indoors and outdoors. This species was resistant to DDT (87-94%), Malathion (14-23%), deltamethrin (5-16%) and alpha cypermethrin (49-

51%) in M. P. Site of transmission appears to be predominantly indoors, a few sporozoite positive mosquitoes were collected from light traps placed outdoors.

Challenges:

- People spend nights in forest for collecting and drying Tendu leaves and Mahua flowers, and in watch huts (which are not fully covered) in fields for protecting crops
- Unplanned settlements near project sites
- Treated nets distributed by the Programme are utilized for other purposes. As the houses are not big enough to place the nets properly, people do not sleep under the nets but cover themselves improperly with nets

Research Areas Identified:

- Site of Malaria transmission especially in the forests
- Role of different sibling species in malaria transmission as these sibling species vary in their responses to insecticides, biting rhythm, vectorial potential etc.

Suggestions:

- The distribution of the LLINs which is planned as priority in Tribal areas is also to be taken up in rural areas prone for high incidence of malaria.
- The reduction of cattle population in the villages will divert vectors to humans. Therefore increase in livestock population would reduce malaria transmission in villages (zooprophylaxis).

Malaria Vector in Urban Areas – Anopheles *stephensi*:

In this session Dr. Ashwini Kumar, NIMR, Dr. B. R. Mane, NVBDCP, Pune (Maharashtra) and Dr. B. N. Nagpal, NIMR, Delhi were the speakers. Dr. R. M. Bhatt, NIMR was the rapporteur. Highlights from the presentations and the discussions are given below:

There are three ecological forms of *An. stephensi*, Type form, Intermediate and var. *mysorensis*. It is the vector in urban areas and has been responsible for several epidemics in the country in the post-eradication years. Type form is the predominant form in urban areas and is involved in the transmission of malaria, while *mysorensis* may not be involved in transmission because of it's largely zoophagic feeding behaviour and low parity rate during the transmission season. In rural areas of arid semi-arid and climatic zones of Rajasthan both Type form and *mysorensis* are sympatric. Breeding sites observed are over-head tanks, domestic cement tanks, tankas, curing tanks, disused wells, jharias, earthern pots and in Rajasthan where var. *Mysorensis* was found sympatric with the Type form, breeding of *mysorensis* was also found in ponds in forested areas, pits, river margins and river-bed pools, margins of streams/drains. Type form rests indoor throughout the year while *mysorensis* exhibits seasonal variation—indoors from February to June, indoor and outdoor July to August and outdoor from September to January. Both endophagy and exophagy have been observed. It is an opportunistic feeder biting animals as well as human beings, predominantly zoophilic species. Biting starts early outside in the court yards and adults enter the houses

after 23.00 hrs and rest on the unsprayed surfaces. Biting rhythm is bimodal with a larger peak around midnight and a smaller peak in the morning hours of 0300-0500. Adult resting is found on the walls of wells, wet bricks/laterite walls, barrels, underneath water receptacles, cycle wheels, roof tiles, walls of tankas and indoors on clothes and all kinds of hanging objects.

Areas of Research Identified:

- Bionomics and behavioural studies in Bombay Municipal Corporation area.
- Resistance profile of adults and larvae to different insecticides in different areas/regions
- Trials to establish the true value of fogging in transmission control
- Develop randomized control design with indigenous larvivorous species especially in coastal areas
- Multi-centric trials to establish the utility of LLINs in urban slums in different ecosystems

Suggestions:

- Because of its resting pattern, bio-environmental methods including larvicidal (wherever feasible), environmental management and manipulation appear to be the best options to control the vector.
- Promotion of LLINs and impregnated curtains as per their suitability in urban slums
- Emphasis on vector control in the lean season to prevent the build-up of malaria cases in the monsoon season.
- Development of Model-bye laws and implementation
- Legislative measures to be strictly implemented for—Mosquito proofing of over-head tanks and sumps, hermitical sealing of wells, access for inspection and preventing vector breeding in construction sites, residences and cooperative society buildings, and against employment of migrant labour/workers without a valid health card.
- Linkages to be established with Jawaharlal Nehru National Urban Renewal Mission (JNNURM).
- Establishment of National Task Force for *An. stephensi* control

Major Vector in Andaman-Nicobar Islands – *Anopheles sundiacus*:

In this session Dr. M.K Das, NIMR and Dr. K.S Gill, NVBDCP, Delhi were the speakers, and Dr.S. Sabesan, VCRC, Puducherry was the rapporteur. Highlights from the presentations and the discussions are given below:

An. sundiacus is a complex of five species, and in India species D is found. The distribution of this species is now restricted to A& N Islands in India. Breeding is found both in brackish and fresh water collections. Mainly breeds in brackish water but also in fresh water. Major breeding places are swamps and pits along the bunds etc. containing stagnant brackish water. Also breeds in salt water lagoons, creeks, wells, canoe, overhead tanks and fresh water pools in coastal areas. It can tolerate salinity from 0.08 to 2.6% and pH up to 8.5. Resting habits vary, as it exhibits both indoor and outdoor resting. Exophagy is also observed. This species is predominantly zoophagic with anthropophilic index (AI) of 2.5%, but in human dwellings

AI as high as 18-22% was observed. Adults bite primarily pigs and cattle but readily bite man indoors and outdoors. Bimodal biting activity with peak biting around 23.00 hrs and the second peak around 02.00 hrs. It is susceptible to all insecticides used in the Programme including DDT. It is capable of flying up to 1.9 km distance.

Research Areas Identified:

- *An. sundiacus was* found to transmit monkey malaria, *P. cynomolgi* in the Great Nicobar Island in 1981. Thus emergence of malaria zoonoses of simian origin in Great Nicobar Island needs to be monitored. If malaria zoonoses is found, in depth studies to define the dynamics of simian and human malaria transmission cycles of *P. cynomolgi* by *An. sundiacus* needs to be studied.
- As each island has a local population of *An. sundiacus*, malaria determinants dynamics and socio-cultural variations, investigations are required to develop island specific strategy to control A*n sundiacus transmi*.
- Due to continuous spray of DDT for over 50 years, and ecological changes that have occurred in Car Nicobar islands due to Tsunami upheaval, detailed vector bionomics studies in all the islands to develop and plan control strategies.

Suggestions:

- Removal of sand bar to allow the drainage of water from the estuary at low tide areas and blocking of the influx of sea water at high tide areas.
- Integrated bio-environmental methods of control:

  - Elimination of brackish water habitats by drainage could be effective in decreasing vector densities
  - Introduction of larvivorous fishes, *Gambusia affinis* and *Ophiocara aporos*
  - Installation of sluice gates across creeks

Insecticide Resistance in Vectors:

Dr. K. Raghavendra, NIMR, Delhi was the speaker and Dr. Gunasekaran, VCRC, Puducherry was the rapporteur. Highlights from the presentation and the discussions are given below:

Dr. Raghavendra presented the existing strategy of malaria control in the country and the insecticides that are being used in the programme for various methods. He presented on the chronological introduction of insecticides from 1955-2007 in the country and the resistance developed to them. He presented the district-wise resistance map of *An. culicifacies* which exhibits DDT resistance in 141 districts, Malathion resistance in 71 and pyrethroids resistance in 21 districts. He also mentioned that other major vector species are still largely susceptible to all the insecticides. Discussed on bio-chemical mechanisms that were found responsible for resistance to DDT - glutathione transferase, to BHC - Gamma amino acid butyric acid receptor (GABA), to Malathion - Malathion carboxyl esterase, and to pyrethroids it is mixed function oxidases and esterases, and the cross resistance patterns these mechanisms exhibited. Presenting on the factors that influence the development of resistance including genetic, biological and operational factors, he discussed on the possible insecticide

resistance management strategies—use of enhanced dose of insecticide, discontinuation of use of insecticide for vector control after the desired epidemiological impact is achieved, rational use of insecticides that can be used. As an evidence of discontinuation of use of insecticide for a few years, he mentioned the reversion of deltamethrin resistance observed in *An. culcifacies* in Ukai Dam area district, Surat, Gujarat. He discussed a promising new pyrolle group insecticide molecule – chlorfenaphyl with novel mode of action. He presented the areas of organizational support NIMR and other ICMR institutes are providing to the Programme in the area of evaluation of insecticides and other vector control strategies and in mapping the resistance. Discussing the reasons for earlier success with IRS namely effective insecticides, vector susceptibility and people's co-operation and participation, he also presented the following probable reasons for not achieving the success with insecticides:

- Multiple disease vectors (nine vectors (six major), multiple ecotypes, ecotype specific vectors, members of species complexes with differential behavior and response to insecticides/interventions, roles in transmission etc.
- Lack of trained entomologists
- Wide spread Insecticide resistance in major vector *An. culicifacies*
- Failure to use situation specific VC options including IVM
- Development of resistance in disease vectors due to use of insecticides in other sectors, agriculture
- Apathy in people to Government's efforts
- Non-practicing of appropriate management strategies - operational/technical

Research Areas Identified:

- Development of molecular markers for screening and monitoring of resistance to different insecticides.
- Development of strategies and their evaluation for the management of resistance
- Development of strategies for systematic monitoring of resistance, and data generation, dissemination and networking
- Development of strategies for ccommunity sensitization at grass-root level for its active involvement

Day 2: 5th October 2011

The day started with a session on dengue and Chickungunya vectors which was chaired by Professor M.K.K Pillai (former Professor University of Delhi) and co-chaired by Dr. P. Jambulingam, Director VCRC Puducherry. Dr. N. Arunachalan, CRME, Madurai was the rapporteur.

In this session Dr. Vinod Joshi, DMRC, Jodhpur on *Aedes aegypti*, Dr. Pradeep Kumar on *Aedes albopictus*, Dr. B. K. Tyagi on Surveillance tools and Dr. S Sridharan, Chennai (Tamil Nadu), Dr.Dilip Kumar, Kerala and Dr. Kalpana Baruha, NVBDCP, Delhi on state/country wide issues on Dengue vectors and factors contributing to the spread of Dengue &Chickungunya in the country, made presentations. The highlights of the presentations and of the discussion are given below:

Dengue and Chickungunya vectors:

In the absence of medicines for the treatment and vaccines to prevent dengue and Chickungunya, vector control becomes very important strategy in the control of these two diseases. *Aedes aegypti* is the major vector for dengue and Chickungunya in India except that in Kerala *Ae. albopictus* was found as the major vector of Chickungunya. *Ae. albopictus* has also been incriminated as a vector of dengue in Kerala and Tamil Nadu

Aedes aegypti

Ae. aegypti is a container breeder and a day biting mosquito. A variety of breeding habitats of this species are found in domestic and peri-domestic water collections in pots, coolers, clay-pitchers, broken utensils, barrels, cisterns and cement tanks, tanks for cattle drinking, tree holes in parks/zoos and tyres. In Rajasthan vertical transmission was found to be an important factor in dengue epidemics.

Suggestions:

During January- April i.e., well before rainy season, larval surveillance to identify breeding foci and virus-active larval foci for planning anti-larval measures

***Aedes albopictus* - Asian tiger mosquito**

It is considered as the most invasive mosquito species in the World. Kerala was the worst affected State in India by Chickungunya fever during 2007 and *Ae. albopictus* was the main vector species. This species was incriminated as a vector of dengue in Kerala state. It is naturally a tree-hole breeder, but has now invaded artificial / natural containers in plantation sectors and also is spreading to coastal as well as urban situations in Kerala. In plantation sector the key breeding habitats recorded were discarded/unused rubber latex collection containers which are perennial with an increased abundance in summer which experiences intermittent rain. Rubber plantations are located in midlands region of Kerala stretching from Kanyakumari to Kasaragod. Breeding is also found in pineapple leaf axils (during summer season) and in fallen leaves of *Areca* plantations. In pine apple plantation areas, *Ae. albopictus* breeding is recorded only during March-May. Pine apple plantations are cultivated as inter-crop in rubber plantations. Kerala and Karnataka state are the largest producers of *Areca* in India. *Areca* cultivation areas are restricted to North Kerala and Dakshin Kannada. Innumerable shed leaves of Areca were found to be the key breeding habitats of *Ae. albopictus* in the *Areca* plantation belt. It is predominantly exophilic species with outdoor resting per man hour density of 1.57 and indoor resting per man hour density 0.05. It is also a day a biting species with peak biting at dawn and dusk. It is an opportunistic feeder, in Kerala it was found to be highly anthropophilic with 92.79% AI (cattle population was relatively low). Currently its prevalence had been recorded in the entire stretch of midland and coastal sections of Kerala.

Surveillance tools:

Stegomiya indices (Container Index, House Index and Breteau Index) for knowing prevalence and pupal demographical surveys to comprehend density/population estimates were discussed. In low *Aedes* infestation areas pupal surveys will be more useful in assessing the risk as few as 2 adult female *Ae. aegypti e*merging daily in a locality of 100 people could be sufficient threshold to spread dengue. Ovitraps are also used as surveillance tool. Ovitrap Index (OI) is the percent positive Ovitraps to the total number of recovered Ovitraps. Mean Number of *Ae. aegypti* and *Ae albopictus* larvae per total number of recovered Ovitraps can also be estimated.

Research Areas Identified:

- Transmission dynamics of dengue during inter-epidemic period.
- Relative roles of *Ae. aegypti* and *Ae. albopictus* in dengue transmission in India
- Development of methods for virus typing in mosquitoes during pre-rainy season, which can be used as predictor of DHF in the following months.
- *Aedes* surveillance in different eco-epidemiological settings
- Development of transmission risk model
- Vector bionomics and transmission dynamics of dengue and Chickungunya, and identifying local risk factors.
- Vector mapping - occurrence, distribution, behavior and their transition in time and space in different environments.
- Clustering of dengue and Chickungunya cases – Assessing the extent of involvement of *Ae. Aegypti* & *Ae. albopictus*
- Impact assessment - indiscreet & long term use of outdoor fogging on vector, human safety, hazards on non target organism
- Feasibility and effectiveness of selective residual spray using pyrethroids
- Testing susceptibility status to Temephos
- A community based IVM strategy with inter-sectoral collaboration involving better plantation practices was found as an effective strategy for management of *Aedes* population in two villages in Kerala – extension of this strategy to other areas.
- *Aedes* breeding in pineapple plantations was found to be a seasonal problem. Trials with *Bacillus thurungiensis* slow release formulations
- Trials using personal protection measures (use of DEPA in the community was found highly effective for 5-6 hours)
- Filling of tree holes and introduction of *Romanomermis iyengari* into tree holes
- Applicability of *Aedes* larval indices – critical threshold for forecasting an impending epidemic situations

The closing ceremony of brainstorm meeting of the VECTOR SCIENCE FORUM held on 5th October, 2011 at 11:30AM was presided over by Dr. V. M. Katoch - Secretary DHR & DG ICMR. Dr. Rashmi Arora, Head, Division of Epidemiology and Communicable Diseases welcomed Dr. V. M. Katoch - Secretary DHR &DG ICMR, Dr. A. C. Dhariwal, Director, NVBDCP, Delhi, Dr. V. P. Sharma, chairman of the Meeting, Shri Sanjiv Datta, Financial adviser, ICMR, Delhi, Shri, Arun Baroka, Senior Deputy Director General, Administration, ICMR, Delhi and all the participants of the Meeting and gave a brief update on the actions taken under VSF. She mentioned that the two actions i.e. organization of brainstorming meeting and development of website of forum are being done now. She then requested Dr. V.

M. Katoch, secretary DHR & DG ICMR to launch the "Vector Science Forum WEB site" on this august occasion.

Dr Rashmi Arora then requested Dr. V.P. Sharma to brief the Chief Guest and other dignitaries to present of the highlights of the proceedings and present the recommendations drafted by the Group after 1&1/2 day of deliberations. Dr. Sharma said this is the first of its kind in the world. He emphasized the need for entomological research in the country and mentioned the programme officers from different states/districts highlighted the absence of entomological setups in their areas to carrying out surveys for planning control strategies. He then presented the following recommendations the group has prepared:

Recommendations of the Brainstorming Meeting Group

Vector Science Forum reiterates its commitment to partner with programme people to accelerate development of improved methods of pathogen detection, treatment and vector identification and control of vector borne diseases. Members of the Vector Science Forum (VSF) will work with the government system to remove bottlenecks and facilitate strengthening of research towards prevention and control of vector-borne diseases in the country.

Recommendations for malaria vector research:

1. Comparison of epidemiological effectiveness of indoor residual spraying using DDT 50% @1g/m^2 (two rounds) with that using DDT 75% @ 1 & 2g/m^2 (one round).

2. A sub-group of Vector Science Forum (VSF) may be constituted to formulate insecticide resistance management strategies for malaria control in India.

3. Devising appropriate vector control strategies for different endemic strata of the country (based on API) for malaria control in collaboration with the Directorate of NVBDCP

4. Bionomics of malaria vectors in the problem areas of Andhra Pradesh, Rajasthan, UP, Jharkhand, Odisha, Maharashtra, Kerala, West Bengal, Chhattisgarh, Madhya Pradesh and North-Eastern states.

5. Development of novel vector sampling and surveillance tools; and bar-coding of anopheline fauna of the country

6. Studies on impact assessment of LLINs and on behavioural change of vectors in relation to malaria transmission.

7. Development, testing and evaluation of novel vector control tools.

8. Indigenous production of test kits for monitoring insecticide susceptibility/ resistance in adults and larvae.

9. In addition to anti-larval measures, promotion of insecticide treated nets/ LLINs/ treated materials at construction/developmental project sites covering the high risk migrant/slum population.

10. Establishing relative role of each of the sympatric species viz., *An. fluviatilis, An. culicifacies* and *An. annularis,* and *An. minimus* and *An. dirus* in malaria transmission.

11. Human resource development to carry out health impact assessment of developmental projects with special reference to vector ecology.

Recommendations for Dengue &Chickungunya vectors:

1. Distribution pattern of *Aedes aegypti* and *Ae. albopictus* in dengue and Chickungunya endemic states

2. Role of 'sylvatic cycle' during inter-epidemic period

3. Examination of species complex in *Ae. albopictus*

4. Development of tools for *Ae. albopictus* surveillance in different eco-epidemiological settings

5. Development and testing of new vector control tools

6. Formulation of well structured vector control strategy

This was followed by remarks of Shri Sanjeev Datta, Financial Adviser, ICMR, Shri Arun Baroka, Senior Deputy Director General, ICMR, Dr. A. C. Dhariwal, Director, National vector Borne Disease Control Programme. Secretary DHR & DG, ICMR then expressed his views on the activities under the Vector Science Forum.

Sh. Arun Baroka Sr DDG (Adm) ICMR in his address congratulated the ECD division and all dignitaries for having such a fruitful interaction. He stressed upon the need of having such brainstorming meetings regularly in future.

Sh. Sanjeev Dutta (Financial Advisor, ICMR) also gave encouraging remarks for holding such a meaningful and creative workshop. He particularly mentioned that focus of planning and empowerment has to change from bottom to top instead of top to bottom approach.

Dr. Dhariwal, Director, NVBDCP in his address said that the biggest beneficiary of the VSF is NVBDCP, and this forum has facilitated collaboration between experts and programme people. He mentioned that the programme is addressing the issue of under reporting of malaria cases and deaths, and absence of entomological surveillance as the entomology units have become weak due to lack of staff. The tools should be developed for urban malaria control as large cases of malaria are being reported from Delhi and other urban areas in the country and said that research activities in JE need to be undertaken in newer areas where JE is being reported to strengthen JE control programme,. Detection of JE in adults in Assam is being tackled by vaccinating adults with the support from DG, ICMR. He mentioned that

tools are there for the elimination of kala- azar and the elimination programme has to be taken in mission mode fashion, and the presence of zoonotic foci needs to be examined. Finally he said that malariologists are living at a time when there is a window of opportunity to demonstrate disease elimination using the modern and time tested technologies in vector control.

Dr V. M. Katoch, Secretary DHR, Govt of India & DG ICMR delivered a thought provoking address on the occasion. Appreciating the efforts of Vector Science Forum, he said that we should take messages from the success stories of diseases already controlled/eradicated. He then thanked ECD division for the efforts taken to organise this meeting. Vector-borne diseases are global issues and there should be a cohesive voice on vectors and vector-borne diseases. As on today, the efforts are diffuse and little as compared to the magnitude of the problem, and entomologists and epidemiologists should address the diseases control holistically and not in isolation. He advised all concerned to fix the targets which are achievable, and carry out focussed science which is linked to practice. Referring to the WEB site, DHR Secretary and DG ICMR said the people will look at the Forum Web site for knowledge and it should be developed accordingly. He said that the Vector Science Forum has started off very well and he is optimistic about it. He mentioned that this type of participatory meetings will help build the Forum and this should be sustained, the programme of NBDCP should now be a science backed program. He congratulated and thanked the organizers for their painstaking efforts to make the event happen the way it has. Dr. Katoch suggested that VSF should create a cohesive Force to fight against vector-borne diseases and the recommendations identified by the Group should be put into action at the earliest

The vote of thanks was given by Dr Nivedita, Scientist D, ECD Division, ICMR and she invited all for the lunch.

The meeting ended on a very positive note for a bright future for the Vector Science Forum.

List of invitees for brainstorming meeting:

1) Dr. V.P. Sharma (former director, NIMR) – Chairman
2) *Prof. Dileep Deobagkar, Vice-Chancellor, Goa University
3) Dr. M. K. K. Pillai, Retd. Professor, University of Delhi, Delhi
4) *Dr. P.K. Rajagopalan (former Director, VCRC)
5) Dr. Sarala K. Subbarao (former Director, NIMR)
6) Dr. T. Adak, NIMR, Delhi
7) *Dr Anil Prakash, RMRC, Dibrugarh
8) Dr. K. Ilango, Zoological Survey of India for Southern region, Chennai
9) Dr. Vijay Veer, Defence Research Development Establishment, Gwalior, M. P.
10) Prof. S. K. Ghakar, Deptt. of Bioscience, M.D. University, Rohtak.
11) *Dr. P. L. Joshi (former director, NVBDCP)
12) Dr. A. P. Dash (former director, NIMR), Regional Adviser, WHO-SEARO, Delhi
13) Dr. P. Jambulingam, Director, VCRC, Puducherry
14) Dr. B.K. Tyagi, Director-in-charge, CRME, Madurai
15) Dr. N. Arunachalam, CRME, Madurai
16) Dr. Neeru Singh, Director, RMRCT, Jabalpur
17) Dr. A. C. Mishra, Director, NIV, Pune
18) Director, RMRC, Portblair
19) *Director, RMRC Dibrugarh
20) *Director, RMRI, Patna
21) Director, NIMR, New Delhi
22) Director, RMRC, Bhubaneshwar
23) *Director-in-Charge, Desert Medical Research Centre, Jodhpur
24) Dr. A. C. Dhariwal, Director, NVBDCP, Delhi
25) *Dr. L. S. Chauhan, Director, NCDC, Delhi
26) *Dr. Shiv Lal, Adviser, NCDC (Formerly Special DG, DGHS), Delhi
27) Dr. R. S. Sharma, NVBDCP, Delhi
28) Dr. G. S. Sonal, Addl. Director, NVBDCP, Delhi
29) Dr. K. S. Gill, NVBDCP, Delhi
30) Dr. Kalpana Baruah, NVBDCP
31) Dr. P. K. Srivatsav, NVBDCP, Delhi
32) Dr. S. Sabesan, VCRC, Puducherry
33) Dr. S. Hoti, VCRC, Puducherry
34) Dr. K. Gunasekaran, VCRC, Puducherry
35) Dr. Pradeep Kumar, VCRC, Puducherry
36) Dr. Hazra, RMRC, Bhubaneshwar
37) Dr. Namita Mohapatra, RMRC, Bhuvaneshwar
38) Dr. Vinod Joshi, DMRC, Jodhpur
39) Mr. V. Thenmozi, CRME, Madurai
40) Dr. Rajnikant, ICMR
41) *Dr. Vas Dev, NIMR, Assam
42) Dr. Ashwini Kumar, NIMR, Goa
43) Dr. M. K. Das, NIMR, Jharkhand
44) Dr. Nutan Nanda, NIMR, Delhi
45) Dr. O.P. Singh, NIMR, Delhi
46) Dr. B. N. Nagpal, NIMR, Delhi
47) Dr. R. C. Dhiman, NIMR, Delhi
48) Dr. K. Raghavendra, NIMR, Delhi

49) Dr. S. K. Sharma, NIMR, Delhi
50) Dr. R.M. Bhatt, NIMR, Chattisgarh
51) Dr. C. P. Batra, NIMR, Delhi
52) Dr. R. K. Singh, NIMR, Delhi
53) Dr. S. P. Singh, NIMR, Delhi
54) Dr. Rajni Kant Dixit, NIMR, Delhi
55) Dr. Vijay Kumar, RMRIMS, Patna

* did not attend the meeting

State NVBDCP Officials:

56) Dr J C Paliwal, State Coordinator, Dte. Of Health Services, 6th Floor, Satpura Bhawan, Bhopal, Madhya Pradesh
57) Dr M MPradhan Asst. Director, Joint Director of Health Services (Mal &Fil), Behind Capital Hospital, Unit-VI, Bhubaneswar-751001, Odisha
58) Dr B. Prameela, Medical Officer, Joint Director of Health Services (Mal &Fil), Behind Capital Hospital, Unit-VI, Bhubaneswar-751001, Odisha
59) *Dr Kirti Mishra, Consultant (Entomologist), Joint Director of Health Services, (Malaria & Filaria), Behind Capital Hospital, Unit-VI, Bhubaneswar-751001, Odisha
60) *Dr. Kurien George, O/o Joint Director- Malaria, Block 5, Dr Jivaraj Mehtru Bhawan, Ghandhi Nagar, Gujarat.
61) *Dr A S Bhosle, State Coordinator, Joint Director (Malaria & Filaria & VBDs), Arogya Bhavan, Opp. Vishrantwadi Police Station, Yerawada, Pune-411 006, Maharashtra
62) Dr D Nar Hari, Entomologist, Directorate of health services, 16-2-754/A/41 APAU Colony Gaddiannaram, Hyderabad, A. P.
63) Dr. S. Sridharan, Chief Entomologist, Dte. Of Public Health and Preventive Medicine, Anna Salai, Peynampet, Chennai-600006
64) Dr. T. Dilip kumar, Asst. Director, DHS, Kerala
65) Dr. Ramesh Chander, Chief Entomologist, 633/13, GovindVihar, Near C.D. Girls Public School, Chinhat, Faizabad Road, Lucknow, Uttar Pradesh
66) *Dr. P. K. Phuken, NVBDCP, 505,Meghmallar Santoor Apartment, Jaya Nagar, Six Mile, Guwahati, Assam
67) *Dr S V Gette, Assistant. Director, Regional office of Health & FW and Regional Leprosy Training & Research Institute, Lalpur, Raipur, Chhattisgarh - 492001
68) *Dr. A. T. S Sinha, Entomologist, Office of State Malaria Officer, Namkum, Ranchi - 834010,
69) Mr Prasad Rao, DMO, District Malaria Office, Visakhapatnam, A. P.
70) Dr. B R Mane, State Entomologist, Joint Director (Mal &Fil& VBD), Arogya Bhavan, Opp. Vishrantwadi Police Station, Yerawada, Pune-411 006, Maharashtra

* did not attend the meeting

Participants from ICMR Hqrs:

Dr. Rashmi Arora, Scientist G & Head ECD
Dr. Nivedita Gupta, Scientist D,
Dr. A. K. Bagga, Scientist D