icipe Tropical Insect Science for Development

A Report of the Deliberations of the Malaria Task Force Meeting

Identifying Research Priorities in Vector Biology and Ecology for Integrated Malaria Control in Africa

ICIPE Headquarters,
Duduville, Kasarani, Nairobi

4–8th February 1996

icipe Tropical Insect Science for Development

A Report of the Deliberations of the Malaria Task Force Meeting

Identifying Research Priorities in Vector Biology and Ecology for Integrated Malaria Control in Africa

ICIPE Headquarters,
Duduville, Kasarani, Nairobi

4–8th February 1996

EXECUTIVE SUMMARY

Of mosquito-borne diseases — malaria, filariasis, dengue, yellow fever and Japanese encephalitis — malaria is by far the most important in terms of the number of individuals it affects and the mortality it causes. It affects nearly half the world population (2.2 billion people) in some 90 countries, with 300-500 million estimated clinical cases each year, 1.5–3.0 million deaths, 90% of which occur in tropical Africa. The worsening malaria situation in the world led the WHO to declare malaria control of global priority. However, incidences of other diseases have also been on the increase in some areas. Vector control is acknowledged as an essential part of control programmes of these diseases to which ICIPE can make vital contributions.

In February 1996, ICIPE together with WHO and the Netherlands government sponsored a Task Force Meeting of mosquito and malaria experts from Africa, USA, Europe and Asia to review the status of malaria vector research and to identify critical gaps which ICIPE could address. A unanimous conclusion of the meeting was that much of the information needed for effective vector control focussed on disease control is incomplete, and, in some important aspects, lacking. Surprisingly little is known about the relation between inter and intra-specific diversity among mosquito species, their vectorial dynamics, and underlying population genetics, nor between disease incidence and population dynamics of critical mosquito populations in different environments. A recurring paradox in Africa is apparent lack of direct relation between transmission pressure and malaria disease. Litttle is known about larval population ecology and physiology, and particularly the relation between environment, competitive population dynamics of different sibling species (e.g. of *Anopheles gambiae*) and vectorial fitness of adults. As a result, no meaningful ecosystem based quantitative models can be formulated to guide proactive vector control strategies. Moreover, some of the key behaviours of malaria vectors, such as host location and oviposition, and their mediating cues, have not been investigated in any detail. The discovery of semiochemical cues from such research could provide powerful tools for behavioural manipulation of critical vectors.

NEEDS AND KNOWLEDGE GAPS

Gaps in malaria vector biology and ecology

1. Among the factors which make the control of malaria in Africa especially imperative and challenging are the rising resistance to drugs and pesticides; outbreaks of the disease in areas such as the Kenya highlands that were formerly malaria-free; influence of abiotic factors such as climatic change, civil strife and urban migration on disease incidence;

theirs? What attracts them to each other to form the mating pair? How are breeding sites found and selected? What is the role of visual and olfactory(chemical) cues in this respect?

(vi) How do the adults locate their hosts (host-finding behaviour)? What chemical cues or other factors emanating from the host or the environment are involved?

(vii) Is there a difference in the behaviour of resistant and non-resistant mosquitoes?

(viii) What are the physiological effects of attractants and repellents? Can control methods such as bednets, for instance, produce an avoidance response?

(ix) What is the effect of parasites on the adult mosquito?

5. There is a gap in knowledge about species **distribution and stratification.** There have been several admirable efforts at mapping species, such as that by the South African Institute for Medical Research, and stratification based on endemicity levels and vector species done by WHO in South Africa, Mauritius, Somalia and Sudan, but this is needed in other countries as well.

6. Although there is some basic knowledge about the systematics and biology and ecology of the terrestial adult anophelines, very little is known about their **aquatic larval population ecology and physiology.** Although research in this area is admittedly difficult, questions that need to be answered include the following:

(i) What is the role of mosquito larvae in the food web and ecology of water-based systems?

(ii) What is the relative contribution of different feeding sites to overall disease transmission pressure?

(iii) What is the basis of the competiition between the *Anopheles gambiae* sibling species?

(iv) What is the nature and role of larval feeding behaviour in population dynamics? Is the vectorial fitness of the adult related to larval size?

7. Almost no biological information exists about the **egg stage** of the mosquito, yet this could offer an avenue for possible vector control. This is an obvious gap in knowledge.

8. Although laudable work on vector identification has been done in Africa utilising a variety of techniques including PCR (polymerase chain reaction) and DNA probes, the **lack of a reliable vector species identification service** in Africa constitutes a major research handicap. There is an urgent

need for a vector species identification centre. In order to be effective, such an identification centre should have well equipped laboratories, reliable services, trained staff, an insectary, a mosquito reference collection, and a well equiped library.

9. There is a need for development and **improvement of the PCR** technique for species identification and for the development of molecular biology techniques for the rapid detection of mosquito resistance to pesticides and of the parasite to chemotherapy.

10. The nature of **vector-parasite interactions**, especially at the molecular level, and the mechanisms underlying these interactions, is not well understood. Knowledge of these interactions could reveal vulnerable points which could be manipulated to disrupt key biological processes that allow parasite development and transmission. Some of the questions to be answered include the following:

    (i) What is the role of trypsin in parasite development?
    (ii) Does the inhibition of ookininetes binding to lectin-based molecules open the way for "glycotherapy" as a method of control?
    (iii) Can transmission-blocking antibodies be developed and used for control?
    (iv) What is the cell biology of the infection process, and how does this result in vector specificity?

11. The relationship between **transmission pressure and malaria disease** is not well understood. Recent epidemiological studies confirm that malaria vector competence varies across species. But, whereas it has always been assumed that there is a direct relationship between the intensity of malaria (malaria rate/incidence) and the entomological innoculation rate (EIR), recent studies in Kenya suggest that the malaria rate is not necessarily a function of EIR. Studies on the transmission rate and the incidence of severe malaria at the Kenya Coast found that although the biting rates were very low, the incidence of severe malaria was unusually high, and exposure to even one infected mosquito can result in severe malaria. The situation for Kisumu in western Kenya was the opposite: despite a very high EIR, cases of severe malaria were comparatively few. There is need for further studies to shed more light on this apparent paradox.

12. Current vector control methods rely largely on synthetic insecticides or permethrin/deltamethrin-impregnated bednets. Both these methods have failed to effectively interrupt malaria transmission, especially in

holoendemic areas. Furthermore, eradication or complete interrruption of malaria transmission is neither feasible nor desirable in holoendemic areas, as it will allow for the maintenance of natural immunity. Conventional methods of control need to be re-examined in light of the foregoing. Some questions that remain to be answered include the following:

(i) In the case of bednets, do they really reduce deaths in areas of high transmission?
(ii) Will the most vulnerable groups, pregnant women and children become more susceptible to malaria if they stop using bednets?
(iii) What are more effective methods of fabric impregnation?
(iv) Is the use of bednets producing mosquito tolerence to pyrethroids, as reports from Kenya and Dubai suggest?

13. The use of non-conventional control or repellent substances such as neem and other **botanicals need to be investigated,** in light of their traditional uses in some cases and their generally lower costs and local availability.

14. Applied research without sound theoretical underpinnings is not sustainable. There is need to carefully **balance strategic and applied issues** in the design of mosquito and malaria control projects.

Needs for capacity building and collaboration in malaria vector research

15. **Training** in all aspects of insect science, with a specialisation on malaria vectors is needed **at all levels**: for postgraduate(MSc and PhD) students, postdoctorate fellows, technicians, and management and supervisory staff. Postdoctorate trainees should be attached to on-going projects.

16. It is important for African training institutions to link up with each other and with institutions in the North and in other countries of the South, for maximum **sharing of resources and expertise.** This can be achieved, for instance, by exchange of staff, research students, postdoctorates and visiting scientists. This is already being done in South Africa and at the ICIPE through the African Regional Postgraduate Programme in Insect Science (ARPPIS). ARPPIS is a training network of about 30 universities in Africa who collaborate with ICIPE in training students at PhD and MSc.levels in insect science.

17. Links between researchers of international organisations and those of national organisations have historically been weak or even non-existent in most of Africa. There is need to establish and **strengthen collaboration** between the two groups.

18. African institutions suffer from a plethora of problems, including poor supervision due to the high student to staff ratio; poor general facilities,utilities and infrastructure; lack of specialised research facilities such as an insectory and reference collections; and a general lack of funds for conducting research. There is a need to **identify and equip "centres of excellence"**, which would serve national programmes throughout Africa, and act as incubation points for the development of national research cababilities.

19. There is need for a **multidisiplinary approach** to training and capacity building, with social scientists and epidemiologists, for instance, working together with entomologists.An integrated approach that brings together agricultural, medical and forest entomolgy will be required in order to fully address the problem of malaria in Africa.

RECOMMENDATIONS FOR ICIPE'S PROGRAMME DEVELOPMENT

20. The Task Force Meeting participants unanimously endorsed ICIPE's role in malaria vector research, in four general activity areas. The research orientation should be problem solving, innovative and aimed at filling in the knowlege gaps. It should also be multidisciplinary, network-coordinated research with a well-defined bandwidth .The four areas are:
    (i) basic strategic research whose output is relevant to malaria control in Africa
    (ii) operational research, through networking with African national institutions
    (iii) research capacity building
    (iv) provision of services, such as species identification, resistance monitoring, etc.

21. The over-riding strategy recommended by the participants was that ICIPE should develop *novel* concepts for eventual use in control, i.e., no bednets, no insecticides, and no drugs.

Recommendations for strategic research in integrated vector and disease control

22. All activities and projects undertaken relating to strategic research should include the following principles:

    (i) Incorporation of social and economic considerations in the development, implementation, and assessment of control strategies. ICIPE's Social Science Department would play a major role here and in (ii) & (iii) below.

(ii) Stratification of malaria eco-epidemiological zones in preparation for control operations.

(iii) Assessment of the effectiveness and impact of interventions.

23. ICIPE should undertake basic research with an applied outcome, and with a focus on product development. The products should be tested in the field and in various ecological settings. The scientific direction and product development should be built on current ICIPE interests and upon the needs of the local communities and other target groups.

24. Malaria vector ecology is the basic foundation that provides the theoretical underpinning upon which other vector research components will be built.

The main research components that would together contribute to the development of an integrated mosquito/malaria control programme at ICIPE were identified as follows:

(i) vector ecology and eco-epidemiology, including effects of environmental change

(ii) population genetics

(iii) Behaviour and chemical ecology of both adult and larval stages, especially use of botanicals, odour baits, oviposition pheromones, repellents and attractants.

(iv) modelling of vector populations and disease dynamics

25. The priority areas for ICIPE's research in genetics and molecular biology research were suggested as being in:

(i) the genetics and biochemistry of insecticide resistance

(ii) vector-parasite interactions (in collaboration with other on-going programmes

(iii) provision of field support for vaccine development

26. Research in population genetics is important in understanding the mosquito in its natural biological community. The knowledge so gleaned will be valuable to many control strategies.

27. ICIPE's experience in biologial control should be utilised by undertaking research into the development of bacteria such as *Bacillus thuringiensis(Bt)* and fungi for vector control.

28. The following specific topics for strategic research needed for effective vector management were recommended:

(i) Eco-epidemiological zoning, employing GIS and other techniques
(ii) Larval ecology, especially the place of *Anopheles* larvae in the food chain, encompassing research on food webs in specific agro-ecosystems
(iii) Behavioural biology so as to gain a better understanding of behaviouralchange, such as for example vector behaviour in the dry season and its impact on transmission dynamics and species competition

Intervention or Operational Research

29. In the area of operational research, the following topics and activites were recommended:

(i) development of attractive devices for sampling and control
(ii) assessment of the contribution of different vector groups to malaria transmission
(iii) monitoring of climate change-induced transmission patterns in highland areas
(iv) studies on the man-made micro-environmental change and its impact on mosqitoes and transmission
(v) exploration of habitat management as a control strategy
(vi) testing the efficacy of insecticides in experimental huts
(vii) development of techniques to track the spread of insecticide resistance and especially monitoring of resistance to pyrethroids and cross resistance between pyrethroids
(viii) development of genetic control tools that would directly reduce vector fitness or block pathogen transmission.

Capacity Building and Collaboration

30. The priorities in capacity building and levels of training linked to ICIPE's programme goals were identified as follows:

(i) PhD - level training, particularly in the research component , through the exisiting ARPPIS programme
(ii) training of middle-level(MSc) workers, particularly in the research component
(iii) postdoctoral level training, integrated into on-going malaria research projects

(iv) specialised short courses

The meeting did not reach a consensus about the need for offering coursework or the training of technicians by ICIPE.

31. Networking and collaboration should be undertaken by ICIPE with the following:

(i) national research institutes in Africa
(ii) CGIAR institutes
(iii) the ORSTOM network in Francophone West Africa
(iv) international organisations and programmes, such as WHO, TDR, PEEM, etc.
(iv) "centres of excellence" in industrialised countries
(v) NGO's, such as AMREF

It was recommended that ICIPE collaborate with national research systems, such as the Kenya Medical Research Institute(KEMRI) in this research. Kenya was thought to be a good starting point for collaboration with national institutes because it has a relatively strong national governmental malaria control strategy.

33. Mobilisation of funds could be appraoched through:

(i) Policy frameworks such as those of WHO; Agenda 2l; the Biodiversity Convention, the Ramsah Convention, etc.
(ii) Assessment of non-conventional desks in bilateral agencies
(iii) "Packaging" of proposals in line with current priorities of national and international malaria control strategies and funding agencies.

ACKNOWLEDGEMENTS

ICIPE is grateful for the encouragement and support of the Netherlands Government, the Government of Denmark, WHO, and ORSTOM in the Centre's endeavors to re-establish its medical vector research activities.

PROGRAMME

A REPORT OF THE DELIBERATIONS OF THE MALARIA TASK FORCE MEETING

Identifying Research Priorities in Vector Biology and Ecology for Integrated Malaria Control in Africa

TASK FORCE MEETING TO IDENTIFY AREAS OF RESEACH IN VECTOR BIOLOGY AND ECOLOGY IN SUPPORT OF MALARIA CONTROL IN AFRICA

Nairobi, 4–8 February1996
Venue:Rachel Galun Hall

Objectives:

To review potential methods for the control of malaria vectors, with particular reference to integrated control approaches;

To make recommendations for strategic research activities on fundamental and applied aspects of malaria vector control;

To recommend a suitable institutional framework for effective mosquito research and for the development of integrated control strategies, and to assess the suitability of the ICIPE as the centre for such studies in Africa;

To make recommendations for mobilizing and/or training of suitable personnel, to sustain research and application work on malaria vector control in Africa.

Task Force Chairmen: Robert Bos and Peter Esbjerg

Programme

Sunday, 4th February: Arrival of participants

Monday, 5th February: Current situation, Research Status and Needs

0800	:	Registration
0830	:	Welcome and Opening remarks: **Hans R. Herren,** ***Director General, ICIPE***
0840	:	Malaria in Africa: Current situation and outlook for control **(Robert Bos)**
0920	:	Vector research in aid of malaria control: historical solutions and future developments **(Caroline Maxwell)**
1000	:	COFFEE/TEA

1030	:	Malaria vector research in Eastern and Southern Africa: laboratory studies ***(R. Hunt)***
1110	:	Malaria vector research in East Africa: field studies ***(F. W. Mosha)***
1150	:	Malaria vector research in West Africa ***(Sekou T. Traore)***
1230	:	Discussion
1300	:	LUNCH
1400	:	Need for research in vector biology and ecology for malaria control ***(W.A. Hawley)***
1430	:	ICIPE as International Centre For Vector Research ***(Peter Esbjerg)***
1500		Discussion
1530	:	COFFEE/TEA
1610	:	First workshop: Needs and constraints in current research in ecology, epidemiology, behaviour, genetics, molecular biology, control; (participants are divided in small groups to discuss different topics as indicated by the Chairmen).
1800	:	Adjourn

Tuesday, 6th February : Recent advances: Background

0830	:	Recent advances in mosquito genetics ***(F. H. Collins)***
0900	:	Recent advances in mosquito/parasite interactions ***(P.F.Billingsley)***
0930	:	Recent advances in mosquito behaviour ***(W. Takken)***
1000	:	COFFEE/TEA
1030	:	Recent advances in malaria epidemiology ***(J.C. Beier)***
1100	:	Recent advances in vector control ***(S. Lindsay)***
1130	:	Recent advances in malaria control ***(S.K. Subbarao)***
1200	:	Recent advances on malaria research in Orstom ***(D. Fontenille)***
1230	:	General Discussion
1300	:	LUNCH
1400	:	Second workshop: research in integrated vector and disease control in Africa
1700	:	Adjourn
1930	:	Dinner to be hosted by ICIPE Director General (Nyama Choma Ranch, Safari Park Hotel)

BLACK

LIST OF PARTICIPANTS

Dr Amha Aseffa
Professor and Scientist
College of Medicine
Department of Biochemistry
& Molecular Biology
Howard University
Washington, D.C. 20059
U.S.A.
Tel: no. 202 806 7606
Fax: 202 806 5721

Dr E.J. Asimeng
Medical Entomologist & Parasitologist
Medipest Consult and Research Ltd.
Vector Control Specialists
3 Riverside Drive
P.O. Box 14756
Nairobi, Kenya
Tel: 254-2-441699

Dr John C. Beier
Associate Professor
Department of Tropical Medicine
Tulane University
1501 Canal Street, Rm. 505
New Oleans, LA 70112
U.S.A.
Tel: 1-504 585 6949
Fax: 1-504 587 7113
e-mail: jbeier@mailhost..tcs.tulane.edu

Dr. Peter F. Billingsley
Department of Zoology
University of Aberdeen
Tillydrone Avenue
Abardeen AB9-2TN
Scotland
U.K.
Tel: 44 1 224 272 882
Fax: 44 1 224 272 396
e-mail: p.billingsley@abdn.ac.uk

Dr Robert Bos
Executive Secretary
WHO/FAO/UNEP/UNCHS/Panel of Experts on Environmental Management for Vector Control
World Health Organisation
CH-1211 Geneva
SWITZERLAND
Tel: +41 22 791 35555
Fax: +41 22 791 4159
E-mail Bos@WHO.CH

Dr Frank Collins
Chief, Vector Genetics Section
Division of Parasitic Diseases
Centers for Disease Control
ATLANTA, GEORGIA
U.S.A.
Tel: 1-770 488 7465
Fax: 1-770 488 7794
e-mail: fhc1@ciddpd2.em.cdc.gov

Prof. Peter Esbjerg
Chairman, ICIPE Programme Committee
Royal Vet. and Agricultural University
Bulowsvej 13, Frederiksberg
DK-1870 COPENHAGEN
Denmark
Tel: 35 35 28 26 86
Fax: 45 35 28 26 70

Dr Didier Fontenille
Medical Entomologist
Head, ORSTOM Laboratory of Medical Zoology
Institut Pasteur
B.P. 1386, DAKAR
Senegal
Tel. 221 32 43 07
Fax: 221 23 48 74
e-mail: Fontenil@dakar.orstom.sn

Dr Andrew K. Githeko
Senior Research Officer (Medical Entomologist)
Kenya Medical Research Institute
Vector Biology and Control Research Centre
P.O. Box 1578
Kisumu, KENYA
Tel. 254-035-44366/7

Dr Richard H. Hunt
Consultant, Department of Medical Entomology
South African Institute for Medical Research
Hospital Street, P.O. Box 1038
JOHANNESBURG, 2000
South Africa
Tel: 489 93 90
Fax: 489 90 01

Dr William A. Hawley
Kenya Medical Research Institute/CDC
P.O. Box 30137
NAIROBI,
Kenya
Tel: 254-2-713008
Fax: 254-2-714745
E-mail: hawley@arcc.or.ke

Dr Flemming Konradsen
Environment Health Specialist
International Irrigation Management Institute
P.O. Box 2075
127, Sunil Mawatha, Battaramulla
Colombo, SRI LANKA
Tel: 94 1 86 74 04
Fax: 94 1 86 68 54
E-mail: immi@cgnet.com

Dr Steve Lindsay
Malaria Unit
Department for Vector/Biology Transmission
Danish Bilharziasis Laboratory
Jaegersborg Allé 1D
DK-2920 Charlottenlund
DENMARK
Tel: 5 39 62 61 68
Fax: 45 39 62 61 21
E-mail: biladblp@pop.denet.dk

Dr Caroline Maxwell
National Institute of Medical Research
Ubwari Field Station
P.O. Box 81
Muheza, Mkuo waTanga
TANZANIA
Fax: 0873 131 5766

Dr F.W. Mosha
Director
Tropical Pesticides Research Institute (TPRI)
P.O. Box 3024
Arusha
TANZANIA
Tel: 057 8813/14
Fax: 057 8217

Professor Richard Mwangi
Professor of Zoology
University of Nairobi
P.O. Box 30772
NAIROBI, Kenya
Tel: 254-2-43185

Dr Graham Reid
Senior Program Specialist
Ecosystem Health
International Development Research Centre
P.O. Box 8500
OTTAWA, Ontario
Canada
Tel: 613 236 6163
Fax: 1-613 567 7748
e-mail: greid@idrc.ca

Dr Vincent Robert
Medical Entomologist
ORSTOM Laboratory of Medical Zoology
Institut Pasteur
DAKAR, Senegal
Tel: 221 32 09 62
Fax: 221 23 48 74
e-mail: robert@belair.orstom.sn

Dr (Mrs.) Sarala K. Subbarao
Deputy Director
Malaria Research Centre
Indian Council of Medical Research
22 Sham Nath Marg
DELHI 110054
INDIA
Tel: 91 11 235 721/224 7983
Fax: 91 11 72 34 234
e-mail: vps@mrcicmr.ren.nic.in

Dr Willem Takken
Medical/Veterinary Entomologist
Wageningen Agricultural University
Department of Entomology
THE NETHERLANDS
Tel: 31 8370 484 652
Fax: 31 8370 84821
e-mail:willem
takken@medew.ento.wau.nl

Dr Fantamady Sekou Traore
Medical Entomologist (Cytogntist)
Malaria and Training Centre
National School of Medicine and
Pharmacy
Research Pharmacie BP 1805
MALI
Tel: 223 22 52 77
Fax: 223 22 98 79
e-mail: cheick@mrtcbko.malinet.ml

ICIPE STAFF

Dr. Hans R.Herren, *Director General*
Prof. Ahmed Hassanali, *Interim Deputy Director General*
Mrs. Rhoda A. Odingo, *Director International Cooperation*
Dr. Steve Mihok, *Ag. Programme Leader, Disease Vector Management Programme*
Dr. E.O. Osir, *Head, Molecular Biology and Biochemistry Department*
Dr. N.K. Maniania, *Ag. Head, Pathology and Microbiology Department*
Prof. Fassil G. Kiros, *Head, Social Science Department*
Dr. K. Ampong-Nyarko, *Ag. Head, Ecology and Biodiversity Department*
Dr. R.K. Saini, *Ag. Head, Behavioural Biology Department*
Dr. L. Lwande, *Ag. Head, Chemichal Ecology Department*
Dr. C.M. Mutero, *EU Project Coordinator*
Dr. Muhinda E. Mugunga, *ICIPE/Hebrew Collaborative Project*

ICIPE Science Press
PO Box 72913
Nairobi, Kenya