A Manual on

Control of Malaria

with special reference to Andhra Pradesh, India

Prasanta Mahapatra
V. B. Sai Kumar
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Disclaimer

These practice guidelines on malaria have been prepared following consultation with experts and is based on information available at the time of its preparation. Health officials and health workers should have regard to any information on these matters which may become available subsequent to the preparation of the manual.

The guidelines, suggestions and recommendations are made in good faith. The authors recommend that persons with specific problems consult a medical practitioner. Neither the Institute of Health Systems, Hyderabad nor any other person associated with the preparation of these guidelines accepts legal liability or responsibility for such advice or recommendations.

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Publisher's Note

Preparation of this manual was commissioned by the Government of Andhra Pradesh. Copies of the manual for official circulation have been published by the Director of Health, Hyderabad, Andhra Pradesh.

We feel that the manual has wider application and would be of interest to general public, health system researchers, public health officials elsewhere, both in and outside India. This priced publication has been brought out by the IHS publications to make it available to a wider audience.

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Preface

Government of Andhra Pradesh commissioned[1] the Institute of Health Systems to prepare a comprehensive manual to achieve better control of the Malaria situation in the state. We, the Malaria Manual Preparation Team, at IHS are very pleased to offer, through this manual, our contributions towards control of malaria in the state. Immediately after commissioning, we started collecting all available material about malaria control activities in the state. We interacted with the malaria control programme officers, and officials at Directorate of Health, dealing with malaria. We also discussed the matter among the Institute's faculty and attended the National Workshop on Communicable Disease Control conducted by the State Government in December, which was very informative.

This manual departs from traditional programme implementation manuals in the sense that this is a manual addressed to every one in the state, who have a role towards control of malaria. We have not repeated many of the administrative forms and instructions already contained in the Operational Manual for Malaria Action Programme (MAP), 1995 issued by the National Malaria Eradication Programme (NAMP). We start with insights on malaria problem which may help every one contribute to its prevention & control. In the Chapter -II an overview on malaria parasite and how it causes malaria is presented.

Details on entomological profile and mosquito vector biology, are explained in the Chapter-III. More emphasis is given on the entomological field techniques which will help build a strong surveillance system. We strongly believe that the study of entomology in colleges and universities, can play an important role for surveillance. Hence, model syllabus on applied entomology for inclusion in Bachelors and Masters courses in life sciences discipline are recommended in this chapter.

Indicators needed to assess malaria situation are presented in Chapter-IV. These key indicators help immensely in forecasting malaria epidemics. A detailed review on situation of malaria in the state of AP is given in the fifth Chapter. In the Chapter-VI, details on what individuals, families and neighbourhoods do to keep out malaria are presented. The chapter also includes personal protection measures.

Practice guidelines for diagnosis and treatment of malaria are given in Chapter-VII. These guidelines should be adopted by practitioners and healthcare delivery institutions in both public and private sector, with appropriate modifications to suit local conditions. The next chapter describes environmental, chemical and biological control measures of mosquito vector. Recommendations of expert committee are given in Chapter IX.

This manual is a result of collaborative effort of many people,who contributed generously with experiences drawn from their respective work spheres. Mr.Ratna Joseph, District Malaria Officer, Krishna District, was kind enough to spend two weeks with the Institute and helped us in getting started. We thank Dr.Gurunath Babu, Addl. Director (Malaria & Filaria), AP for providing us with official information and data on malaria incidence.

[1]Government of AP GORt. No. 1495 dated 7/12/2000, HM&FW department.

We thank Dr. SK Ghosh, Asst. Director, Malaria Research Centre, Bangalore for visiting IHS and sharing with us his rich experiences in the field of malaria prevention and control. Our thanks are also due to Dr. Alaham Ravi, Sr. Entomologist, Hyderabad for his inputs from his field experiences. The services of Mr. V.L. Kanta Rao, Chief Entomologist, Pest Control (India) Ltd, formerly State Programme officer (Malaria), AP for his valuable suggestions, is duly acknowledged. We thank Shri M. Nagarjuna IAS, for his help in providing data on malaria in the state.

We are very grateful to the Government of AP and Shri C. Arjuna Rao, Special Chief Secretary to Government of AP and Shri A.K.Tigidi, Secretary Health, Medical and Family Welfare Department. Shri Arjuna Rao has been the primary source of inspiration for our work.

June 15 2001,
Hyderabad

Prasanta Mahapatra, Director
V.B Sai Kumar, Faculty
Dhanaraj, Research Assistant

About Institute of Health Systems

Institute of Health Systems (IHS) is a civil society institution. It was established in 1990 and registered under the Societies Registration Act[1]. A group of concerned citizens, each specialising in a different field having linkages with health care, realised that the health services, in India, had been viewed as a technological affair. There are a lot of areas in the health care delivery system which cannot be handled well with medical technical skills that our health staff are usually equipped with. They recognised the need for development of skills in interdisciplinary areas like health management, health economics, health informatics, medical sociology, health policy studies, etc. The need for operations research to arrive at solutions appropriate to local needs was recognised. The Institute was set up to fill in this gap and to realise the vision of an equitable and cost-effective health care delivery system in India. IHS objectives include health systems research, development of interdisciplinary skills to improve efficacy of health care delivery system, health policy analysis, application of information technology in health sector.

The Institute is governed by a system of authorities consisting of an executive committee, a general body and the board of governors. Programs and activities of the Institute are carried by a team of faculty and staff lead by the Director, who is the chief academic and executive officer of the Institute. IHS is registered as a charitable scientific institution under section 12A of the Income Tax Act[2]. Contributions to IHS are eligible for exemption under section 80G of the Income Tax Act[3]. The Institute has been granted permanent registration by the Government of India Ministry of Home Affairs under the Foreign Contributions Regulation Act[4]. Starting with the first meeting held in July 1994, annual general body meetings are conducted every year, around December - January. IHS files its audited accounts with the Income Tax department every year. Annual reports are filed with the registrar of societies and are accessible to public through the registrar of documents. In addition the annual reports, and audited accounts of the Institute are made available, along with other publications of the Institute, to interested persons for a small charge. Membership of the Institute is open to any person who has consistently evinced interest and demonstrated commitment towards objectives of the institute and to Institutions with complementary objectives.

The Institute is largely supported by project based funding and income from services provided by it. IHS services, activities and projects broadly fall into research, training and consultancy assignments. The Institute strives to maintain a balance between these three modes of learning and application to provide an environment for intellectual development, knowledge based work and at the same time keep the skill set of its faculty well grounded to realities of social services delivery in India and other developing countries. The Institute fosters a team of faculty from multiple disciplines, provides modern office facilities, knowledge based resources, and an enriched work environment.

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[1]Registration number 3748/90, under the AP Telengana Area Societies Registration Act. 1350 Fasli.

[2]Commissioner of Income Tax letter no. II/12A & 80G/64/90-91 dated December 19, 1990.

[3]First granted by Commissioner IT AP-II, Hyderabad letter no. H.Qrs. No.II/12A & 80G/64/90-91 dated December 31, 1990. Latest renewal for the period 01-04-99 till 31-03-2002 by Commissioner IT, AP Proceedings number Hqrs-II/12A & 80G/77/97-98, dated 07-10-99.

[4]IHS permanent FCRA registration number is 010230292 vide Govt. of India, Ministry of Home Affairs letter no. II/21022/61(4)/93-FCRA-III.

Contents

I. Insights About the Malaria Problem

Malaria is a disease caused by overwhelming presence, in blood, of Plasmodium parasites. The parasite can be *Plasmodium vivax* or *Plasmodium falciparum, Plasmodium ovale,* or *Plasmodium malariae*. Accordingly, experts refer to vivax malaria, falciparum malaria, ovale malaria, and quartan malaria in case of infection with *P. malariae* (Gilles, 1993) depending on the species of parasite causing the disease. Two of these, namely vivax and falciparum malaria are prevalent in Andhra Pradesh. There are important differences in manifestation and outcome of these two types of malaria. Both varieties of malaria manifest with fever. But falciparum malaria can affect the brain (cerebral malaria), and other vital organs, leading to death. Most adult deaths due to malaria are due to falciparum malaria. Both vivax and falciparum malaria can cause death of infants, mostly on account of high fever and convulsions. Malaria fever is of sudden onset, usually accompanied by chills and recedes with sweating. Fever is usually accompanied by body ache. Typically episodes of malaria fever appear at regular intervals. However, the most important characteristic of malaria fever is that the fever recedes completely between two episodes. This complete relief between two episodes of fever is an important differentiating characteristic between fever due to malaria and other causes like viral fever.

Note, however, that mere presence of malaria parasite in blood does not necessarily manifest as disease. Hence the expression "overwhelming presence" of malaria parasite in blood was used above. Some people living in malaria endemic areas may carry the malaria parasite in their blood without any illness. Although complete immunity from malaria is not yet established, many people living in malaria endemic areas show partial resistance to disease, even in presence of malaria parasite in blood. Note that malaria endemicity is a key factor in development and sustenance by the local community of partial resistance to the disease. Thus, visitors to malaria endemic areas are most susceptible to the disease. Project works in malaria endemic areas, usually attract large number of migrant labourers. Urban slums, many of which show high risks of malaria, usually receive a constant flow of immigrants from the country side. Infants and pregnant women are also more susceptible to suffer from malaria, even if the pregnant woman is a usual resident of the malaria endemic areas.

The malaria parasites are transmitted by female Anophelene mosquitoes. The malaria transmitting mosquito species in Andhra Pradesh are *Anopheles culicifacies, An. fluviatilis, and An. stephensi.* General understanding of mosquito behaviour can help people adopt life styles to minimise human mosquito contact. An understanding of mosquito breeding behaviour helps us to keep the mosquito population in check. For example longevity of mosquito has an important effect on the malaria transmission potential. If mosquitoes do not survive long enough, then its ability to transmit malaria parasite from one infected individual to another is reduced. Similarly, the malaria parasite gametocyte ingested by a mosquito should multiply into spores (sporogony) for the mosquito to be infective. Seasonal variations in relative humidity and temperature affect the process of sporogony in mosquito and the latter's life expectancy. Mosquito density is also a major determinant of malaria transmission. Density of mosquitoes depends on its life expectancy and availability of

breeding sites. Low relative humidity and temperature effect, reduce mosquito longevity and breeding. Rainfall can influence malaria transmission in several ways. By increasing humidity and breeding sites, it can lead to increase in mosquito density. Very heavy and incessant rainfall may, however, flush the breeding places of mosquitoes, thereby reduceing mosquito output.

Malaria is a focal disease. By this we understand that high risk of malaria in one habitation does not necessarily mean that the neighbouring habitation will have similar risks. Focal character of malaria is largely due to the fact that mosquitoes generally not fly long distance and height. The focal character of malaria has very important implications for control of the disease. Firstly, residents of a village or habitation can focus to improve their residential environment and reap the resultant benefits of reduced mosquito population. Secondly control measures have to be focused and tailored to the specific environmental conditions of each habitation.

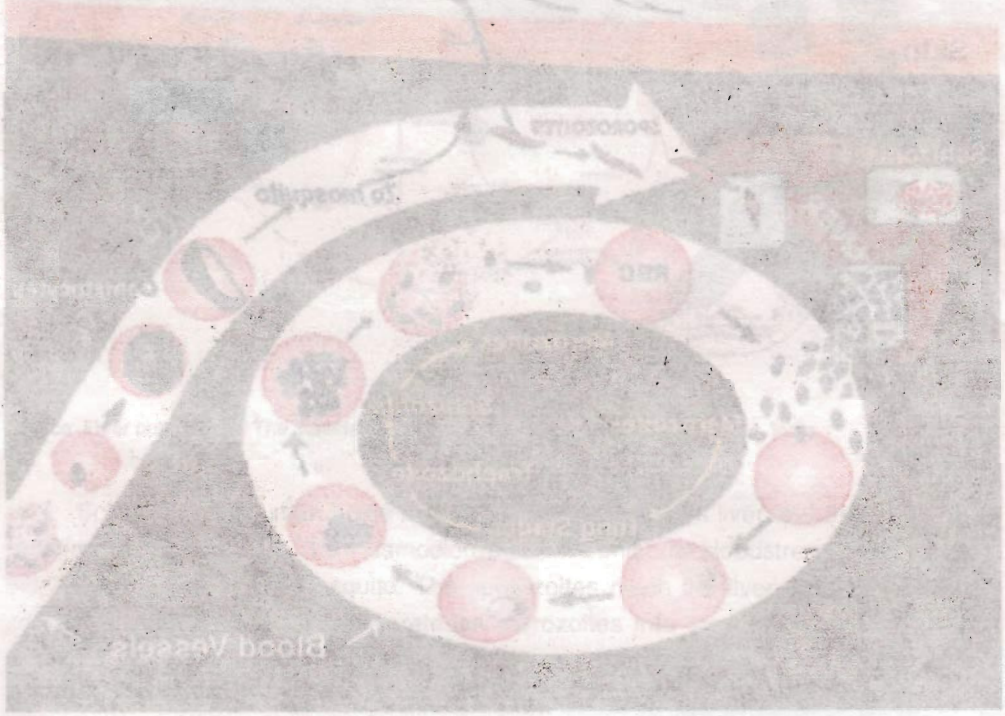
Can we and should we eradicate malaria? Unfortunately we do not have a simple answer to this very natural question. In 1940s and 1950s malaria used to be rampant in almost all tropical and sub tropical areas of the world. Armed with the discovery of anti malarial drugs and insecticides, public health experts first launched malaria control programmes. In India, the National Malaria Control Programme was started in 1953. This resulted in dramatic reduction of malaria incidence. Encouraged by the initial success, the National Malaria Eradication Programme was launched in India, in the year 1958. Eradication programmes in certain parts of the world succeeded, particularly in small islands. For example; Mauritius, Jamaica, Taiwan, etc. (Spielman and James, 1990). But on larger landmasses like India, the goal of eradication could not be achieved completely due to several factors. In certain places of the world, large scale aerial spray of insecticides was taken up to rid the environment, of all insects and pests. The adverse effects of such large scale environmental interventions became evident. Massive destruction of natural ecosystem of insects led to the appearance of new diseases and new problems.

Eradication doctrine requires operational perfection because success depends on elimination of the last infected case. That is why the NMEP strategy sought indoor spraying of all households with insecticides. So far complete coverage of all households with residual insecticide spray could not be achieved in practice. In contrast intensified-control doctrine permits slippage because a certain specified level of transmission is tolerable. In place of perfection, intensified-control programmes seek to apply a combination of techniques. The concept of integrated pest management in agriculture has some relevance for control of vector-borne diseases like malaria, albeit with appropriate modification.

Current strategy is to minimise the malaria incidence, morbidity and mortality by encouraging conducive life style, environmental practices, biological control of mosquitoes and selective use of insecticides to tackle temporary increases in mosquito density. The key strategy is to control mosquito density and minimise human mosquito contact. Mosquito density is to be primarily controlled by biological measures like release of fish feed on mosquito larvae, and environmental practices to reduce breeding sites. Insecticide spray is to be resorted to only when seasonal conditions lead to uncontrolled increase in mosquito density. Morbidity and mortality can be reduced by early diagnosis, appropriate and timely

treatment of malaria cases. Thus mosquito density control, avoidance of mosquito exposure, and malaria case management are the three key strategies to keep the malaria problem in check.

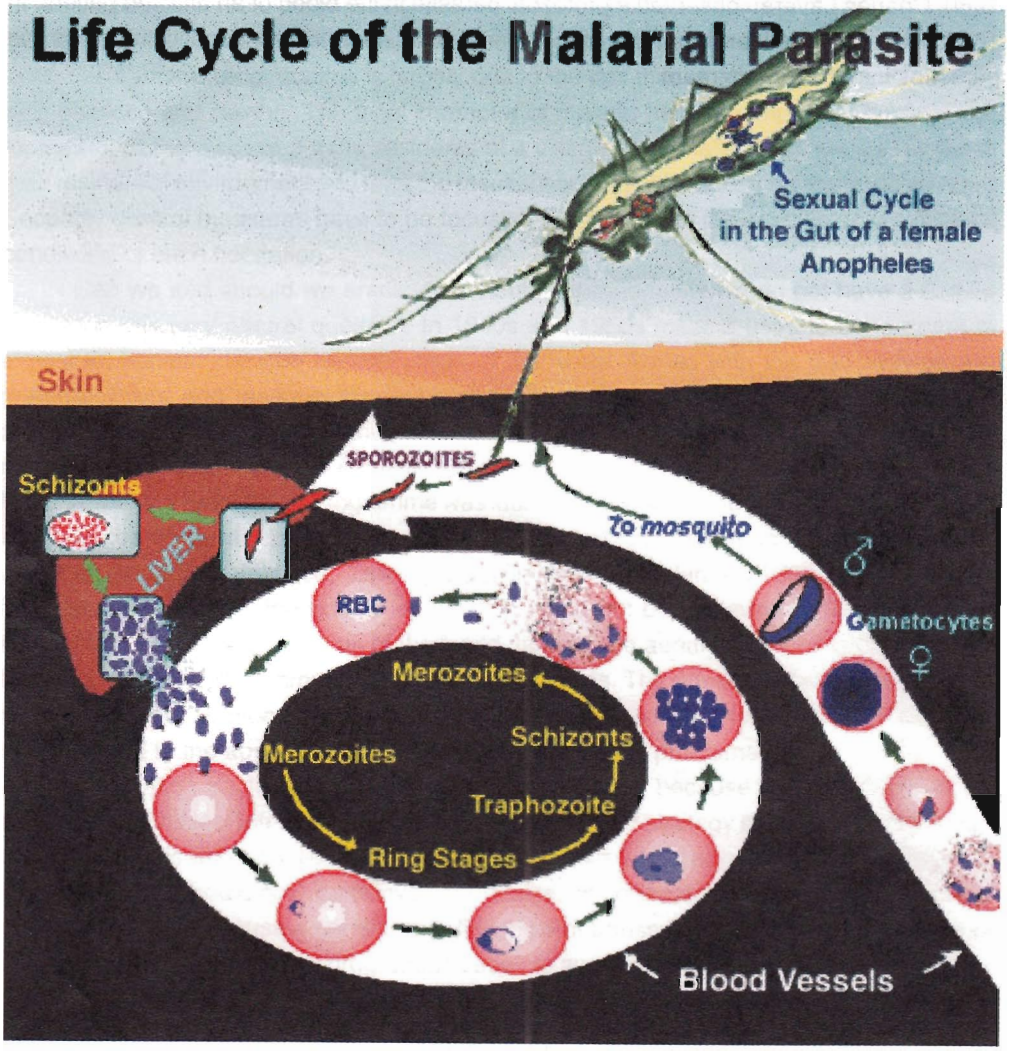
Finally, a little bit of history. Malaria means "bad air" in Italian, reflecting the pre-1880 view that it was caused by gases from the swampy regions where many cases occur. In 1880, Charles Laveran observed a protozoal parasite in the blood of an afflicted patient. In 1898, Ronald Ross found that the bite of the female *Anopheles* mosquito transmits the parasites into the bloodstream.



II. The malaria parasite

A. An overview of the malaria parasite

Figure-2.1

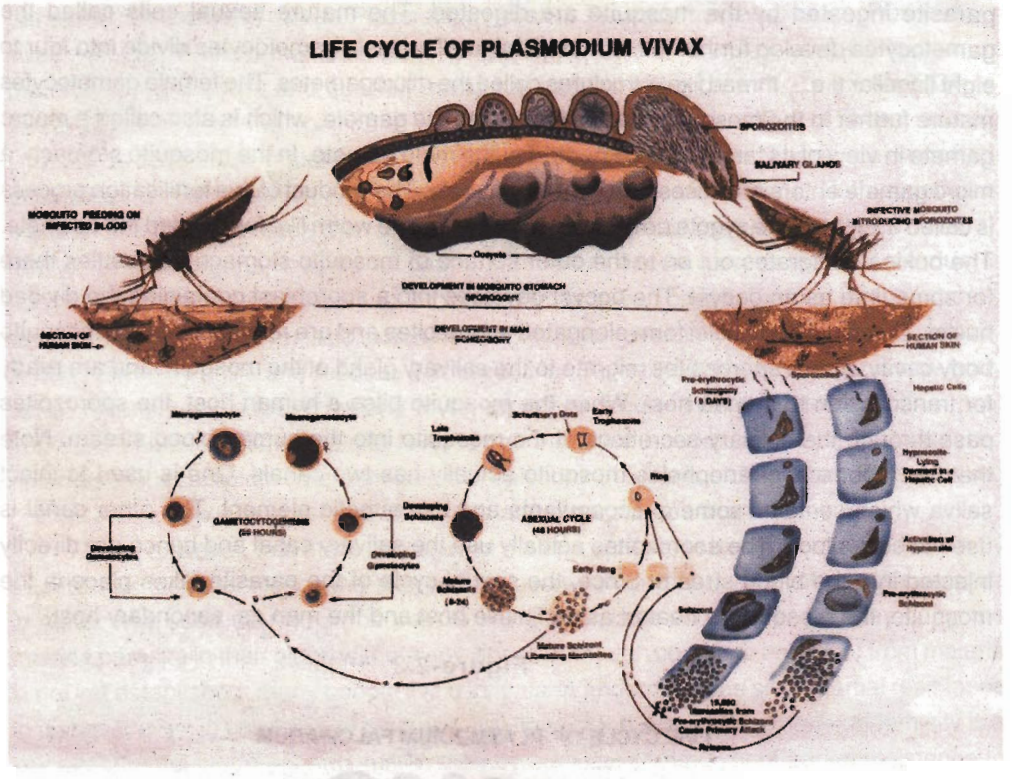


Source : http://www.malaria.org/lifecycle.html. With permission from Prof. Shobhona Sharma, Tata Institute for Fundamental Research, Mumbai, India through her letter dated 25th June, 2001.

There are four species of malaria parasites which may infect human beings. These are (a) *Plasmodium vivax,* (b) *Plasmodium falciparum,* (c) *Plasmodium ovale,* and (d) *Plasmodium malariae.* In Andhra Pradesh, malaria is due to the *Plasmodium vivax* or the *Plasmodium falciparum.* Life cycle of all these varieties of malaria parasite is largely the same (Figure-2.1). It consists of an exogenous sexual phase and an endogenous asexual phase. Note that the exogenous - endogenous nomenclature is with respect to the human

host. These parasites undergo two types of multiplication, by asexual division (schizogony) in the human host and a single sexual multiplication (sporogony) in the mosquito host.

Figure-2.2



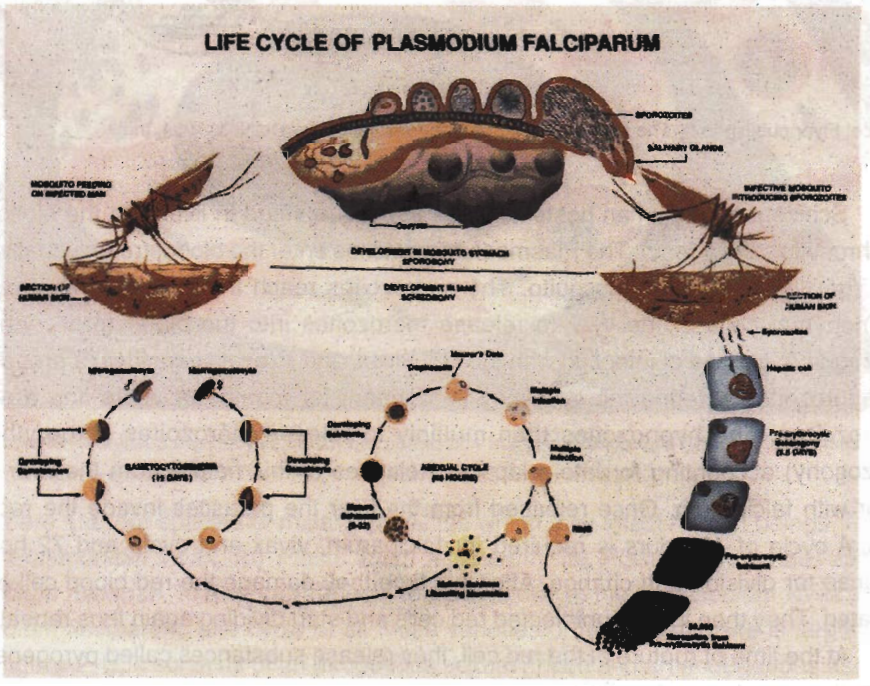
Source: Flyer published by The Malaria Research Centre, ICMR, New Delhi, 110054, India

Schizogony in human hosts includes the tissue stage in liver and the blood stage (erythrocytic schizogony). The Plasmodium parasites enter the bloodstream usually after a bite from the Anopheles mosquito. The sporozoites reach the liver and multiply within parenchymal cells of the liver to release merozoites into the blood (pre erythrocytic schizogony). In case of infection with the *P. vivax,* and *P. ovale* parasites, a proportion of the sporozoites entering the liver may lie dormant for months or years and are called hypnozoites. The hypnozoites then multiply to release merozoites (exoerythrocytic schizogony) accounting for late relapses. Relapses of this nature from the liver do not occur with falciparum. Once released from the liver the parasites invade the red blood cells. A cycle of 48 hours is required for falciparum, vivax and ovale and 72 hours for malariae for division and change. After this time they damage the red blood cell and are liberated. They then invade uninfected red cells and start dividing again thus repeating the cycle. At the time of rupture of the red cell, they release substances called pyrogens which cause the symptoms of malaria.

B. Malaria parasite in mosquito host

When a female anophelene mosquito bites a human host harbouring malaria parasite, its blood meal usually contains a dose of malaria parasites. The asexual forms of the malaria parasite ingested by the mosquito are digested. The mature sexual cells called the gametocytes develop further in the mosquito gut. The male gametocytes divide into four to eight flagellar (i.e. thread like) structures called the microgametes. The female gametocytes mature further in the mosquito gut and form a female gamete, which is also called a macro gamete in view of its larger size compared to the male gamete. In the mosquito stomach, a micro gamete enters and fuses with a macro gamete. The product of this fertilisation process is called a zygote. The zygote develops into a long mobile worm like form called the ookinete. The ookinete migrates out on to the outer surface of mosquito stomach and settles there for some time as an oocyst. The oocyst develops into a sporoblast containing the divided nuclei. These divided nuclei form elongated sporozoites and are released into the mosquito body cavity. These sporozoites migrate to the salivary gland of the mosquito and are ready for transmission to human host. When the mosquito bites a human host, the sporozoites pass through the salivary secretions of the mosquito into the human blood stream. Note that the proboscis of anopheles mosquito actually has two canals. One is used to inject saliva which contains some anticoagulants and anaesthetic element. The other canal is used to suck blood. The sporozoites actually use the salivary canal and hence are directly injected into the blood stream. Since, the sexual cycle of the parasite takes place in the mosquito, the mosquito is treated as definitive host and the man as secondary host.

Figure-2.3



Source: Flyer published by The Malaria Research Centre, ICMR, New Delhi, 110054, India

C. Malaria parasite in human host

1. The tissue phase

Sporozoites inoculated by a mosquito into the human host circulate in the blood for about half an hour and then disappear. Many are cleared by the human phagocytes. But few find their way to the liver tissue (parenchymal cells or hepatocytes). There is a difference, according to species, in further development of the sporozoites in liver. A sporozoite may continue to develop and multiply (pre erythrocytic schizogony) or may shrink in size and stay dormant for a certain period of time. The normal course for all species of the malaria parasite, is for the sporozoites to rapidly develop into schizonts and release merozoites to the blood. This is called pre erythrocytic schizogony. The shrunken and dormant forms are called hypnozoites. A certain proportion of *P. vivax* and *P. ovale* sporozoites entering into the human liver develop into hypnozoites and the rest continue with normal rapid pre erythrocytic schizogony. The hypnozoites remain dormant for considerable periods and then begin to grow eventually releasing a wave of merozoites into the blood. This gives rise to a clinically recognised relapse of malaria. Since *P. vivax* and *P. ovale* give rise to hypnozoites, these are said to cause relapsing type of malaria. There is no evidence of true relapses in *P. falciparum* or *P. malariae*. The process of reactivation of hypnozoites and their development into schizonts followed by release of merozoites into blood is referred to as exoerythrocytic schizogony. The two terms, namely pre erythrocytic schizogony and exoerythrocytic schizogony applied respectively to rapid schizogony in liver and delayed schizogony in liver respectively would, at present, appear confusing. Both processes of schizogony are in fact exoerythrocytic i.e. take place outside the red blood cells. Earlier it used to be believed that the delayed schizogony in liver may be due to re-entry of merozoites released by the schizonts in liver cells into neighbouring liver cells to start a fresh process of development. Hence the first round of development of sporozoites into schizonts followed by merozoites was referred to as primary exoerythrocytic schizogony and the process thought to be set in motion by re-entry of merozoites into other liver cells was labelled as secondary exoerythrocytic schizogony. It was discovered in 1980 that the sporozoites of the relapsing species of malaria parasites differentiate either into hypnozoites or into developing tissue schizonts in varying proportions, depending on the strain (Gilles, 1993). The hypnozoites remain dormant in hepatocytes as uni-nucleated forms for considerable periods and then grow into schizonts. Though delayed, the development of schizonts is a continuation of the first entry by sporozoites from mosquito bite into the liver cells. Hence this is also a primary but delayed schizogony. Moreover the term "exoerythrocytic" does not convey the anatomical site of development of the sporozoites. Since liver is the only place where the rapid and delayed exoerythrocytic schizogony takes place, it would be desirable to label this stage in life cycle of the malaria parasite on the basis of its anatomic site and time from the infecting mosquito bite. Hence it is recommended that the terms rapid hepatic schizogony (rapid schizogony in liver) or delayed hepatic schizogony (delayed schizogony in liver) be preferred to describe the hepatic stage in life cycle of the malaria parasite.

2. The erythrocytic phase

The merozoites released into circulation by liver tissue schizonts enter the red blood cells (RBC). In the case of falciparum malaria, about 40,000 merozoites are released simultaneously from parenchyma cells, whereas in vivax, 10,000 merozoites are released from exo-erythrocytic cycle. In the case of *P.ovale*, 15,000 merozoites were released and in *P.malariae*, 2000 merozoites were released. Antibodies present in partially immune patients may cause the mature merozoites to clump and thereby prevent further invasion of erythrocytes. The youngest stage of the parasite in red blood cells are rounded bodies with annular looking cytoplasm. These are known as the ring forms of the malaria parasite and can be detected by microscopy. The ring forms grow into irregular shapes called trophozoites. The parasite lives on cytoplasm of the RBC and absorbs haemoglobin from it and leaves off hematin. After growing for some time, the nucleus of the trophozoite divides asexually along with division of the cytoplasm forming a schizont. Mature schizonts divide into merozoites. The RBC eventually bursts releasing the merozoites into the blood stream. The merozoites enter fresh RBC and repeat the cycle. This erythrocytic cycle of schizogony is repeated over and over again. The progressive increase in parasitaemia resulting from repeated erythrocytic schizogony is halted either by drug treatment or development of immune response by the host. The length of erythrocytic phase is known as schizogonic periodicity and differs according to the species of malaria parasite. For vivax, falciparum, and ovale malaria it is 48 hours. For *P. malariae* malaria it is 72 hours, and hence the name quartan malaria. In early stages of infection there may be groups (brood) of parasites developing at different times so that the resultant malaria fever does not show any specific periodicity. Later the schizogonic periodicity is better synchronised and the febrile symptoms assume a more definite three or four day pattern. This fact is important for diagnosis. The classical medical description usually emphasises the 48 or 72 hour periodicity of the malarial fever. Faced with fever that completely remits between episodes but does not necessarily follow the expected 48 hour cycle, clinicians may rule out malaria and attribute the fever to other causes. Considering that the 48 hour periodicity takes some time to develop, it will be wrong to rule out malaria purely on the ground of lack of classical periodicity. Moreover, the classical periodicity may never appear due to alterations caused by antibiotics and chemotherapeutic agents like sulphonamide, which may be prescribed in such situations. Hence a more appropriate characteristic of malaria fever would be to look for complete remission of fever and related symptoms between two episodes. In the case of vivax infection, all stages of the parasite from rings to gametocyte stage appear at the same time, while in case of falciparum malaria, only early stage of the parasite, ring stage (early trophozoite) are seen in peripheral blood, while they disappear from the peripheral blood and develop in bone marrow etc. and the gametocyte reappear in peripheral blood after nine days.

After several rounds of erythrocytic schizogony, some merozoites develop into sexual form. These merozoites do not divide and instead mature into gametocytes. The number of gametocytes increase with increasing number of cycles of erythrocytic schizogony. The form of mature gametocytes vary according to the parasite species. Falciparum gametocytes are crescent shaped. The vivax and other species gametocytes are round. The difference is recognisable by microscopy.

III. Learning about the mosquito vector

Scientific study of the mosquito vector is highly important for control of malaria. The scientific study of insects is referred to as entomology. Hence control programme, communications and literature on malaria control often refer to "entomological study". This expression in the context of malaria control simply refers to scientific study of the mosquito vector. There appears to be some confusion about the rationale for use of the expression vector for mosquitoes incriminated in malaria transmission. Hence the chapter starts with a short discussion about the meaning of the word vector and its connotation in the context of malaria epidemiology. A short overview of the mosquito species and Anopheline varieties incriminated in AP is given in the section the section titled "malaria transmitting mosquitoes". The next section presents the anopheline biology. The following two sections present the concepts of vectorial competence and vectorial capacity both important for cost-effective control of malaria. Computation of vectorial competence and capacity and other relevant aspects of vector behaviour requires local data on mosquitoes. Hence common entomological field techniques used to collect such data are described then. Thereafter, available information of mosquitoes in AP is presented. Finally, the state infrastructure for entomological study of vector mosquitoes and the potential for institutions of higher learning to play an active role is described.

A. Why is a disease transmitting mosquito called a vector?

In mathematics a quantity having both magnitude and direction is called a vector. A scalar, on the other hand, is a number representing only magnitude. Analogously, the word vector is used to distinguish the active disease transmitting role of mosquitoes from that of other insects which transmit diseases passively. A vector should have a direction. Here the direction of transmission is the human host of malaria parasite. The female Anopheline mosquito, which transmits malaria, actively looks for the human host for a blood meal. This active seeking of human beings by the mosquito for its own reasons, gives direction to the malaria parasite. On the other hand some insects, for example flies may carry pathogens, but do not actively seek human beings. Their contact with human beings, is more a result of human behaviour rather than an active search for humans by the insect. Hence we say that such disease transmitting insects lack direction. Insects which require a blood meal are called haematophagous. It is the requirement of blood meal that gives the human ward direction to haematophagous insects. Thus the pathogen carrying haematophagous insects are called vectors.

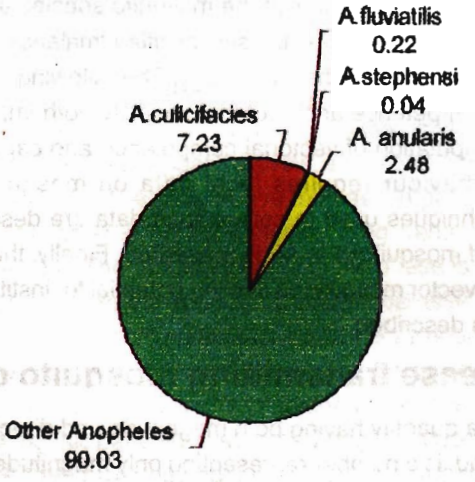
Haematophagous directionality greatly enhances communicability (Spielman and James, 1990). The basic reproduction rate of a vector-borne pathogen generally exceeds that of other pathogens. Each primary vector-borne infection may be communicated to hundreds of secondary infections.

B. Malaria transmitting mosquitoes

There are over 3100 mosquito species belonging to 34 genera in the world (VCRC, 1989). Of these, only 300 species transmit human and animal diseases. Four genera of

vector mosquitoes are involved in transmission of various parasites and pathogens to human beings[1]. These are; (a) *Anopheles,* (b) *Culex*, (c) *Aedes*, and (d) *Mansonia* mosquitoes. The Anopheles mosquitoes are involved in transmission of malaria which is the subject of this manual[2]. About 55 species[3] of Anopheline mosquitoes are found in India. Out of these nine are known vectors of malaria (Rahman *et al.,* 1989). Malaria vectors in Andhra Pradesh are *Anopheles culicifacies, Anopheles fluviatilis, Anopheles stephensi,* and *A. annularis* (Figure-3.1).

Figure-3.1: Anopheles species composition of adult mosquito collected by hand catch in AP, 1999



Source: Compiled from Annual Technical Report #2 for 1999, Directorate of Health - Malaria Wing, Andhra Pradesh.

Anopheles varuna is a secondary vector, used to be found in the Eastern ghats region but appears to have become rare. Other anopheline species not involved in transmission of malaria constitute a major part of the hand catches. The figure does not show mosquito of any other species, because the practice is to ignore non Anopheline catches for purpose of this report by entomologist working on malaria control.

It may be of some interest to note that research on malaria transmission by the Anopheline mosquito was carried out by Sir Ronald Ross at Hyderabad, in Andhra Pradesh. Ross worked from an office which now forms part of the Begumpet airport complex. In 1898, Ronald Ross proved that the bite of the female Anopheles mosquito transmits the parasites into the bloodstream.

1Mosquitoes from a fifth genus namely *Armigeres* are a source of nuisance in urban areas, but do not actually transmit any disease. These mosquitoes breed in areas with high organic content like septic tanks, and on effluents from industries handling organic matters or organic compound.

2Briefly, the Culex fauna consists of 57 species. Culex quinquefasciatus transmits filaria caused by the nematode Wuchereria bancrofti. The genus Mansonia is represented by seven species. Of these *M. annulifera* and *M. indiana* transmit Brugia malayi filariasis. Culex vlanui group of mosquitoes transmit Japanese encephalitis. The genus Aedes is represented by, *Ae. aegypti* and *Ae. albopictus*. These are the vectors for dengue and haemorrhagic fever.

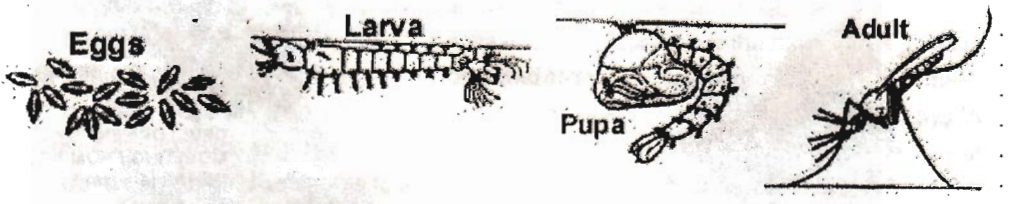
3Rahman, Sharma, and Rajagopal, (1989 p186) give identification key for 53 Anopheline species. Two recently found species are; *An. mysorensiss*, and *An. dirus*.

C. Anopheline mosquito biology

1. Life cycle:

Mosquitoes live on land, can fly short distances and rise to small heights. They lay eggs in a variety of water sources ranging from small containers to vast expanses of marshland. The choice of water body for laying of eggs varies according to the species. The eggs hatch into larvae which always live in water. The mosquito larvae hang on to water surface, feed on micro organisms just below the water surface and breath air from the water surface. The pupal stage does not feed, but unlike most insect pupae, is extremely active. The adult emerges from the pupal case, using air pressure and assume terrestrial existence.

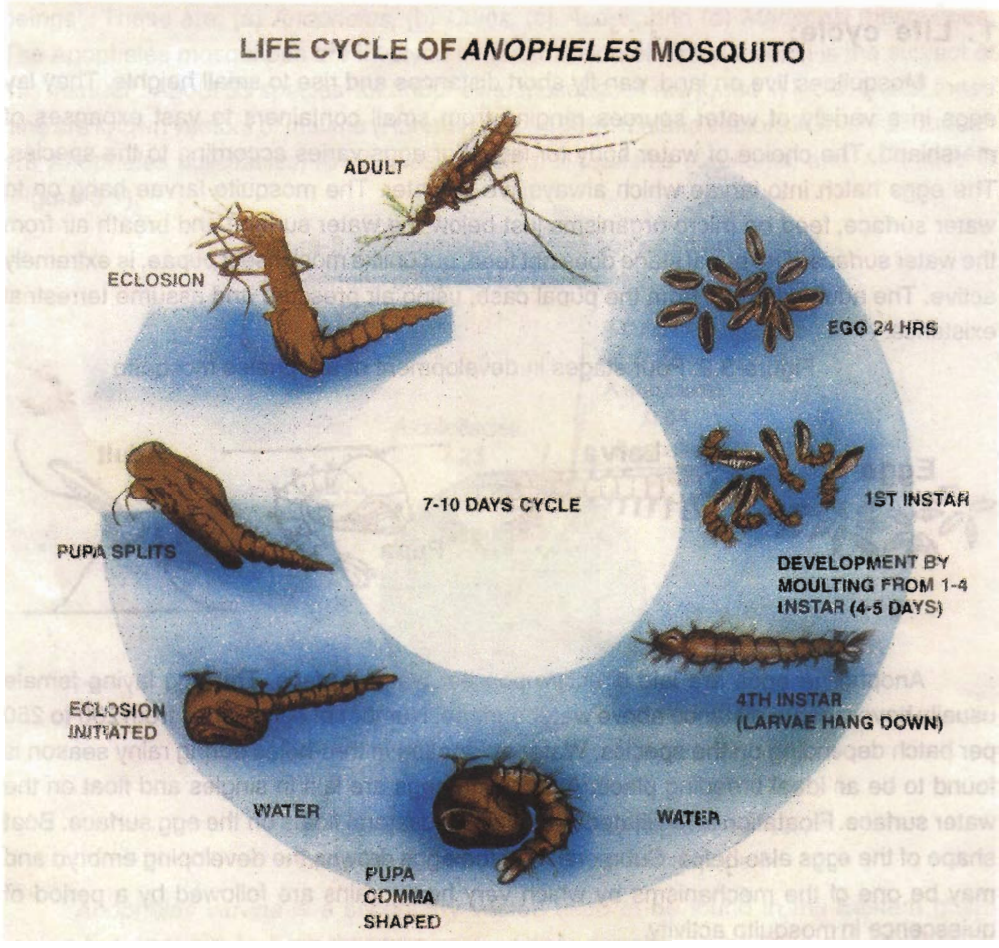
Figure-3.2: Four stages in development of anopheles mosquito



Anopheline eggs are laid directly upon the water surface. The egg laying female usually hovers some distance above water surface. Number of eggs varies from 200 to 250 per batch depending on the species. Water stagnation in tree-holes during rainy season is found to be an ideal breeding place. Anopheline eggs are laid in singles and float on the water surface. Floatation is facilitated by the air filled lateral floats on the egg surface. Boat shape of the eggs also helps. Submersion of the eggs drowns the developing embryo and may be one of the mechanisms by which very heavy rains are followed by a period of quiescence in mosquito activity.

These eggs hatch into first instar larvae within 24 hours. The larvae lie parallel to the water surface, often in the line of intersection formed by air, water, and emergent vegetation. The larva begins to feed and grow bigger in size (ecdysis). Mosquito larvae wriggle a lot and they feed on organic particles, pollen, dead plant substances and other planktonic substances. When grown sufficiently, the outer body cover is periodically discarded by a process called moulting and the subsequent stage is the next instar. The mosquito larva has four such instars and the fourth instar larva moults into the next stage of the life cycle called pupa. For development of larvae, the water must remain for at least a week, and the surface must be free of mold. Predator fish may reduce anopheles larval density, given sufficient time.

Figure-3.3



Source: Flyer published by The Malaria Research Centre, ICMR, New Delhi, 110054, India

The pupae are 'Comma shaped' with a flexible abdomen for swimming and a pair of trumpet like (air bubble) structure on the dorsal surface for breathing. They are lighter than water and float on the surface of water. They appear as round immobile floating bodies and when disturbed they are as active as the larval stage and move about in water by jerking of its body. In about 2-3 days the pupa splits and the adult emerges.

Equal numbers of male and female adult mosquitoes continuously emerge from the breeding sites, but males emerge first. The emerged adults rest for sometime near the breeding site and later flies off to suitable resting sites till its wings and legs are well stretched and its body gets hardened. Following complete rotation of the genitalia, males participate in the act of mating which is called nuptial dance. For most species, males form swarms and females enter these swarms to get inseminated.

Following mating the anophelene mosquito require a blood meal for the development of eggs. Accordingly, the female Anopheline mosquito bites humans and sucks the blood

for the development and maturation of its ovaries. During the act of feeding (blood sucking) these mosquitoes inject their saliva into the host (man) and during this process it transmits parasites. Following the egg laying, the adult female feeds again on the host and after digesting the blood it lays another batch of eggs. **On an average, adult mosquito survives for 15-30 days in tropical climate.** The male mosquitoes on the other hand feed only on plant juices and nectar.

2. Breeding habitats

The breeding habitats of mosquitoes vary from **large and usually permanent collections of water,** such as fresh water swamps, marshes, rice fields and burrow pits to smaller collections of temporary water such as small pools, puddles, ditches, drains and gulleys. A variety of natural habitats such as, water filled tree holes, rock pools, water-filled bamboo stumps, leaf axis, water-filled split coconut husks, crab holes, and snail shells serve as ideal breeding ground for **fresh water breeding mosquito like *the Anopheles*.** While natural habitat provide ideal breeding ground for mosquito in rural areas, man-made habitats are the major contributing factors in urban areas. These habitats can be classified into two major categories i.e. polluted water habitats and stagnant clean water ones. **The polluted water breeding habitats supports breeding of *Culex quinquefasciatus* and *Armigeres* species. Clean water breading habitat support *Anopheles* and *Aedes* species**. Anophelines can breed in several temporary and permanent habitats such as:

i. ***Puddles: Leaking public taps due to negligence and often pilferage of taps, water goes on flowing from the taps creating mosquitogenic conditions around them.***

ii. ***Receptacles: Discarded tins, water storage mud pots, plastic containers, waste bottles, soap boxes, tar drums, flower pots and grinding stones provide ideal breeding sites for mosquitoes soon after rains. Though individually each of these habitats are of minor importance but collectively their contribution could be substantial.***

iii. ***Overhead tanks: Majority of the overhead tanks are the ideal breeding ground for anopheline mosquitoes transmitting malaria in urban areas, when kept open. Egg laying can be stopped by providing a closely fitting lid to the overhead tank.***

iv. ***Wells: Provision of protected water supply to almost all house has led to the disuse of existing wells, The dumping of garbage and letting out of effluents into these wells converts them into breeding places.***

A few mosquitoes like *Anopheles sundaicus* breed almost exclusively in brackish or salt water, such as salt water marshes and mangroove swamps and are consequently restricted to mostly coastal areas.

Though almost any collection of permanent or temporary water can constitute a mosquito larval habitat, they are absent from large expanses of uninterrupted water such as lakes, especially if they have large numbers of fish and other predators which are likely to feed on the mosquito larvae. They are also absent from large rivers and fast flowing

streams due to ripples, except that they may occur in marshy areas and isolated pools and puddles formed at the edges of flowing water. Generally, smaller water bodies are the major breeding sites of mosquitoes.

3. Resting and feeding habits

The biting and feeding habits vary from species to species. Some species prefer to bite and feed on man and other species prefer other animals. Species that bite man are called as anthropophilic and that bite other animals (mammals, birds and amphibian) are called zoophilic. Odour, temperature of and carbondioxide emanating from the body are the stimuli that play role in the attraction of the female towards the host. Some species prefer to feed only in the night time and some only during day time and some at any time of the day. The habit of feeding inside the dwellings is known as endophagic and feeding out side is known as exophagic. Some species can be endophagic in one area and exophagic in another area.

After obtaining the blood meal from host, the mosquitoes rest either inside the dwellings or outside. The habit of resting outside the dwelling is known as exophilic and inside the dwelling as endophilic. There is a misconception that trees and bushes are responsible for mosquito breeding but they only provide the resting places for outdoor resting mosquitoes. During the rest period, the blood meal get digested with corresponding development of ovary. By the time the blood is fully digested the ovaries are also fully developed (gravid condition) and the eggs are ready for laying. The duration between emergence and oviposition is known as gonotrophic cycle.

Table- 3.1: Terms used to describe resting and feeding habit of mosquitoes

Term, synonym	Meaning	Simpler terms
anthropophagic/phillic	Preference to feed on humans	
zoophagic/phillic	Preference to feed on animals	
endophagic	The habit of feeding inside dwellings.	Indoor-feeder
exophagic	The habit of feeding out side.	Outdoor-feeder
endophillic	The habit of resting inside dwellings.	Indoor-rester
exophillic	The habit of resting outside dwellings.	Outdoor-rester

The above description has used quite a few not so familiar terms used by entomologist to describe feeding and resting habits of insects. Brief description or tabular presentation of resting and feeding habits may some time use these entomological terms without explaining the meaning in simple terms. Hence these terms are summarised in Table-3.1 for ready reference. Moreover, it will be desirable to use easily understood terms, since knowledge and awareness of feeding and resting habits by the general public can help in mosquito avoidance behaviour. Hence certain common English equivalents are recommended for use. These are shown in the third column of Table-3.1.

Each mosquito species has specific combination of various habits like

anthropophilism, zoophilism, endophagy, endophily and exophily and this combination may change from area to area and from season to season. All these habits assume great importance in the epidemiology, transmission and control of any vector-borne disease.

D. Vector competence

Vector competence, in the context of malaria transmission, refers to mosquito characteristics that affect its suitability as a host for transmission of malaria parasite. In other words, vector competence refers to ability of an anopheline mosquito to transmit the malaria parasite. Factors contributing to vector competence are; (a) pathogen uptake, (b) pathogen development, (c) and (c) pathogen output.

The saliva injected by blood meal seeking mosquito into the human skin contains antihemostatic and immunosuppressive components. These salivary components alter the feeding site in a manner that may enhance the site's receptivity to delivery of circulating malaria parasite. A mosquito must survive a minimum period equivalent to the incubation period of the parasite / pathogen inside the body in order to become a successful vector. The survival of the vector species mainly depends on temperature and moisture.

E. Vectorial capacity[4]

Vectorial capacity represents an entomological restatement of the basic reproduction rate of a vector-borne pathogen, synthesizing all variables that affect communicability. The pathogens must mature rapidly and abundantly in the vector, and must be delivered to a suitable host. The relevant variables generally are considered to include effective density relative to the reservoir host, frequency of feeding, and longevity of the vector.

In 1950s, Macdonald (1952) developed a predictive model for malaria incidence. This work stimulated field studies that eventually proved the concept's usefulness and practicality. Macdonald's model constitutes an important basis for epidemiological entomology. The model calculates the number of secondary cases that a certain vector population will generate from a single case originally introduced into a region. This convention represents the basic reproduction rate. If the equation is simplified to consider the number of potentially infective bites, only entomological parameters need be considered greatly simplifying field work. This simplified equation is now termed vectorial capacity. Although basic reproduction rate has proved difficult to evaluate because of human variable, vectorial capacity is somewhat more amenable to study.

Vectorial capacity may be expressed as follows: an infective human host entering an endemic focus will be exposed to some measurable number of vectors m per day, an anthropophagic proportion that will deliver a number a bites per day. The product ma represents the human biting rate. A proportion p of these blood-fed vectors survives each day. Because none is infective before the parasite reaches the ducts of the salivary glands, they must survive this extrinsic incubation period, which lasts n days. Thus a proportion p^n remains alive after this period. These surviving and infected vectors then have a life

4Reproduced from Spielman and James, 1990.

expectancy of *-l/(ln P)* during which time a proportion *a* will bite human hosts each day. The product represents vectorial capacity (VC):

$$VC = \frac{ma^2p^n}{-lnp}$$

Vectorial capacity would represent basic reproduction rate if vector competence were perfect. Every vector biting an infective human host would become infected, and every infective bite would infect the host. Of course, this does not happen in the real world. Entomological inoculation rates measure potential incidence as the product of effective vector density *ma* and sporozoite rate *s*. Such rates always exceed the parasitological inoculation rates, an estimate of actual incidence corresponding to prevalence of infection in infants that are one year old.

The vectorial capacity equation helps us in understanding and ranking of its components in hierarchy important for prioritisation of interventions. Most powerful determinant of vectorial capacity is the life expectancy *p* which contributes exponentially. Thus environmental conditions favouring longer life expectancy of mosquitoes, has a very powerful effect on malaria transmission. The next important determinants are narrowness of mosquito range and frequency of feeding, which contribute as the square. Vector abundance and vector competence provide linear contributions to vectorial capacity.

ICMR's Malaria Research Centre (1989) reports that vectorial capacity shows a very high positive correlation with infection rates like the slide positivity rate (SPR, *r=0.79*) and infant parasite rate (IPR, *r=0.76*). SPR figures are easily available. Hence SPR can be substituted and used for malariogenic stratification (Sharma, Sharma, and Dhillon 1996 p166). This linkage is implicit in the definition of vectorial capacity. SPR is certainly an effective indicator of malaria situation in the absence of entomological studies. The key difference lies in the extent to which the two indicators can help us in minimising human suffering due to malaria. A high SPR means that already a significant number of human beings in the locality are either suffering from malaria or are most likely to suffer. SPR indicator allows us, to prevent further spread of malaria infection in the community. Study of vector behaviour and modeling of vectorial capacity in an area from time to time, can allow us to even prevent a high SPR and thereby further reducing human suffering. Thus, if the technical and managerial aspects of good quality entomological study can be handled, then computation of vectorial capacity as a surveillance tool can help us to further minimise the incidence of malaria in the state.

F. Entomological field techniques:

Field techniques for collection of mosquitoes is an important step in study of mosquito behaviour. The collection data provide important information about vectorial capacity. Field techniques coupled with laboratory techniques can provide a complete understanding of the mosquito species in the area and their behaviour. Common field techniques are described here to facilitate an understanding of entomological work and to enable health workers to better appreciate the entomological indexes calculated on the basis of mosquito collection data.

1. Tools for field work:

The following tools are needed for the collection of mosquitoes: sucking tube; torch; unwaxed paper cups ; mosquito netting; cotton wool; mosquito cages; test-tubes; rubber stoppers for test-tubes; rubber bands; insulated picnic box; chloroform; trays; towels; pencil; notebook. Test-tubes should normally be 150 mm long and 16 mm in diameter, but smaller ones (100 mm X 10 mm or 60 mm X 10 mm) may also be used. Small tubes are useful for collecting single specimens or when specimens are to be kept for some time before being examined and processed.

A sucking tube can be made locally using glass or transparent plastic tube. Wire mesh between the collecting tube and the rubber tubing is necessary to keep the mosquitoes in the collecting tube and prevent their being sucked into the mouth and swallowed. (Precaution: plastic tubing should not be exposed to chloroform, which makes it lose its transparency.) Sucking tubes and test-tubes should be kept clean. If they become dirty, clean them with wet cotton wool and ensure that they are perfectly dry before use. They should be carried in a way that will prevent breakage.

Cups made up of unwaxed paper are very suitable containers for holding and transporting live mosquitoes with minimum mortality. When these are bought in bulk, they are very cheap and can be frequently replaced. Never reuse cups that have held mosquitoes collected from sprayed houses, as residues of insecticide may kill mosquitoes that you keep alive. If suitable paper cups are not available, small mosquito cages can be used or containers can be made from other locally available materials. The hole in the netting over the cup is only large enough for the sucking tube to be inserted. If this hole is too large the mosquitoes can easily escape or become damaged in the attempt.

2. Collecting mosquitoes using a sucking tube

Following procedure can be used to collect a mosquito and transfer it to a paper cup by means of a sucking tube.

i. ***With the mouthpiece in your mouth, hold the sucking tube with its opening 1-2 cm away from the mosquito.***
ii. ***Move the end of the sucking tube closer to the mosquito and, at the same time, suck gently but quickly so as to draw the mosquito into the tube.***
iii. ***Place your finger over the tube to prevent the mosquito from escaping.***
iv. ***Place the end of the tube , with your finger still in position, near the hole in the mesh covering the paper cup. Remove your finger and quickly put the tube into the hole.***
v. ***Blow gently into the mouthpiece so as to transfer the mosquito to the paper cup; at the same time, tap the tube with your index finger to disturb resting mosquitoes.***
vi. ***Use the same technique to transfer mosquitoes between different containers.***

Be careful not to suck or blow too hard, as mosquitoes are fragile and can easily lose legs or otherwise damaged. Do not collect more than five mosquitoes in the sucking tube before transferring them to the paper cup; They are likely to damage, if they collide each

other. Identification of species is important and may be hampered if the specimen is damaged.

3. Collecting mosquitoes using a test-tube

A test-tube can be used to collect mosquitoes by the following method.

*i. **Hold the mouth of the tube directly over the mosquito.***

*ii. **When the mosquito is disturbed it will fly into the tube.***

*iii. **Close the mouth of the tube with your index finger or thumb.***

*iv. **Remove your finger and push a plug of cotton wool into the tube.***

*v. **Push the plug down until the mosquito is trapped in the bottom 2 cm of the tube.***

*vi. **Collect a second mosquito as described above and insert second plug to trap it in the next 2 cm of the tube. In this way, several mosquitoes may be collected in one test-tube.***

*vii. **Record on a slip of paper all the data described above. Put the paper in the tube.***

4. Labelling and recording collections.

i. Accurate and complete labelling is extremely important. During a field trip, mosquitoes are collected at many sites. In the laboratory it is impossible to know the source of collections if the cups or test-tubes are unmarked or not labelled completely and correctly. Labelling should be done with soft pencil.

ii. A record must be also kept in a note book or on a field form for all collections made during a field trip. particular attention should be given to keeping a record of all nonproductive collecting efforts as well as collecting that yields mosquitoes. The data which should record will vary with the purpose of collection, but the minimum essential information are as follows:

a. Location
b. Date and time of collection
c. Type of structure (house, stable, outdoor shelter, etc.)
d. Whether the structure has been sprayed and, if, so, when this was last done.
e. Name of the mosquito collector.

5. Keeping mosquitoes alive in the field

Field collections must be sent to the laboratory as soon as possible. If mosquitoes are to be kept for some time in the field, precautions must be taken to keep them in good condition. Remember that dead mosquitoes dry out and become brittle, and cannot be dissected. In order to keep mosquitoes alive in papercups/test-tubes, the following steps are necessary.

*i. **Soak pieces of cotton in 5-8% sugar solution.***

*ii. **Squeeze out any excess sugar solution and place the cotton wool over the top of papercups/test-tubes.***

*iii. **Place papercups/test-tubes holding mosquitoes upright in a deep tray, a card board box or, preferably, an insulated picnic box.***

iv. Cover the cups or tubes with a damp towel. Keep the towel damp until the mosquitoes reach the laboratory.

6. Transport of live mosquitoes

Adult mosquitoes collected in the field have to be transported to the laboratory for examination. Mosquitoes can be transported safely over long distances with following precautions:

i. Cover the container with damp cotton wool.

ii. Place papercups/test-tubes holding mosquitoes upright in a deep tray, a card board box or, preferably, an insulated picnic box.

iii. Pack the newspaper or other material between the cups to minimise the movement.

iv. Cover the cups or tubes with a damp towel. Keep the towel damp until the mosquitoes reach the laboratory.

v. Close the box as tightly as possible to prevent loss of moisture.

During the period of transportation, it is essential to make sure that the mosquitoes are not left in a vehicle with the doors and windows closed, or in direct sun light.

7. Outdoor collection of mosquitoes

Some mosquito species enter houses at night to bite and rest indoors during the day. Other species do not enter buildings but bite outside and then rest in the following kinds of outdoor location:

a. On vegetation;

b. On solid surfaces in sheltered places, such as the banks of streams and ditches, holes in rocks, culverts, cracks in stone walls, caves animal burrows, on the trunks or stems of larger vegetation such as banana trees, and in old termite mounds.

Outdoor collection is performed in either the natural resting places described above or in shelters specially constructed for the purpose. Artificial shelters have the advantage of providing concentrated sites for collections and more representative samples that can be used for quantitative work.

Data from outdoor collections are important in evaluating the impact of any anti-vector measures, and provide information about:

a. The species that habitually rest outdoors
b. The relative numbers of mosquitoes resting outdoors
c. Seasonal changes in outdoor resting habits
d. Any alterations in the relative numbers of mosquitoes resting outdoors following the application of insecticides in house and other buildings

Smears made on filter paper from blood-fed specimens may be subjected to precipitin tests to determine the host preferences of mosquitoes.

i. Choice of method for outdoor collection

The choice of method for outdoor collection depends partly on the behaviour of the malaria vector; that is, whether it prefers to rest on vegetation or on solid surfaces. The

three common methods used to collect mosquitoes resting on vegetation involve the use of a sucking tube and torch, a hand net, and a drop net.

Anopheline species that normally rest on solid surfaces are collected with the aid of a sucking tube and torch from natural or artificial shelters. Both patience and skill are essential in collecting from natural shelters, since the population density of mosquitoes is usually much lower than in artificial shelters and the resting surfaces are irregular.

ii. Collecting mosquitoes outdoors with a sucking tube

Direct collection from vegetation using a sucking tube (and transferring captured mosquitoes to a paper cup) usually takes a considerable time and may enable you to find only a few mosquitoes. Collections from both natural and artificial shelters are also made using a sucking tube and torch. Well-placed shelters normally yield more mosquitoes than natural environments.

There is an important difference between these two kinds of collection in respect of the information that should be recorded:

a. After searches in vegetation you should record the number of collections and the total time spent searching.
b. After searches in artificial shelters you should record the number of shelters examined and the time spent in each.

iii. Collecting mosquitoes outdoors using a hand net

A hand net (or sweep net) is used to collect mosquitoes resting on vegetation. The correct method of use is to move the hand net swiftly over the tops of all grasses or close to the ground around bushes. Make sure that you record the number of collections and the total time spent collecting.

8. Direct Catches of mosquitoes from bait

i. General rules

Certain important rules should be observed while carrying out this type of collection:

a. Do not smoke while collecting.
b. Change in personnel being utilized as human baits hourly, so as to minimize possible differences in their attractiveness of mosquitoes.
c. Do not use any oil or ointment that might act as a mosquito repellent.

ii. Human bait outdoors

The person acting as human bait for outdoor collection should be positioned in the general area of the house or room selected for indoor collection. The site selected should be an area of the village where local people normally sit during the evenings.

iii. Efficiency of direct collection

Collections taken directly from human bait using su

king tubes, normally reflect quite accurately the number of biting mosquitoes. Collections made using trap nets with human bait generally yield fewer mosquitoes and less representative samples.

iv. When and where to make direct catches from human bait

Direct collection of biting mosquitoes is performed during the night because this is when most malaria vectors take blood meals. The collections are often made during the entire period from dusk to dawn. However, this should be done only when absolutely necessary, and by two teams of collectors, each in shifts during the night. If the peak biting time is known, collection can be confined to this period. Peak biting times can be deduced early in programme from the results or several whole-night collections, allowing subsequent regular collections to be made over a period of only three to four hours. Thus, both indoor and outdoor collection from human bait may be conducted to accommodate the normal resting and sleeping habits of the local people. Remember that night time habits may vary seasonally. It is important that one should not smoke during collections and that one keeps as still as possible when collecting mosquitoes from one's own body.

v. Direct collection of biting mosquitoes from human bait

The collection of mosquitoes from one's own body is common way of obtaining biting specimens, especially of Anopheles. The technique adapted is by selecting a quiet place either inside or outside a house. Clothing should be adjusted such that the legs are exposed upto the knees. One has to remain in this position, when one feels a bite, the torch should be quickly turned on to find out whether the mosquito is anophelene or culicine. If the mosquito is anopheline, or one is unsure, it should be collected with sucking tube and transferred into a container. One cup should be used for each hour of collection.

Alternatively, one person can serve as a bait and another as collector. In this case, the following technique is adopted. The person acting as bait sits or lies in a quite place, inside or outside the house as appropriate, with his or her clothing adjusted to expose skin as much as acceptable. Using a torch and a sucking tube or test tube , the collector checks and collects biting anophelines every two or three minutes. The mosquitoes are then transferred to paper cup. One cup is used for each hour of collection.

vi. Ethical considerations:

In the past it was considered acceptable to allow mosquitoes to bite a person engaged in night collection. However, for ethical reasons it is now desirable to examine whether health workers should be routinely exposed to the risk of contracting malaria. In fact, it is not necessary to permit mosquitoes to feed, they can be collected as soon as they settle on the skin, since it can be safely assumed that biting would normally follow. Landing rates should therefore be measured instead of biting rates.

Nevertheless, those involved in collection will continue to be bitten since mosquito repellents cannot be used, this is unavoidable. It is, of course, understood that both collectors and people serving as bait, should take an appropriate drug for prophylaxis of malaria. When trap nets are used, the risk to collectors can be minimized by using protective inner nets, although this reduces the efficiency of collection.

G. Mosquitoes in Andhra Pradesh

Malaria vectors in Andhra Pradesh are *Anopheles culicifacies* (mostly in rural areas), *Anopheles fluviatilis* (forest & hilly areas), *Anopheles stephensi* (mostly urban areas), *A. sundaicus* (coastal area). The species of anophelene mosquitoes collected in different districts of AP are given in the appendix at the end of this chapter (Appendix-3.2)

Information about species composition of mosquitoes in AP is based on hand catch reports from various zonal entomological offices for the year 1999 as shown in Figure-3.1. Note that the programme collects mosquitoes through insect collectors from very few locations in each district. The table in Appendix-1 of this chapter shows district wise break-up of number of sites from where these mosquitoes were collected. Clearly the number of collection sites is very small compared to the vast geographical spread of the state and its population. Thus, the results would not be representative of the state. Moreover, other operational factors like time of day during which mosquitoes are collected would also affect the extent to which these results would correspond to real malaria transmission activity. However, these reports are one of very few sources of information about mosquitoes in AP.

In 1991, malaria vector mosquitoes were collected from selected districts by a joint team from the ICMR's Malaria Research Centre, National Malaria Programme office, and the Malaria wing of the AP Directorate of Health. This team worked in the month of December 1991. Table-3.2 gives a summary of the vectors, their resting, feeding habits and breeding sites, observed by them. Here again this short term survey took place in the month of December, which is a low transmission month. Hence, although the findings would not be representative of the peak malaria transmission season, they give some idea about mosquito vector composition in AP.

Table- 3.2: Malaria vector mosquitoes collected from selected districts in AP by the one time short period field study in December 1991 and the preferred breeding places.

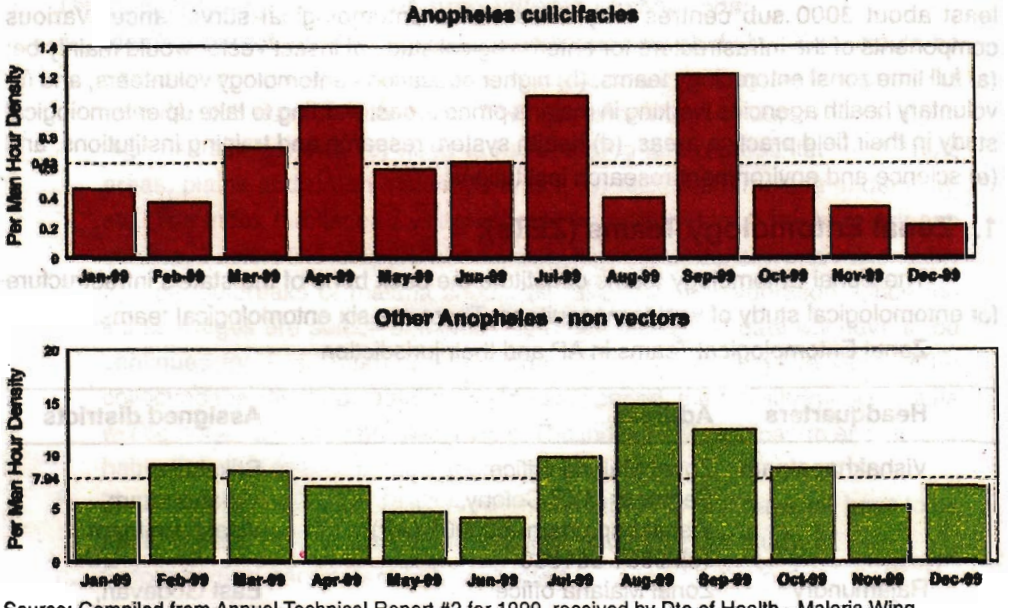
Study District	Vectors	PMH - Indoor	PMH - Outdoor	Resting and Feeding habits	Breeding places
East Godavari	A. a	0.8	0.2	Exo., zoo	Stagnant water with vegetation, tanks, pools, etc.
West Godavari	A. c.	1.4	0.6	Exo., zoo	Paddy fields, irrigation channels and slow moving streams, pools in river beds, rain water collections, etc.
Srikakulam	A.c	1.9	0	Endo., zoo	Slow moving stream, irrigation channel, paddy fields, pools in river bed, etc.
Vizag.	A.f	1.9	0	Exo., zoo	Slow moving streams and channels foot hill streams, irrigation channels with grassy margins, swamps.
Vizianagaram	A.c.	6	0	Endo., zoo	Paddy fields, irrigation channels, pools in river beds, slow moving streams, etc.
Warangal	A.c.	0.5	0	Exo., zoo	Pools in river beds, irrigation channel, paddy fields, slow moving streams, ponds

[1] Source: AP State Malaria Office, Directorate of Health; AP State District wise entomological profile, 1999.

[2] PMH Indoor is per man hour catch indoors and PMH outdoor is per man hour catch outdoors.

Figure-3.4 shows seasonal activity of Anopheline mosquito in AP. The upper panel shows vector density of culicifacies summarised from all insect collections. The lower panels shows seasonal density of non vector Anopheles. The dotted horizontal line represents the annual average density to allow comparison of each months density to all year mosquito density. Density measure used here is the number of mosquitoes of concerned species caught per man hour of effort. As said earlier the data is not representative. Data used to generate the two charts in Figure-3.4 are given in Appendix-3.1 to this chapter. The lower panel chart is consistent with our understanding of seasonal variations in mosquito density.

Figure-3.4: Seasonal variation in density of vector and non vector Anopheline in AP, 1999



Source: Compiled from Annual Technical Report #2 for 1999, received by Dte of Health - Malaria Wing.

It shows an increase in the months from July-September which is the rainy season. The culicifacies density pattern shows rise in density during July and September, but a fall in August. This could be a sampling error. The lower panel chart shows a declining trend in the summer months starting from February and continuing till June. But the upper panel shows a rise in culicifacies density in March and April. This could either be a sampling error, or be real and contributed by increased breeding of culicifacies species.

A combination of *An. culicifacies* and *An. stephensi*, may give rise to a constant transmission pattern. In rainy season, *An. culicifacies* breeds in irrigated fields and drainage. This species of mosquito is most active in rainy season. Drying conditions promote abundance of *An. stephensi*, which breeds mainly in wells, overhead tanks, water puddles and the beds of streams. As a result malaria transmission may go on throughout the year.

H. State infrastructure for entomological study of vector mosquitoes and the role of institutions of higher learning

In Chapter -I malaria was described as a focal disease. The focal character of the

disease is largely contributed by the behaviour of vector mosquitoes. Since mosquitoes do not generally fly long distances, nor for that matter great heights, the effects of mosquito breeding activity usually remains confined to its surroundings. A direct implication of this focal nature of malaria is that, we need to scientifically study mosquito activity by locality. Studying mosquitoes in a few areas of the state would not help. Ideally, each human habitation should be studied. Taking a pragmatic view the modified plan of operations recommends each subsidiary health centre (sub centre) as the unit of analysis for identification of high risk areas. There are nearly 10000 sub centres in AP. About 1500 of these were identified as high risk sub centres in the year 2001. Assuming that some sub centres would move in and out of the high risk label depending on the success or failure of bio environmental vector control measures and other factors like movement of labour, at least about 3000 sub centres may need active entomological surveillance. Various components of the infrastructure for entomological study of insect vector would mainly be; (a) full time zonal entomology teams, (b) higher education - entomology volunteers, and (c) voluntary health agencies working in malaria prone areas, wanting to take up entomological study in their field practice areas, (d) health system research and training institutions, and (e) science and environment research institutions.

1. Zonal Entomology Teams (ZETs):

The Zonal Entomology teams constitute the back bone of the state's infrastructure for entomological study of vector mosquitoes. There are six entomological teams.

Zonal Entomological Teams in AP and their jurisdiction

Headquarters	Address	Assigned districts
Vishakhapatnam	Zonal Malaria Office Sector-9, MVP Colony, Vishakhapatnam -530001 (AP) Tel: 0891-551980	Srikakulam, Vizianagaram, Visakhapatnam.
Rajamundry	Zonal Malaria office Rajamundry- 533101 (AP) Tel: 0883-478689	East Godavari, West Godavari, Krishna.
Guntur	Zonal Malaria office Lane-3/10, Brodiepet, Guntur- 522002 (AP) Tel: 0863-44854	Guntur, Prakasham Nellore
Cuddapah	Zonal Malaria Office Prakash Nagar, Cuddapah - 516004 (AP) Tel-: 08562-44854	Cuddapah, Kurnool Ananthapur, Chittoor
Hyderabad	Zonal Malaria Office Plot No. 49, Sripuram Colony, Malakpet Hyderabad -500036 (AP) Tel: 040-4549823	Hyderabad, Rangareddy, Mahaboobnagar, Nalgonda, Medak, Nizamabad
Warangal	Zonal Malaria Office Subedari, Hanamkonda Warangal - 506001 (AP) Tel: 08712-71300	Warangal, Adilabad Khammam, Karimnagar.

Functions of the zonal entomological teams include; (a) direct entomological study in index villages, (b) to motivate higher education institutions to incorporate applied entomology syllabus and set up applied entomological study programmes (c) to motivate and support applied entomological study centres to set up entomological volunteer programmes, and (d) to co-ordinate with research institutions in the area and motivate them to adopt specific sub centres for regular entomological studies, (e) to co-ordinate with all entomological study teams in the area, collect and collate entomological study reports from all sources, and (f) organise continuing education programmes and workshops to update the skills and exchange of experience on entomological studies in the area.

i. Direct entomological study of index villages / habitations:

a. Identification of the PHC for regular entomological study by ZETs should be based on a comprehensive review of many factors including; (a) the number of high risk sub centres within each PHC, (b) percentage of population living in high risk sub centres, (c) need to have appropriate representation of Tribal areas, plains and urban malarious areas, (d) *falciparum* malaria endemicity, etc. The index habitation / village should be selected from the high risk sub centres. Factors like *falciparum* endemicity, high vector density, and vulnerability to focal outbreaks of malaria should be taken into consideration. Once the index villages are selected, monitoring of entomological data will have to be continued for a minimum of three years but not exceeding five years. After collecting the stipulated data during the said period, the monitoring of the data will be done from other problem PHCs. The index PHC, sub centre and village/ habitation should be changed after five years.

b. Time to be spent in each PHC: A minimum of three to four days will have to be spent in each PHC to facilitate meaningful entomological study.

c. Entomological parameters to be collected.

   a. Vector Density: Per man hour densities of mosquitoes by aspirator tube and flash light method will be monitored by spending 2 to 3 hours by two Insect Collectors in the morning hours. This should be done in all index villages.

   b. Pyrethrum spray collection (PSC): Whenever mosquito densities are low or more mosquitoes are required, this method may also be used as supplementary to hand collection method. Blood meal sample for precipitin test may also be collected with this method.

   c. Whole night collection: The human bait collection from 6.00 p.m. to 6.00 a.m. may be done in one of the index villages in a district. This information should be collected positively during transmission season and at least once during every quarter on indoor as well as on outdoor human baits. Animal bait collection may be done simultaneously with the human bait once during transmission season and second time during non-transmission season. Hourly collection will be separately recorded for the entire 12 hours.

d. Recording of abnormal condition and dissection of mosquitoes: All the female specimens of vectors and suspected vectors will be dissected for oocytes and

sporozoites after classifying the abdominal condition. The dissection of mosquitoes of whole night human bait is also done separately. A good proportion (not less than 200 females) will also be examined for parity rate during a month.

e. Susceptibility Test:

a. Adult Test: The susceptibility status of all vectors and suspected vectors should be determined at least once a year in all the districts. Priority should be given to those districts where no information has been collected during the preceding five years. The test should be done with the diagnostic doses of DDT, deltamethrin (DL) and malathion (Mal). Whenever the sufficient number of mosquitoes are collected, information for the LT 50 values may also be collected by changing the time of exposure. In districts where the vector has been found to be resistant to DDT, DL and Mal, test with synthetic pyrethroids may also be conducted. The impregnated papers of diagnostic doses will be supplied by the Directorate of NMEP to entomological zones on request after procuring same from WHO.

b. Larval Test: The larval susceptibility tests are conducted once a year in every district where chemical larvicides / biocides are in use. The Susceptibility tests shall be conducted on priority in the urban areas where organophosphorus compounds such as temephos and fenthion are being used as larvicides.

f. Contact Bio-assay: This test should be conducted during spray season at two weekly intervals to determine the residual efficacy of the adulticide.

g. Reporting: The monthly technical (entomological) reports should be submitted every month. The reports should be sent by 10th of every succeeding month to the State Health Directorate. The annual Entomological Report may be sent by February of the succeeding year.

ii. Development of applied entomology study programmes

a. Motivate and assist colleges and universities in the zone having life sciences, and related subjects to activise applied entomology teaching with help of field work, etc. The ZETs can support such centres by accepting faculties and student volunteers as members of field study teams.

b. In colleges and universities where the applied entomology programme takes root, the concerned faculty should be encouraged to start applied entomology volunteer programme and assume responsibility for regular entomological study of a suitable high risk sub centre area, nearer to the concerned college.

2. Higher education entomology study centres:

Colleges and universities with life science and related programmes can play an important role in entomological study of selected areas in the surrounding community for determination of malaria risk. There are many advantages to this approach. Students will have practical orientation and will be able to use their skills. They will use science to understand and assess one aspect of their immediate environment.

A recommended syllabus for applied entomology content in Bachelors and Masters

level degree courses is provided in Appendix-3.2. Following are some resources useful for planning and implementation of an applied entomology / medical entomology module for college graduates and post graduates.

Resources for applied entomology curriculum in colleges and universities

Resource	Remarks
To The Head of Sales, WHO Regional Office for South-East Asia, World Health House, Indraprastha Estate, Mahatma Gandhi Road, New Delhi, 110002 Tel: 91-11-3317804 ;3317823 Fax: 91-11-3318607 email: bookorders@whosea.org	Has useful publications of entomological field techniques. WHO usually updates its literature on subjects with public health importance.
The Director Malaria Research Centre (ICMR) 22-Shamnath Marg, Delhi-110054 Tel:91-11-396190 ; 3981905 Fax: 91-11-2946150	This is a National Research Facility, focussing extensively on malaria research. The Centre has many scientists working on various projects, who may be useful resource persons.
Medical Entomologist, Filariasis Research and Training Centre, (Government of AP-HM&FW Dept.), Kakinada- 533004 (AP)	Studies mosquito behaviour and carries out field studies mostly in filaria prone areas of the state. It also conducts training programmes on epidemiology of filariasis. Has practicing medical entomologists who may be resource persons.
The Director Vector Control Research Centre, Indian Council of Medical Research, Indira Nagar, Pondicherry- 605 006 Tel: 91-413-372396 Fax: 91-413-372041 email: mosquito@md5.vsnl.net.in	This is a National Research Facility focussing on vector behaviour aspects of Vector borne disease. Faculty can be useful resource for course design, evaluation, guidance of entomological workshops. Useful destination for study tours. Source of publication on insects and vectors prevalent in the Indian context.

Appendix-3.1

Density of Anopheline species recorded by hand catch in AP, 1999

Month	Man hrs	Catch	culicifac.	fluviatilis	stephensi	anularis	Others
Jan-99	245	1,517	0.47	0	0	0.13	5.59
Feb-99	473	4,689	0.37	0.04	0	0.09	9.39
Mar-99	424	4,031	0.73	0.03	0	0.14	8.59
Apr-99	353	2,960	1.01	0	0	0.09	7.27
May-99	554	3,105	0.59	0	0	0.12	4.9
Jun-99	714	3,886	0.65	0.09	0	0.44	4.27
Jul-99	679	7,755	1.08	0	0	0.38	9.96
Aug-99	304	4,786	0.4	0	0.03	0.21	15.09
Sep-99	392	5,469	1.22	0	0	0.2	12.52
Oct-99	492	4,689	0.48	0	0	0.09	8.95
Nov-99	497	2,963	0.35	0	0	0.27	5.34
Dec-99	523	4,027	0.22	0	0	0.2	7.27
1999	5,650	49,877	0.64	0.01	0	0.22	7.95

[1] Source: Compiled from Annual Technical Report #2 for 1999, received by Dte. of Health - Malaria Wing.
[2] Density expressed in Number of mosquitoes of the concerned species caught per man hour of effort.

Appendix -3.2

Applied entomology syllabus recommended for inclusion in B.Sc / M.Sc curriculum of courses in life science areas, parasitology, entomology, etc.

1. Introduction to medical entomology

i. Identification of common vectors like (a) Mosquitoes, (b) Flies, (c) Fleas, (d) Bedbugs, (e) Triotamine bugs, (f) Lice, (g) Cockroaches, (h) Ticks and mites

ii. Identification of mosquitoes: Distinguish mosquitoes from other insects on the basis of external characteristics. Recognition of adult mosquitoes. Recognition of different type of mosquitoes, (a) anophelene, and (b) culicine. Distinguishing female mosquitoes from males. Distinguishing female anophelene mosquitoes from female culicines. Distinguishing between mosquito eggs, larvae and pupae from other insects. Distinguishing between anophelene and culicine eggs, larvae and pupae.

2. Entomological field techniques

i. Hand collection of indoor-resting mosquitoes: Familiarization with essential equipment; (a) sucking tube, (b) paper cups with net covers, (c) cotton wool, (d) pencil and note book. Normal resting places of mosquitoes in houses. Labeling and record keeping.

ii. Out door collection of mosquitoes: Familiarization with essential equipment; (a) Sucking tube, (b) Torch, (c) Hand net, (d) Drop net, (e) Paper cups with net covers, (f) Cotton wool, (g) Pencil and note book. Collection sites. Collection of mosquitoes using a sucking tube. Collecting mosquitoes using hand net and drop net. Labeling and records keeping.

iii. Collecting mosquitoes in baited trap nets: Familiarization with essential equipment like (a) trap nets, (b) sucking tube, (c) torch, (d) paper cups with net covers, (e) cotton wool, (f) pencil and note book. Collection sites, and behaviour of mosquito vector. Collection by trap nets. Labeling and record keeping.

iv. Collecting larvae and pupae from breeding sites: Familiarization with essential equipment; (a) dipper, (b) larval net, (c) well net, (d) spoon, (e) large tray, (f) pipette, (g) specimen collecting tubes, (h) 70% alcohol solution or 2% formalin, and (i) pencil and note book. Preferred breeding sites of malarial vectors. Methods of collecting larvae and pupae, labeling and record keeping.

3. Vector dynamics and entomological survey:

i. Entomological transmission indexes: Sampling of eggs. Larval density. Adult vector density.

ii. Vector competence: Pathogen uptake. Pathogen development. Pathogen output.

iii. Vectorial capacity.

4. Community role in vector control

i. Household practices having a bearing on mosquito breeding, risk of vector borne disease, etc. Community action bearing on risk of vector borne disease.

Appendix-3.3

Species of anophelene mosquitoes found in different districts of AP

1	*A.hyrcanus*	8	*A.tessellatus*	15	*A. pallidus*
2	*A.barbirostris*	9	*A.fluviatilis*	16	*A.maculatus*
3	*A.turkhudi*	10	*A.subpictus*	17	*A.theobaldi*
4	*A.culcifacies*	11	*A.vagus*	18	*A.spelendidus*
5	*A.aconitus*	12	*A.jeyporiensis*	19	*A.jamesi*
6	*A.varuna*	13	*A.stephensi*	20	*A.gigas*
7	*A.minimus*	14	*A.ramsayi*	21	*A.annularis*

IV. Indicators of malaria situation

Commonly used indicators to measure malaria disease frequency and mosquito situation are given here. More detailed description of indicators used for measurement of malaria can be found in Sharma RS *et al.*, (1996).

A. Indicators useful for epidemiological surveillance of malaria

1. ABER / MBER: Annual / Monthly Blood Examination Rate

Denotes the number of blood smears examined in a year.

$$\text{ABER} = \frac{\text{Number of blood smears collected and examined during the year}}{\text{Population covered by surveillance}} \times 100$$

$$\text{MBER} = \frac{\text{Number of blood smears collected and examined during the month}}{\text{Population covered by surveillance}} \times 100$$

Note that the denominator population is the same for both ABER and MBER. Hence ABER for a given year is the sum of all MBERs in that year. Blood slides routinely collected in active and passive surveillance by all agencies including private practitioners, hospitals, nursing homes, voluntary health care institutions, fever treatment personnel. Blood smears collected during a mass survey, contact survey and follow-up are not been included.

The level of ABER depends on the true fever rate in the community, availability of health Care facilities, and adequacy of the surveillance system. Accurate estimates of malaria incidence can be made, if the MBER equals the true fever rate in the community. In other words if blood smears from all fever cases are examined for malaria parasite, an accurate estimate of malaria incidence can be made. To avoid fever recall bias, a fortnightly survey of fever cases and collection of blood smears is considered ideal. Assuming that fever rate in a community is about 15% per annum (which include passive blood smear collection of the new OPD, ABER of 10-15% and MBER of 0.8% during non transmission season and 1.2 to 1.5% during the transmission season is considered adequate. In other words, the ABER indicates adequacy of the surveillance system and there by determines the level of confidence to be attached to various parasitological indicators calculated from the results of blood smear examination.

2. API: Annual parasite incidence

Denotes the annual incidence of malaria cases per 1000 population.

$$\text{API} = \frac{\text{Number of blood smears found positive for malaria parasite}}{\text{Population covered by surveillance}} \times 1000$$

It is a dependent parameter of ABER. Most important to measure the purpose of intervention measures. Under MPO, it was used to plan vector control measures with indoor residual spray.

3. AFI: Annual Falciparum Incidence

Denotes the annual amount of *P. falciparum* cases per 1000 population.

$$AFI = \frac{\text{Number of blood falciparum cases in a year}}{\text{Population covered by surveillance}} \times 1000$$

It is also dependent parameter of ABER. Most important for mass and contact smear collection in the falciparum area and selective vector control with focal spray.

4. SPR: Slide Positivity Rate

Denotes the percent of population suffering from malaria at a given time.

$$SPR = \frac{\text{Number of blood smears found positive for malaria parasite}}{\text{Total number of blood smears examined}} \times 100$$

It varies from month to month and reflects the Malaria transmission season. SPR is a more dependable parameter to determine the parasite load in the community and effectiveness of control measures. Sharma et al. (1996) observed the following relationship between ABER, APR, and SPR.

SPR as an estimator of malaria incidence at different levels of coverage of blood slide collection as measured by ABER

ABER	SPR - API relationship	Estimator property
2.5%	SPR ≈ 4 x API	API gives an under estimate of true incidence. SPR provides a reasonable estimate of true incidence.
5%	SPR ≈ 2 x API	
<9%	SPR < API	
9-11%	SPR ≈ API	Both SPR and API are good estimates of true incidence.
12-15%	SPR ≈ (0.8 x API) to (0.66 x API)	API gives more accurate estimate of true incidence. SPR tends to be an under estimate of true incidence
20%	SPR ≈ 0.5 xAPI	

5. SFR: Slide Falciparum Rate

Denotes the percent of falciparum case out of the blood smears examined.

$$SFR = \frac{\text{Number of blood smears found positive for P. falciparum}}{\text{Total number of blood smears examined}} \times 100$$

The first impact of control measures are reflected on SFR. It pin points areas of *P. falciparum* predominance which is responsible for malaria mortality.

6. PF%: *P. falciparum*

Denotes the falciparum parasite load in the community among the malaria cases examined.

$$PF\% = \frac{\text{Number of blood smears found positive for P. falciparum}}{\text{Total number of blood smears found positive for parasite}} \times 100$$

This parameter gives the relative proportion of *P.falciparum* infections and identifies the trends of *falciparum* incidence in relation to total case load of malaria parasite.

7. IPR: Infant parasite rate

Is measured in the children of age group below 1 year

$$IPR = \frac{\text{Number of infants positive for malaria parasite}}{\text{Total number of infant blood smears examined}} \times 100$$

It gives a great deal of information regarding malaria transmission in the area during the epidemiological year (June-May) specially in *P. falciparum* dominated area.

8. CPR: Child parasite rate

Is measured in the children of 2-9 year age group to estimate the malaria endemicity

$$CPR = \frac{\text{Number of 2-9 years children found positive for malaria parasite}}{\text{Total number of 2-9 year children whose blood smears are examined}} \times 100$$

This indicates the prevalence of malaria parasite and its distribution at a point of time in the population of a locality.

9. Antimalarial drug consumption

Ask all distributors of pharmaceutical products in the area to provide a fortnightly report of sale of identified antimalarial drugs to pharmaceutical retailers, hospitals, nursing homes and clinics. Use chloroquine as the index antimalarial. Let the typical adult dose of cholorquine be 600 mg. Also collect data from the PHC about the quantity of chloroquine administered or distributed to fever cases both for presumptive and definitive treatment. Alternatively, fortnightly account of chloroquine issues by malaria programme officer to the concerned area can also be used. Thus chloroquine consumption data has to be collected from both private and public sector. Then compute equivalent adult doses of antimalarial per 1000 population. For example, Adult Doses of Chloroquine (ADC) per 1000 population can be computed as follows:

$$ADC = \frac{\text{Total chloroquin sale in mgs to retailers and clinic + total choloroquine mg distributed by Malaria Pgm}}{\text{Population of the area x 600}} \times 100$$

This indicator is easily obtained and useful for surveillance of malaria incidence in areas where medical care facilities are reasonably developed. So this indicator will be useful for all urban areas, and major Gram Panchayats.

10. Proportional Case Rate (PCR)

It is the ratio of clinically diagnosed malaria cases to the total fever cases seeking medical care.

$$PCR = \frac{\text{Clinically diagnosed malaria cases}}{\text{Total fever cases seeking care}}$$

11. Malaria contributed mortality

Use the cause of death reports for the area and compute cause specific mortality mortality proportion for malaria, expressed as percentage. Call this the malaria mortality percentage (MMP).

$$MMP = \frac{\text{Malaria deaths in the area during the reporting period}}{\text{Total deaths in the area during the same reporting period}} \times 100$$

12. Incubation interval:

The transmission in a particular area, is dependent on the incubation period of the parasite, within the vector from the time of picking up of the gametocyte plus the time taken for completion of schizogony in the human beings plus the time taken for the gametocyte to get matured which reflects on the transmission in the area.

B. Identification of high malaria risk areas and related indicators:

1. Criteria for identification of high malaria risk sub centres in rural areas:

If any one of the following criteria is satisfied, with respect to one or more habitations within the area of operation of the subcentre, it should be labelled as high malaria risk sub centre.

i. ***Death(s) due to malaria during the last three years. Malarial deaths are usually identified on the basis of clinical diagnosis or microscopic confirmation of presence of P. falciparum in blood.***
ii. ***Doubling of SPR during the last three years, and the SPR reaches 4% or more by the second or third year.***
iii. ***Consistently high average SPR during last three years, i.e. SPR is more than 5%.***
iv. ***SPR >= 3% and PF% >= 30%.***
v. ***Existence of a focus of chloroquine resistant P.falciparum.***
vi. ***Large scale aggregation of labour from other areas.***
vii. ***Appearance of new settlement of people migrating from other areas.***

2. Criteria for identification of high malaria risk urban areas:

If any one of the following criteria is satisfied by an urban area, it should be labelled as high malaria risk city or town.

i. ***SPR >= 5% during any of the last three years.***
ii. ***PCR >= 33%***

3. Percent population living in high malaria risk areas:

Percent population at risk is arrived at by adding up the population of all subcentres and urban areas identified as high malaria risk areas according the criteria described above. Percentage is calculated with respect to the total population of the entity for which this indicator is to be computed.

C. Indicators of the mosquito situation (entomological transmission indexes)

Measurement of the mosquito population and its structure (i.e. species composition) helps in recognising high risk environment for malaria transmission and to assess the impact of vector control measures. Measuring absolute population of mosquitoes is time consuming and is usually not feasible. Routine and continuous sampling of one or more stages in mosquito life cycle can be used to study relative fluctuation in population, to monitor effectiveness of vector control measures and to identify impeding rise in malarious activity in the concerned area.

1. Sampling of eggs

Monitoring number of eggs laid in oviposition sites would give depict the relative change in a population size. However, sampling of Anopheline eggs poses a special problem as the eggs are laid in widely scattered area in damp surface and rotting debris and are not visible. Available methods of extraction or soaking are cumbersome. Moreover species determination form eggs is difficult. So for all practical purposes, monitoring mosquito egg deposits is infeasible.

2. Larval density

Larval population can be sampled by a dipper which can be made from a small enamel bowl of 300 to 400 ml capacity by attaching it to a handle of about one metre length. The dipper should necessarily be white to help detect larvae, particularly the early instars. The number of dips made and the number of captured larvae are to be recorded. The density of larvae is expressed in terms of average number of different instars per dip.

$$\text{Per dip captures} = \frac{\text{Number of larvae collected}}{\text{Number of dips made}}$$

This measure, indicates efficiency of larval control measures on breeding activity in water bodies.

3. Adult vector density

Adult mosquitoes can be sampled by (a) human volunteer baits, (b) manual collection of resting mosquitoes, or (c) trapping mosquitoes during their flights and swarming activity.

i. Hand catch: Collect resting mosquitoes by an oral aspirator. An oral aspirator consists of glass or plastic tubing of 8-12 mm diameter and 30-45 cm length. A piece of mosquito netting or fine gauge is fixed in one end of the glass tube. To this a 50 cm long rubber tubing is attached. The mosquito netting plug is to prevent sucking of captured mosquito into the operator's mouth. By positioning the glass tube behind resting mosquito, they can be sucked into the tube and later transferred to a test tube. Collection has to go on for a fixed duration of time. Suspected resting places of mosquitoes should be searched thoroughly with the aid of torch lights to collect them. Density of resting mosquito is expressed in terms of man hour density or man hour hand captures. High vector density indicates high potential for malaria transmission.

$$\text{Man hours and captures} = \frac{\text{Number of mosquitces collected}}{\text{Number of man hours sperit in search}}$$

ii. Traps: Resting mosquitoes can also be collected by providing artificial shelters which can act as a trap like black box, mud pot or pit shelters, etc. However, these methods may not work where there are too many breeding sites.

iii. Outdoor resting mosquitoes are collected with help of sweepnets, dropnets or mechanical aspirators.

iv. Sampling the human biting population: A person rolls up his shirt sleeves and trousers, exposing arms and legs and sits quietly. When the mosquito lands on the body and starts probing, the bait himself or another person collects these mosquitoes by oral aspirators. Periodic searches of the exposed body, using a torchlight helps locate biting mosquitoes. Biting mosquitoes have to be collected over a period to time and is also reported as landing density. The landing density can be expressed as landing mosquito on man/hour or night. Biting collections become more significant index of vector population, when carried out at regular intervals by the same person(s), since some individuals are more attractive to mosquitoes than others. For species biting in day time, the index may be based on the number of mosquitoes alighting upon the clothing of the volunteer bait in a given time, i.e. the landing rate.

v. Light traps: Light traps can been used widely to obtain data on the abundance and species composition of mosquitoes. When mosquitoes approach the light they are sucked downwards through a screen funnel into a killing jar or mesh bag suspended below the trap. The light and fan are generally operated by electricity from the mains supply but batteries can be used in remote areas. Carbondioxide used in conjuction with the light trap increases the number of mosquitoes and range of species collected. About half to one kg of dry ice (solid carbondioxide) wrapped in a double layer of newspaper or aluminium foil and suspended alongside or slightly above the trap is usually sufficient for one night. The technique may be particularly useful in areas where mosquitoes are scarce. Similarly, lactic acid can also be used with light traps to attract mosquitoes. There is considerable variation in attractiveness of light traps to different species of mosquito. An evaluation of light-trap collections should be made in conjuction with other sampling methods. Once its suitability and performance is assessed, the light traps provide a more feasible means of sampling adult mosquito population.

4. Sporozoite rate

Incriminates the mosquito species as malaria vector. An indicator of vector competency.

$$\text{Sporozoite rate} = \frac{\text{No. of fermale mosquitces positive for sporozdites}}{\text{No of vector mosquitoes dissected}} \times 100$$

5. Wall scraping test for residual insecticide

A 25 Sq. Cm area of the wall supposed to have been sprayed with insecticides, is scraped to a depth of 1.3 mm and is tested for presence of insecticide. This can be used to evaluate quality and coverage of insecticide spray operations. For example a random sample

of households can be selected from the areas assigned for insecticide spray. Wall scraping test can show the proportion of households showing some signs of spray and also the quantity of residual insecticity. Based on this data an estimate can be prepared of the coverage and quality of insecticide spray.

D. Functional indicators of programme performance

Currently, the functional role of public health authority is to minimize the risk of disease for the population. Malaria is a focal disease. This means that risk of suffering from malaria is largely determined by the circumstances in the immediate neighbourhood . That is why the current programme strategy seeks to identify high risk areas as focus control measures in such areas. Ideally, habitations should be the unit of analysis for determination of malaria risk status. For pragmatic reasons, the malaria control programme has fixed the sub centre (usually covering population between 3000-5000 population) as the unit for malaria risk analysis. Following functional indicators are recommended keeping the above goal and strategy in mind.

$$\text{Exit High Risk Index Relative} = \frac{\text{Current population living in high risk areas}}{\text{Population living in high risk areas during last year}}$$

$$\text{Exit High Risk Index - Current/Both year} = \frac{\text{Current population living in high risk areas}}{\text{Population living in high risk areas during the both year}}$$

V. Review of the malaria situation in the state

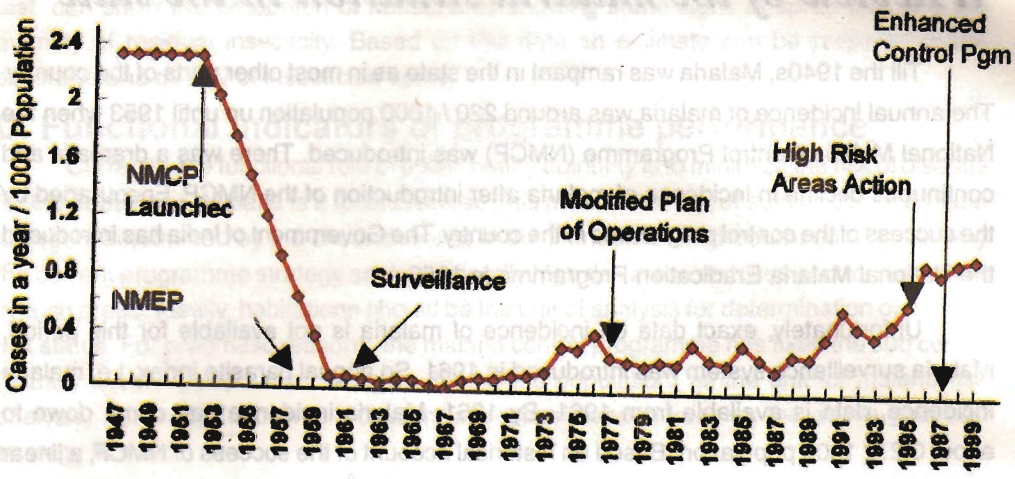
Till the 1940s, Malaria was rampant in the state as in most other parts of the country. The annual incidence of malaria was around 220 / 1000 population up until 1953 when the National Malaria Control Programme (NMCP) was introduced. There was a dramatic and continuous decline in incidence of malaria after introduction of the NMCP. Encouraged by the success of the control programme in the country. The Government of India has introduced the National Malaria Eradication Programme in 1958.

Unfortunately, exact data on incidence of malaria is not available for this period. Malaria surveillance system was introduced in 1961. So annual parasite index, i.e. malaria incidence, data is available from 1961. By 1961, Malaria incidence had come down to about 0.27 / 1000 population. Based on historical account of the success of NMCP, a linear decline in incidence is assumed for the period 1953 to 1960. What ever may have been the pattern of decline in this period, malaria incidence reduced very dramatically by more than 99% of its level prior to introduction of the NMCP. Figure-5.1 shows trend of malaria incidence for over 50 years. As will be seen later, the state is experiencing a resurgence of malaria. However, when viewed in comparison to the high incidence in the 1940s and early 1950s, the significant gains in control of malaria become obvious.

Figure-5.1 also locates the time of introduction of major interventions to control malaria in the country. The NMCP was introduced in 1953, followed by the NMEP in 1958. A National malaria control programme (NMCP) was launched in April, 1953. Spraying of DDT to control the mosquitoes was adopted. Countrywide incidence of malaria came down from 75 million cases in 1952 to 2 million cases per year in 1958. The National malaria eradication programme (NMEP) was launched in the state since 1958. NMEP sought to abolish the human reservoir of malaria parasite and thereby eradicate the disease. The eradication strategy consisted of residual insecticidal spray, active case detection with treatment. The country wide incidence reduced to 0.1 million cases by 1965-66 with no deaths. There was a resurgence of malaria during mid seventies.

Responding to this, a modified plan of operations (MPO) was introduced in 1977. Main components of this strategy include selective insecticidal spray in high risk areas, establishment of drug distribution centres (DDCs) and fever treatment depots (FTDs). In 1995 high risk areas action plan was introduced in order to minimise use of insecticides and to focus insecticidal spraying only in high risk areas. In 1997 the enhanced control programme was introduced in certain high risk tracts like the tribal areas.

Figure-5.1: Long term trend of malaria incidence in Andhra Pradesh

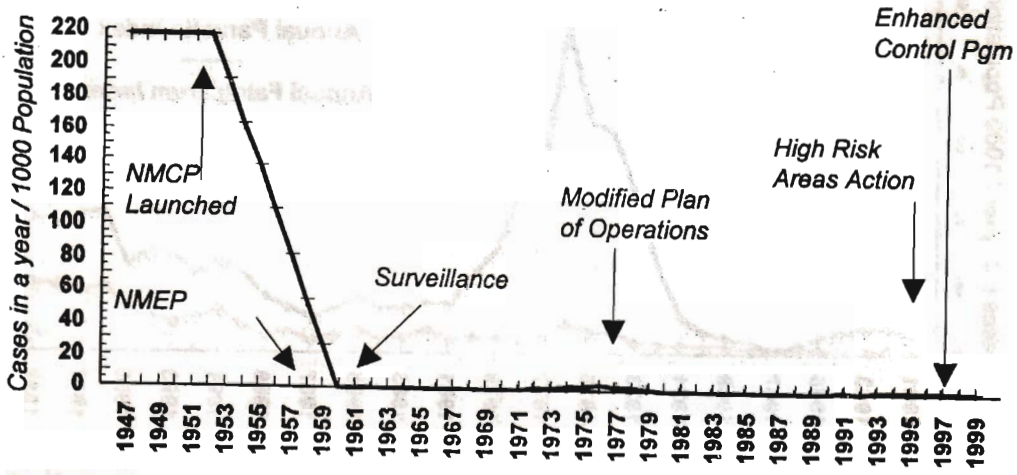


Source: API estimate for 1947-52 is based on estimated malaria cases in whole of India and population in 1947. API for the period 1953-60 is based on linear interpolation using malaria incidence just prior to introduction of NMCP and first surveillance data in 1961. Data for the years 1961-95 and after is based on surveillance data collected and reported by the Malaria programme authorities and published in Sharma, Sharma, and Dhillon 1996. Data for the years 1996 and after has been collected from the AP Directorate of Health - Malaria Programme Office.

Falciparum malaria is more severe and is usually responsible for most of the deaths due to this disease. Hence an understanding of the trend in incidence of falciparum malaria is useful. Figure-5.2 shows long term trend of falciparum malaria. After introduction of the surveillance programme in 1961, specific data about the annual falciparum index is available. This information is based on species of malaria parasite determined by examination of blood slides.

Data is available for the period between 1953 to 1960. Although specific information about incidence falciparum malaria before 1953 is not available, we have data about deaths due to malaria. Since falciparum malaria is known to cause most deaths due to malaria, the pre 1953 incidence is estimated from information about the number of deaths due to malaria. In other words the pre 1953 falciparum incidence shown in Figure-5.2 is an underestimate, since we know that all falciparum cases do not lead to death.

Figure-5.2: Falciparum malaria trend in AP, 1947-2000.

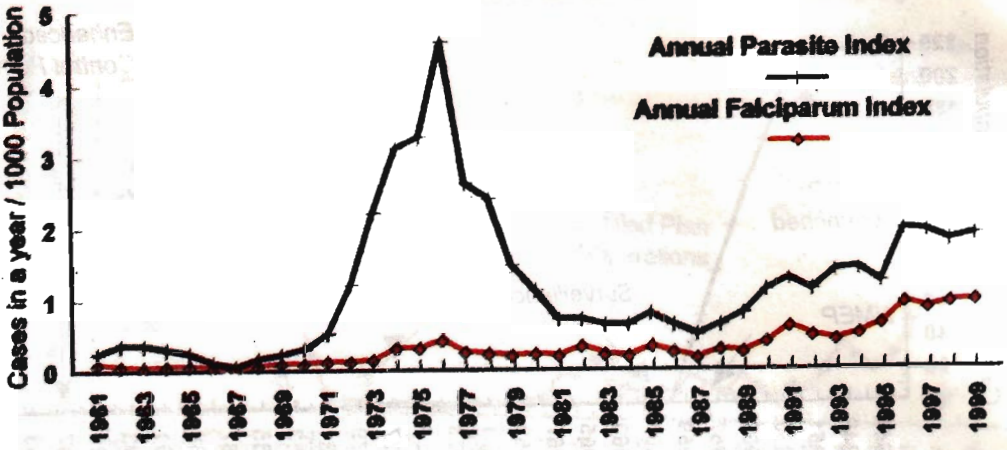


Source: See footnote to Figure-1

Clearly there was a dramatic decline in incidence of falciparum malaria after introduction of the NMCP. By 1960 the annual falciparum index had declined to 0.09 / 1000 population from the high level of at least 2.32 / 1000 population in 1952. The incidence of falciparum malaria was the lowest around 1967. By 1973, there was a resurgence, which has continued since then till date.

Figure-5.3 shows the trend of combined incidence of both vivax and falciparum malaria (annual parasite index) as well as the disaggregated incidence of falciparum malaria (annual falciparum index). This figure brings out the malaria trend after 1960s more clearly. Due to the very high level of incidence prior to 1953, details of malaria incidence trend after 1960s was not very clear in Figures 5.1 and 5.2. The Y axis in Figure-5.3 is rescaled within the small range of 0 to 5 / 1000 population compared to the 0 t0 220 / 1000 population range in the previous two figures. Hence the pattern in the 1970s, 1980s and 1990s is more clearly visible here. As said earlier, there was a resurgence during mid 1970s. Incidence of vivax and falciparum malaria increased during this period. But the spurt in vivax malaria was quite high. The modified plan of operations (MPO) introduced in 1977, surely reversed the trend of vivax malaria. But the falciparum malaria continued to rise at a slow but steady pace. Since the mid 1980s there is again a resurgence of vivax malaria in the state. This time, however, the resurgence of vivax malaria is not as sudden and acute as it was in the mid 1970s. The resurgence of falciparum malaria has continued unabated. Note that the API includes both vivax and falciparum malaria. As can be seen from Figure-5.3 most of the increase in API during the late 1980s and 1990s appears to have been contributed by the increased incidence of falciparum malaria. Recent increases in malarial deaths can be attributed to the fact that most of the current resurgence consists of the falciparum variety.

Figure-5.3: Incidence trend of all forms of malaria and falciparum malaria in AP, 1961-2000



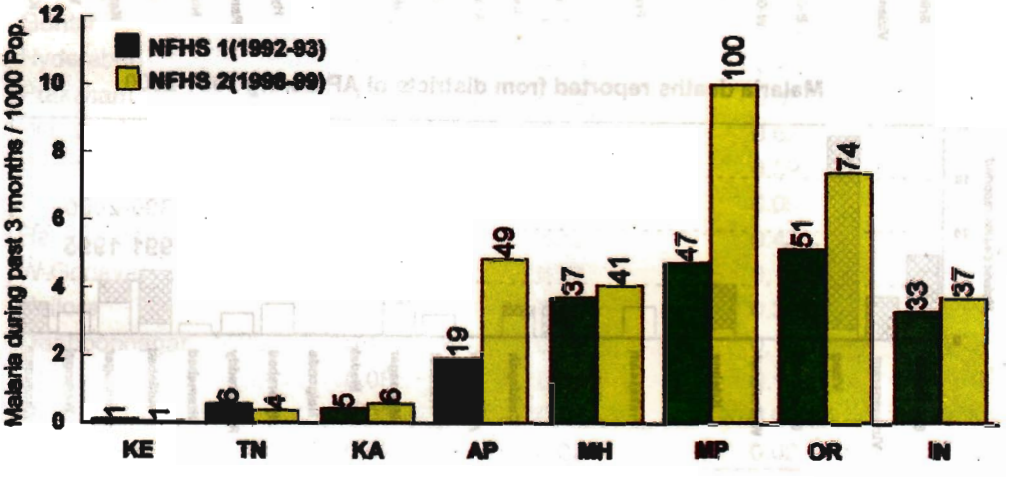
Source: See footnote to Figure-1

In fact, except for the initial decline during the 1950s, *P. falciparum* appears to have been never under control. This could be due to lack of any impact of control measures in hard core falciparum areas which are usually the hilly regions of the state mostly inhabited by various tribes. In other words, malaria was prevalent in some hard core areas which in subsequent years appeared in the form of focal outbreaks.

The estimates of malaria incidence used to generate Figures 5.1 to 5.3 are based on reports of positive blood slides collected by the malaria programme staff. In addition the two National Family Health Surveys (NFHS) provide us with an independent estimate of malaria incidence during the 1990s. However there is a large difference in malaria incidence estimated from the NFHS and health department reports of annual parasite index shown in Figures 5.1 to 5.3. According to the health department reports (Figure-5.3) the average malaria incidence in the state has been between 1 to 2 cases per 1000 population. Compare this with the estimate of 19 to 49 cases per 1000 population reported by the NFHS. The public health departmental figures are based on examination of blood slides collected from fever cases. Although, blood slides are collected by health workers through house to house surveillance of fever cases, those who resort to public healthcare institutions for treatment will tend to be picked up more easily by the malaria blood slide examination system. Household consumption surveys (NSS) show that nearly 75% of ambulatory care is obtained from the private sector. Many of the fever cases resorting to private health care providers would tend to be not picked up by the blood slide collection activity of the malaria control programme. The annual parasite index is calculated from the blood slides collected by the malaria programme and found to be positive for malaria parasite. The denominator is the total population of the area. If the blood slide collection is missing out nearly 75% of ambulatory cases, then the malaria incidence estimated from departmental reports of positive slides would be an underestimate by 3 to 4 times. If we adjust the malaria incidence in Figures 5.1 to 5.3 upwards by four times, the resulting estimate for 1990s will be between 4 to 8 cases per 1000 persons. Compare this with the NFHS figure of 19 to 49 cases per 1000 population. The NFHS figure is based on a small sample size of about 4000 to 5000

households and is based on recall by the household head or another adult about morbidity experience by all members in the household. The malaria question in the NFHS household survey was framed as "Did any one listed suffer from malaria at any time during the last three months?". There was no effort in NFHS questionnaire to establish the diagnosis of malaria. The report is based on perceptions of the respondent. Suppose the respondents would have connected malaria with fever. Even then there was no provision in the NFHS questionnaire to differentiate different cause of fever. The method clearly allows for overestimation of malaria by a very large margin. We are comparing this overestimate with an alternative estimate which is based on laboratory confirmation of malaria. Hence it would not be advisable to use the NFHS data to estimate the level of malaria incidence. The data however, remains useful to assess time trend of malaria, since the same question was asked at two different points of time and to make interstate comparisons. Figure-5.4 is used for these two purposes only in this review of malaria situation in AP.

Figure-5.4: Recent trends of malaria incidence in AP, and neighbouring states.



Source:NFHS data from IIPS(1995)Table-8.2p 205; NFHS-2 data from IIPS (2000) Table6.8p 202

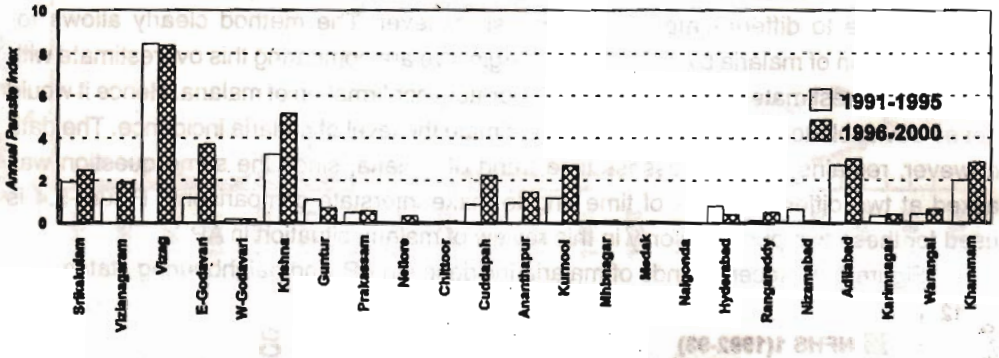
NFHS data in Figure 5.4 corroborates the rise of malaria in 1990s observed from the health department data. Comparing to different states, we find that incidence of malaria in the state of AP is similar to the incidence in Maharashtra and Orissa, and is less than the incidence in Madhya Pradesh. Malaria incidence in Tamil Nadu, Karnataka and Kerala is considerably lower.

Incidence of urban malaria seemed to be on rise. It is estimated that about 40.8% of the total positive cases of malaria are from the urban areas. Considering that the share of urban population is around 27%, the incidence of malaria in urban areas is disproportionately higher.

District wise analysis of malaria incidence based on a cumulative blood smear data from 1991-2000 helps us identify malaria endemic districts. Incidence of malaria has been very high in Vishakhapatnam district. Other malarious districts are Adilabad, Khammam, Srikakulam, Vizianagaram, East Godavari, Krishna districts. Srikakulam, Vizianagaram, East Godavari, Cuddapah, Anantapur, Kurnool, and Khammam districts experienced significant increase in malaria incidence during the second half of the 1990s (1996-200)

over the first half (1991-95) incidence. Deaths due to malaria has been mostly in Vishakhapatnam, East Godavari, Srikakulam, Vizianagaram, Adilabad, Krishna, Chittoor, and Khammam districts.

Figure-5.5: District wise malaria situation in AP during 1991-2000



Malaria deaths reported from districts of AP during 1991-2000

Districts like Medak, Nalgonda, Mahboobnagar, Chittoor, and Nellore appear to have been largely free of malaria. The case fatality rate appears to be high in Chittoor district giving rise to some deaths due to malaria, despite a generally low level of incidence.

Table-5.1: AP district wise malaria incidence, 1991-2000

District	1991-2000	1991-95	1996-2000
Vishakhapatnam	8.41	8.46	8.35
Krishna	4.23	3.28	5.18
Adilabad	2.87	2.72	3.01
Khammam	2.46	2.06	2.86
E-Godavari	2.43	1.18	3.67
Srikakulam	2.22	1.97	2.46
Kurnool	1.93	1.16	2.70
Cuddapah	1.55	0.89	2.22
Vizianagaram	1.54	1.12	1.96
All AP	**1.51**	**1.28**	**1.75**
Anantapur	1.22	0.95	1.48
Guntur	0.95	1.13	0.76
Hyderabad	0.62	0.79	0.45
Prakasam	0.54	0.53	0.55
Warangal	0.52	0.41	0.62
Karimnagar	0.37	0.35	0.39
Nizamabad	0.37	0.65	0.09
Rangareddy	0.30	0.12	0.47
W-Godavari	0.20	0.21	0.19
Nellore	0.19	0.06	0.32
Mahboobnagar	0.13	0.12	0.14
Chittoor	0.08	0.04	0.11
Medak	0.03	0.03	0.03
Nalgonda	0.02	0.02	0.02

VI. What can individuals, families, and neighbourhoods do to keep out malaria?

Congenial household environment, and personal care by all members of the community is critical for control of malaria. The most important personal responsibility is to avoid exposure to mosquito. At the first sight, it may appear, that individuals can hardly do anything to avoid exposure to mosquitoes. Since mosquito breeding is dependent on climatic conditions and environment, one would ask, what is it that an individual can do to avoid exposure to mosquitoes? The fact is that appropriate practices by individuals, families, households and neighbourhoods, can contribute to near total elimination of malaria in the concerned neighbourhood. Since malaria is a focal disease, it will suffice if each one of us take care of our respective neighbourhoods. Then we will be left with the problem of travellers whose business, work and entertainment takes them to other neighbourhoods. This can be helped by personal habits and lifestyle measures.

We have seen from vectorial capacity model that longevity of the anopheles mosquito makes the maximum contribution to malaria transmission. This is followed in importance by the frequency of feeding on human blood, i.e. the mosquito biting rate. The next in order of importance is vector abundance. Families and households in malaria endemic areas can help to reduce mosquito longevity by allowing spraying of residual insecticides inside their dwellings. Residual insecticides inside the dwelling have a direct effect on vector mosquito, since these are the ones which would most often enter human dwellings. Frequency of feeding and biting by vector mosquito can be reduced if individuals protect themselves from mosquito bites by avoiding exposure and adopting personal and indoor protection strategies. Families, households and neighbourhoods can contribute to reduce vector abundance by being careful to not allow mosquito breeding sites develop in own household and by reminding the neighbours of their responsibility to keep their premises free of mosquito breeding sites. This chapter describes relevant life style issues and describes various opportunities available to individuals, families and neighbourhoods to avoid malaria for oneself and to check its transmission in the neighbourhood.

A. Household protection of exposure to mosquito bites:

1. If you live in areas with high risk of malaria:

a. You can know if your household lies in a malarious area, by asking neighbours, local health workers and public health authorities, like the health assistant, Primary Health Centre Medical Officer, or from news paper reports of malaria transmission. Also ask your doctor or any other doctor who may be practicing in your area.

b. Arrange for spraying of residual insecticides to the walls of your house. The Public Health Department in Tribal areas usually has provision for indoor spraying of residual insecticides, in high risk areas. To avail this service, contact multipurpose health assistant, PHC Medical Officer, or Malaria programme officer of your area.

B. Personal protection:

1. Basic precautions against mosquito bite:

i. *Close doors and windows before dusk and keep them closed throughout night. In summer, you may like to keep the windows open to allow breeze. In such situations, appropriately position mosquito repellent smoke. In case of bedroom, you could close the doors and windows in the evenings, and use an indoor mosquito repellent product so that it attains sufficient concentration to prevent entry of mosquitoes or repel the ones already present. You can then open the windows, when you sleep.*

ii. *To repel mosquitoes in the evening and night from inside the dwelling, use mosquito repellent products or alternatively follow traditional smoking practices.*

iii. *Use mosquito net. This, not only protects from mosquito bite but prevents from snake bite also.*

iv. *Cover babies cradle with a mosquito net. Use special baby mosquito nets.*

v. *Do not sleep outdoors. If you must, then use a mosquito net and secure it well to prevent entry of mosquitoes.*

vi. *If you can afford, install mesh to your windows and such other openings to make your house mosquito proof. Remember that simple fitment of mesh does not make a house mosquito proof. If you do not cultivate the habit of closing of doors, and windows or are not careful to close all other openings, then mosquitoes may enter the house and stay put. So the basic precautions against mosquito bite, will still need to be followed even after you install mesh to your doors and windows. In other words, its your habit and life style that makes your house mosquito proof!*

2. Additional precautions if you live in forest and hilly areas or there are a lot of mosquitoes in your area:

i. *Wear clothes that cover as much of your body as is possible. Use functional designs that allow you to work and keep your body covered. Use dress material that is comfortable and does not allow mosquitoes to bite through it. The population of mosquitoes is comparatively high in hilly areas. So keeping the body covered reduces the risk of exposure.*

ii. *Do not sleep in the open area in deep forest even during day time.*

iii. *Avoid unnecessary journeys to forest. For essential trips to forest, use proper covering of the full body.*

iv. *Never forget to use the mosquito net. This, not only protects from mosquito bite but prevents from snake bite also.*

v. *Arrange for spraying of residual insecticides in your house. The Public Health Department in Tribal areas usually has provision for indoor spraying of residual insecticides, in high risk areas. To avail this service, contact multipurpose health assistant, PHC Medical Officer, or Malaria programme officer of your area.*

3. Mosquito repellent products for household use:

a. Mosquito Coils: Coils containing natural pyrethrum and herbal products are used to repel mosquitoes from its vicinity. When a coil is burnt, the smoulder can provide protection for about 6-7 hours in a close room. Coils do not require electricity and

hence can be used in remote areas. Some commercial brands of mosquito repellent coils are; Tortoise, Rooster, Jet, Mortein, Falcon etc. (should not be used in closed rooms)

b. Mosquito mats: The mats are impregnated with Allethrin or bio-allethrin. When it is heated on a plate fitted with an electric device produces vapours, which either knock down or repel the mosquitoes. There are several brands available in the market with varied protection time. The volatile pyrethroid mats are more effective and better accepted by the community than the burning or smouldering coils. Examples of commercially available mosquito mats are; Good knight, Jet, Casper, Banish etc.

c. Liquid formulation of repellents: Liquid formulation of Dimethyl phthalate (DMP); N, N-diethyl-m-toulamide(DEET) and N, N-diethyl phenyl acetamide (DEPA) can provide protection against mosquito vector as well as other heamatophagous arthropods, when applied locally. These substances are volatile and protection time is limited to few hours only. Studies show that DEET is more effective and provides more protection period than DMP and DEPA. Ex. Good knight, Allout etc.

d. Cream formulations: Creams containing DEET/DMP/Permethrin alone or in combination are used as repellents. The protection time varies for different products. Ex. Odomos etc.

e. Soap formulation: Soaps are produced with either DEET,DMP or permethrin. Spreading a film of the soap gives effective results upto a few hours, but experiment shows that after rinsing with water all repellence was lost. However, it is less effective than the liquid formulations.

f. Natural oils: Oils of Citronella, Lemon Grass, Palm rosa, Neem etc. are having repellent action of varying degree against various species of mosquitoes.

g. Electrocuting devices: Electric buzzers are available in the market which emits the sound (wing-beat frequency) of a male mosquito and this sound act as repellent to mated females. But studies reveals that the buzzers are set at a much higher frequency than of mosquito wing beats and thus they are not giving any significant result.

h. Use of Ultraviolet lights: Ultraviolet lights are also used in a specially designed trap to attract the mosquitoes and electrocute them. These devices are widely used in the hotels and restaurants for the control of houseflies and other flying insects. Ex. Pest-o-flash etc.

4. When you travel:

a. Carry and use a mosquito net. Alternatively use mosquito repellent mats, coils or apply mosquito repellent cream.

b. If you happen to be in a malaria endemic area, hilly or forest areas, avoid unnecessary trips outdoor, particularly in the evenings.

c. Drinking green coconut water is good for health. Drinking green coconut water and eating the tender coconut is fun. However, the split half or unsplit coconut shell when discarded, can hold water and provide breeding opportunity to mosquitoes. Hence make sure you ask the green coconut vendor to cut the shell into four pieces. This will avoid the shell being an unintended receptacle of stagnant water.

5. Treatment of bednets with synthetic Pyrethroid:

Simple bednets are already being used to prevent mosquito bite and diseases transmitted by them. Pyrethroid impregnated bednets against malaria were first introduced in China and Kenya and this has helped in reducing mortality and morbidity due to malaria. The treated bednets have been found to provide more protection than the untreated one by preventing mosquitoes from entering through holes of the torn net or biting the nets. It may reduce the transmission if used on large scale. These treated nets when used widely in a community can even protect the non users by 'mass killing' effect. Synthetic pyrethroids like deltamethrin, lambda-cyhalothrin, permethrin, cyfluthrin, cypermethrin etc. are used for the impregnation of the bednets in different dosages. The dosage for impregnation of bed nets are; deltamethrin 15-25 mg/m^2 and permethrin 200-500 mg/m^2 etc. Generally cotton, polyester or nylon nets may be used without any significant difference in its effectiveness after impregnation with the same dose of insecticide. No structural deterioration has been observed in the cotton netting due to the impregnation with the pyrethroids. However, to maintain the dose of pyrethroid used for impregnation dripping should be avoided and nets should be dried in shade by spreading on a non absorbent surface (such as plastic ground sheet) and allowed to get semi dry. Semi dried mosquito nets are then hung on a wire and allowed to dry completely. Studies showed that nets impregnated with 25 mg/m^2 deltamethrin if not washed remains effective till 10 months providing 100% mortality and it gradually declines up to 18 months. Even after single wash with common soap/ detergent the nets were found to be still effective though not as before washing.

Mosquito nets should be large enough to cover a bed properly. For a single bed , mosquito net of 10 m^2 and for a double bed 15m^2 would be appropriate. Approximately, 10-15 cm cotton cloth be properly hammed with the net for tucking under the mattress or bed. For proper ventilation mesh size of about 3 to 4 mm (i.e. 6-8 holes per linear inch or 3-4 holes per linear cm) is recommended.

In India few field trials have been undertaken by various institutes to study its impact on malaria as well as Filariasis in different eco-geographical conditions. Reduction in the transmission of malaria to some extent was observed in some places where it was in continuous use for 2-3 years. Encouraging results were obtained by the synthetic pyrethroid impregnated nets in North eastern India against *An. minimus* transmitted malaria based on which NMEP has recommended the use of impregnated bednets to combat malaria in NE region.

6. Treatment of curtains with synthetic Pyrethroid:

However, in certain situations mosquito nets are not accepted by the community. Under such situations doors and window curtains can be impregnated with the synthetic pyrethroids to prevent the entry of mosquitoes and other insect vectors. Curtains may be effective against day biting mosquito and other insect vectors. Curtains may be effective against day biting mosquitoes. A field trial at Delhi and Ghaziabad conducted by ICMR using Deltamethrin 100 mg/m2 sprayed on both sides of the curtain yielded good result.

7. Use of other impregnated materials:

Jute ropes impregnated with 1% esbiothrin mixed with kerosene oil can be used in the slums and other labour settlements for the control of adult mosquitoes. This rope when

allowed to smoulder from dusk to dawn inside the room prevents the mosquito bite by repelling them. Eaves (the part of the roof which meets or overhangs the walls of a building) in the poorly constructed/mud houses, slums etc. can be covered with pyrethroid impregnated gunny bags to prevent the entry of mosquitoes. This strategy has been adopted to control J.E. on experimental basis by screening the piggeries with pyrethroid impregnated gunny bags.

8. Impregnation of clothing and other fabrics with repellents:

Volatile synthetic repellents like N,N-Diethyl-m-toluamide(DEET), Dimethyl pthalate(DMP) and Di-ethyl phenyl acetamide (DEPA) are used to impregnate the jackets and trousers by the Military personnel to prevent the bite of mosquitoes and other insect vector. Netting Jackets with hoods impregnated (at the rate of 0.25 gm/gm netting DEET) provided good protection for several weeks.

C. Household environment to minimise mosquito breeding:

Mosquitogenic conditions around the household and the neighbourhood can be reduced or even eliminated if families take a little bit of care. Here are a few precautions and practices to avoid mosquito breeding around your household.

a. Fully close the lids of the overhead tanks, under ground sump, septic tank.
b. Keep the septic tanks and over head tanks sealed properly to prevent the entry and exit of mosquitoes. Tie a piece of mosquito net cloth on the ventilation pipe of the septic tank.
c. Do not allow water to stagnate in any open container.
d. Completely scrub and clean and change the water of flower vase, open water storage once in a week
e. Keep your house drain clean. Do not throw garbage except in dustbins. Throwing garbage in drains will block water flow.
f. Any leaky water taps should be repaired immediately since it could lead to stagnation and mosquito breeding.
g. Do not throw empty tins, pots, containers on the terrace and donot allow water to stagnate in it. Do not keep any unused items like bottles, tyres, plastic items, etc. in the open area. Keep the empty flower pots inverted.
h. Cultivate kitchen garden where effluents from the house could be diverted.

D. If someone in your house has fever!

Malaria disease usually manifests with fever. But fever is a very common symptom for many other diseases. It is relatively easy to recognise fever. If however, you keep a systematic record of temperature and some simple signs, you can help your doctor arrive at the correct diagnosis and give appropriate treatment to the member of your household.

1. Recognising fever and measuring body temperature:

It is often wise to take a sick person's temperature, even if (s)he does not seem to have a fever. If the person is very sick, take the temperature at least four times each day and note it down. If there is no thermometer, you can get an idea of the temperature by

putting the back of one hand on the sick person's forehead and the other on your own or that of another healthy person. If the sick person has fever, you can feel the difference.

It is important to find out when and how the fever comes, how long it lasts, and how it goes away. If you give the person any medicine to reduce fever or headache (for example paracetamol or aspirin) then the time when such medicines are given should be recorded. This will help the doctor properly interpret the nature of fever. The type of fever is of great help in diagnosis of the disease.

i. How to take the temperature:

a. Clean the thermometer well with soap and water or spirit. If it is a traditional mercury thermometer, then shake it hard, with a snap of the wrist until it reads less than 36 degrees centigrade or 96 degrees Fahrenheit.

b. In conscious adults, the thermometer can be under the tongue or in the armpit. If thermometer is placed under the tongue, ask the person to breathe through the nose and keep the lips firmly closed. In case of young children place the thermometer in the fold of groin and bend the child's thigh on the abdomen.

c. Keep it there for two minutes. Note that it is desirable to keep the thermometer in its recording place for a little longer than what may have been recommended by the manufacturer.

d. Read it.

e. Wash the thermometer with soap water, allow it to dry and replace its holder.

ii. How to read thermometer:

a. In case of digital thermometers, reading is easy, in which the temperature is displayed through the counter. Note, however, that these thermometers use the same display area to display more than one type of information. It is very important to read the instructions manual of such thermometers to understand what information is displayed when.

b. In case of mercury thermometer, turn the thermometer until you can see the silver line. The point where the silver line stops marks the temperature.

2. Observe the pulse (heart beat):

Feel the persons pulse at the wrist. Place at least two and preferably three of your finger tips on inner side of the person's wrist above base of the thumb. Adjust your finger tips till you feel regular beats. Apply a little bit of pressure and try to feel regular beats of arterial pressure. Count the number of beats for a minute. This is the pulse rate.

Normal pulse rate	
Adults	60-80 per minute
Children	80 to 100 per minute
Babies	100 to 140 per minute

The pulse gets much faster with exercise, and when a person is nervous, is frightened, has a fever or in acute pain. Generally the pulse increases 20 beats per minute for each degree centigrade rise in fever.

3. Observe breathing:

Pay special attention to the way the sick person breathes - the depth (deep or shallow), rate (how often breaths are taken), and difficulty. Notice if both sides of the chest move equally when (s)he breathes. Count the number of breaths per minute. Between 12 and 20 breaths a minute is normal for adults and older children. Upto 30 breaths per minute is normal for children and 40 for babies. People with a high fever or serious chest infection like pneumonia breath more quickly than normal.

4. Consult doctor:

A catalogue of the above observations about temperature, pulse and respiration from the beginning of the fever, will be very helpful for the doctor to arrive at a diagnosis. If you happen to live in a malaria prone area, and your doctor is practicing in the same area, then (s)he would know and want to rule out malaria. There is no harm in asking and drawing your doctors attention to the malaria proneness of your area. If you live in an area where malaria is rare, and the person in your household with fever did travel to a malaria prone area within a few weeks of developing the fever, then do not forget to inform your doctor about it. Do draw your doctor's attention to the possibility of malaria.

Note that in malaria endemic areas, the normal practice for doctors is to collect a blood slide for identification of malaria parasites if any, and to give presumptive treatment against malaria, even before the blood smear examination report is known. Since the presumptive treatment for malaria is quite safe, this practice minimises the risk of suffering and possible death from malaria.

Caution about complete sterility of needles for blood smear!

Ask for sterilised and disposable needles to prick your finger, and avoid the risk of hepatitis, HIV etc.

VII. Practice guidelines for diagnosis and treatment of malaria

A. Attention clinicians:

The purpose of this guideline is to help ensure quality of care for individual patients. Practitioners are encouraged to use the information provided here, but the recommendations may not be appropriate for use in all circumstances. Decisions to adopt any particular recommendation must be made by the practitioner in light of available resources and the circumstances presented by individual cases.

B. Purpose and scope:

In many parts of the state, malaria continues to be an important source of morbidity. Most cases of malaria can be well managed by outpatient consultation. A doctor typically encounters many fever cases in the clinic. Differential diagnosis of fever cases, recognition or ruling out of malaria is critical to successful management of fever cases. Left untreated, malarial fever can give rise to complications and may lead to death. Hence, clinics and outpatient departments and health workers should put in place and follow a systematic protocol to facilitate recognition of malaria cases, presumptive and definitive treatment of malaria, and management of complications, if any. Hospitals and nursing homes may receive severe malaria cases. Any health care institution offering hospitalisation services, and serving to malaria endemic areas must be well equipped to handle severe malaria cases.

These practice guidelines are recommended for adoption by medical practitioners, clinics, hospitals, and nursing homes, with appropriate modifications to suit local conditions. The guidelines should be adopted by practitioners and health care delivery institutions in both public and private sector.

C. Uncomplicated malaria:

1. Clinical presentation:

The presenting symptom of malaria is fever. Malarial fever is intermittent. There are three types of fever - the continuous, the remittent, and the intermittent. Continuous fever is one, where the body temperature does not reach normal at any time of the day and fluctuates in a very narrow range of say, one degree centigrade. In remittent fever, the range of fluctuation of body temperature is wider, but the temperature does not reach normal level any time of the day. Intermittent fever is characterised by paroxysms of fever and periods of complete relief from fever. When a paroxysm of intermittent fever occurs daily, the fever is described as quotidian, in case of alternate day paroxysms, the fever is called tertian and for gaps of two days between the paroxysms of fever, the term quartan is used. Malarial fever is intermittent. Although classical description of malaria symptoms talk about tertian and quartan periodicity, such definite periodicity may be lacking in practice, particularly during early phases of development of malarial fever. The tertian or quartan periodicity may not develop later during the course of illness, because of medications etc. Hence, more importance should be attached to the intermittent nature of malarial fever, rather than its exact periodicity.

Typically, malarial fever is of sudden onset accompanied by chilly sensation to uncontrollable shivering and sensation of extreme cold followed. This is followed by feeling of burning heat, leading to profuse sweating and remission. The fever may rise up to 104 degrees Fahrenheit and may last for ± to 2 hours. Headache, body ache, nausea, remission-by crisis after sweating, palpable liver and spleen, convulsions, disorientation, photophobia etc. may be associated features. In children, depending on the degree of temperature, complications such as convulsions, dehydration and disorientation may be present.

Uncomplicated malaria due to all parasite species including vivax and falciparum, present almost similar symptoms. Differentiation of falciparum malaria from other forms is of very high clinical importance. The risk of development of severe forms of malaria exists in case of falciparum infection. But clinical signs and symptoms of uncomplicated malaria are not of much help. Species identification of malaria parasite from blood smear is an important diagnostic aid to differentiate falciparum malaria from other forms. However, blood smear results may take some time to come. Moreover, malaria and for that matter falciparum malaria as well cannot be ruled out purely on the basis of a single negative result from blood smear examination. The most important help is the knowledge of falciparum endemicity in the area or history of travel to a falciparum endemic area. In addition close monitoring of the patient and repeat blood smear examination is required.

2. Clinical diagnosis:

The most important element in the clinical diagnosis of malaria, in both endemic and non endemic areas, is to have a high degree of suspicion. Knowledge about malaria endemicity in the area from which clinics patients come helps in diagnosis of malaria. Because the distribution of malaria in the state is patchy, a travel history indicative of exposure is important. Other disease known to present with fever should be ruled out.

Important diseases presenting with fever and their differential diagnosis

Malaria	Begins suddenly with rising temperature and chills. Fever lasts for few hours. Sweating begins as the temperature drops. Between fevers, the person looks and feels more or less well.
Typhoid	Begins like a cold. Gradual rise of temperature over a period of days. Sometimes diarrhoea, and dehydration, trembling or delirium. Person very ill. Blood culture during first ten days of fever is usually positive for typhoid. Positive stool culture after tenth day with increasing frequency up to fourth or fifth week is diagnostic of typhoid.
Hepatitis	Person loses appetite. Does not wish to eat or smoke. Wants to vomit (nausea). Jaundice. Tender liver enlargement - suspect hepatitis. Person with hepatitis is usually very weak. Van den Berg reaction is direct in hepatitis, and indirect in case of jaundice due to malaria.
Respiratory infection	Fast shallow breathing. Temperature rises quickly. Cough with green, yellow or bloody mucus. May be pain in chest. Person very ill.

Septic foci	Septic foci like otitis media, abscess, cellulitis, etc. do present with high fever. The daily rise of temperature is in the late afternoon or evening. Septic foci are associated with pain and tenderness in the local area.
Rheumatic fever	Most common in children and teenagers. Pain in joints. High fever. Positive history of sore throat. May be pain in chest with shortness of breath or uncontrolled movements of arms and legs.
Tuberculosis	Begins slowly with tiredness. Loss of weight and cough. Fever in the evening. Temperature goes down in the morning. May be sweating at night. This may go on for months.
Childbirth fever	Begins a day or more after giving birth. Starts with a slight fever, which often rises later. Foul-smelling vaginal discharge. Pain and sometimes bleeding from vagina.

Source: Based on VHAIs edition of Where there is no doctor by David Werner, Satyamala, and VHAI, 1980, p31-33; and Sharma, Sharma, and Dhillon, 1996 p106-108.

No age, sex group is exempt from malaria. However infants, children and pregnant women are more susceptible to severe complications.

3. Microscopic diagnosis:

i. Collection and examination of blood smears:

Blood smears should be made from all the patients reporting with fever or with history of fever, if suspected for malaria. Slide may be taken even though fever is not present at the time of reporting of patient. In the majority of cases, thick and thin blood smears for malaria parasite under microscope show malaria parasite. Thick films are more useful than thin films, in case of low density parasitemia. The blood smear is stained with Giemsa and examined through a microscope using the 100X oil immersion objective. Services of laboratory technicians trained in identification of malaria parasite should be availed. In general, greater the parasite density in the peripheral blood, greater the likelihood that severe disease is present or will develop. However, some people may develop severe and even fatal malaria with a very low peripheral parasitemia.

ii. Advantages of microscopy are;

a. It is sensitive. When used by skilled and careful technicians, microscopy can detect densities as low as 5-10 parasites per μl blood. Under general field conditions, however, the detection capabilities of a typical microscopist might be more realistically placed at 100 parasites per μl of blood.
b. It is informative. When parasites are found, their species and circulating stage can be found.
c. It is relatively inexpensive and a general diagnostic technique that can be shared with other disease control programmes.

iii. Some disadvantages of microscopy are;

a. There may be delay in availability of microscopy results.
b. Its sensitiveness and reliability for diagnosis of malaria depends on good techniques, reagents, microscope, and most importantly well trained and well supervised technicians.

4. Rapid Diagnostic Tests (RDT) for malaria[1]

These tests are based on the detection of antigens derived from malaria parasites in lysed blood, using immunochromatographic methods.

i. Antigens targeted by currently available RDTs

a. Histidine-rich protein II (HRP-II) is a water-soluble protein produced by trophozoites and young (but not mature) gametocytes of *P. falciparum*. Commercial kits currently available detect HRP-II from *P. falciparum* only.

b. Parasite lactate dehydrogenase (pLDH) is produced by asexual and sexual stages (gametocytes) of malaria parasites. Test kits currently available detect pLDH from all four Plasmodium species that infect humans. They can distinguish *P. falciparum* from the non falciparum species, but cannot distinguish between *vivax, ovale* and *malariae*.

c. Other antigen(s) that are present in all four species are also targeted in kits that combine detection of the HRP-II antigen of *P. falciparum* together with that of an, as yet unspecified, "pan-malarial" antigen of the other species.

d. Some kits that detect all four Plasmodium species mentioned in their labelling are only two species (e.g. PF/PV). This can lead to confusion about their diagnostic capabilities.

ii. General test procedure:

a. A finger-prick blood specimen is collected (2-50 µl depending on kit), using a variety of micro capillary tubes.

b. The blood specimen is mixed (in a separate test tube or a well, or on a sample pad) with a buffer solution that contains a haemolysing compound as well as a specific antibody that is labelled with a visually identifiable marker (such as colloidal gold). If the antigen under investigation is present, antigen/antibody complex is formed. In some kits, the labelled antibody is pre-deposited during manufacture on to the sample pad or in the well, and only a lysing / washing buffer is added to the blood.

iii. Test performance;

a. The sensitivity of RDTs has been most studied for *P. falciparum* since the HRP-II kits have been available for a longer time. Sensitivity of RDTs is more than 90% for detection of *P.falciparum* malaria at 100 parasites per µl blood. Below 100 parasites per µl blood, sensitivity decreases markedly.

b. The pLDH kits for non-falciparum species may also achieve a comparable level of sensitivity, particularly for *P.vivax*. But more studies are needed to assess the sensitivity and specificity of these antigens.

iv. Disadvantages of currently available RDTs

a. Commercially available RDTs targeting HRP-II can detect only *P.falciparum*. In AP, such kits will be useful in the tribal areas where *P. falciparum* is endemic. Even in these areas, these kits will detect only a portion of cases and will miss out malaria cases due to other species.

b. The HRP-II based RDTs can give positive results for upto two weeks following chemotherapy and parasite clearance.

1Extracted from Report "New Perspectives. Malaria Diagnosis. Report of a Joint WHO.USAID informal consultation, 25-27 October, 1999; WHO/MAL/2000.1091.

c. RDTs are more expensive.

d. RDTs that detect antigens produced by gametocytes (such as pLDH) can give positive results in infections where only gametocytes are present. Gametocytes are not pathogenic, and gametocytes of *P. falciparum* can persist following chemotherapy without implying drug resistance. Such positive RDT results can thus lead to erroneous interpretations (false positives) and unnecessary treatment of people not suffering from malaria.

5. Management of malaria:

Case management of malaria consists of presumptive antimalarial treatment, definitive i.e. radical treatment with antimalarials, and supportive treatment.

i. **Presumptive treatment: In malaria endemic areas, it is safe to presume that all fever cases are malaria. Hence presumptive treatment is given to all fever cases or persons with history of fever during the preceding 15 days immediately after the blood smear is collected. All persons with fever are given presumptive treatment irrespective of age and sex including infants and pregnant women. The presumptive treatment is also to be administered to fever cases where the blood smears are not collected. The choice of antimalarial drugs and their dosage varies according to the nature of endemicity.**

a. Where simple vivax malaria is endemic:

Medicine	Patient's age group				
	< 1 year	1-4 yr.	5-8 yr.	9-14 yr.	15 + yr.
Single dose chloroquin10 mg / kg body weight	75 mg	150 mg	300 mg	450 mg	600 mg

b. Known falciparum endemic areas but no chloroquine resistance: For example; the hilly areas.

Day	Medicine	Patient's age group				
		< 1 year	1-4 yr.	5-8 yr.	9-14 yr.	15 + yr.
Day-1	Chloroquine 10 mg/kg.bw.	75 mg	150 mg	300 mg	450 mg	600 mg
	Primaquine[1] 0.75 mg/kg.bw.	Nil	12.5 mg	15 mg	30 mg	45 mg
Day-2	Chloroquine 10 mg/kg.bw.	75 mg	150 mg	300 mg	450 mg	600 mg
Day-3	Chloroquine 5 mg/kg.bw.	37.5 mg	75 mg	150 mg	225 mg	300 mg

[1] Note: Pregnant women and infants are not to be given Primaquine. Instead, pregnant women should be given full dose of chloroquine only followed by weekly doses of 400 mg chloroquine till 5 weeks after delivery. Then they are treated with primaquine. Infants are given 5 mg/kg.bw. of chloroquine till they become one year of age. Then, they are given primaquine.

c. Known falciparum endemic areas and possible chloroquine resistance: Sulphalene / Sulphadoxine 1500 mg + Pyrimethamine 75 mg. If microscopic diagnosis is not available, include chloroquine to treat possible vivax infection. Note that the sulfa combination has very little action on *P. vivax*.

ii. *Definitive i.e. Radical Treatment (RT): Radical treatment with antimalarials is given after confirmation of diagnosis and identification of the parasite species. The choice of drugs and dosage schedule varies according to the parasite species and its susceptibility status.*

a. Radical treatment of vivax malaria:

Day	Medicine	Patient's age group				
		< 1 year	1-4 yr.	5-8 yr.	9-14 yr.	15 + yr.
Day-1	Chloroquine 10 mg/kg.bw.	75 mg	150 mg	300 mg	450 mg	600 mg
	Primaquine[1]	Nil	2.5 mg	5 mg	10 mg	15 mg
Day-2	Primaquine[1]	Nil	2.5 mg	5 mg	10 mg	15 mg
Day-3	Primaquine[1]	Nil	2.5 mg	5 mg	10 mg	15 mg
Day-4	Primaquine[1]	Nil	2.5 mg	5 mg	10 mg	15 mg

Note: Pregnant women and infants are not to be given Primaquine. Instead pregnant women should be given full dose of chloroquine only followed by weekly doses of 400 mg chloroquine till 5 weeks after delivery. Then they are treated with primaquine. Infants are given 5 mg/kg.bw. of chloroquine till they become one year of age. Then, they are given primaquine.

a. Though Chloroquine clears all the erythrocytic stages of *P.vivax*, it has no action on the hypnozoites which persist in the liver and can cause relapse. Primaquine is the only drug which has action on the hypnozoites. Therefore Primaquine is given along with chloroquine to radically treat the vivax infection

b. In high risk areas with mixed vivax and falciparum endemicity, the patient might have received 3 days presumptive treatment with 1500 mg Chloroquine. Therefore, further chloroquine need not be given but Primaquine is to be given for four days.

b. Radical treatment of Falciparum malaria: If presumptive treatment for *P. falciparum* has been given, no further action is required after identification of parasite species. Observe for clinical signs of cure. If clinical signs do not go away investigate for other infections or pathologies. Also consider the possibility of chloroquine resistant Falciparum malaria. If no presumptive treatment was given, then provide the following definitive antimalarial treatment. Note that the following choice of drugs and dosage schedule for radical treatment of *P. falciparum* infection is the same as presumptive treatment.

Day	Medicine	Patient's age group				
		< 1 year	1-4 yr.	5-8 yr.	9-14 yr.	15 + yr.
Day-1	Chloroquine 10 mg/kg.bw.	75 mg	150 mg	300 mg	450 mg	600 mg
	Primaquine[1] 0.75 mg/Kg.bw.	Nil	12.5 mg	15 mg	30 mg	45 mg
Day-2	Chloroquine 10mg/kg.bw.	75 mg	150 mg	300 mg	450 mg	600 mg
Day-3	Chloroquine 5 mg/kg.bw.	37.5 mg	75 mg	150 mg	225 mg	300 mg

Note: Pregnant women and infants are not be given Primaquine. Instead pregnant women should be given full dose of chloroquin only followed by weekly doses of 400 mg chloroquin till 5 weeks after delivery. Then they are treated with primaquin. Infants are given 5 mg/kg.bw. of chloroquin till they become one year of age. Then they are given primaquine.

a. In the case of *P. falciparum*, Chloroquine has no action against gametocytes. Primaquine has such action and therefore it is given along with chloroquine to radically cure *P. falciparum* infection.

c. Radical treatment of Chloroquine resistant[2] Falciparum malaria: Long acting sulpha with pyrimethamine is given. In cases of resistance to these drugs and in severe and complicated Falciparum malaria I.V. Quinine is given. For details see management of severe malaria.

Day	Medicine	Patient's age group				
		< 1 year	1-4 yr.	5-8 yr.	9-14 yr.	15 + yr.
Day-1	Sulfalene / Sulfadoxine	125 mg	500 mg	750 mg	1000mg	1500mg
	Pyrimethamine	6.25 mg	6.25 mg	37.5 mg	50 mg	75 mg
Day-2	Primaquin[1].	Nil	12.5 mg	15 mg	30 mg	45 mg

Note: Pregnant women and infants are not be given Primaquine. Primaquin is given a day after the long acting sulfa drugs, to minimise the risk of haemolytic crisis in G6PD deficient persons.

6. Management of associated signs and symptoms and general supportive treatment:

i. Fever: Tepid sponging to bring fever down. Continue sponging till fever comes down to less than 101 degree Fahrenheit. If air-conditioned room is available, it should be preferred. In case of very high fever, the patient may be covered with bed sheets soaked in water and put under a fan till the temperature is brought down to less than 101 degrees Fahrenheit.

ii. Convulsions: Infants and young children may develop convulsions. If convulsions develop, give diazepam intra muscular or intravenous, dose = 0.15 mg / kg of body weight. Continue diazepam at 8 hour intervals till convulsions are controlled.

iii. Disorientation: Young children may be disoriented as a result of high fever. Bring down fever by sponging.

2Note that information on chloroquin resistance keeps on changing. The latest information can be obtained from the District Malaria Officer or the District Medical and Health Officer.

iv. *Dehydration: Closely monitor fluid intake and output. Monitor urine output. Dehydration should be treated with intravenous fluids. Too much fluid can also cause pulmonary congestion. Hence guard against overloading of fluids. Strict accounting of intake and output helps in this.*

v. *Anaemia: Malaria causes destruction of RBCs. Many malaria patients are usually anaemic to start with. Hence, give oral preparations of iron and folic acid. Monitor blood haemoglobin levels and consider blood transfusion, if haemoglobin level falls below 7 gm / 100 ml.*

7. Malaria in pregnancy:

Malaria in pregnant women is very serious leading to abortion and maternal death. Proper care should be taken during the period of pregnancy. Following steps should be taken:

a. Change of place. If possible, the expectant mother may be shifted from malarious area to non-malarious area till delivery.

b. Personal protection : Since biting time of all the vector mosquitoes starts just after the dusk and ends at dawn, it is advisable that the pregnant women should not move out of the house during this period. Use of bed nets preferably impregnated with insecticides is strongly recommended. In forest and forest fringe malarious areas pregnant women should avoid going to the forest for wood collection. Vector like *An. fluviatilis* in deep forest where sunlight is less may even bite during day time.

c. Chemoprophylaxis : See the treatment chapter

d. Therapeutic Treatment : See the treatment chapter.

8. Malaria in Infants and Children:

Infants below the age of 3 months are generally protected from malarial infection due to passive maternal acquired immunity. However, malaria in infants and children below the age of 9 are highly vulnerable and need special attention.

i. *Parents should take immediate attention in the event of sudden episode of fever.*

ii. *Protect them from mosquito bite using mosquito nets. Specially designed mosquito nets for infants are available in the market.*

iii. *Provide immediate steps for treating them from the nearby health facility. In serious cases hospitalisation is utmost necessary.*

iv. *Treating practitioner immediately start treatment as per the national drug policy mentioned in this manual.*

9. Special guidelines for practitioners catering to patients from tribal areas:

In most of the tribal areas malaria is presented in endemic form resulting from near persistent transmission in the area. In such areas asymptomatic malaria cases are very high to the tune of around 20 %. Most of the tribal areas are remotely located and thus inaccessible. This results in non-existence of health delivery system in such areas. Moreover, self health seeking is very poor due to various socio-ethno-cultural and traditional problems. It has been observed that most of the tribal population use their own traditional system of treatment and belief and thus leads to slow death. The use of traditional medicines is not

always curative for which more investigations are required. In tribal areas, it is important for all the practitioners to follow the following steps:

i. *Treat any suspected or frank fever case as malaria.*
ii. *Spleno-hepatomegaly is very common in these areas specially in children. This is an important clinical parameter for detecting malaria cases.*
iii. *Follow national drug policy as mentioned in the treatment chapter.*
iv. *Guide the local people to protect and keep away from mosquito bites. These methods have been mentioned in the respective chapter of this manual.*

10. Special guidelines for practitioners catering to patients from urban slums:

Most of the urban slums are semi-permanent type of tropical aggregations. In such areas, people are clustered from different sectors and parts of the country in connection with developmental activity in the urban sectors. This includes people from hard core malarious areas. This becomes the initial trigger of the malaria transmission. The urban malaria vector *An. stephensi* exclusively breeds in overhead tanks, wells, fountains, cisterns, cemented tanks. The practitioners should do the following:

i. *Take proper case history of the patients. Try to find out the origin of the people. If the patients come from malarious areas initially diagnose clinically and confirm subsequently by pathological diagnosis.*
ii. *Treat the patient as per the national drug policy mentioned in this manual.*
iii. *In severe and complicated cases, do not hesitate to send the patient immediately to nearest hospital.*
iv. *Must report the cases to the nearest health department for proper anti-vector measures.*
v. *Promote health awareness among the slum dwellers.*

11. Special guidelines for practitioners catering to migrant labour and floating populations:

Since these population are of temporary habitat nature, it is difficult to find out the source of infection. The patients might have picked up the infection locally or carried from their place of origin. But malaria should be suspected in all cases of fever among migrant labourers.

D. Severe malaria:

Severe malaria is caused by *P. falciparum* infection and usually occurs as a result of delay in treating an uncomplicated attack of falciparum malaria. Some times, especially in children, severe malaria may develop very rapidly. Recognising and prompt treatment of uncomplicated falciparum malaria is of vital importance.

P. falciparum (Malignant): **Most of the cases may present similar to *P. vivax* or other malaria cases, but in some cases it may lead to complications such as:**

Hyperthermia.
Severe anaemia resulting in hypoxia.
Hypoglycaemia.
Dehydration.

Pulmonary oedema.
Cerebral malaria
Shock-general collapse-algid malaria.
Gastro-intestinal manifestations.
Acute renal failure (ARF)
Haemolytic jaundice leading to liver damage.
Petechial haemorrhages. Mostly due to pathological change in RBC and blockage of internal capillaries.

CEREBRAL MALARIA:

SIGNS AND SYMPTOMS:

Fever	*- Hyperpyrexia, hypothermia in terminal stages.*
Eyes	*- Open staring or disconjugate movements, photophobia.*
Retinal changes	*- Occasional retinal haemorrhage.*
Kidney	*- Anuria, oliguria.*
Lungs	*- Basal congestion, stertorous breathing, oedema.*
Neck rigidity	*- Not present.*
Intracranial pressure	*- Usually not raised.*
CSF	*- clear.*
Reflexes	*- Abdominal absent, plantar-extensor.*
Circulatory	*- Petechial haemorrhages or intra vascular clotting.*
CNS	*- Deep coma, mental aberration, delerium, convulsions or localised twitching of muscles, transient peresis.*

DIFFERENTIAL DIAGNOSIS: CEREBRAL MALARIA

Common features	*- Patient with hyperpyrexia suddenly goes into coma.*
Heat stroke	*- Occurs during summer, exposure to heat, absence of sweating.*
Meningitis	*- Gradual onset, neck rigidity, CSF changes.*
Viral encephalitis	*- epidemic of cases.* *- Several cases with similar history.* *- Neck rigidity.* *- Typical headache.* *- Post-monsoon season.*
Cerebro vascular episodes	*- Sudden origin.* *- CSF changes.* *- Higher age group.* *- Characteristic history.*
Hypertensive encephalopathy	*- History of long standing hypertension.*
Encephalitis	*- Onset sudden.* *- CSF changes.*

Hypo or hyperglycemic coma	*- History of diabetes.*
Uremic and hepatic coma	*- History of chronic kidney disease.*
Exclude	*- Epilepsy, typhoid encephalopathy, brain abscess, narcotic poisoning, Cough and acute respiratory infections, cold with running nose, Skin rash suggestive of eruptive Illness, Burning micturation, Skin infections such as, boils, abscess, infected wounds, painful swelling of joints, ear discharge.*

Differences in clinical picture of malaria in adults and children

Signs and symptoms	Adults	Children
Cough	Uncommon	Common
Convulsions	Common in cerebral involvement of hypoglycaemia	Most common in cerebral involvement or hypoglycaemia, usually non-specific
Duration of symptoms before features of severity develop	Commonly several days 4-5 days	Usually during the first few days
Jaundice	Common	Uncommon
Resolution of coma after start of treatment	Usually 2-4 days	Usually 1-2 days
Hypoglycaemia	Uncommon usually, Quinine induced, more often in pregnancy.	Common, usually pre-treatment.
Pulmonary oedema	Common	Rare
Renal failure	Common	Rare
Neurological sequelae	Uncommon	Occur in about 10% of cases
CSF pressure	Normal	Variable
CSF changes	Normal	Normal

Errors in diagnosis can occur if there is failure to examine blood film, or improper microscopic diagnoses. Anaemia is very common with *P. falciparum* malaria due to destruction of RBCs. It is normocytic, hypo/normochromic type, with haematocrit-20% or less, Hb-7 gm or less.

E. General rules of antimalarial therapy:

i. *Most antimalarials are absorbed from the gut rapidly. Oral administration of antimalarials should be preferred in all cases who can swallow and retain antimalarial compounds.*

ii. *Intravenous antimalarials like Quinine or Armetisinin should be used in comatose patients or patients who cannot retain antimalarials administered orally, usually due to gastrointestinal irritation and vomit out.*

iii. *Chloroquine is the drug of choice for treatment of P.vivax, P.malarie and P. falciparum malaria parasites. Only if resistance to chloroquin is suspected other antimalarials should be used.*

F. Some general remarks about antimalarials

i. *Quinine in dosages prescribed for treatment of malaria does not induce abortion or miscarriage in pregnant women. Risk of abortion is higher in untreated cases.*

ii. *Chloroquine resistant cases allergic to sulfa drugs are to be treated with quinine or a combination of quinine and tetracycline.*

iii. *Long acting sulfa and pyrimethamine combination has very little effect on P. vivax and will not give clinical relief in such cases. These are drug of choice for oral administration in case of chloroquine resistant falciparum infection. Note that prolonged administration of long acting sulfa combination can produce Stevens-Johnson syndrome, agranulocytosis, aplastic anaemia. These drugs are not suitable for prolonged suppressive treatment. Their dosage should be followed strictly. They should be given to infants and pregnant women with caution. There is higher risk of death on account of prolonged use of sulfa combination as suppressive / prophylactic than that with P. falciparum infection provided the case is detected and treated in time.*

iv. *Chloroquine, primaquine or pyrimethamine should never be given on empty stomach.*

v. *Patients having gastrointestinal upset or those who cannot take or retain oral drugs should be given parenteral antimalarials, even if they are conscious.*

vi. *During administration of primaquine, look for acute toxicity - cyanosis, smoky urine. If present, stop the drug, observe the case and if required, transfer the case to a hospital.*

G. Glossary of antimalarial drugs

1. Chloroquine:

i. *It is a 4-aminoquinoline which has marked and rapid schizonticidal activity against infections of all species of the parasite. it also has gametocytocidal action against P. vivax*

ii. *The dose is 25mg/kg body weight given over three days.When used for chemoprophylaxis, 5mg/kg weekly is the dose. No abortifacient or teratogenic effect has been reported with use of Chloroquine. Therefore it is very safe in pregnancy either in treatment or prophylaxis. It is very efficiently absorbed after oral use. Therapeutic concentration in plasma is reached within 30 minutes. It has a*

elimination half life of about 10 days. Transient nausea and other gastro-intestinal symptoms may be seen. Pruritus may be seen in dark skinned people. Blurred vision may be seen temporarily.

iii. Chloroquine has a low margin of safety specially In children. Acute poisoning is very dangerous. Death may result with a single dose of 1.5 to 2 gm even in adults. Symptoms may include headache, nausea, diarrhoea, dizziness, muscular weakness and blurred vision which may be dramatic with loss of vision. Cardiovascular toxicity with hypotension and cardiac arrhythmias may be progressing on to collapse. Treatment is only symptomatic.

2. Primaquine:

i. It is an 8-aminoquinoline, highly active against gametocytes of all human malaria species and hypnozites of P.vivax. Primaquine is readily absorbed when taken orally. It has a plasma half life of about 5 hours.

ii. The adverse effects include haemolysis, specially in those with G-6-PD deficiency. Similarly haemolysis occurs in the RBCs with foetal haemoglobin. Therefore it should not be used in infants, because they may have foetal Hb for varying period. Because it can cross placental barrier and cause haemolysis in the foetus, It should not be used in pregnancy. Primaquine may cause methaemoglobinaemia or suppression of myeloid activity. Folinic acid may be used as an antidote.

iii. The MPHWs must be told to ask the malaria positive cases whether they have dark coloured urine and look for cyanosis when they are being administered radical treatment.

3. Quinine:

i. Quinine is the drug of choice in severe and complicated cases of P. falciparum, specially cerebral malaria. It should be given intravenously by slow infusion in isotonic fluid /5% dextrose saline over 8 hours. The dose is 10 mg/kg maximum of three times a day. It can cause severe hypotension, if injected rapidly because of its cardiovascular suppressant activity. It can also cause hypoglycemia as it stimulates secretion of insulin from pancreatic beta cells.

ii. It is safe in pregnancy. Oral formulations are available but should be reserved for use in multi-drug resistant P. falciparum. It can also cause cinchonism with tinnitus, muffled hearing, vertigo or dizziness.

4. Sulfa / Pyrimethamine drug combinations:

i. Tablets containing 500 mg of sulfadoxine / sulfalene and 25 mg of pyrimethamine are available. They are highly active against blood schizonts of P. falciparum but less effective against P. vivax. They should be restricted for use against Chloroquine resistant P. falciparum infection which is not complicated. They are active in a single dose of three tablets. They are not to be used in pregnancy and lactation and so also in young infants. Adverse effects include hypersensitivity involving skin and mucous membrane (Stevens-Johnson syndrome).

5. Mefloquine:

i. It is a 4-quinoline methanol chemically related to quinine. It is a potent long acting blood schizonticide active against all species of plasmodia. However development o f resistance is quite fast. It is not marketed in India but imported formulations are available as 250 mg tablets. The dosage is 15 mg/kg bw i.e. 3 tablets in an adult in a single dose. It is not safe in pregnancy. Adverse effects are frequent-dizziness, nausea, vomiting, diarrhea and abdominal pain. Neuro -psychiatric adverse reactions and cardiovascular effects (bradycardia and sinus arrhythmia) can also occur.

6. Artemisinin and its derivatives:

i. Artemisinin, Artesunate and Artemether are available. They are active against both P. vivax and P. falciparum. However, their use is to be restricted to Chloroquine resistant P. falciparum case with complications such as cerebral malaria where quinine can not be used. Artesunate is available as injections containing 60 mg. Four injections at 0, 4, 24, and 48 hours are to be given.

VIII. Control of mosquito vector

A. Environmental control:

The key idea of environmental control is to manage the environment around human habitations and urban areas as to reduce the source of mosquito breeding and reduce human-vector contact. The term 'source reduction' refers to any measure that will prevent or eliminate the breeding of mosquitoes in their natural or man-made habitats. Environmental modifications do not happen in short notice nor can they be effected during the ordinary course of public health work. Engineers, architects and planners working on various construction projects and maintenance operations can make long lasting contributions towards a healthy environment. Public health officials can help the process by reminding the concerned engineers, project authorities and municipal service providers of the possible effect of various works on breeding of mosquitoes. Following are some examples of engineering activities that can reduce mosquito breeding sources.

i. *Proper preparation of reservoir site, clearance of trees and vegetation between high and low water levels. Provisions for fluctuating water levels. Appropriate marginal drainage to avoid pool along the margins. Maintenance of shoreline, vegetation control and drift removal.*

ii. *Filling of small holes, abandoned ditches, borrow pits and similar water pockets. Sanitary land fills using refuse disposal, demolition, mining etc.*

iii. *Drainage: Removal of unwanted water from the land surface or below it. This has a marked effect in reducing the breeding of mosquitoes.*

   a. Surface drainage: It involves the shaping of land surface, the improvement of natural water courses and the construction of open ditches. Drains should be as few and short as possible with proper gradient.

   b. Subsoil drains: They prevent water logging and improve aeration and leaching. It has been claimed that subsoil drainage is self-cleaning, permits a rapid inspection, and requires no oiling. Coastal swamp drains: Some coastal swamps may be drained by constructing embankments (bunds) to prevent the inflow of sea water at high tides; fitting large pipes into the bunds with automatic outflow gates allows the removal of water from the lagoon into sea.

   c. Water sources in rural areas with potential for breeding: Principal breeding sites in rural areas include water management systems, storage tanks, transmission lines, public stand posts, rain water collections, irrigated fields, canals and domestic storage facilities such as underground / overhead tanks, water containers, ornamental tanks, fountains, water pools, curing tanks, flower pots, building tanks and wells. Jet water irrigation in tanks and cisterns, mosquito proof nets to reservoirs, de-watering of water containers, flower pots once in a week. Expanded polysystymic beads (EPS) in disused wells are very effective.

   d. Urban areas: Faulty design, poor construction and inadequate maintenance increases mosquitogenic potential in urban water management systems. Sullage, sewage, storm water, rain water collection, wells, overhead tanks, disused articles, roof gutters, tanks and ornamental tanks are the prominent breeding sources in

urban areas. Environmental management resources to be incorporated for mosquito control in drainage system are.

a. Use of underground conduits, instead of open drains as for as possible.
b. Lining of drains and open ditches.
c. Good alignment of drains and avoidance of sharp curves.
d. Flushing of drains, canals and out fall streams.
e. Maintenance of adequate self-cleaning facility by avoiding undue deposition and silt.
f. Effective collection and disposal of domestic sullage water.
g. Effective collection and disposal of solid waste.
h. Proper maintenance of open drains and underground sewages.

In addition certain environmental manipulation can produce temporary conditions unfavourable to breeding of vectors in their habitats. Changing water levels, streamlining and flushing, change of salinity, cleaning, shading, vegetation removal etc. are the examples of environmental manipulation activities.

A detailed geographical reconnaissance should be undertaken in the PHC area, starting from the high risk areas. A survey of all the breeding places of vector (anophelines) in and around the villages and habitations has to be taken up. Identify appropriate authorities who can intervene to effect necessary environmental modifications and help reduce mosquito breeding sites in the PHC area and write to them. Stay prepared with the list of such environmental modification needs and use them to draw attention of various authorities during inter-departmental co-ordination meetings. Table-8.1 gives an overview of bio-environmental control of mosquitoes and departments who may be involved in environmental modification measures.

Bioenvironmental control of mosquito breeding

Breeding site	Remedial Measures	Sector Involved
Tank	Larvivorous fish introduction. De-weeding and shore line maintenance with proper sloping	Fisheries, Health Village Panchayat
Seepage	Subsoil drainage / canalization to nearest stream, or Application of bio-larvicide, or Plantation in marshy areas	Irrigation, Health, Forest
Stream	Canalization through minor engineering methods, or Application of bio-larvicide, or Introduction of larvivorus fish in perennial bed pools, or De-weeding and regular maintenance of margins	Irrigation, Health, Fisheries, Gram Panchayat
Used Well	Larvivorous fish introduction	Fisheries, Health
Unused Well	To be sealed hermetically, or Introduction of EPS beads	Gram Panchayat & community
Irrigation Channel	De-weeding and regular maintenance	Irrigation Gram Panchayat
Borrow Pit	Source reduction by filling , or Introduction of larvivorus fish	Gram Panchayat & community
Irrigation Pit	Introduction of larvivorus fish and regular maintenance	Community
Paddy Field	Intermittent irrigation, or Introduction of larvivorus fish	Community Irrigation

B. Biological control of mosquitoes by larvivorous fish:

Among all the biological methods of mosquito control, use of larvivorous fish has been the most useful and successful. Two types of fishes namely *Gambusia* and Guppy. A larvivorous fish species for control of mosquito larvae should ideally be surface feeding and carnivorous in nature since mosquito larvae also stay on the surface. The fish should be agile and hardy to survive in water bodies where the mosquito larvae are found. Other desirable characteristics include; (a) small size, so that the fish can move to the margins of the water surface, (b) high reproductive capacity and rapid maturity, (c) high degree of tolerance to salinity and pollution, (d) be difficult to catch and be able to escape from natural enemies, (e) not have any commercial value, and (f) can withstand transport and handling. Keeping these requirements in mind, Guppy *(Poecilia reticulata)* and Gambusia *(Gambusia affinis)* are extensively used in the malaria control programme. Guppy should be used only in wells and other confined water bodies. Gambusia should be used in large water bodies. A limitation is that these fishes cannot move freely in water bodies having high vegetation.

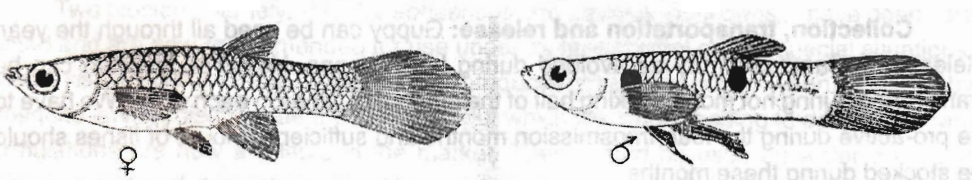
Gambusia affinis: Generally called 'Mosquito Fish'. A native of south-eastern United States, eastern Mexico and Caribbean Island. Dr. B.A Rao imported it to India from Italy in 1928. Subsequently, this fish was transported to many parts of India for malaria control.

Gambusia (*Gambusia affinis*) fish female and male

Source: Indigenous Larvivorous Fishes of India by Menon A.G.K., 1991; Malaria Research Centre, ICMR, New Delhi, 110054, India

Body of *Gambusia* is cylindrical and compressed. Males are smaller at 3.5 cm (1.5 inches), and females are about 6 cm (2.5 inches). Both sexes are uniformly grey-green or grey-brown in colour. Females attain sexual maturity in 90 to 100 days, when gravid, it has a black area in front of the anal fin. Prolific breeder, internal fertilisation, viviparous. Gives birth to 35 - 80 young ones in every 10 weeks after a gestation period of 7-15 days. Breeds atleast thrice in a year. These fish are tolerant to salinity and resistant to organic pollution. Preferred temperature is between 10-35 °C but can withstand freezing temperature. This fish should be used only in large water bodies like tanks and lakes.

Guppy fish (*Lebistes reticulatas*) female and male



Source: Indigenous Larvivorous Fishes of India by Menon A.G.K., 1991; Malaria Research Centre, ICMR, New Delhi, 110054, India

Guppy (*Poecilia reticulata*) Native of Netherlands, West Indies and from western Venezuela to Guyana. Major Selby imported this to India from London in 1908. Males brightly coloured. Size : Female - 4 cm; Male - 2 cm. This species cannot tolerate temperature <10° C; ideal temperature 22-24° C. This is also viviparous, prolific breeder, give birth to hundreds of fries and breeds four times in a year. Can tolerate pollution better than Gambusia and reported to be well established in sludge water and other habitats. This fish is best for controlling mosquitoes in confined water ecosystem like wells, fountains, cisterns, over head tanks, underground tanks.

Differentiation of Guppy and Gambusia fish.

Characters	Guppy	Gambusia
Size	Generally smaller	Generally bigger
Colour	Males: beautifully coloured. Females: usually colourless	Both sexes are uniformly grey-green or grey-brown
Tail fin	Male: irregular, elliptical, highly coloured. Female: slightly semicircular. No black lines.	Regular semicircular in both sexes. Black spots present on the tail fin in semicircular fashion.
Dorsal and anal fins in females	Both the fins are present on the same transverse line	The fins are not present on the same transverse line. Dorsal fin is located nearer to the caudal fin.

These fishes can be cultured in small manageable permanent tanks (100-500 square metres). There is no need of making new hatchery. Naturally available tanks or big wells may be used for hatcheries. Since both these fishes are prolific breeders, 500 to 1000 fishes are sufficient for initial culture. It is advisable that at least one good hatchery be maintained in each sub-centre of a Primary Health Centre. It is necessary to put inorganic manure and organic manure for better production and growth of fishes in the hatcheries. Generally for edible fish culture, a dose of 1000 kg of cattle dung manure or about 560 gm to 1.21 kg per hectare of poultry manure is used once in a month. Two kilograms of commercially available NPK can be applied once in a week. Later on, it is necessary to apply once in a month or when the water becomes clear. Supplementary feeding may also be provided with the following fish feed consisting of equal parts of groundnut cake, rice bran, and wheat flour. Mix and blend the items thoroughly. Put water three times the quantity of the mixture, so that a liquid suspension is formed. The feed may be supplemented once in a week. Commercially available breads have also been suitable for food supplement.

Collection, transportation and release: Guppy can be used all through the year. Release of *Gambusia* may be avoided during hot seasons. However, this fish can be transported during hot months taking half of the amount of fishes in each drum. We have to be pro-active during the lean transmission months and sufficient amount of fishes should be stocked during these months.

Following materials are required for collection, transportation and release of fishes.

(i). Drag net - Nylon mosquito net of 16 mesh per cm^2 - 4 m in length and 1 m width. (ii). Ring net - Iron ring of 38-40 cm diameter with 150 cm long iron handle. In this ring, a 'U' shaped nylon mosquito net measuring 40 cm diameter and 50 cm long is fitted. The two ends of the iron ring is fixed at the base with an adjustable nut with bolt in such a way that the round mosquito net can be inserted or removed as and when required. For small quantity of fish` U' net is used to catch fish. (iii). Plastic drums - 100 lt capacity are required for transportation of fish from mother stock to the villages. (iv). Plastic buckets - 10 lt capacity are required for transportation of fish from plastic drum to different mosquito breeding sites in the villages. (v). Strainers: Big - 22 cm diameter. Small - 12 cm diameter. (vi) Rope - 15 m long.

Fishes are collected using drag net by two persons and another person to collect the fishes from the net with the help of a big strainer. Generally these fishes are available at the margins. After removing the debris, the fishes are stocked in plastic drums having approximately 50 lt water. In short distances, approximately 1000-1200 fishes are transported in each drum to avoid overcrowding and mortality. Fishes coming on the surface water in the drum is indicator for overcrowding. Drums containing the fishes are transported to the villages. Proper care should be taken to avoid jerks and aquatic weeds or strainers should be kept in the drum to avoid spilling of water during transportation. The fishes are transferred to small buckets using strainer from the drum and introduced in the breeding habitats at the rate of 2-3 fish/m^2. In this way, about 100-150 fishes are released in each well by dropping them from the top with the help of a small strainer. In tanks approximately 1000-3000 fishes (*Gambusia*) may be released depending on the size of the tank. Guppy can withstand long transportation period while Gambusia is delicate than Guppy. Accordingly, *Gambusia* should be released immediately after transportation.

Transportation of fishes for more than 5 to 6 hours, need special arrangements and care. Closed plastic/polythene bags with sufficient amount of oxygen are used for long distance transportation. Prior to packing, the fishes are kept in small hatchery for conditioning and defecation for 24 hours. Polythene bags (74 cm x 46 cm) are half-filled with water and about 500 fishes are kept. The bags are filled with sufficient amount of oxygen and tied tightly with jute rope and kept in tin canister. The canisters should be transported immediately to the respective destination. In this way, the fishes can survive for 24 - 30 hours. The polythene bags should be kept for 15 - 30 minutes before finally releasing in the new hatchery.

1. Biocides:

Two biocides namely, *Bacillus sphaericus* and *Bacillus thuringensis* have been field tested and are now recommended for use under malaria control only in special situations. These kill mosquito larvae. The bacteria produces crystalline toxin, when ingested by mosquito larvae, disintegrate the mosquito gut which ultimately leading to death. Different formulations are now available in the market. They should be used on water bodies in domestic and peri-domestic areas. However, the bioicides, being new larvicides, should not be used for larval control in potable water i.e. drinking water collections / supply lines.

Preparation of Biocide suspension: After weighing 500 gms of *B. sphaericus* or 250 gms of *B. thuringiensis* powder and measuring ten litres of potable water, the suspension should be prepared in two stages as given below. First a thin paste of biocide is prepared by adding a small quantity of water from the already measured water to 250 gms of *B. thuringiensis* or 500 gms of *B. sphaericus* powder. Then the thick paste is diluted with the remaining part of potable water and constantly stirred to obtain homogenous suspension. This gives 2.5% suspension of *B. thuringiensis* or 5% suspension of *B. sphaericus*.

Application: The suspension is sprayed @ one litre over 50 sq. metres or linear metres (20 c.c. per sq. metre or 200 litres per hectare water surface) using knapsack sprayers. Frequency of spraying is once in two weeks for *B. thuringiensis* and once in three weeks for *B. sphaericus*.

C. Chemical control of vector mosquitoes

The advantage of biological vector control measures is that they are sustainable over long periods and do not have any adverse ecosystem effect nor any adverse economic implication. One disadvantage is that, these measures take longer duration to build up and hence have a delayed effect. For example, gambusia or guppy fish will take time to establish in the targeted water bodies. Sometimes, the fish may be washed away entirely due to heavy rains. Despite biological control measures, mosquito population in an area and its vectorial capacity may increase due to various reasons. Unless the vector population and its vectorial capacity is controlled within an short time, malaria transmission may assume hyperendemic levels. Chemical insecticides are useful in such situations for selective vector control. One of three insecticide compounds can be used, namely (a) DDT (organochloride), (b) Malathion (organophospate), and (c) synthetic pyrethroids. Choice of insecticide is based on susceptibility status of the mosquito vector in the area, cost of insecticide, and other economic effects of the insecticide. Insectcidal spray is targeted on human dwellings so that residual insecticide inside the dwellings would kill resting mosquitoes and thereby decrease the probability of man mosquito contact. The female anopheles mosquito, which bites a person, rests on the wall door or any secluded surface. The insecticide which is applied to such surfaces will get absorbed by the mosquito and will kill it or reduce it's longetivity considerably. Such effect lasts for a period of two and half months in case of DDT and about one and half months in case of malathion.

Insecticidal spray should be taken up before onset of transmission season, in (a) high risk sub centre areas, and (b) those with API 2 or above. Priority of spray will be given to 'High Risk" areas. Refer to chapter IV for details of criteria for identification of high risk areas.

i. Requirement of insecticides: Having selected the population for spray, the insecticide requirement is calculated as under. The insecticide parameters are given @ per million population per annum. For smaller population, calculate proportionately.

a. DDT 50% wp @ 150 MT (per million population) for two rounds of spray. In areas where third / special round is proposed in selected villages, give additional requirement @ 75 MT per million for population of those villages only.

b. Malathion 25% wp @ 900 MT (per million Population) for three rounds of spray. If in some areas a further round is required in selected villages, calculate @ 300 MT per million for the special round for the selected villages only.

c. Synthetic Pyrethroids:

1) Deltamethrin 2.5% wp @ 60 MT (per million population) for two rounds of spray. In areas where third/special round is proposed in selected villages, give additional requirement @ 30 Mt per million for population of selected villages only.

2) Cyfluthrin 10% wp @ 18.75 MT (per million population) for two rounds of spray (Special round @ 9.38 MT as above).

3) Lambdacyhalothrin 10% wp @ 18.75 MT (per million population) for two rounds of spray (Special round @ 9.38 MT as above).

iii. Safe handling and storage of insecticides:

a. Precautions for handling of Organo-phosphorus Compounds

b. While using organo-phosphorus (Malathion) compounds, it is necessary to use protective clothing.

c. While making suspension - Use rubber gloves so that skin of hands does not come in direct contact with insecticide.

d. The cholinesterase level of all spray men employed in spraying of malathion should be monitored regularly at the recommended intervals and those showing a drop in cholinesterase level should be given rest and suitable medical care. For estimation of cholinesterase level , standard technique recommended by WHO should be used.

e. Avoid contamination of cooked food or food material.

iii. Precautions for handling of Synthetic Pyrethroids:

a. Use protective clothing.

b. The exposed skin, hands, face and eyes should not come in direct contact with the insecticide.

c. In case of accidental contamination, wash liberally with soap and water.

d. Avoid contamination of cooked food or food material.

iv. Storage of insecticides:

a. The FTDs or Voluntary Link Workers in their headquarters should be selected and are made responsible for safe storage of insecticide.

b. Select and earmark insecticide dumping stations well in advance in each PHC, keeping in mind the communication facilities during rainy season.

c. Indicate the quantity of insecticide to be stored in each dumping station.

d. Fix the date by which the insecticide will be placed in the dumping station.

e. Ensure proper safety of insecticide at the dumping station and also take steps to prevent any health or environmental hazard due to insecticide while storing at the dumping station.

f. Make sure that full quantity of insecticide required for all rounds of spray (2 or 3 rounds as the case may be) is transported to the dumping stations with adequate safety precautions.

g. Store the insecticide away from the food, children and animals. Keep the insecticide preferably in enclosed and locked location.

h. Ensure that the containers are properly labelled.

i. Empty containers should be destroyed so that they are not used for storing food materials or for other household purposes.

v. Advance spray programme

a. Prepare a habitation-wise advance spray programme for each round of spray showing date of spray, population, number of houses and rooms to be sprayed, quantity of insecticide required and number of spray squads to be deployed.

b. Quantity required for spraying a house of 150 sq. meters is given below:

Insecticide	Qty
DDT 50% wp	300 gm.
Malathion 25% wp	1200 gms.
Deltamethrin 2.5% wp	120 gms.
Cyfluthrin 10% wp	37.5 gms.
Lambdacyhalothrin 10% wp	37.5 gms.

c. The nozzle tip, preferably of stainless-steel, should be flat fan type and the discharge rate should be between 740 cc and 800 cc per minute. The nozzle tip should be discarded if the discharge rate exceeds 850 cc per minute. It takes about 5 minutes to spray a house with an average sprayable surface area of 150 sq. meters. The spray lance should be kept 45 cm away from the wall surface and the swaths should be parallel overlapping one-third area of the preceeding swath.

d. Seasonal spray staff:

1) One Trained Field Worker. He will supervise the spray and keep records.
2) Each spray squad comprises of:
3) Five field workers (unskilled): One pump man, one spray man for each stirrup pump and one for bringing water to prepare suspension for two pumps.
4) Each spray squad can cover 60-80 houses a day (i.e. 30-40 houses per pump).
5) In hills / foot hills a squad can cover 50 to 60 houses per day (i.e. 25 to 30 houses per pump).

e. **No. of spray squads required to cover the area:**

f. $\frac{\text{Dwellings in the village targeted}}{60}$ = No. of spray squads.

g. Equipment for one squad

ITEM	QUANTITY
Stirrup pumps	Two
Spare nozzle tips for spray pump	One
Bucket 15 lit.	Four
Bucket 5/10 lit.	One
Asbestos thread	Three metres
Pump washers	Two
Measuring mug	One
Straining cloth	One metre
Plastic sheet (3x3 mtr)	One
Soap	One

h. The MPHW (Male) or supervisor of the camp should have extra spray pumps, nozzle tips, washers, asbestos threads, wire and set of tools for minor repair of pumps. It should contain a pipe wrench, pliers, screwdrivers and a set of spanners.The pump repair tool set should be with squad supervisor.

IX. Recommendations of the Expert Committee on communicable diseases - Govt. of AP

The government of Andhra Pradesh has constituted Expert Committees for study of Malaria, Japanese Encephalitis, Dengue fever and Gastroenteritis. The meeting of the expert committee was held at Committee Hall of Directorate of Health, Office of Director of Health Services, Sultan Bazar, Hyderabad on 5th March 2001. Following are the recommendations:

i. *The committee felt that there is need for strengthening the existing surveillance system to make it more systematic, sensitive and functional, with built in feed back system and user friendly for identified communicable diseases. Setting up a network of public health laboratories with strong Microbiology and Epidemiology components.*

ii. *Strengthen IEC programmes, identify role of NGOs and community for training, rehabilitation, for provision of safe water - linking appropriate actions for better resource mobilization (e.g.Zilla Parishad for vector control measures, IEC, chlorination etc. by Panchayat).*

iii. *Monitoring, surveillance and control of malaria, which is critical for mounting effective control measures. The present system of having zonal teams needs improvement and strengthening. In view of the increasing threat of prevalent vector borne disease, it would be better to have district level teams, which would be responsible for monitoring breeding sites, vector species, employing eco-friendly measures and involving community as well as schools and colleges in control activities.*

iv. *Entomological surveillance for vector species, density and infectivity rate.*

v. *Establishing threshold values for various vector parameters at appropriate levels for constant monitoring and initiating adequate actions (like linking vector density with insecticidal spray).*

vi. *Restrict fogging for only epidemic control measures with built-in mechanism for evaluating its impact (with test mosquitoes).*

vii. *There is an urgent need to have MPW(M) posts filled up as per norms in high-risk areas like tribal populations. MPW(M) could be considered for use as unipurpose worker (malaria and other vector-borne diseases).*

viii. *Better understanding of vector, food and water borne diseases and for interaction between different sectors of the society and concerted efforts by all the concerned departments.*

ix. *Conducting short duration training course for private practitioners on management of malaria, so that they are convinced for the need to provide effective treatment to all malaria cases.*

x. *Central assistance for malaria control could be in the form of fund, than material supply, so that a local need based decision could be taken for appropriate utilization.*

xi. *The State Government's allocations should also be need based.*

xii. *Local administration funds allocations may be used for vector control activities by actual agreement.*

xiii. *Additional resources for malaria control should be mobilized from other sources like industry for local use.*

The expert committee members can also visit the problematic districts and interact with programme officials and community at large.

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Abbreviations

A.a.	Anopheles annularis
ABER	Annual Blood Examination Rate
A.c.	Anopheles culicifacies
ADC	Adult Doses of Chloroquine
ADC	Anti Malarial Drug Consumption
A.f.	Anopheles fluviatilis
AFI	Annual Falciparum Incidence
AP	Andhra Pradesh
API	Annual Parasite Incidence
ARF	Acute Renal Failure
B.Sc.	Bachelor of Science
cc	Cubic Centimetre
CHAI	Catholic Health Association of India
cm	Centimetre
CNS	Central Nervous System
CPR	Child Parasite Rate
CSF	Cerebrospinal Fluid
DDCs	Drug Distribution Centres
DDT	Dichloro Diphenyl Trichloroethane
DEPA	Di-ethyl Phenyl Acetamide
DEET	N, N, diethyl-m-toulamide
DL	Deltamethrin
DMP	Dimethyl Pthalate
Dte	Directorate
EPS	Expanded Polysystymic Beads
FTDs	Fever Treatment Depots
G6PD	Glucose -6-Phosphate Dehydrogenase
Hb	Haemoglobin
HIV	Human Immunodeficiency Virus
HM&FW	Health Medical & Family Welfare
HRP	Histidine Rich Protein
ICMR	Indian Council of Medical Research
IEC	Information Education & Communication
IIPS	International Institute of Population Studies
IPR	Infant Parasite Rate
IV	Intra Venous
Kg	Kilogram
LT	Larval Test
LT50	Lethal Time to kill 50% of Vector Population
Mal	Malathion

MAP	Malaria Action Programme
MBER	Monthly Blood Examination Rate
mgs	Milligrams
ml	Millilitre
MMP	Malaria Mortality Percentage
MPHW	Multi Purpose Health Workers
MPO	Modified Plan of Operation
MPW(F)	Multi Purpose Worker (Female)
MPW(M)	Multi Purpose Worker (Male)
M.Sc.	Master of Science
μl	Micro Litre
NAMP	National Anti Malaria Programme
NGOs	Non-Governmental Organisations
NFHS	National Family Health Survey
NMCP	National Malaria Control Programme
NMEP	National Malaria Eradication Programme
NPK	Nitrogen Phosphorus Potassium
NSS	National Sample Survey
OPD	Out Patient Department
PCR	Proportional Case Rate
Pf	Plasmodium falciparum
Pgm	Programme
PHC	Primary Health Centre
PLDH	Parasite Lactate Dehydrogenase
PMH	Per Man Hour
PSC	Pyrethrum Spray Collection
Pv	Plasmodium vivax
RBC	Red Blood Cells
RDT	Rapid Diagnostic Tests
SFR	Slide Falciparum Rate
SPR	Slide Positivity Rate
sq.cm.	Square Centimetre
VC	Vectorial Capacity
VCRC	Vector Control Research Centre
VHAI	Voluntary Health Association of India
WHO	World Health Organisation
WP	Wettable Powder
ZETs	Zonal Entomology Teams

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