CDAlert

Monthly Newsletter of National Institute of Communicable Diseases,
Directorate General of Health Services, Government of India

January 2005 Vol.9 : No.1

CONTROL OF MOSQUITO VECTORS OF HUMAN DISEASES : CURRENT CONCEPT

In India malaria, filariasis, dengue fever/ DHF, and Japanese encephalitis are major vector borne diseases. The disease control programme prepare the vector control strategies to prevent mortality and reduce morbidity caused by these diseases.

Among several insect and acarine vectors of human diseases, the most important are the mosquitoes due to their involvement in the transmission of diseases like malaria, filariasis, Japanese encephalitis, and dengue fever/DHF. Infections like plague (flea borne), scrub typhus (mite borne), and KFD (tick borne), among others, are of occasional and sporadic occurrences and therefore assume lesser importance from the routine vector control standpoint.

The conventional methods of mosquito control include the use of chemical insecticides as anti-adult and anti-larval measures. High numbers of mosquitoes can develop in untreated standing water as a result of flood or irrigation and may be the cause for epidemics. Such situations require special efforts for the control of vectors where as chemical insecticides are required as a short-term measure to contain epidemic.

Recently, researchers have clearly demonstrated that mosquitoes can be controlled not only by chemical methods but also by physical and biological methods which are equally effective with minimal damage to the environment, provided the strategy used is sound.

As a consequence, the concept that has emerged is of vector management. The control of vectors of human diseases by vector management has to be an highly organized progamme based on sound data on the vectors, humans, the environment, and the feasibility of application of the best and latest techniques and materials depending upon local situation. The aim should be to control the vectors with minimal adverse side effects on humans, animals and the environment.

THE NEED FOR MOSQUITO CONTROL

Mosquitoes have long been a part of our ecosystems, but human activities for industrial development, urbanization, agriculture, etc, have increased their populations much beyond their natural levels. Mosquitoes can transmit diseases from man to man, and animals to man, as well as cause serious annoyance problem.

There are mainly two reasons to control mosquitoes:

Anopheles **mosquito (malaria vector)**

- To avoid nuisance biting,

  and

- To prevent the spread of mosquito-borne diseases.

It is a common knowledge that mosquitoes are of nuisance value, but most people do not realize the magnitude of the health threat that they represent. Some of the world's most dreaded diseases are known to be transmitted by mosquitoes. India is ravaged every year by malaria, dengue/dengue-hemorrhagic fever and Japanese encephalitis. To overcome the above problems, control of mosquitoes is therefore, an integral part of the disease control strategy.

THE ADVANTAGES OF MOSQUITO CONTROL

Eradication of mosquitoes is impossible; therefore, man's effort to control mosquitoes is an on-going battle. The benefits being derived from mosquito control are to significantly reduce the threat from mosquito-borne diseases, and an overall improvement in the quality of life. On the other hand, the risks associated with mosquito control by chemicals are also of major concern to human health, and the health of our environment. Through modern technology and newer approaches, mosquito control can be really effective in reducing the risk and threat to human health and the environment which is now envisaged in the integration of conventional and modern methods and technologies for vector control by Integrated Mosquito Management.

MOSQUITO BEHAVIOUR, ECOLOGY AND DISEASE POTENTIAL

Mosquito genera	Disease transmitted	Breeding places	Resting places
Anopheles	Malaria	Fresh water pools, ponds, paddy fields, irrigation channels, river bed pools, slow moving streams, wells, overhead tanks, etc.	Walls hanging objects in human dwellings, cattle sheds, etc.
Aedes	Dengue	All types of domestic and peri-domestic containers (plastic, metal, cemented, earthen, paper, etc.)	In human houses, on hanging objects, underneath furniture, etc.
Culex	• Japanese encephalitis • West Nile • Filariasis	• Rice field, ponds with water hyacinth and other aquatic vegetation • Polluted stagnant water bodies, drains, etc.	• Outdoor aquatic/land vegetation • Walls and other objects in human houses & cattle sheds

INTEGRATED MOSQUITO MANAGEMENT (IMM)

The goal of mosquito control should be "To control mosquitoes in a safe, efficient, and cost-effective manner, and while doing so prevent damage to humans, animals, and the natural environment".

This task can be successfully accomplished through the implementation of a comprehensive plan of integrated control approach, known as Integrated Mosquito Management. The plan is based on sound scientific knowledge about the mosquito bionomics and ecology and makes use of the latest technology about equipment and materials. Together these methods would furnish a cost-effective level of mosquito suppression required to protect man and domestic animals from harassment of frequent bites, and the disease. This concept is not simply combining several technological approaches, it essentially envisages a strong scientific data base, on the following lines so as to formulate the strategy for IMM.

- Which mosquito species are locally important as vectors of human diseases?
- Which mosquito species are important as the primary source of annoyance?
- What are the important breeding sites of different mosquito species?
- What is the seasonal pattern of mosquito breeding?
- What are the resting places of adult mosquitoes?
- What are the feeding preferences of vector mosquitoes?

The above information can enable programme managers to formulate strategies for appropriate mosquito control measures, which may be applied most effectively, economically, and safely with minimal disruption to the local environment. This should not be a one-time exercise. The database should be periodically updated and reviewed for effective implementation of vector control operations.

Modern integrated mosquito management programme therefore requires a vast array of knowledge and competence in a number of technological specialties. For example large database on various aspects of mosquito dynamics, can thus be generated by carrying out different types of entomological surveys.

LARVAL AND PUPAL SURVEYS

The basis of a mosquito control programme is a comprehensive survey, which can be used:

- to map out and locate all potential larval development habitats,
- to identify the mosquito species present,
- to predict the time and location of effective control strategies.

The survey methods include the larval and pupal surveys in diverse types of breeding places in and around human habitation within about 2-3 kms. Larval and pupal surveys are very effective and efficient in monitoring populations and species composition. But, before starting the routine breeding site inspection and larvicidal operations, all sites within the proposed jurisdiction must be identified and mapped. The mosquito breeding sites can also be identified using new digital Geographical Information System (GIS) technology, using digital aerial photos and satellite imagery.

ADULT MOSQUITO MONITORING

Several methods are available for sampling adult mosquitoes. Light traps may be used in certain situations like forest zones. The traps are used to capture nocturnal mosquitoes. The trap consists of a small incandescent bulb to attract mosquitoes, and a fan to force them down into a mesh net. Other techniques include sweep netting outdoor vegetation, making resting, landing/ biting mosquito collections using a simple aspirator.

The mosquito collection data are entered into the computer for analysis. This may be done on seasonal basis to identify population trends, component species and to effectively time the vector control operations

COMPUTER TECHNOLOGY & MOSQUITO CONTROL

One of the most important tools in our arsenal against mosquitoes is not just a new spray machine or some new formulation of an insecticide, but a computer. Computer technology, as in most industries, has become an integral part of a modern mosquito control programme.

Computers are used in a variety of ways including a GIS which is used to store information on the nature and number of breeding places, landscape features, mosquito population data, climate and local weather conditions, and then to develop comprehensive maps for operational use and also to report results of control measures. Complex spatial analysis can also be performed to understand and recognize intricate relationships between mosquito breeding sites and disease transmission or human annoyance.

BIOLOGICAL CONTROL OF MOSQUITO LARVA

The primary objective of the Integrated Mosquito Management is to inhibit the development of mosquito larvae so as to minimize the need for the use of chemical insecticides to control adult mosquitoes and to deter them from laying eggs in their potential breeding sites.

The principle of biological control methods take advantage of natural enemies of mosquitoes and other biological /naturalistic means to reduce mosquito populations. Based on the current research findings, these methods broadly fall into 3 categories:

- Predators that devour mosquitoes
- Parasites/pathogens that kill mosquitoes
- Growth regulators that act against the hormonal systems of mosquitoes to preclude complete development.

Predators

There are a large number of predators of mosquitoes. Spiders, mites, dragonflies, birds, frogs etc may eat adults. Larvae may be eaten by some invertebrates like water beetle dragonfly, water spiders and also by vertebrates like fish. Among the fish species which predate upon larval stages of mosquitoes, *Gambusia affinins* and *Poecilia reticulata* are the most widely used predators. These are called larvivorous fish and are being used for the control of malaria and filariasis respectively. The former species has a much wider application as it can effectively control the mosquitoe vectors of malaria. These fish are small surface feeding which readily attack and devour aquatic stage mosquitoes. They are very adaptable to most water conditions, bear live young which begin feeding immediately, and their gestation period is quite short so that they are able to produce several generations per season. One fully grown adult can eat several mosquito larvae.

Parasites/Pathogens

There are some species of parasites like nematodes and protozoa which are known to be pathogenic to mosquitoes only under certain conditions. These may be used as bio-control agents, however, more research data are required for wider application. Many bacteria, fungi and viruses are known to kill mosquito larvae. Among them the most widely used are the bacteria *viz Bacillus thuringiensis* var. *israelensis* and *B. sphaericus* which are biological products, affect only mosquitoes and other insects, and are environmentally safe. Biological control agents usually act on a narrow spectrum of species and their effects are, therefore, more amenable to ecological containment. As many candidate biological control agents are sensitive to environmental contamination, their use is restricted to ecosystems relatively free from pollution with chemicals.

Mosquito growth regulator

Another biological control agent is methoprene, a chemical which is similar to the juvenile hormone of the mosquito and is a mosquito growth regulator. It can be used in environmentally sensitive areas as it disrupts normal development and metamorphosis of the larval mosquitoes. This prevents the emergence of adult mosquitoes. When applied to the breeding sites of mosquitoes, it is taken up at the larval stage. It introduces physiological changes in the larva which interferes with normal development and does not allow

***Aedes aegypti* - vector of dengue fever/DHF**

larva to develop and emerge as adult. The chemical is environmentally safe and does not affect vertebrate animals.

ENVIRONMENTAL METHODS FOR CONTROL OF MOSQUITOES

This method deals with effective manipulation of environment for environmental management (EM) for mosquito control. The EM is aimed at limiting mosquito breeding to the extent that they are no more a major threat to humans as far as transmission of diseases are concerned. Optimum development of the environment would also involve provision of infrastructural facilities and land use. For mosquito control by EM all organizations concerned, directly or indirectly with land and water use, should be involved to assist and coordinate environmental management practices. The EM will then ensure proper construction of facilities like irrigation channels, drains, dams, roads, household sewerage systems, etc. All useless water bodies and potential water-holding excavations and depressions will have to be eliminated by filling with soil, etc. Much of water stagnation in drains is due to poor gradient and inefficient garbage disposal systems.

Environmental management methods for mosquito control basically include:

- Measures designed to prevent mosquitoes from feeding on man by screening of houses.
- Measures designed to prevent or reduce the breeding of mosquitoes by eliminating the collection of water or by altering the environment.
- Measures designed to destroy the larvae of mosquitoes, preferably by non-chemical methods.

Physical control/ source reduction

Physical methods of mosquito control usually involve manipulation of the natural environment to disrupt the larval development of mosquitoes. Some of the most important physical methods to reduce/ minimize mosquito breeding includes improving the gradient of the drains, irrigation canals and other water channels, straightenening the margins of big water bodies, and periodic deweeding of ponds/ lakes. These source reduction methods are a feasible option for controlling mosquitoes. Other methods may include clearing the clogged ditches and polluted water drains.

Filling for Mosquito Control

Filling raises the level of soil so that proper run-off of water occurs & standing water providing mosquito larval habitat is eliminated. This technique is used for small or large ground depressions created by burrowing of earth, vehicles & by any other means. Filling will prevent accumulation of water in these depressions and the breeding of mosquitoes, particularly in small transient water bodies, shall be greatly reduced. In India, during monsoon season, mosquitoes, like the malaria vector *An. culicifacies,* prefer to breed in such transient waters and may be involved in outbreaks/epidemics.

Personal protection against adult mosquitoes

While venturing for mosquito larval control, adult mosquito control can be combined with the use of mosquito nets. These nets not only provide protection against the vicious bite of mosquito, they significantly mitigate the transmission of mosquito-borne diseases. The insecticide impregnated bednets are mainly known to reduce man-mosquito contact but can also kill the adult mosquitoes coming in contact with the net. Use of bednets are good examples of methods for personal protection, resulting in a reduction of man-vector contact more than the vector control.

Other physical methods for control

Various physical methods have been developed either to control vector populations or to reduce man/vector contact. Physical methods designed for use in situations where chemical larvicides are inadequate or inappropriate, which interfere with either breathing in larvae and pupae or oviposition in adults could be the following:

- petroleum hydrocarbons (MLO)
- monolayers (long-chain aliphatic alcohols)
- polystyrene beads.

Mesh screens can be used for mosquito proofing of human houses and buildings. Mesh proofing of inlets and outlets of septic tanks, domestic drinking-water storage vessels, etc., effectively serves to control vector breeding in the peri-domestic environment.

Traps of many different types are used extensively to control populations of a variety of insects, animal reservoirs and vectors. Oviposition pheromones, possibly combined with insecticides, hold promise for the improvement of ovitraps for container-breeding mosquitoes.

Physical methods of control do not require extensive expertise in local vector biology and ecology. They are therefore applicable under a wide variety of conditions. This characteristic renders physical control, either alone or in combination with chemical methods and/or environmental management, particularly suitable for integration into primary health care programmes.

CHEMICAL CONTROL OF MOSQUITOES

While advocating biological and physical methods of vector control, the importance of the use of chemical insecticides to reduce mosquito populations cannot be underestimated particularly in certain situations, like epidemics, or as an area specific control strategy as part of IMM. Also, mosquito control by chemicals has considerable advantage where physical and biological methods are either not feasible, uneconomical or partially successful. Chemical insecticides usually give immediate control of either larvae or adult mosquitoes and can be more effective tool for vector control, if used selectively, to supplement other routine control methods. Though several insecticide formulations and application options are available, each has its own drawbacks. In the long run too much of dependence on chemical insecticides would not only be expensive, it is also likely

***Culex quinquefasciatus* - vector of filariasis**

to cause environmental damage, and is of temporary nature. The use of ULV (ultra-low volume) formulated insecticides for use in ground application gives only temporary relief in certain situations and is not very cost-effective. The use of ULV aerial spray is unaffordable by developing countries. Similarly, residual insecticide application is not only fraught with the risk of environmental pollution, it is also labour intensive.

ECONOMIC THRESHOLD AND IMM

For effective IMM an economic threshold level must also be set. This is the level of mosquito abundance at which control measures should be enacted so that the vector population does not continue to grow to reach the economic injury level. We should not wait till the injury level is reached before controls are applied. The overall goal of IMM is to lower the mean level of mosquito abundance below the economic threshold so that the peak fluctuations rarely reach the economic injury level. When the mosquito population rises above the economic threshold, insecticides may be the only remedy. However the choice of insecticides, dosages selected, and the application be so timed so as to minimize disruption of the ecosystem and adverse effects on non-target organisms.

Effectiveness of IMM

The effectiveness of IMM would rest upon

- the understanding of the ecologies of the mosquito species which are vectors of human health importance.
- the understanding of the point where we can break down the components affecting mosquito populations, rank them in importance, and eventually describe their effects.
- developing surveillance mechanism which will give us the information needed to predict vector population trends and measure the effects of control measures.
- constant up-dating of IMM programme taking into account changes in the ecologies of mosquitoes and development of new control strategy.
- new information, periodically added, about the population biology of mosquitoes in relation to the disease dynamics.

How can JE vector be controlled by IMM?

In India *Cx. tritaeniorhynchus* is a major mosquito vector of Japanese encephalitis in rural areas. The mosquito is known for its exophilic behaviour. However, during epidemic situations the species has also been reported to rest, in low densities, in indoor situations like human dwellings and cattle sheds. Recent studies carried out by NICD in an encephalitis outbreak area of Andhra Pradesh, have clearly demonstrated that *Culex tritaeniorhynchus* predominantly rests in outdoor situations on a variety of ground vegetations. The studies, carried out in July 2003, have shown several-fold higher density of the vector species on vegetation in outdoor situation, as compared to the indoor situation, in Warangal and Karim Nagar districts. The mosquito species was also found to breed quite extensively in different water bodies like village ponds, paddy fields, etc. In such situations two options are available to check mosquito population growth:

i) use of bio-control agents against larval stages of the vector, and

ii) measures against the exophilic adults resting in vegetation.

The application of IMM in this situation requires the use of bio-control agents like predators, parasites, pathogens, and/or growth regulators to check the growth of immature stages in aquatic habitats. However, during transmission season when the breeding potential of the mosquito increases several times, the exophilic adult population needs to be controlled by limited and area specific use of chemical insecticides. This would interrupt disease transmission and prevent outbreak. In order to succeed in disease control activity, the prerequisite to the application of various methods employed in IMM is the thorough analysis of the local situation with regard to vector dynamics and ecology.

...about CD*Alert*

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Acknowledgement: Financial assistance by WHO/USAID is duly acknowledged.