MOSQUITO CONTROL

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Introduction

Mosquitoes are considered as the most dangerous group of animals to human welfare. Apart from their biting nuisance, they transmit fatal human diseases. The total number of deaths due to malaria, one of the mosquito borne diseases, exceeds one million per year in Africa alone. Therefore, the control of mosquitoes has been an important issue since late 19th century, when mosquitoes were first identified as vectors of human diseases.

Taxonomically mosquitoes belong to the Class Insecta, Order Diptera and Family Culicidae. There are about 38 genera and 3450 species worldwide. In Sri Lanka about 140 species can be found. Male mosquitoes feed on sugary substances like fruit juices. Females feed on blood. A blood meal is essential for a female to develop its eggs. They can transmit various pathogens to the host while they feed. There are four major mosquito borne diseases in Sri Lanka (Table 1).

Biology

Females lay eggs (eggs mature 2-3 days after a blood meal) on the water surface or on the wall of a water container. Breeding sites differ from species to species. For example, *Anopheles culicifacies* prefers water pools in riverbeds, *Culex tritaeniorhynchus* prefers paddy fields, *Aedes aegypti* prefers tree holes and small water containers like water filled tyres, tins or buckets. Eggs are laid singly eg. *Anopheles* or in rafts eg. *Culex*. Out of all the types, eggs of

Table 1: Major mosquito borne diseases, and vectors in Sri Lanka

Disease	Major Vector	Pathogen
1. Malaria	*Anopheles culicifacies* *Anopheles subpictus*	Protozoan (*Plasmodium*)
2. Filariasis	*Culex quinquefasciatus*	Nematode worm (*Wuchereria*)
3. Dengue	*Aedes aegypti* *Aedes albopictus*	Virus
4. Japanese encephalitis	*Culex tritaeniorhynchus* *Culex gelidus*	Virus

It is important to understand the biology of a mosquito species before developing control strategies.

Aedes species are well known for their resistance to desiccation. Mosquito larvae live in water and often come to the surface for breathing. There are four larval stages (instars) and the whole larval life is about one week in the tropics. Then the larva becomes a pupa and after about 2-3 days the adult emerges. On average the life span of an adult is 1 - 2 weeks. Mosquitoes usually fly within a range of two kilometres.

However, wind currents may carry them considerable distances. Some mosquito species prefer to rest inside houses (indoor resting or endophilic) while others prefer to stay outside (outdoor resting or exophilic). Some prefer to feed on humans (anthropophilic) while others prefer to feed on other animals (zoophilic). Some species prefer to feed during daytime and others prefer nighttime feeding. It should be clear now that the habits and habitats of mosquitoes differ from species to species. Therefore, according to the species of interest, control methodologies should be developed. Mosquito control can be carried out at various levels. Larval control programmes and adult control programmes are launched to reduce mosquito abundance. Also, measures can be taken to protect you from mosquitoes. These strategies can be discussed under four topics; personal protection, house design and the habitats in and around houses, modification and manipulation of the environment and use of insecticides.

Personal Protection

Various chemicals such as deet (N,N- diethyl-3- toluamide) are available in the market as mosquito repellents. They are in the form of sprays, body lotions/oils *etc.* and not toxic as insecticides. In villages, various smokes (eg. cashew husks) and herbal extracts (*eg.* neem) and oils (eg. *Citronella* oil) are used to repel mosquitoes. Also wearing cloths to cover the whole body reduces the chances of getting bitten. As a preventive measure, visiting risky places during peak biting hours (for most of the mosquito species peak biting times are immediately before sunset and immediately after sunset) should be avoided. Another measure is the use of bed nets. However, bed nets will not be effective against daytime biting mosquitoes except to protect babies and young children sleeping during the daytime.

House design and the habitats in and around houses

Houses close to water bodies have a higher exposure to mosquitoes. If the direction of the wind is from the water body to the house, wind currents often bring newly emerged adults to the house. Therefore, these factors should be avoided if possible. A proper ceiling will not allow mosquitoes to enter houses through the gap between the wall and the roof. Screening other openings with mosquito nets or mesh is also important. If the screening of windows and doors is not possible they should be kept closed at least during the peak biting hours. Inside the houses, water containers, which can act as mosquito breeding sites should be managed properly. For example water of flower vases should be replaced once in two days, small water cups used as ant traps (*eg.* cups kept under table legs) should be filled with salt or soap mixed water so that larvae can not develop in them. In the garden, small containers such as cans, coconut husk shells should be removed or destroyed. Small depressions, tree holes, abundant ditches etc. which can act as breeding sites should be filled with soil, rubble, rubbish or cement. Gutters, blocked with leaves making small water pools, should be cleaned regularly. Overhead tanks, sewage pits etc. should be covered with

removable mosquito proof lids/cement slabs or expanded polystyrene beads, which are non-toxic. Polystyrene beads can be used even to cover larger bodies like abandoned gem pits.

Modification and manipulation of the environment

Drainage systems used in agriculture or for the transportation of sewage and rainwater are often important sources of breeding because of poor design and maintenance. Proper drainage systems should be established. It should follow the natural flow of water whenever possible. Sharp bends should be avoided. Margins or banks should be smooth and deep so that small water pools cannot be created. In larger canals regular fluctuation of the water level and flushing the breeding sites (stream sluicing) dislodge larvae. Marshy areas with high water tables often create good breeding sites for mosquitoes. Trees with high growth and evaporation rates *eg.* eucalyptus, can be grown to dry up these lands. Ponds, pools and lakes are excellent mosquito breeding sites. Certain species of fish, crustaceans and nematode worms feed on mosquito larvae and can be used in larval control. Rearing of larvivorous fish species is an easy and highly successful method used in larval control programmes. Fast growing water plants *eg. Azolla* that float on the surface can be used to cover the water surface.

Use of insecticides

Insecticides are the major tools used today in most of the mosquito control programmes. These are chemicals or biological materials that are used to control insect pests. Bio-insecticides have been produced using the bacteria species *Bacillus thuringiensis* and *Bacillus sphericus*. These bacteria produce toxic crystals, which can kill mosquito larvae once ingested. Crystals and spores of the bacteria are used as insecticides in the form of wettable powders. However, the use is restricted due to high production cost and low stability in storage.

The most successful synthetic insecticides are neuro-inhibitors. Despite the increasing cost and the risk of environmental contamination, these are the most widely used agents for insect pest control in the world today. Commonly used synthetic insecticides can be divided into four major groups; organochlorines, organo-phosphates (OPs), carbamates and pyrethroids. Today the use of organochlorines has been discontinued in many countries because of resistance and concerns for the environment but DDT still remains the most widely used insecticide for malaria control. All these insecticides attack the nervous system of the insect. For OPs and carbamates the target site is acetylcholinesterase (AChE), the enzyme which hydrolyses the neuro-transmitter acetylcholine. Cyclodienes, a sub-group of organochlorines, binds to the γ-aminobutyric acid (GABA) receptors in the Cl^- channels of the neurons and modulate the Cl^- conductance across the nerve membrane. The rest of the organochlorines (DDT + its analogues) and pyrethroids bind to Na^+ channel proteins of the nerve membrane inactivating their regulation. For organophosphates and carbamates the target site is acetylcholinesterase (AChE), the enzyme that hydrolyses the neurotransmitter acetylcholine.

Biology of the mosquito species should have been well understood to decide where to apply insecticides. *eg.* to control *Anopheles culicifacies* which breed in river beds, larvicides should be applied to rivers and other water streams; house spraying of adulticides is effective because they are indoor resting. But these applications may have very little effect on

other species. However, in situations where immediate results are needed eg. during outbreaks, vehicle or aircraft mounted aerosol generators are used to spray the whole area. Today mosquito coils are heavily used to kill /repel mosquitoes. Insecticides present in these coils are volatile pyrethroids. Recommended dosages of these insecticides have been proved to be harmless to humans. However, overnight exposure to the smoke of these coils which contains insecticides, other chemicals, carbon monoxide *etc*. may cause illnesses specially in the respiratory system.

Although it is not common in Sri Lanka, the use of insecticide impregnated bednets is a successful control measure in countries like Africa. Again the pyrethroids in harmless quantities are used. Villagers of rural areas are educated to prepare their own impregnated nets by the World Health Organization. Small quantities of insecticides can be incorporated into mosquito screening meshes, curtains, garments and even to wall paints.

Continuous exposure to insecticides (even to mosquito coils) can lead to the development of insecticide resistance in mosquitoes. Major mechanisms of insecticide resistance involve either an alteration in the rate of insecticide metabolism *ie.* detoxification, or an alteration within the target site of the insecticide. Increased metabolism is due to qualitative and/or quantitative changes of mosquito enzymes, which metabolise insecticides. Esterases, Glutathione-S-transferases and monoxygenases are the major groups involved. Target site alteration is often due to highly specific point mutations so that the altered target site does not respond to insecticides but performs its normal physiological functions within the mosquito body.

Sri Lanka, being a tropical agricultural country, heavily depends on synthetic insecticides, (mostly OPs and carbamates and recently pyrethroids) for control of agricultural insect pests and disease vectors such as mosquitoes. Mosquito control programmes have been mainly based on the usage of DDT prior to 1975-1977 and malathion (adulticide), temephos (larvicide) and fenthion (larvicide) until recently when other OPs and pyrethroids were introduced. It is always advisable to collect information about the underlying mechanisms of insecticide resistance in the field mosquito populations to decide the most effective insecticides.

As we all are aware insecticides pollute our environment. Therefore, it is desirable to go for other options *eg.* destroying the breeding sites, whenever possible. However, the last and the most effective option, which has to be taken in disease outbreaks, is the use of insecticides.