Since time immemorial, millions and millions of people have been dying due to the menacing activity of a moving bombshell that transmits some of the world’s worst life threatening and devastating diseases. This living jeopardy had once become the nightmare of one of the greatest scientists, Sir Ronald Ross (Nobel prize winner for Physiology in the year 1902). It is none other than the deadly mosquito.

Mosquitoes transmit many parasitic and viral diseases like Malaria, Chikungunya, Dengue, Filariasis, Westnile fever etc that are on the rise in many tropical and subtropical countries. Over the past few decades, efforts have been made to develop mosquito control strategies by targeting the larval or the adult stages and use of biological agents and genetic engineering techniques against the disease-transmitting mosquitoes.

**Chemical Methods**

Pesticides including Organochlorine (DDT), Organophosphates (Malathion, Parathion), Carbamates (Carbaryl), Pyrethroids (Resermethrin, Sumithrin, Pyrethrin, Permethrin) are the most commonly used chemicals along with insecticides and impregnated bed nets such as Olyset nets recommended by WHO, which are currently in use in rural malaria endemic areas. On the other hand, insecticide-impregnated paint (Vernacide) and mosquito repellents (DEET, BITE BLOCKER/GREEN BAN) are also in use these days. But unfortunately due to the rampant use resistance has developed in mosquitoes to almost every chemical class of insecticides.

**Non-Chemical Methods**

Surface-active agents (SAA) like Arosurf have effectively being used to control mosquitoes (Aedes, Culex and Anopheles). SAA enables better coverage of breeding habitats and is effective in controlling the larval population. Other non-chemical agents like expanded polystyrene beads (EPS) and insect growth regulators (IGRs) like Diflubenzuron, Methoprene, and Fenoxycarb are highly active against larvae of mosquitoes and other insects. The IGRs in general have a good margin of safety to most non-target biota and are relatively safe to man and domestic animals.

These compounds do not induce quick mortality in the early stages treated which is indeed a desirable feature of a control agent because larval stages of mosquitoes are an important source of food for fish and wild life. On account of selectiveness in their mode of action and potentiality in acting on target species, IGRs could play an important role in vector programs in the future. No likelihood of resistance has been reported against these IGRs. Ecdysone agonists are the ideal IGRs that inhibit developmental stages and are found to be effective against Culex quinquefasciatus, Aedes aegypti, Anopheles gambiae etc.

**Biological Methods**

In the last few decades, there is growing acceptance for alternate biocontrol agents that are currently being used in controlling larval populations in different breeding habitats. Biocontrol agents are natural predators, parasites or pathogens that could be used in maintaining the density of target organisms at a lower average. Some of the important advantages of biological control are:

- Low level of toxicity
- Resistance development is negligible
- Safe for humans and animals
- Persistence in environment is very minute
- Higher recycling potential

Modern researchers are inclined to use biocontrol agents rather than chemical insecticides due to the residual effects of chemical insecticides, widespread resistance in target insects, high refusal rate for indoor spray, soaring price of chemical insecticides and other operational difficulties. Effective biocontrol agents include predatory fish like Gambusia (Gambusia affinis), Guppies (Poecilia reticulate), cyprinids, Tilapia and killfish that have been used in many countries for controlling larva of Anopheine and culicine larva.

Recently, in Somalia, larvivorous fish Oreochromis spilurus was found to be effective against malaria vectors. Biocides or biolarvicides (bacilli-based larvivorous fish Aedes mosquito sucking blood)

Aedes mosquito sucking blood

SCIENCE REPORTER, July 2010 45

Biswa Ranjan Maharana & Manjit Panigrahi
mosquito larvicides) like *Bacillus thuringiensis* subsp. *israelensis* (Bti) and *Bacillus sphaericus* (Bs) are sporeforming bacteria which upon sporulation produce a parasporal crystal toxic to some invertebrates, mostly mosquitoes and nematodes. Bti is toxic to both mosquito and blackfly whereas Bs only to mosquitoes. Both Bti and Bs, have shown great promise, particularly those breeding in highly polluted water.

Bti is now commercially available as Teknar, Deltox and Bactimos in different formulations (e.g. liquid concentrate and water dispersible powder). Bs is still undergoing the marketing process and is expected to be effective against all larval stages of Anopheles, Culex and Aedes mosquitoes. Several viral genera such as cytoplasmic Polyhedrosis virus and iridescent virus have shown promising results in mosquito control. Entomopathogenic fungus like *Lagenidium, Culinomyces* etc have also shown their efficacy in controlling mosquitoes by killing them either at the larval or adult stages. Parasitic wasps are helpful in suppressing the mosquito population by killing them. Many scientists have also tried to control various genera of mosquito by genetic manipulation method commonly known as sterile insect technique (SIT). In 1962 and 1975 *Culex fatigans* and *Culex pipiens fatigans* were controlled in India by this novel approach.

Despite decades of international efforts we are still not in a position to completely control such a minute creature having immense potential to create havoc worldwide.

Non-blood sucking predatory mosquitoes such as *Toxorhyncites splendens*, *T. brevipalpis*, *T. amboinensis* and *T. theobaldi* were found to be effective against mosquito larvae. Prolonged efficacy of a combination of bacteria (Bti) and copepods (*Mesocyclops aspericornis*) in controlling immature forms of *Ae. aegypti* in peridomestic water containers was achieved in Thailand.

Other biological control agents such as cyclopoid copepods (*Mesocyclops pehpeiensis* and *Macrocylops distictus*) are used as control agents against dengue vector *Aedes albopictus* in Japan. Protozoa like *Thelohania*, *Parathelohania*, *Nosema*, *Amblyospora* and *Vavoria* were found to be infective to many groups of mosquitoes. Researchers have also uncovered the biocontrol potential of dragonfly nymph like *Brachythemis contaminata* against the larvae of *Ae. aegypti*, *An. stephensi*, and *Cx. quinquefasciatus*.

Despite decades of international efforts we are still not in a position to completely control such a minute creature having immense potential to create havoc worldwide. Malaria is among the deadliest infectious diseases in the world and kills an estimated 1-3 million people every year. Mosquitoes are developing resistance to every group of chemicals including microbial drugs and insect growth regulators. If no new measures to fight against mosquitoes are initiated, the numbers of malaria cases are predicted to double in the next 20 years.

Among the new approaches being tried is a novel strategy to develop a transgenic mosquito (introduce into the mosquito a gene that interferes with the development of the malaria parasite). There are three basic requirements to achieve genetic modification of mosquitoes: (a) a method to introduce foreign genes into the germ line (transformation); (b) the availability of a suitable promoter to drive the expression of foreign genes in the appropriate tissue and at the appropriate time; and (c) the identification of appropriate gene products (effector genes) capable of interfering with the development of the malarial parasite.

But several loose ends have to be tied up before we can expect to release transgenic insects to block human diseases. Integrated pest management with conventional strategy as well as public awareness is highly indispensable to control such a tiny creature.

However, complete eradication of mosquito population is not desirable due to ecological constraints. Holistic and integrative approaches, although tedious and time consuming, are needed in a manner that maximizes the merits in terms of public health benefits.

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