Entomological aspects of Dengue

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World Health Organisation (WHO) has shown that among the diseases transmitted by mosquitos, dengue has become a rapidly spreading disease throughout the world. During the past 50 years or so, the incidence of dengue has increased by about 50 fold. Numerical data has revealed that dengue occupies the second place in this respect, the first being malaria.

The dengue causing virus belongs to the flavivirus category, and occurs in four forms. The manner in which these forms multiply within the mosquito vector is not identical. Also the distribution of the different forms changes from time to time.

The main mosquito vector that spreads dengue is *Aedes aegypti.* In addition a few other types of mosquito with the potential ability to spread the disease (potential vectors) have been identified. The main among these is *Aedes albopictusas.* Both these species of mosquito live in many tropical and sub tropical countries in which dengue has been spread.

Aedes aegypti has an African origin. There is scientific evidence to show that initially these lived mostly in forests, but with the establishment of human settlements close to forests two sub species-Aedes *aedes aegypti* and *Aedes aegypti formosus* have evolved. It is believed that the ancient *aegypti* mosquito spread to Europe with the slave trade, and the eggs of the mosquito were transported from Africa to Europe through the ports of Portugal and Spain. Subsequently it spread to Asia and Australia from Europe.

The origin of the *Aedes albopictus* mosquito is associated with the countries of the western Pacific and South Eastern Asia. It has also be seen that this mosquito is spreading fast in the temperate regions of the world. Due to its ancient origin this mosquito is also known as the Asian Tiger Mosquito.

Aedes mosquito is characterized by its black colour, and small to moderate body size (4-7mm) with black and white striped markings arranged as rings. These striped markings are also seen in the 3 pairs of legs. It is possible to distinguish between *Aedes aegyptis* and *Aedes albopictus* by the shape of the white coloured markings on their shoulders. In *Aedes aegypti* it is lyre shaped while in *Aedes albopictus* it is present as a white coloured line on the shoulder. (Fig. 1)

One hundred and forty one (141)

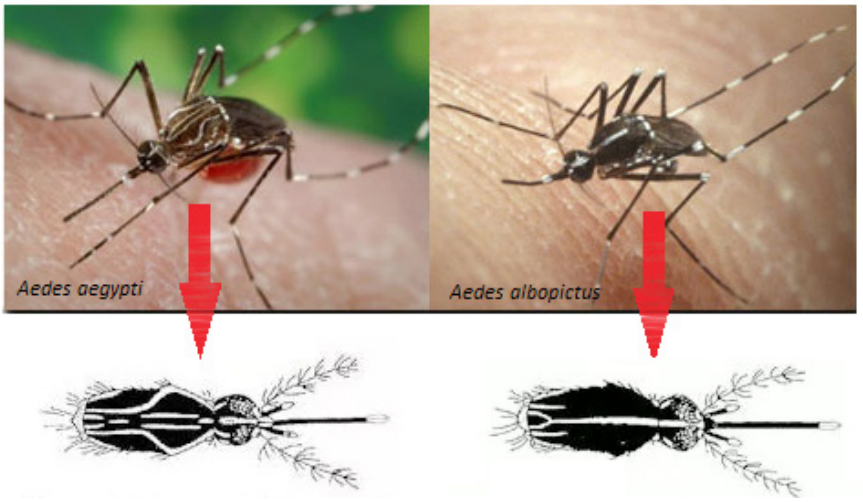

Fig 1 : Differences between *Ae.aegyti and Ae.albopictus*

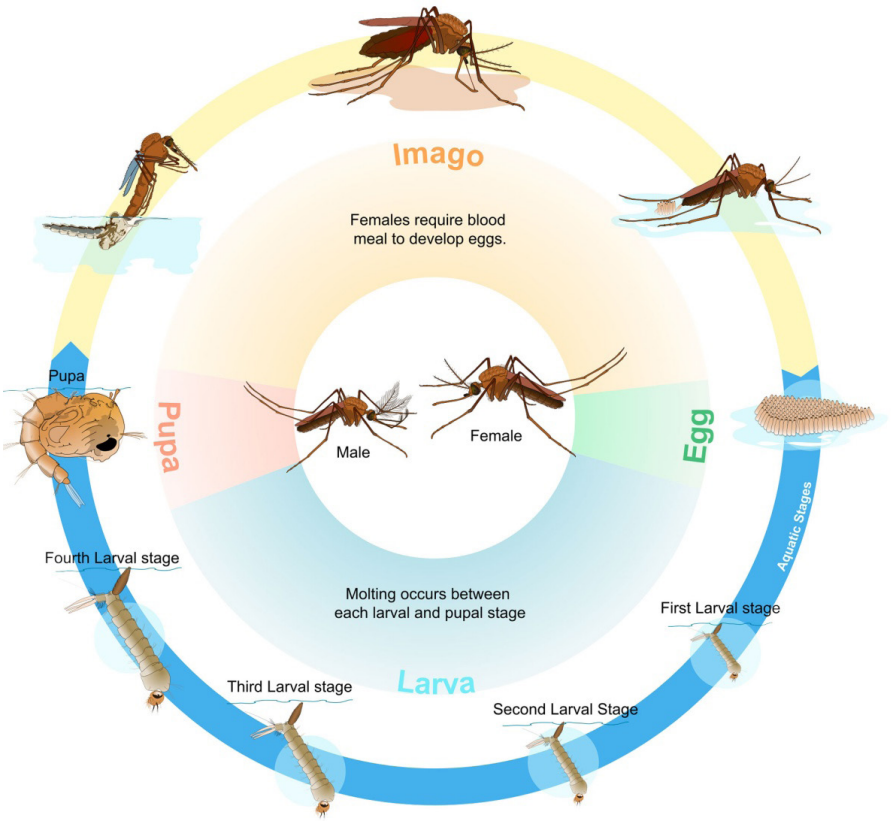

Fig 2 : Life Cycle of Mosquitoes

mosquito species have been reported from Sri Lanka, of which 48 species belong to the genus *Aedes*. Of these the vectors of dengue in Sri Lanka are *Aedes aegypti* and *Aedes albopictus*. *Aedes aegypti* is the main vector. Research has shown that *Aedes albopictus* acts as a reservoir and contributes to maintain the virus during the dry seasons during which dengue is not an epidemic. The life span of *Aedes aegypti* and *Aedes albopictus* is about 2-3 weeks (Note 1)

Vector competence and Vectorial capacity

Heparin which is an anti-clotting agent present in the saliva of the mosquito is introduced into the blood of the human when the mosquito sucks the blood. Heparin temporarily prevents the blood from clotting. The dengue virus is introduced into the body of the human along with this saliva. Subsequent to sucking the blood from the human, the virus multiplies efficiently within the mosquito. The ability of the virus to travel easily within the body of the mosquito to reach its salivary glands, and the subsequent ability to again introduce the virus into the human host is known as the vector competence. Vector competence has been observed in both *Aedes aegypti* and *Aedes albopictus*. The vectorial capacity is the yard stick used to indicate the efficiency with which the vector transmits the diseases. It is determined by environmental factors as well as the biological factors of the mosquito. The vectorial capacity of *Aedes aegypti* is greater than that of *Aedes albopictus*. The reason for this is that *Aedes aegypti* mosquito inhabits house holds and sucks blood specially from humans. In order to obtain a full blood meal (that is to completely fill the abdomen) it sucks the blood several times. Hence when considering the efficiency of spread of the disease among humans, *Aedes aegypti* is the important and capable mosquito. *Aedes albopictus* mostly inhabits places outside of dwelling houses and prefers to suck blood from animals. It sucks blood mainly from mammals, but shows a tendency to suck blood from amphibians, reptites and birds too. In addition *Aedes albopictus* tries to obtain its full blood meal in one attempt. Hence *Aedes albopictus* shows a lesser tendency in spreading the disease. The virus can be seen in these mosquitos throughtout its life span, and it has been discovered that the virus can be transmitted to the next

Note 1.

The mosquito exhibits complete metamorphosis. The female mosquito lays eggs after fertilization. Then after four larval stages it reaches the pupal stage. The adult mosquito emerges form the pupa (figure 1). The egg, larval and pupal stages are spent in an aqueous environment. Only the adult stage is terrestrial. The life span of the adult mosquito varies with the species of the mosquito.

Fig 3 : Intercourse of Mosquitoes takes place in the air

generation too through its eggs.

Mating and oviposition behavior

Generally the mosquito is fertilized only once during its life span. The female mosquito stores a large number of sperms in the sperm storage sac, the spermotheca. Another special feature is that intercourse takes place in the air (inflight) (Fig. 3).

Aedes aegypti lays its eggs mostly inside discarded waste materials such as inside tin containers and yoghurt cups (Fig.4). *Aedes albopictus* lays its eggs usually in places where "natural" water collects such as in cavities of tree trunks, flowers and leaves with accumulated water (Note 2).

The female mosquito generally lays about 100-200 eggs at a time. A single mosquito lays eggs about 4-5 times during its life span. The eggs are pasted singly keeping varied distances between them. Therefore there is the risk of the eggs drying up. Even if the eggs dry up, in most instances they are not destroyed. More over all the eggs are not laid at a single location. Few eggs are laid at a time in a location and thus the eggs are distributed throughout a region. The probability of observing eggs of other species of *Aedes* and a few of the *culex* and *Anopheles* mosquito eggs in a given location does exist. However, due to the present environmental and other factors there seems to be a change in the locations where eggs are laid. The latest research shows that both species of *Aedes* may lay eggs in open water bodies of extreme salinity, as well as in wells and in toilet pits.

Feeding and resting behavior

The dengue vector mosquitos suck blood at times when there is light. They sting between about 6-11am and 3-7pm. But these times may vary slightly depending on the prevailing environmental and biological factors. Theoretically

Note 2.

The sites or locations where Aedes aegypti and Aedes albopictus mosquito frequently lay their eggs in Sri Lanka, are as follows:
1. Discarded waste materials (plastic containers, clay vessels, yoghurt and ice cream cups, broken porcelain objects, coconut shells).
2. Vessels in which water is stored (cement water stroage tanks, barrels).
3. Tyres and non functioning appliances.
4. Buildings (rain water gutters, open concrete balconies).
5. House hold and institutional appliances (Trays in refrigerators, flower vases, vessels used for feeding of pets, bird baths).
6. Natural sites(crevices) holes in tree trunks, the cut surfaces of bamboos, the tips of plant leaves.
7. Other locations (abandoned boats, wells cemeteries and pit latrines).

Fig 4 : Environmental Management Sources

even though these mosquitos do not sting during night time, inside well lit houses sometimes they may suck blood in the night.

Aedes aegypti rests in dark and high humidity locations such as on hanging clothes, window curtains, the dark (shaded) sides of furniture in houses and buildings. The chances of these mosquitos resting in dark location of vegetation outside of houses is very little. However *Aedes albopictus* rests mostly in the dark locations of vegetation outside of houses and in the dark locations of materials thrown out.

Flight range and dispersal of mosquitos

The basis for this is the chances of being able to lay eggs and the extent of the human population. These two factors are well provided in the urban and semi urban environments. So the dengue disease is common in them. Generally these mosquitos are dispersed over distances of about 100-200 meters from where the eggs are laid. However if the above conditions exist to a lesser extent, the distance increases to about 400m. These mosquitos (the adult mosquitos or eggs) may disperse throughout the entire globe. They may be transmitted by vehicles, aeroplanes and ships. In addition to this horizontal dispersal, *Aedes aegypti* especially could be seen at higher elevations (vertical dispersal) too. There are reports of them being present in 6-7 storied buildings.

The rapid spread of both *Aedes aegypti* and *Aedes albopictus* is affected by climatic changes, such as high temperature, rainfall and changes in humidity, and also by man's effect on the environment. The main causes are irregular urbanization, the deficiencies in the management of waste materials, the inefficient and disorganized methods employed by local government institutions and other governmental institutions to control the mosquitos. The breakdown of the attitudes of people is also a cause. The introduction of medication which could destroy the dengue virus, or the production of a vaccine to confer immunity to the virus are still in the experimental stage. Therefore it has become necessary to control the disease by the use of compulsory control measures the spread of the mosquito.

Now let us consider the methods and actions to be followed to

Fig 5 : Man made mosquito breeding and multiplication locations

control the mosquito.

The completion of the life cycle of the mosquito and the sucking of blood takes place in a restricted area. The most suitable solution to control the mosquito is to destroy the breading and multification locations of the mosquito (Fig.5). These locations are provided by the activities of man in his dwelling (home) environments. It is possible to deprive the mosquito of most locations where the mosquito lays eggs by the management of solid waste. To achieve this end it is compulsory to clean houses and institutions on a regular basis, at least a few days every week, and dispose the waste material in an organized and correct manner. In order to make this mission successful it is necessary to enforce the exsisting laws and regulations, and constantly make the people aware through communication media on a regular basis. Also it is possible to spray Bti bacteria to pineapple plantations, ornamental plantings such as pandanus, bromeliads, and to rainwater gutters. Introduction of larvae eating (Larvivorus) fish into water storing tanks and barrels is a successful solution. Because *Aedes albopictus* mostly lays its eggs in places where 'natural' water collects and also because it is difficult to clean the rainwater gutters in very tall buildings it is possible to multiply the larvae eating mosquitos - Toxorhynchites in a laboratory and 'release' them (Fig.6).

These control methods come under the categories of environmental management and biological control. Through these the larvae of the vector mosquitos can be controlled. However, when the mosquito population increases or when a large number of dengue patients are reported, it is compulsory to destroy the vector mosquito by

Fig 6 : Larvivorus fish, Bti, and Toxorhyuchites Larvivorous mosquitoes for biological control

Fig 7 : Application of chemical incesticides - chemical control

chemical methods. The larvae destroying liquid Temphos or its granules (pebbles) can be used. In order to destroy the vector mosquitos chemical insecticiales such as malathion and pyrethroids can also be used. The application of these chemical insecticides can be done by Thermal fogging (Fig.7) or as ultra low volume sprays. For this it is necessary to get the advice of scientists dealing with larvae. Using the data, that these scientists have obtained by investigation of vector mosquitos, the insecticides are sprayed according to an organized procedure. If the insecticides are sprayed in an irregular manner the mosquito will very soon develop resistance to the insecticide. That is, the mosquito population becomes resistant to the insecticide faster than the production of successful insecticides. Due to the adverse effects of insecticides on the environment and on animals including man, insecticides should be used only on specific occasions. In addition various types of mosquito repellents can be used to prevent being bitten by mosquitos. Various types of repellents are available in the market and most of them belong to the category of insecticides known as pyrethroids. In addition there are the plant extracts such as citronella oil, margosa oil and oscimum (maduruthala) species that can be used.

The simultaneous introduction of a variety of methods of control in a region is known as integrated vector control. The necessity of employing a scientific larval control procedure is obvious in such methods of control. The need for collaboration of many related parties such as the Ministry of Health, local government bodies, Ministry of Environmental affairs, security forces, civil societies and the public, and also the use of a great deal of resources reflect the constrains in controlling dengue.

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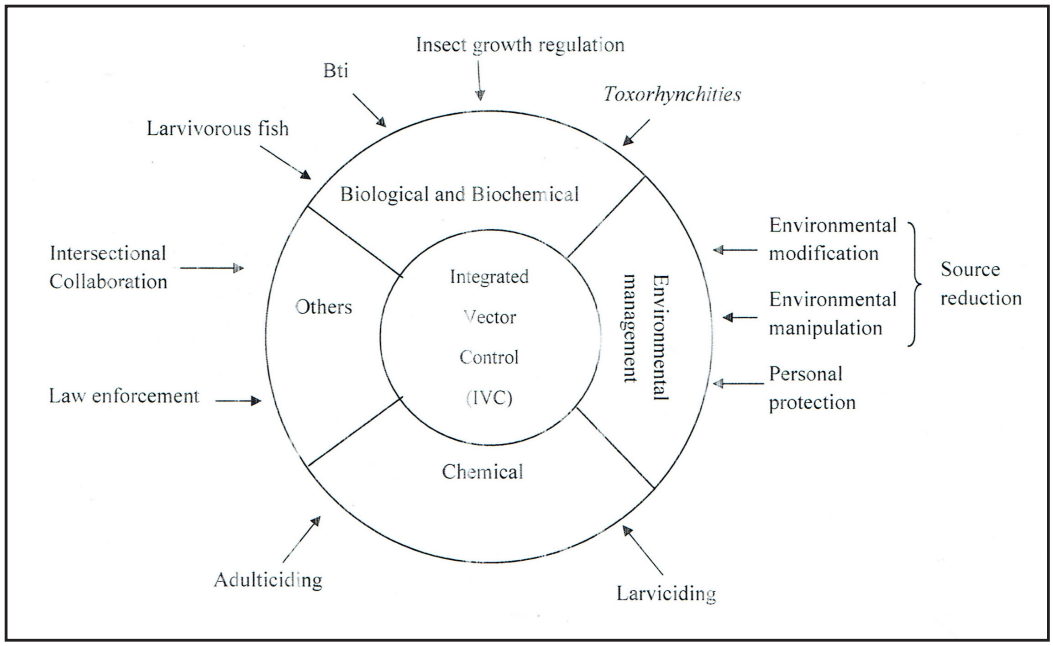

Diagram 1 : Integrated Dengue Vector Control