They may be little, weighing only 2.5 milligrams, but mosquitoes have survived through the ages. Fossil records and zoogeographic evidence suggest that these insects evolved during the dinosaur period of Jurassic age around 210 million years ago. Dinosaurs are long gone, but the mosquitoes have adapted and evolved to produce extensive taxonomic, genetic and ecological diversity.

Mosquitoes are found throughout the world except in places that are permanently frozen. Three quarters of the available mosquito species are native to the tropics and sub-tropics. The largest population of individual species occurs in the Arctic Tundra. A total of 3500 mosquito species exist, of which 350 species have been reported in India.

Mosquitoes are estimated to transmit disease to more than 700 million people annually. Some of the major diseases transmitted by these are malaria, filaria, dengue, chikungunya, Japanese Encephalitis (JE), yellow fever, West Nile Fever (WNF), Western Equine Encephalitis (WEE), Eastern Equine Encephalitis (EEE), Venezuelan Equine Encephalitis (VEE), and California Encephalitis (CE).

To understand how to curb this menace, more research has been performed with mosquitoes during the last hundred years than with any other family of invertebrates. Researchers have carried out intensive investigations dealing with their systematics, morphology, biology, physiology, ecology and disease epidemiology and more recently genetics and molecular biology.

The ecology, behaviour, development and survival of mosquitoes as also the transmission of different diseases are strongly influenced by climatic factors. Temperature, rainfall, humidity are especially important, along with wind and duration of daylight. It is the complex interplay of all these factors that determines the overall effect of climate on the local prevalence of mosquito-borne diseases. Mosquitoes use a variety of strategies to exploit the timing and location of such microclimates to maximum advantage.

As we enter the summer season full throttle, you have surely begun spotting these little devils. Let us learn more about the varieties of mosquitoes, especially those that are disease vectors. Let’s start with the Culicidae family that consists of three subfamilies – Anophelinae, Culicinae and Toxorhynchitinae.

Anopheles
Anopheles comprises 450 species of which 66 are medically important for their Plasmodium-carrying capacity. In India, 58 Anopheline species have been recorded of which 10 are known to be malarial vectors. Six important malarial vectors include An. culicifacies, An. stephensi, An. fluviatilis, An. minimus, An. dirus and An. sundacicus.

We can identify Anopheles by the three to four black spots on the upper edge of the wing, greyish brown body and pale bands on maxillary pulp. Antennae in male mosquitoes are bushy and look like bottle brushes known as plumose. In females, antennae do not have such dense hairs and are called pilose. Anopheles rest at an angle of 45° to 90° with the resting surface except An. culicifacies.

The primary vector An. culicifacies has widespread distribution, and efficiently transmits both ordinary and cerebral malaria. It breeds proficiently during monsoon and causes 60-70% of the incidence of malaria. An. stephensi is an urban vector and accounts for 12% of malaria cases annually. An. fluviatilis inhabits hilly regions in the country contributing to about 15% of malaria cases each year. An. minimus causes malaria in tea garden belts and foothill regions. An. dirus is mainly confined to the forest and forest fringe

The average life cycle is 7-10 days, but it varies at different seasons according to the climatic conditions. Temperature plays an important determining factor in the life cycle of a mosquito.
Some species in egg stage in winter await spring for hatching. Few species spend the winter dormant as larvae and a few as adults. Mosquitoes themselves are not affected by the viruses or parasites they carry because of their immune system.

An. minimus, An. dirus and An. fluviatilis maintain stable malaria in the northeastern states. An. sundaicus is at present restricted to Andaman and Nicobar Islands, though it was earlier prevalent in coastal Odisha. Forested areas are bestowed with all the malaria-causing elements at their optimal efficacy. In India, 8% of the tribal people contribute to the 30% of total malaria cases.

Besides malaria transmission, few Anophelines namely An. gambiae, An. funestus, An. punctulatus and An. sinensis carry the filarial parasite Wuchereria bancrofti in some parts of the world including East Africa and Papua New Guinea. An. barbirostris and An. hycanus can transmit Japanese encephalitis virus also. It has been seen that An. stephensi can carry the Japanese encephalitis vector.

Vector Control and Mosquito Resistance

The magnitude of vector-borne diseases is increasing with enormous population growth, rapid industrialization, indiscriminate urbanization and gross neglect of the environment. Integrated Vector Management (IVM) strategies are being worked out control vector-borne diseases.

Physical methods along with personal protection are always given first preference. But to lessen the huge mosquito population, chemical means have become essential either as larvicides or as adulticides in a variety of breeding grounds and resting places. Organochlorine and organophosphorous insecticides have been used for a long time.

Due to frequent application of the insecticides, mosquitoes have developed resistance against one or more chemical compounds. In most cases, a resistant population may show resistance to other compounds within the same chemical class, resulting in cross-resistance. Insecticide resistance is a matter of concern in India with regard to malarial vectors mainly An. culicifacies and An. stephensi. DDT resistance was first reported in An. culicifacies in 1958 in Gujarat and later from many other states. Pesticide HCH (BHC) was introduced in 1958 and the first case of resistance was registered in 1962.

An. culicifacies achieved the distinction of double resistance to DDT and HCH in 286 districts in 16 states and 2 union territories by 1990. This species later became resistant to malathion and even exhibited deltamethrin resistance in Surat and Rameshwaram by 2002. An. stephensi became resistant to DDT in 34 districts of 7 states, whereas An. fluviatilis, An. dirus and An. minimus are found to be susceptible to DDT. Managing the existing and future spread of resistance is the primary solution to sustaining insecticide-based vector control, as resistance is a natural evolutionary outcome from environmental stress caused by confined pesticide onslaught.

Biocontrol measures have been successfully adopted in many areas applying different biolarvicides i.e. Bacillus thuringiensis (Bt), B. sphaericus etc. and larvivorous fishes i.e. Guppy (Poeckelia), Gambusia etc. without any harmful effects on humans or the environment. Mosquito control by bioengineering mechanisms like Sterile Insect Technique (SIT) for male sterilization and introducing genetically modified mosquitoes (GMM) are still in the laboratory or in trial fields. SIT is less successful than expected because of low degree of competitiveness between sterile and wild males. Genetic manipulation of mosquitoes rendering them refractory to human pathogens or altering host preference is thought to be promising, though the success rate is yet to be confirmed.

Major Anopheline vectors are anthropophilic and feed on the blood of humans inside the house (endophilic). Their biting hours vary throughout the night depending on the species. Their flight range is two to three kilometres and flight sound is not audible.

Mosquitoes are highly sensitive to temperature. Anopheles and falciparum malaria transmission are sustained only when temperature is about 16°C. Anopheles breed in fresh water bodies like riversides, lakes, cisterns, wells, paddy fields etc., but few species can breed even in foul water, muddy ponds and marshlands.

Culex

Sub-family Culicinae contains nearly 3000 species under 33 genera, of which nineteen are available in India. The medically important genera in India are Culex, Aedes, Mansonia and Armigeres. The genus Culex consists of 800 species, of which 59 are found in India.

Culex quinquefasciatus is a footh-water breeding mosquito distributed throughout India, comprising nearly 70% of total mosquito population in urban areas. Biting propensity and nematode parasite transmission of this species vary at different quadrants of night and its flight range is within five kilometres. It is the main vector of filariasis in India having a filarial load of 40% of the global burden.

Culex vishnui, Cx. pseudovishnui and Cx. tritaeniorhynchus are together called Cx. vishnui group. This group generally breeds in paddy fields, grasslands and weeded ponds and is a potential transmitter of JEV and West Nile fever in India.

Aedes

Dengue and chikungunya-causing Aedes aegypti and Ae. albopictus are mainly container breeders, but sometimes share the breeding sites of Anopheles. Dengue virus has also been incriminated in Ae. albimanus, Ae. squenceis and Ae. hebridesus in India. Besides dengue and chikungunya, Aedes transmits the viruses of many other diseases including WEE, EEE, WN, VEE, Rift Valley fever, St. Louis encephalitis, California encephalitis etc. in different parts of the world. Ae. nivus and Ae. polynesians carry W. bancrofti in Sri Lanka and French Polynesia respectively.

In India, the number of Aedes species so far reported is 111. Aedes normally breeds in tree holes, small containers, flower tubs, rejected tyres etc., but also lays...
Toxorhynchites
This mosquito genus named Toxorhynchites is not only non-biting but also helpful for biological control of other mosquito larvae. This predatory mosquito breeds in tree holes, containers left in gardens, rejected tyres etc., along with Aedes. Adults are dark shiny metallic in appearance and the proboscis has a downward curve. About 72 species are known under this genus, of which 8 species have been reported in India. The most commonly available species in India is Toxorhynchites splendens. Larvae are large sized reddish brown with iridescent scales.

Lifestyle of the Little Devils
After half an hour within emergence from the pupa, the adult females fly. But they need another day for male maturation and form swarms at dusk. A female enters into the swarm and mating occurs with a single male. Many Culicines and Anophelines mate in swarms. In some species, the males are attracted by the flight of the female. Copulation in nuptial flight takes place only once in the life of a female and the sperms remain stored in the spermatheca.

In Ae. aegypti, mating is accompanied by a change in behaviour caused by the transfer of matrone, a male hormone, which makes the female refractory to conducive to successive mating and induces host-seeking behaviour. After mating, the females search for warm blood from humans, other mammals and birds. Many females may imbibe nectar prior to mating, presumably to acquire energy for flying and mate finding. Mosquito females generally mate before feeding, but in several Anophelines, a large proportion of virgins may feed blood prior to mating.

Mosquitoes locate their prey by visual, chemical and thermal receptors. They can sense carbon dioxide, octenol, lactic acids and other chemicals excreted on the body surface through sweat from a distance of a hundred feet. They can detect heat and infrared radiation from our body. There are specific receptors on antennal and palpal sensilla. It is reported that there are more than 700 sensilla in each antenna of Aedes. It appears that the hind legs are utilized either for direct perception of warmth or possible convection of currents.

After locating the warm, the female mosquito tries to find out a comparatively less disturbed portion of the body and spots an area using the labellum of the labium. Then she cuts the skin with the help of mandible and ultimately pushes the entire proboscis. In initial biting there is no reaction; but with subsequent bites, the body’s immune system develops antibodies and the site of the bite becomes inflamed and itchy. The mosquito’s pharynx acts as a pumping organ to suck the blood.

After having a full blood meal two to three times her weight, she often hides in households, cattle sheds, bushes etc. Blood provides her nutrition as well as aids egg maturation. Plant juice provides an important energy source during most of the adult lives of both sexes. Males with a ratio of nearly 40% of the total number generally die within a week after mating. After three to four days, the females of different species lay eggs at different breeding sites depending on the species-specific physicochemical properties of water bodies. The egg production in adults is greatly influenced by the nutrition of the larvae. But the number of eggs to be developed and laid per batch is determined by the quantity and quality of blood meal.

Anophelines lay eggs singly. These are boat shaped and with air floats. In Culex, these are laid collectively on a raft. Aedes lay eggs in individual manner and
Toxorhynchites is not only non-biting but also helpful for biological control of other mosquito larvae. Mansonia in clusters. Mansonia eggs are found on the under surface of the aquatic plants. At a time 50-500 eggs may be laid by different mosquito species. Eggs hatch within 2-3 days and larvae come out as wrigglers.

Culex and Mansonia larvae possess long siphon tubes, in Aedes it is shorter. Anopheles do not have any siphon tube, instead there is a pair of spiracles on eighth abdominal segment along with anal gills.

Anopheles larvae remain parallel to the water surface, whereas Culex and Aedes larvae hang from the surface through its siphon tube. The siphon tube of Mansonia larvae is introduced into the root of the floating weeds to obtain oxygen.

Larvae eat microorganisms and organic matter present in water. Anopheles larvae are surface feeders, whereas Culex and Aedes larvae collect food from the bottom also. On completion of four instars, the larvae transform into non-feeding pupae within seven days. These comma-shaped tumblers are nearly as active as the larvae and breathe through thoracic horns.

The pupal stage lasts for two days before the mosquitoes become adults. The average life cycle is 7-10 days, but it varies at different seasons according to the climatic conditions. Temperature plays an important determining factor in the life cycle of a mosquito. A common California mosquito, Culex tarsalis might go through its life in 14 days at 20°C and takes only 10 days at 28°C. Some species are naturally adapted to go through their entire life cycle in as short as four days or as long as a month. Some species in egg stage in winter await Spring for hatching. Few species spend the winter dormant as larvae and a few as adults. Mosquitoes themselves are not affected by the viruses or parasites they carry because of their immune system. The average life span of an adult female is nearly a month.

Dengue and chikungunya-causing Aedes aegypti and Ae. albopictus are mainly container breeders, but sometimes share the breeding sites of Anopheles.