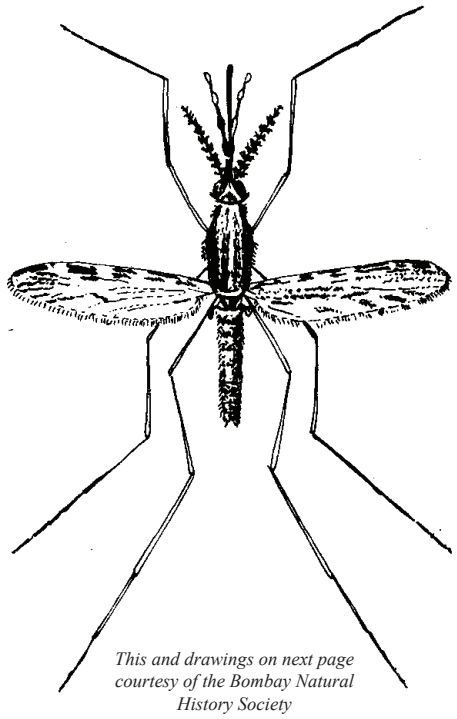
Mosquitoes



This and drawings on next page courtesy of the Bombay Natural History Society

Every night in India some 35-40,000 litres of human blood are sucked out by mosquitoes. Meanwhile, the human population receives in return a variety of potentially deadly or serious diseases, ranging from Malaria (nearly 2 million cases a year), Filaria (20 million people are estimated to be carriers, of whom one million are chronic) and Encephalitis to Chikungunya Fever, West Nile Fever and Dengue Fever, the latter the fastest growing vector-borne disease in the world today. It is also suspected that they can carry active Leprosy bacilli and Hepatitis virus, though this has not been proven outside laboratory conditions, and it is possible that they could introduce the Zika virus to India at some point. The only major relief in this depressing scenario is that there is no indication they can transmit HIV/AIDS; nor do we suffer here from Yellow Fever, which is maintained in monkeys and transmitted to humans by mosquitoes in Africa and South and Central America.

Number of species

At the end of the 19th century there was little interest in these scaly-winged flies, and only some 400 species were identified. Today there are around 3,500 identified species worldwide, of which approximately 300 are known carriers of human and animal diseases. To take the Puducherry area as an example, there are some 30 different species present, of which three are problem species carrying diseases of significance. That only 1 in 10 is a threat doesn't sound too worrying, but it should be. In some parts of Puducherry Filariasis has at times been endemic, with up to 20% of the population infected.

Distribution and importance

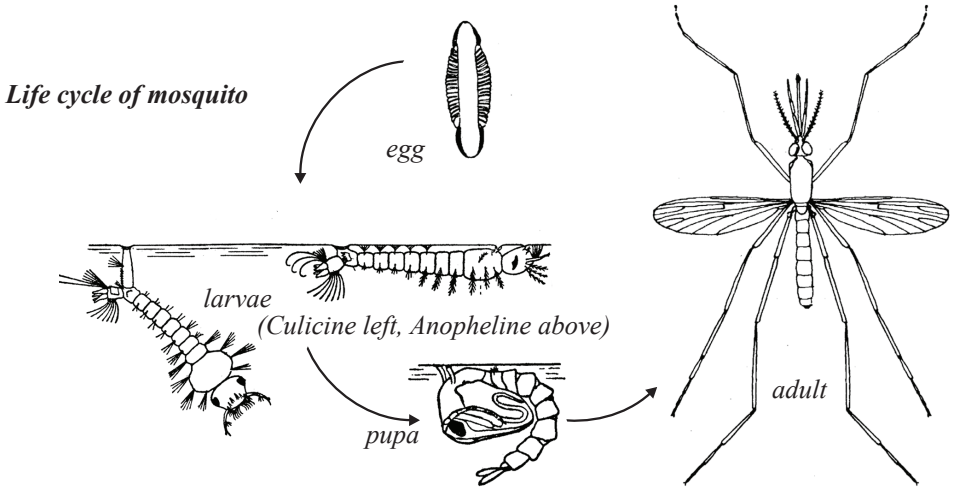
Mosquitoes, which are found in all parts of the world including the Arctic – but not the Antarctic – up to altitudes of 11,500 feet, are the world's most important single group of insects in terms of public health. Since the discovery that they carry human disease, countless attempts have been made to eradicate them from areas of human habitation, but thanks to their incredible ability to adapt to pesticides they have continued to co-exist with us. At best we have never managed to do more than control their numbers.

Breeding / life cycle

The life cycle of mosquitoes is complex, with three stages (egg, larva and pupa) spent in water and only the final stage (the mature insect) outside. The eggs are generally laid on the surface of water, individually or in rafts of anything from 30 to 300, though some species lay on damp surfaces near water such as mud. For water-laying species the type of water is important. Some species, such as the Filaria carrier for example, will only lay in stagnant, poor quality polluted water, while others may need brackish water, the water of salt marshes, or clean fresh water. Other factors are also important: water lit by sunlight is preferred by some species, but not others; likewise still as opposed to running water; and water with vegetation as opposed to without. There is even a species that needs the watery pulp of fallen tropical fruit to breed.

One widely held misconception is that trees and shrubs also provide breeding habitats. The truth is that they only provide cool, shady resting places for the adults, though they may occasionally provide micro breeding habitats in the form of water-holding 'cups', as – for example – where tree branches join the trunk.

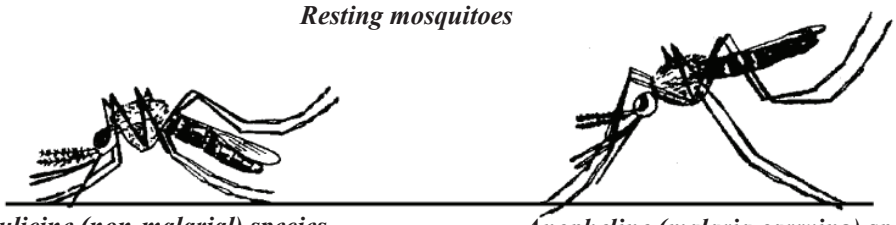
Likewise, certain plants such as Bromeliads also form water-holding receptacles. As little as half a coconut shell of water standing for a fortnight can easily be enough for mosquitoes to complete a breeding cycle here in the tropics, though elsewhere longer may be needed because of the effect temperature has on the organism's development rate. The Arctic is a good example of the latter, and also shows the extremes of adaptation reached, because mosquito larvae there can even remain alive locked in ice during the winter. The result in spring is a nightmare for humans and animals alike, with the insects present in their billions. Protective clothing is essential, unless one can tolerate bite rates of up to ten a minute.



Typically in this part of the world eggs hatch within two days of laying. The larvae – or wrigglers as they are generally known – emerge with the help of a spiked 'egg breaker' on their head. They then begin a very active phase, lasting about a week, of feeding and growth, during which they consume organic particles, dead plant matter, certain micro-organisms and planktonic substances. They swim with a lashing/jerking movement of their bodies, rising to the surface to breathe air, except in the case of a very few species, some of which breathe via plant stems. When at the surface, species can be broadly distinguished by the way they position themselves: the *Anopheline* variety – approximately a third of which carry malaria – lie flat against the surface of the water (see above), and the non-malarial *Culicine* variety hang head down, breathing via a tube at their tail end. Unusual for the insect world is the fact that in all mosquito species the pupae, which are known as bullheads or tumblers, are also active swimmers like the preceding wrigglers.

The lifespan of females can be up to 8 weeks in ideal circumstances, of males around 10 days, though species that hibernate over winter in colder clemates may live as long as 6 months.

Resting mosquitoes



Culicine (non-malarial) species ***Anopheline (malaria carrying) species***

Behaviour

The adult mosquito that emerges from the water environment of its development stages usually remains close to water, or at most is rarely found more than a kilometre or two away. It is mainly a nocturnal creature, hiding by day in shady moist habitats. Some species, however, may also be active during the day in poorly lighted circumstances. Mostly mosquitoes take to the air in the fading light of early evening and remain active until dawn, though certain malaria carriers are more specific: they reach peak activity for an hour at dusk and then again for a further hour at dawn. Most are attracted to light, and in the biting species to lactic acid secretions on the skin of humans and animals, plus the carbon dioxide we exhale. The heat of our bodies may also play a role. The distance at which they can detect us, however, is affected by weather, especially the wind, but is thought to be in the region of 20 to 50 metres.

Whining sound

Of the many common sounds in nature, one of the most familiar is the whining/buzzing noise of a nearby mosquito. All species make the same basic sound, both males and females, which originates from

the rear edge of their wings rubbing at high frequency against two small projections on their body called the halteres. These projections, seen also on houseflies, which lie just behind their wing and are thought to help balance them in flight, are all that remains of another pair of wings lost tens of millions of years ago in the early stages of their evolution. Contrary to what one might expect, the noise doesn't attract mosquitoes to each other. In fact it seems to serve no practical purpose.

Mating

The mating of mosquitoes is a very rapid affair, completed within 10-15 seconds once they link up. The males of many species may often be seen swarming together over a dark object in the early evening. As they swarm, they emit a chemical pheromone to attract females, and any female entering the swarm is quickly seized upon and impregnated. If you move the dark object – which may be nothing more remarkable than your own head of hair – the swarm follows. Actually, it is a paradox of mosquito-human relationships that just when you seem most immersed in a swarm of them you are least likely to be bitten, as becomes clear under the next subhead.

The bite of a mosquito

People generally believe that all mosquitoes bite. If they were told that only 1 in 10 species bite animals or humans, and that only one sex does the biting, they would probably guess that it is the male. After all, the human tendency to anthropomorphise (endow other creatures with human behaviour patterns) naturally leads us to assume that females are the gentler sex, but this is not so with mosquitoes. All the bites that we receive, in company with other animals, wild and domestic, plus creatures such as birds, reptiles, frogs, turtles and snakes, are delivered by females, who bite because they need the protein-rich blood to mature their eggs. Their first blood meal is usually taken five days after emerging from the pupal stage, and then every three days or so throughout their life, which is a more or less continuous egg-laying affair. As they normally only live on average 2-3 weeks that means some 4-5 blood feasts, providing they can find the hosts (some are choosy and will only bite a specific host species). They can extract up to three times their body weight in blood.

Having so said, the "bite" of a mosquito is not actually a bite, in the sense that it doesn't close jaws on you; nor is it a sting in the sense that creatures like wasps sting, with a hypodermic-like jab from their rear end. What they do is "saw" their way through the flesh, using four separate cutting edges which form part of their jaw/mouth structure. These are normally kept in a protective sheath, together with a tube via which blood is siphoned out and a duct that carries anti-coagulant fluid into the wound to keep the blood flowing (*surely one of nature's more brilliant though somewhat distasteful refinements*).

Male mosquitoes, which can usually he distinguished by their more bushy antennae (cf. men's moustaches?) are relatively innocuous and gentle insects, feeding only on nectar and plant juices, which they extract via the same sort of proboscis that the females use to reach our blood. To be fair – and a little gallant? – one should add of course that in between blood feasts the females are just as harmless and gentle as the males, feeding on the same sort of plant juice diet.

Flight

Mosquitoes habitually fly into the wind in an erratic manner in pursuit of host creatures, the height of their flight varying by species. The majority stay close to ground level (you have probably noticed that your feet and lower legs are bitten most); others fly much higher, even at treetop height. As a rule of thumb you can take it that 90% of mosquitoes fly no higher than human head level. Apart from the height factor, some species also have a preference for open areas, while others stick to jungle or tree and shrub-covered terrain.

Eradication programmes

I shall never forget walking in a suburb of Pondicherry late one afternoon in the 1980s, and suddenly – within metres – going from comparative fresh air into a seriously toxic atmosphere. I literally couldn't breathe without coughing violently, and my eyes were stinging painfully, when round the corner came a vehicle spraying a misty cloud of anti-mosquito poison. I literally ran for fresh air, scarcely able to believe that any responsible urban authority could unleash on its human population such a nightmarish experience. No doubt many mosquitoes were killed, but how about the effect on people? Later I learned with even greater concern that the chemical sprayed was malathion, one of the most deadly of pest poisons, and that the spraying was conducted by the local Department of Health.

As already stated, mankind has employed a variety of techniques, all unsuccessful in the long term, to eliminate mosquitoes ever since they were linked to serious human illness. Spraying poisons is one such technique. However, it is now generally accepted that it should not be done in concentrated areas of human

habitation, unless there is an extremely serious and immediate health threat. Even then, the spraying should be done only after people have been warned, and efforts made to clear everyone off the streets. Meanwhile, at best such spraying, which causes more harm to humans than the mosquito population, can only be temporarily and partially successful, because mosquitoes rapidly adapt to poisons, usually within a few generations, and no matter how much an area is sprayed one doesn't kill them all. Furthermore, one kills a whole variety of other creatures at the same time, many of them beneficial to mankind. So what can one do?

Modern control methods

Thankfully, over the past few decades much more subtle scientific approaches have been adopted to control mosquitoes. Sprays are still used, but generally only in places like plantations or similar areas beyond human habitation, and then only as a last resort. In fact it is now a technique to be avoided wherever possible, together with toxic dusts or oils for water surfaces, because of the environmental damage done. Much more effective are the following less harmful control measures recommended and pursued by people like the Vector Control Research Centre (VCRC) near JIPMER Hospital, Puducherry.

Introducing fish. Although all fish will eat mosquito larvae given a chance, species like Guppy (for polluted water), Gambusia (for places like wells and closed water systems, but not in more open areas because they eat the young of other fish) and Tilapia are all suitable in this part of the world because of their hardiness and ready availability.

Introducing or maintaining populations of other predators. Although not always as effective as fish, mosquito predators such as bats, geckos, garden lizards, chameleons, frogs, toads and dragonflies (especially their water-borne nymphs) all play a role in keeping mosquito numbers in check. Therefore any actions which may attract such predator species or maintain them in an area can be seen as positive contributions.

Introducing predator mosquitoes. One of the not-so-long-ago excitements for people in the Auroville area near Puducherry was the news that there is a species of mosquito (*Toxorhynchitis*) which doesn't bite humans, but whose larvae kill the larvae of the worst pest species. It is a very large, very colourful mosquito, and several keen environmentalists had visions of using it to rid the area of disease-carrying species, or at least controlling their numbers. However, that dream proved unrealisable, because *Toxos* breed almost exclusively in the holes/cups of trees, and at the time there were not enough such trees existing in the area to establish and maintain a breeding population. Even if there had been, still complete eradication of unwanted species is not so simple as it sounds, because once the *Toxos* have decimated the prey larvae they run short of food for themselves, and their own numbers dwindle... until more prey species re-establish themselves. (*Nature, in case you hadn't already realised, is extremely fickle and complex.*)

Teaching people environmental sanitation. Not so long ago someone living near Puducherry grumbled to the VCRC people that he was plagued by mosquitoes, despite the fact (or so he claimed) that there were "no ponds or breeding places near the house." A visit by a VCRC expert quickly changed things. Within 30 minutes the expert had found some 20 potential breeding sites. Unknowingly, and despite reasonable intelligence and a desire to avoid mosquitoes, the man had largely created and was maintaining the very problem he was complaining about.

If everyone eliminated potential breeding sites around their own house, and ideally further afield, there would be a substantial drop in mosquito numbers. The fact is, most people are unaware of how they directly contribute to the mosquito problem themselves by creating or ignoring breeding sites all around them. Upturned cans and plastic containers, broken kujas, half coconut shells, open vents to septic tanks, the hollow inside cut stems of bamboo, badly fitted drain covers, blocked drains and gutters, puddles under leaking taps, ornamental ponds without fish, tilted empty flower pots, grinding-stone cups, wells (especially old unused ones where water has become polluted), discarded tyres, open overhead tanks, waste water from cattle sheds, open cesspits, puddles, and many other such places and circumstances all provide ample breeding opportunities.

Mostly people are ignorant of their own contribution, but even when informed the majority are too lazy to act. After all, no-one considers the occasional mosquito bite to be specially serious, nor do they believe that their own limited eradication efforts can make a difference. In theory of course they are right, but – like voting in General Elections – if everyone acted the combined contribution would be immediately noticeable.

Educating architects, builders and landscapers. If every house was designed and built to allow complete water run-off, paid attention to landscaping and proper finishing around the building, avoided the creation of potential breeding sites, and incorporated deterrent measures against adult insects, again there would

be an overall improvement in the mosquito situation. Much more could be done by those commissioning buildings to insist on such features and measures. The same applies to road engineering, town planning and the creation of other environmental features.

Use of pheromones. This is still in the experimental stage, but ultimately could be the most effective technique of all. If scientists can manage to duplicate the sex-attractant pheromones released by males, then they will probably have a fool-proof method of luring the egg-laying females into traps for destruction. The problem (*isn't there always one?*) is that each species has its own pheromone, so it is likely to be a long time before the technique can become effective against all the disease-carrying species.

GM mosquitoes. In June 2014 UK-based scientists announced development of a genetic vector control strategy that wiped out most of the female mosquitoes in a laboratory experiment. In the experiment they inserted a DNA-cutting enzyme into a major malaria carrying species, which ensured that almost no sperm carried the female (Y) chromosome, with the result that the offspring of the genetically modified (GM) mosquitoes were almost exclusively male instead of the usual half-male half-female mix. This is the first time that humans have been able to manipulate the sex ratio of mosquitoes, which is an intriguing prospect. However, more work has yet to be done to see what negative repercussions there may be before such a strategy can be implemented in the wild, even on a local trial basis.

Implementation of controls

All the above control techniques have present or future validity, but who should carry them out? The understanding of vector behaviour and the design of suitable eradication techniques, plus their on-going supervision, calls for the expertise of entomologists and natural scientists, yet in India the job has traditionally been left to the Health Department. To compound the problem, vested interests (chemical manufacturers, etc) plus bureaucratic and political factors have also sometimes combined to render programmes ineffective. Meanwhile, just as the Government tackles road safety awareness, in the same way it could also make people more aware of how they can eliminate mosquito breeding sites around their dwellings. Children in schools should be similarly informed.

Personal mosquito deterrents

So much for control techniques and programmes, but what can one do in the meantime to deter those blood-lusting females? There are of course chemical repellents which can be rubbed on exposed skin, like Deet (though they are developing immunity to it), and mosquito coils one can burn, but not all mosquitoes are repelled and not everyone likes to use such products. More natural are liquids like citronella oil and lemon juice, peppermint, the oil from orange peels, and camphorated alcohol (if you are not on homeopathic medicine). Garlic, neem, perfumes and cigarette smoke have no deterrent effect.

Individually we can make a difference

Of course, we have learned to live with large numbers of mosquitoes, and so we are somewhat resigned to their presence. But it doesn't have to be like that. Why sit back and wait for somebody else to tackle the problem, when a substantial part of it probably lies in our own back garden? Each of us (from today onwards?) can make a positive contribution by at least eliminating potential breeding sites around our own dwelling, school, college or place of work, and ideally further afield. We can also inform and try to influence others around us, specially family and neighbours. And we can try to protect and encourage the predators of mosquitos, such as bats, fish, dragonflies, frogs and toads and their tadpoles, birds such as purple martins, etc.

It all seems to come down to whether people care enough, and whether they have the will to act – like that important job Everybody was sure Somebody would do. Remember? In case not let me remind you. Anybody could have done the job, but Nobody did it. Somebody got angry about that, because it was Everybody's job. Everybody thought Anybody could do it, but Nobody realised that Everybody wouldn't do it. It ended up that Everybody blamed Somebody when Nobody did what Anybody could have done ☺.

Additional miscellania

* A mosquito beats its wings 600 times a second.
* People having blood group 'O' are twice as likely to be bitten as those with blood groups 'A' or 'B'.
* Malaria has killed more people than any other known disease. Although the number of cases worldwide is currently falling, still nearly 200 million people are estimated to be infected by mosquitoes every year, of whom over 400,000 die (approx 10-15,000 in India). 90% of the deaths are among children in sub-Saharan Africa, with one child dying there on average every minute.