No Love for Mosquitoes

by FeiFei Jiang

In the fight against malaria and other insect-borne diseases, scientists take aim at sixteen seconds of mosquito mating.

In steamy sites ranging from Sudan to Tahiti, Mozambique to the United States, researchers are studying the sex life of the male mosquito — in order to halt reproduction. Why? Mosquitoes can be deadly carriers of disease, including malaria and yellow fever.

In July 2008 in Vienna, the world´s leading scientists in mosquito research met to compare notes and map strategies for thwarting the mating of mosquitoes in the wild. The results, down the line, stand to be an important component in arresting the spread of malaria and other insect-borne diseases.

Genetic Science Opens Opportunities

The male mosquito is growing in significance as a target of scientific research due to developments in genetic control techniques. They include the method known as Sterile Insect Technique (SIT), used to control unwanted populations of insect pests. It has been successfully applied against various insects, including the screwworm threatening livestock and fruit flies threatening crops.

The mosquito can become a vector for diseases such as yellow fever, dengue, and malaria — illnesses that are fatal to over 2 million people per year worldwide. The Anopheles mosquito, in particular, carries and spreads the deadly malaria parasite, one of the main foci of the IAEA scientific meeting.

Other techniques such as indoor spraying, insecticide-treated bed nets, and larval treatment are all being used in the war against these tiny harbingers of disease and devastation. SIT, however, may prove to be one of the more effective weapons in the arsenal, with the potential of being able to eliminate entire mosquito vectors in specific regions. The radiation technique sterilises millions of male mosquitoes in the lab and releases them into the wild to mate with female mosquitoes. The goal is to control and eventually eliminate the targeted mosquito population.

"In a nutshell, SIT is birth control for insects," says Mark Benedict of the IAEA´s research laboratories in Seibersdorf, Austria.

The researchers are conscious of the potential human impact of their work. Scientists Jacques Charlwood, currently working in Mozambique, and Alexander Yawson of Ghana have both helped start clinics to treat malaria in the regions in which they work. Says Yawson, "Malaria is the primary cause of death in children under five. Malaria... accounts for 45% of all our patients."

Targeting Males

It is only the female mosquito who feeds on blood, picks up a virus or a parasite, and spreads the disease. Why, then, the recent interest in the male mosquito?

Explains Bart Knols, a Dutch scientist: "The females are responsible for passing on the pathogen between humans... The males, however, play a very important role because they are involved in reproduction and population growth in the field, so if you can control the males... then you can define ways to control that population."

If scientists can successfully control the reproductive process through the males, then the entire mosquito population, including the female disease vectors, may thus be eliminated. One female mosquito

lays hundreds of eggs in her lifetime, but what most do not know is that all of these eggs result from a single mating.

In Search of Sixteen Seconds

Scientists know the basics about how mosquitoes mate, but crucial questions remain.

Typically, the male mosquitoes emerge at sunset and form swarms at a specific location, usually over a visual marker such as a bush or a small tree. The swarm performs what looks like a complicated, interlocked dance — much like a swarm of locusts — but that is based on three simple mathematical principles: keep one's distance, maintain a constant speed, and move towards the centre.

"The swarm is more or less like a disco," Dr. Charlwood describes, gesticulating animatedly. "The males are all dancing around, as if to shout, ´Look at me! Look at me!´"

Scientists are not sure what draws females into the swarm. Some think that the females, when young, act like pseudo-males, instinctively flying to certain attractive visual markers. Others believe that the female mosquitoes are drawn to the swarm by their sense of smell, or perhaps some kind of chemical cue.

When a female enters the swarm, the males can sense her with the aid of her wingbeat frequency, which is lower than that of the males. Once a male has sensed a female, his wingbeat frequency slows to match that of the female. The male then uses his large front claws to snatch the female by the back legs, using the female´s legs like a trapeze bar to swing under her abdomen. In less than one second, the male´s terminalia attach to the female´s abdomen. The connected pair then slowly flies out of the swarm while mating in mid-air. The entire mating process takes less than 16 seconds.

Once mating is over, the female mosquito´s eggs are fertilised; all of the eggs that the female lays in her lifetime will result from this one mating. Thus, if a SIT-sterilised male mates with a wild female, the female´s unfertilised eggs will never hatch.

Plotting the Research

Still, questions remain. Is mating a selective process? If so, what is it that makes a male attractive? Though the even ratio of males-to-females, and the fact that a female only mates once during her lifetime, dictate that on average, each male mates only once a lifetime, the reality may not conform to the math. Perhaps some male mosquitoes mate multiple times, and some are left without any mates at the end of the day.

So what is it that might make some males more successful than others in the mating game? Researchers are currently striving to answer this question, which may help make the lab-grown sterile males competitive as mates when released in the wild.

Mozambique´s Dr. Charlwood is working with a grant from the IAEA to record the swarms mating in high-definition video format in order to better understand the process. Perhaps, he says, the larger male mosquitoes are the most successful ones, or maybe it is the most symmetrical mosquitoes, or the most agile. At present, there is no consensus. Or perhaps it is as the math suggests, and mating is completely anonymous. These are the questions that have inspired last week´s meeting to discuss male mosquitoes and mating processes - and their answers may be the key to the success of many SIT programs.

Interestingly, says Dr. Knols, the SIT is a very "green technology". "You´re releasing an insect that will specifically go out in the environment and look for your target insects, unlike chemical pesticides, for instance," he explains. That helps to make it efficient and environmentally friendly.

Much Work Still Needed

Early results from very preliminary studies of SIT on mosquitoes show great promise. The research file goes back as far as the 1970s in El Salvador, says the IAEA´s Mark Benedict. They focused on one particular malaria vector. "Even though their techniques were very crude, they eliminated an isolated population within one season," he says.

One target area today is an isolated region of Sudan, where a planned SIT facility looks to be up and running by 2010.

"Hopefully, we´ll introduce a novel way for controlling mosquitoes that transmit disease," Dr. Benedict says.

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