

The Mosquito in Pandora's Box

by

Kendra Byler

### The Kenley Farrel Memorial Scholarship 2005 Essay

Mosquitoes have long been a nuisance to mankind. They receive this reputation not only because of their itchy bite, but also because of their notorious abilities to pass on diseases such as Malaria, West Nile Virus, Dengue, Yellow fever, and others. Malaria is the most prevalent of these, killing between 1.5 and 2.7 million and infecting 300-500 million every year (Parker). Research has been done on treating and lessening the effects of malaria, but now scientists are investigating a form of malaria prevention.

Malaria is passed on by an Anopheles mosquito that feeds on an infected bloodstream. The malaria parasite Plasmodium enters and develops in the mosquito's gut and then moves into its salivary glands where it is transmitted into another bloodstream (Mosquitoes vs. malaria). The typical life span of the female mosquito, which actually transmits the virus, can be up to one month, but is normally no longer than two weeks. The parasite actually needs 10 to 21 days of incubation, so the actual number of females that transmit the developed Plasmodium is less than 10% (Malaria). Malaria causes damage to the liver, kidneys, and other parts of the body and is a painful experience (Parker). Unfortunately, there is no vaccine foreseen in the near future. Researchers have turned to finding new ways to undertake this ongoing problem, one of which is to genetically modify the mosquito so that it will not sustain the parasite to begin with. ("First Population Study")

Researching at the European Molecular Biology Laboratory (EMBL) has shown that the protein factors of the mosquito's immune system determine whether the mosquito will transmit the virus. They discovered four different proteins that change how the mosquito reacts to the parasite: They were given the names: TEP1, LRIM1, CTL4, and CTLMA2. TEP1 and LRIM1 proved to work against the parasite, and kill it in the mosquito's gut. The CTL4 and CTLMA2

work in protection of the parasite, thus enabling the mosquito to pass it on. If these proteins were taken out of the mosquito, the parasite would have no shield against the TEPI and LRIM1, thus killing it (Mosquitoes vs. malaria).

Professor Kafatos of EMBL says,

These studies are the first to show the power of the mosquito's immune system and give us some very real options for fighting the disease in the insect before it even has a chance to be passed to a human. . . There is no single 'magic bullet' for controlling this ancient scourge of humanity, but we want to exploit this new lead to contribute to the defeat of malaria. (Mosquitoes vs. malaria)

However, there are numerous aspects of genetic modification to be considered before releasing these mosquitoes and questions remain to be answered.

For example, there has been much progress in developing transgenic mosquitoes, by the transformation of wild mosquitoes, but

Little work has been done with laboratory-generated genotypes to determine the likelihood of transgenic insect establishment, population growth, and persistence when competing with non-transformed wild types in nature... [C]reating insects with appropriate fitness will be critical to the field-level success of transgenic-based control strategies. Important demographic factors are rates of sterility or egg inviability (i.e. progeny production), sex ratio of offspring, juvenile viability, development times, and adult longevity. (Hoddle)

These are factors involved not only that the laboratory has to re-create but also has to find ways to reinforce the mosquito's competence.

An interesting area for molecular biologists, is finding all the variables that need to be considered in adding new material the mosquito's DNA. Several topics to be considered are the differences in their fitness, which depends on the transgene placement in the DNA, any mutations that may occur, results of an interrupted DNA chain, and breakdown effects when they interbreed. A study of this was done on caged transgenic mosquitoes with wild-type mosquitoes and the transgene number declined rapidly and often died out altogether (Hoddle). A test done at the Imperial College of Science Technology and Medicine showed the modified mosquitoes carried the gene for over thirty generations when they were bred among themselves. But, when they were bred with the wild-type mosquitoes, the gene disappeared within 4 - 16 generations ("First Population Study").

In a study completed by the University of California Riverside, the mosquito they produced had a much smaller capability to increase population than the original mosquito. The engineered mosquitoes laid fewer eggs and also had a lower egg-adult survival. This type of data shows a near impossibility for the new mosquito to be able to displace the diseased mosquitoes ("Transgenic Mosquitoes").

The study at Riverside showed that the non-transformed breed reached a pre-determined population point 41% - 47% faster than the transgenic mosquitoes. This clearly shows that researchers need to create a breed that will compete better in the wild, especially since the focus of the study is to have the genetically modified mosquito eventually take over the population of the wild, malaria-carrying mosquitoes (Hoddle).

Their research also showed that

Significant differences existed between lines of transgenic mosquitoes. For example, fecundity was significantly impaired for all transgenic lines in

comparison to non-transformed counterparts. In this study, the authors demonstrated that negative effects of transgenesis on fitness are not uniform, and a strain that performs poorly in one area may outperform other strains when different characters are measured. (Hoddle)

It is necessary to understand what all feeds into these characteristics and what compels the conflicting reports. A standard way of testing and developing is needed in order to compare data on the same level (Hoddle). Standardization is also necessary because of the different ideas they have of breeding with wild species or only interbreeding and eventually outnumbering the wild species, and because of their different methods of testing.

Thomas W. Scott, a medical entomologist at the University of California Davis, has reported his group's recommendations saying that the research in the future also needs to consider the resistance a Plasmodium parasite, for instance, may evolve. The introduced genes are just as likely to form barriers to drugs as the genes they have now. The effectiveness of the vaccines and drugs now used for treatment would be useless if the gene rejected treatment. Careful, consistent testing must be done to prove that such occurrences would not happen, and if they did, they would remain manageable and harmless.

Cells also are able to take the information from its mother cell and produce different proteins by editing the information.

This...means that a certain gene inserted into the DNA of an organism might not produce only the protein that the scientist desires. Since the cell environment of the host DNA determines the editing, different, unanticipated proteins could be produced from the donated gene. (Batten)

These proteins may be infectious proteins that cause other proteins to take on their shape and then replicate in a cell, which causes considerable cellular damage. This event is most frequently observed in the Creutzfeldt - Jakob disease and possibly what occurs in Mad Cow Disease (Batten).

Study is also needed on the affects the modified mosquito would have on human infection. If the modified mosquito does work, it will reduce the amount of people infected; but it has been shown that the severity of the malaria would be worse. This is a result of more people being infected for the first time as adults instead of as children: With malaria, a first time infection for an adult is much more severe than it would be for a child. The team at Davis also recommends future research on insecticides that would potentially kill the new mosquito. They accurately point out that it would be unbeneficial to kill the modified mosquitoes along with the wild ("Mosquito Ecology").

Still another issue that needs to be addressed is the ethical, legal, and social aspects that are related. Topics such as testing grounds are especially a concern: the place would have to be representative of the wild conditions a normal mosquito would live in; the cages they test them in would have to be ecologically isolated; there would need to be sufficient facilities, staffing and funding to operate the studies; and the animals and people involved would be at high risk if anything did not go as planned ("Mosquito Ecology").

The issue of testing the mosquitoes is controversial because the risk to human health is so high. The American Psychological Association (APA) Ethical Guidelines for Research "Participants should not be exposed to harmful or dangerous research procedures. Furthermore, they should be permitted to withdraw from a study at any time if they so desire" (Weiten). The participant must never be coerced into participating in the research. The person must be fully

aware of any risks that go along with the research and not just be shown the fact that would receive a certain amount of money or reward.

Objections of the novel mosquito rise in the light that displacing all the wild varieties of mosquitoes would be difficult. This is true especially considering all the different sub-groups would react differently to the novel gene. However, Professor Andrea Crisanti at Imperial believes doing a study in the Mediterranean region would reduce any risk because the mosquitoes would not be able to breed with the native species. (“First Population Study”).

The innovated mosquito would really be a useful scientific discovery, especially at this crucial time in the world of pathology. A mosquito of this caliber, in theory, would save thousands of lives in a single year; but in reality, the mosquito that is currently developed would be unsuitable for undertaking such a task. Short term problems include fewer and more severe cases of malaria, the gene not surviving in the mosquito, or mutations causing deficiency. Long term affects may involve gradual genetic changes in the mosquito’s DNA that would pose a more dangerous threat of disease, a mosquito that acquires immunity to chemical forms of control, or the mosquito interbreeding with the disease-carrying mosquitoes and being unsuccessful in building malaria-resistant communities.

The concept behind the genetically modified mosquito would be helpful to the world, but it needs to be moved beyond a concept if it is going to work. It needs more study and research before it can be a resourceful action because, as it stands, it poses a great danger to the health of people. Is an “enhanced” mosquito really worth the risk it poses to the world?

Works Cited

- Batten, Don. "Frankenstein foods?" Creation 24 (4):10-13. September 2002.
- Berman, Jessica. "Genetically-Altered Mosquito Could Break the Circle of Malaria Transmission." Voice of America. May 25, 2002. 16 Sep 2005.  
<[http://truthnews.com/tech/2002\\_05\\_genetically\\_altered\\_mosquito.html](http://truthnews.com/tech/2002_05_genetically_altered_mosquito.html)>.
- "First Population Study Of Genetically Modified Mosquitoes Highlights Difficulties Facing Malaria Control Technique." 20 Feb 2003. 6 Sep 2005.  
<<http://www.sciencedaily.com/releases/2003/02/030221080622.htm>>.
- "Flying Bednets." 9 Sep 2005.  
<<http://www.wellcome.ac.uk/en/malaria/TheMosquito/mfengi1.html>>.
- Hodde, Mark S. "HOW FIT ARE GENETICALLY ENGINEERED MOSQUITOES?" Aug 2004. 16 Sep 2005. <<http://www.nbiap.vt.edu/articles/aug0401.htm>>.
- Malaria. "Anopheles Mosquitoes". 7 Sep 2004. 26 Sept 2005.  
<<http://www.cdc.gov/malaria/biology/mosquito/>>.
- "Mosquito Ecology Needs Study if Genetically Modified Mosquitoes are to Curb Disease." UCDAVIS News & Information. 2 Oct 2002. 16 Sep 2004.  
<[http://www.news.ucdavis.edu/search/news\\_detail.lasso?id=6179&title=Mosquito+Ecology+Needs+Study+if+Genetically+Modified+Mosquitoes+are+to+Curb+Disease](http://www.news.ucdavis.edu/search/news_detail.lasso?id=6179&title=Mosquito+Ecology+Needs+Study+if+Genetically+Modified+Mosquitoes+are+to+Curb+Disease)>.
- Mosquitoes vs. malaria : How we can win the fight. 6 Sep 2005.  
<[http://eurekaalert.org/pub\\_releases/2004-03/embl-mvn032204.php](http://eurekaalert.org/pub_releases/2004-03/embl-mvn032204.php)>.
- Parker, Randall. "Genetically Engineered Mosquitoes Could Stop Malaria." 29 March 2004. 6 Sep 2005. <<http://www.futurepundit.com/archives/002022.html>>.
- "Transgenic Mosquitoes are Less Fertile than Their Counterparts in Nature". 13 Jan 2004. 27 Sep 2005. <<http://www.newsroom.ucr.edu/cgi-bin/display.cgi?id=722&type=print>>.
- Weiten, Wayne. Psychology Themes and Variations. Thomas Wadsworth, Belmont: 2004. 6<sup>th</sup> Ed. P 64.