Globe-trotting insects spread resistance

Much to the frustration of scientists, some fruit flies scamper around on insecticide crystals designed to kill them. But now entomologists have identified and described the genetic mutation that appears to make the insects resistant to cyclodiene insecticides.

That mutation, consisting of a single change in the chain of nucleotide bases that make up the flies' DNA, may be responsible for up to 60 percent of all insecticide resistance, says Richard H. ffrench-Constant, an entomologist at the University of Wisconsin-Madison. Furthermore, because scientists found the identical mutation in 58 different strains of fruit flies collected from five continents, ffrench-Constant suggests that it arose in one location and then rapidly spread worldwide.

This genetic change alters the structure of the GABA receptor, an important protein that prevents nerve cells from firing, ffrench-Constant and colleagues report in the June 3 NATURE. Cyclodienes normally bind to this receptor, blocking the passage of inhibiting messages; as a result, the overexcited insect goes into convulsions.

The mutation prevents the cyclodienes from attaching, so the receptor functions normally — even when the fly is doused with the insecticides.

The theory that the mutation spread globally from one population is proving controversial. Such dispersal would entail not only transporting the fruit flies, but also their ability to establish themselves and to predominate over local species, argues entomologist George P. Georghiou at the University of California, Riverside. Insecticide resistance could give alien insects a selective advantage over nonresistant natives, he adds.

Precedence exists for this. Scientists reported in 1991 that a nonmalarial, insecticide-resistant mosquito had migrated worldwide from its African home. Although insects have been transported in ship cargoes in the past, "we are more concerned today because of greater traffic and the phenomenon of resistance," says Georghiou. The prospect of global pest migration may call for stricter quarantine measures in world commerce, says Richard T. Roush, an entomologist at Cornell University.

A single origin is indicated by the mutation itself and by the noncoding genetic material surrounding the mutation, both of which are remarkably similar in all resistant strains, ffrench-Constant says. However, Roush, who uses a different genetic technique to examine the mutation, asserts that there are insufficient data to determine whether the resistance mutation has one origin. In addition, the receptor probably has a limited number of ways it can mutate to become resistant without also killing the insect, making the possibility of multiple origins more likely, Roush says.

Regardless of the mutation's beginnings, its identification should help in insecticide development, the report notes. Since insecticides were first used in the 1940s, over 600 insect species have developed resistance, leading chemists to constantly search for new products. Insecticide resistance now costs an estimated $1.4 billion a year in crop losses in the United States alone.

Cyclodienes are widely used in the developing world, and even though U.S. farmers have not used them in 30 years, resistant insects still inhabit fields and orchards. New insecticides that target the same genetic site as cyclodienes could be automatically impotent in these insects. Now, by understanding the GABA receptor mutation, chemists can avoid developing compounds that bind to this site, says coauthor Alison E. Chalmers, a geneticist with the Rhône-Poulenc Ag Company in Research Triangle Park, N.C. This approach might have avoided the problems of insect resistance to pyrethroids, newer chemicals that target the same genetic site as the U.S.-banned insecticide DDT. Cotton crops today suffer huge losses because of DDT-resistant caterpillars, which also proved pyethroid resistant.

In the long run, ffrench-Constant would like to transfer the insecticide-resistant gene into beneficial insects, such as bumblebees. Such transgenic bees could then survive insecticide exposure. Georghiou notes that evidence of the mutation's rapid spread should further "stimulate interest in alternative methods, the integration of chemical with nonchemical controls." This would reduce insecticide use, thereby delaying the onset of resistance in additional species.

In the near term, ffrench-Constant plans to clone the GABA receptor gene in pest insects, where he expects to find the same mutation that popped up in the fruit fly. *— B. Wuethrich*

Speedy spin kept early Earth from freezing

In the beginning, there was heaven and Earth, and a weak young sun shining faint rays into the newborn solar system. The juvenile sun was so dim, in fact, that it could not have kept the early Earth from freezing solid, causing scientists to wonder what steered our watery planet from a frigid fate that would have precluded life's development. A new study suggests that the Earth may have stayed warm in part because of its dizzying spin and lack of land at the time.

The problem is known as the "faint young sun" paradox. Calculations suggest the sun had only 70 percent of its current strength early in Earth's history, around 4 billion years ago. But earth scientists know that the planet had liquid water during this time, called the Archean Era, indicating that some factor must have compensated for the weak sun. One popular theory holds that the early atmosphere contained up to 1,000 times the current level of carbon dioxide, providing a much stronger greenhouse effect then.

Gregory S. Jenkins from the National Center for Atmospheric Research in Boulder, Colo., however, contends that other aspects of the early Earth would have helped warm the planet. "The bottom line is you don't need that much carbon dioxide," Jenkins says.

He and his colleagues decided to simulate basic features of the early Earth using a general circulation model on a supercomputer, making this the first time researchers have aimed a sophisticated climate model at this early period, says Jenkins. The team focused on how the planet's rotation rate and land coverage influence climate.

Scientists know the Earth's spin has slowed through time because of tidal friction — energy lost as the moon causes water to slosh around the globe. Over the same period, the Earth has gained more continental land through volcanic eruptions and plate tectonic collisions. To simulate the ancient climate, Jenkins' team ran the model using a 14-hour-long day and a world with no land masses.

They found that a faster-spinning Earth has smaller weather systems lying closer to the equator — changes that caused a 20 percent decrease in cloud cover relative to today. The reduction in clouds warmed the planet because more sunlight could reach its surface.

The absence of land also raised temperatures because water absorbs more sunlight than the light-colored land. In total, the two factors raised temperatures 5° to 6°C above what they would have been, the scientists report in the May 20 JOURNAL OF GEOPHYSICAL RESEARCH.

On their own, the fast rotation and lack of land would not warm the climate enough to keep the ocean liquid. But Jenkins says they would provide a significant portion of the warming, indicating that the atmosphere need not have held as much carbon dioxide as proposed.

One of the authors of the carbon dioxide theory, James F. Kasting of Pennsylvania State University in University Park, agrees that the rotation rate and land area could have helped keep the world unfrozen. Even so, he says, carbon dioxide levels must still have reached high values — some 30 to 300 times current concentrations — to provide the rest of the warming power required to augment the rays from a faint young sun.

— R. Monastersky