

The Exterminator

Can an old pesticide that is banned in most countries defeat one of the world's worst diseases?

By Kirsten Weir

Few Americans

ever give much thought to malaria. That wasn't always so. Malaria once infected—and killed—many people in the United States. During the Civil War, more than a million soldiers fell ill with the disease.

By the middle of the 20th century, malaria had been wiped out in the United States, Canada, and northern Europe. But it continues to be a serious health problem in many tropical countries. Malaria kills an estimated 2 million people every year, most of them children under age 5. Despite an international effort to control the disease, malaria rates in Africa have risen over the past few years. "It's going in the wrong direction!" said Roger Bate, the director of Africa Fighting Malaria, a nonprofit research and advocacy group.

Bate is one of several health officials now pushing for broader use of

DDT (*dichlorodiphenyl-trichloroethane*), a chemical that played an important role in kicking malaria out of the United States. They argue that DDT is the best option available for saving lives. But DDT is a touchy subject because it has been banned in the United States and many other countries for decades.

BAD AIR

People once believed that breathing nasty swamp air caused malaria. In fact, the word *malaria* is Italian for "bad air."

Toward the end of the 19th century, scientists identified the true cause: a single-celled parasite they named *Plasmodium*. About the same time, scientists also discovered that mosquitoes act as *vectors* for the parasite, passing it on when



A father rushes his young son, who has lapsed into a coma from severe malaria, to the emergency room of Kisii General Hospital in Kisii, Kenya.

they bite people. A vector is an organism that spreads disease-causing agents from host to host without harm to itself. (See "A Parasite's Circle of Life," page 6.)

The malaria parasites need warm temperatures to develop inside mosquitoes, and the balmy southeastern United States was once hit hard by the disease. Malaria existed nearly everywhere mosquitoes did. During steamy summers, the disease reached as far north as Montreal.

made a serious effort to wipe out malaria, DDT was one of its preferred weapons. It was sprayed on swamps and other wet areas where mosquitoes bred. Small amounts were also applied to some household walls in rural communities.

By 1951, malaria was gone from the United States, but DDT was still used for other purposes. Huge quantities of it were sprayed by airplane on farmland to kill the insect pests that feasted on cotton and other crops. At first, no one worried about possible effects of the chemical on the environment. Then, in 1962, an ecologist named Rachel Carson captured the country's attention with her book *Silent Spring*, which detailed the dangers of DDT.

Carson described the damage done by DDT, which persisted in nature for years without breaking down. The chemical first built up in the tissues of fish. It then accumulated inside eagles and other birds of prey that ate the fish. It caused the birds' eggshells to become thin and brittle. The eggs cracked under their own weight, sending bird populations into a nose-dive. The U.S. government responded by banning DDT in 1972.

DOUBLE WHAMMY

Many other countries followed suit, including a number of nations that relied on DDT for malaria control. A handful of malaria-ridden countries have continued to use DDT to control the disease. But even in those countries, DDT is no longer dumped in mass quantities onto the

A young girl infected with malaria covers her mouth at a health center in Mozambique, but she's not contagious. The disease is transmitted by mosquitoes and cannot be passed from person to person.

SERIOUSLY
SICK

Malaria begins with flulike symptoms: fever, sweating, chills, headaches, muscle aches, and nausea. The symptoms come and go every 48 to 72 hours. Without treatment, the disease can get much worse. The parasites infect and destroy red blood cells, which can lead to severe *anemia*, a condition in which the concentration of red blood cells is too low to supply enough oxygen to the body's tissues. Infected blood cells can also clump together and stick to the body's blood vessels, blocking blood flow to the brain. The result is often blindness, brain damage, or death.

Drugs are available to treat malaria, though many are expensive. To be most effective, the drugs must be taken before the disease becomes severe. Poor families in places such as rural Africa often cannot afford the drugs, or they put off going for treatment until it's too late.

Some *prophylactic*, or preventive, medications are also available. When given to uninfected people, they attack the parasite if it ever gets into the body. But the prophylactic drugs are expensive and hard on the body. Travelers can safely take them for a few weeks or months, but the pills are too toxic for people living in malaria-affected countries to tolerate for long periods of time.

Dozens of species of mosquito can infect humans with malaria, but *Anopheles gambiae*, shown here, is responsible for the majority of malaria cases in Africa.

Changes in living habits—a shift toward city living, better sanitation, and the use of window screens—were largely responsible for the eradication of malaria, but DDT also played a part.

DDT is an *insecticide*, a chemical that kills insects. In the 1930s and 1940s, when the U.S. government

An airplane dumps DDT onto a flock of sheep to kill ticks at an Oregon ranch in 1948. Until DDT was banned in 1972, it was widely used in U.S. agriculture.

land. It is applied only to the inside walls of houses.

Because malaria mosquitoes bite after dusk, protecting people inside their homes can be very effective. DDT packs a double whammy: It repels most mosquitoes and kills those that get too close. It is by far the cheapest insecticide available and lasts twice as long as the alternatives.

South Africa was one nation that continued to use DDT after the United States banned the chemical. By 1996, South Africa had fewer than 10,000 annual malaria deaths. That year, the country switched from DDT to other insecticides. The new insecticides were also widely used in

Some scientists estimate that malaria has killed half of all the people who have ever lived. Today, the disease claims two lives every minute.

farming, and the overexposed mosquitoes quickly became resistant to the chemicals. By 2000, the number of deaths from malaria had risen to more than 60,000. At that point, South Africa turned back to DDT. Within three years, malaria infections dropped nearly to 1996 levels. In other countries where DDT has been used, from Ecuador to Sri Lanka, it has had similar positive effects.

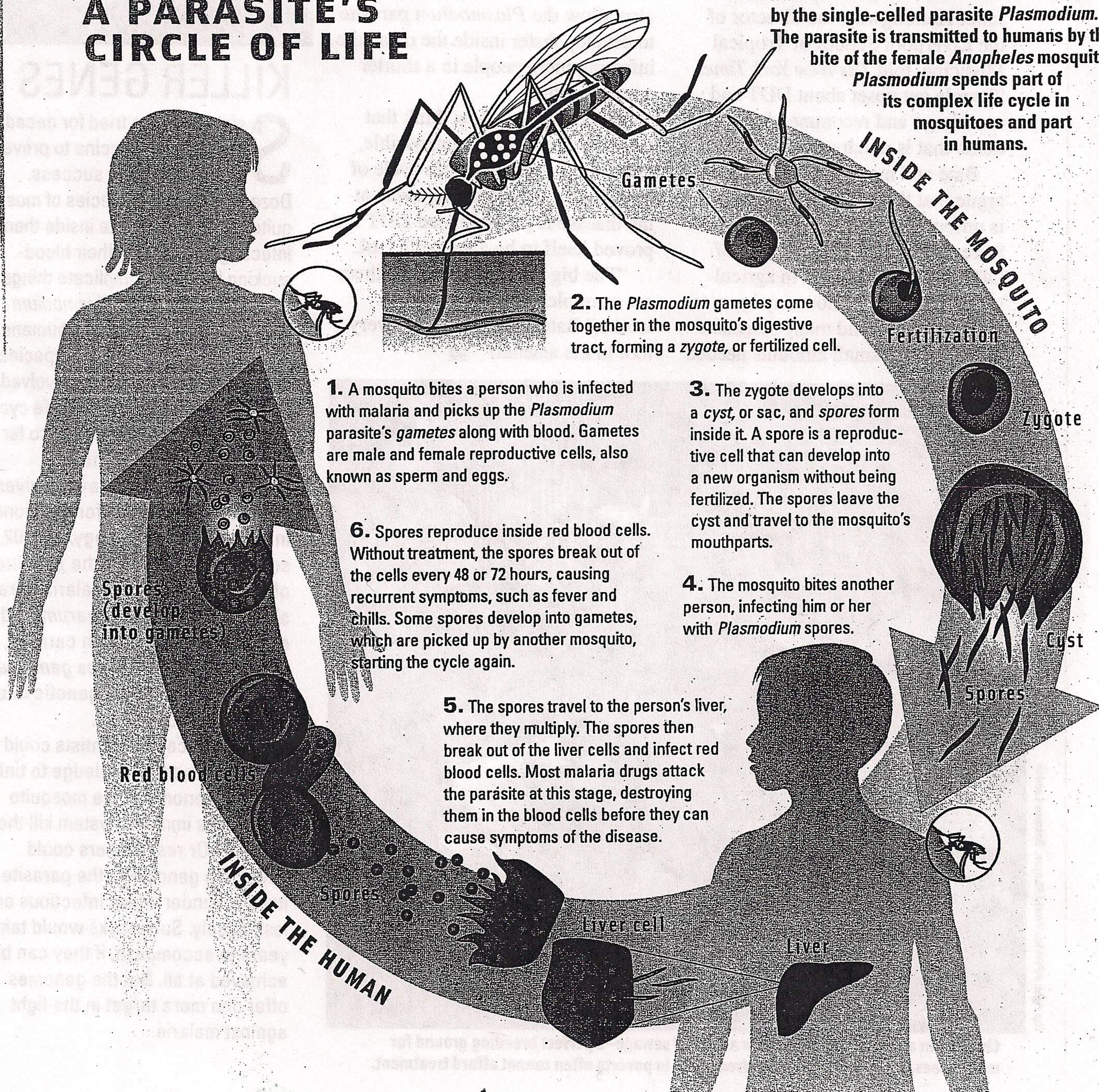
Today, only about 20 countries use DDT for malaria control, according to Roger Bate. Many more could benefit, he says.

PUBLIC FEAR

Why don't more countries use the powerful insecticide? "DDT probably has more opponents than any other insecticide because of its historic use," explained Bate. "But it's

A PARASITE'S CIRCLE OF LIFE

Malaria is an infectious disease caused by the single-celled parasite *Plasmodium*. The parasite is transmitted to humans by the bite of the female *Anopheles* mosquito. *Plasmodium* spends part of its complex life cycle in mosquitoes and part in humans.



2. The *Plasmodium* gametes come together in the mosquito's digestive tract, forming a *zygote*, or fertilized cell.

1. A mosquito bites a person who is infected with malaria and picks up the *Plasmodium* parasite's *gametes* along with blood. Gametes are male and female reproductive cells, also known as sperm and eggs.

3. The zygote develops into a *cyst*, or sac, and *spores* form inside it. A spore is a reproductive cell that can develop into a new organism without being fertilized. The spores leave the cyst and travel to the mosquito's mouthparts.

4. The mosquito bites another person, infecting him or her with *Plasmodium* spores.

6. Spores reproduce inside red blood cells. Without treatment, the spores break out of the cells every 48 or 72 hours, causing recurrent symptoms, such as fever and chills. Some spores develop into gametes, which are picked up by another mosquito, starting the cycle again.

5. The spores travel to the person's liver, where they multiply. The spores then break out of the liver cells and infect red blood cells. Most malaria drugs attack the parasite at this stage, destroying them in the blood cells before they can cause symptoms of the disease.

mistaking the point! All of the problems associated with it in the past are down to the mess that was made of it in farming.”

Some wealthy countries worry about the double standard of supporting the use of a chemical abroad that they've banned at home. The memory of *Silent Spring* and dying bald eagles also lingers. Most of the money that tropical countries use to fight malaria comes from international donors. Many of those donors are reluctant to fund the use of a chemical that scares so many people.

“Why [DDT] can't be dealt with rationally, as you'd deal with any other insecticide, I don't know,” Janet Hemingway, the director of the Liverpool School of Tropical Medicine, told *The New York Times*. “People get upset about DDT and merrily go and recommend an insecticide that is much more toxic.”

Bate and many of his colleagues argue that the public's fear of DDT is unfounded. Billions of Americans were exposed to high amounts of DDT when it was used in agriculture, Bate said, without any harm to human health. And many scientists agree that the small amounts needed

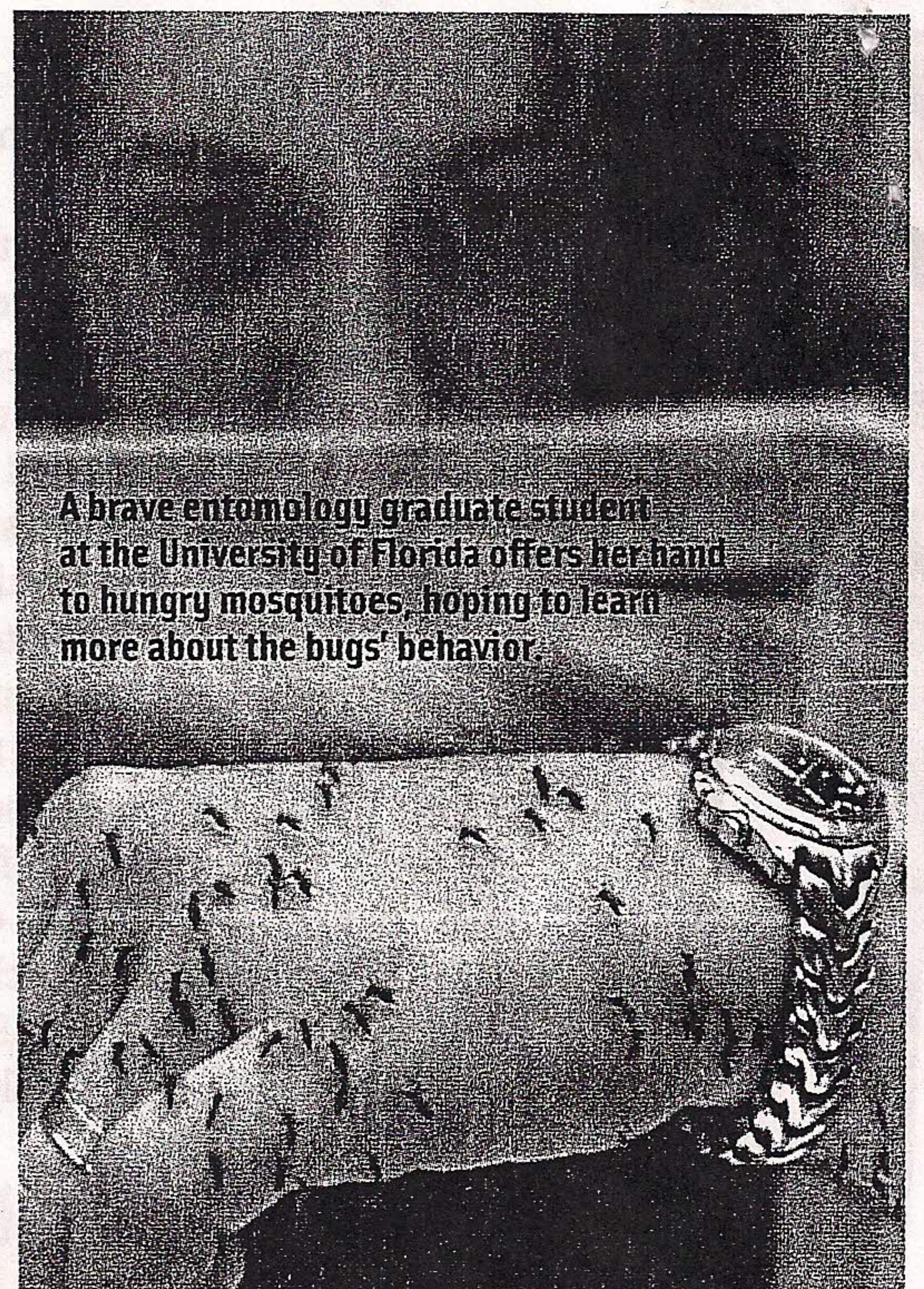
for malaria protection would likely have no significant effect on the environment.

Meanwhile, malaria is not going away. Some scientists estimate that malaria has killed half of all the people who have ever lived. Today, the disease claims two lives every minute. The most severely affected countries are in Africa, where the disease takes the life of one in every 20 children.

Some scientists worry that the situation could become even worse. As global warming heats up the planet, mosquitoes are spreading into areas where they once could not survive. Hotter temperatures also allow the *Plasmodium* parasite to develop faster inside the mosquito, infecting more people in a shorter amount of time.

Most scientists now think that eradicating malaria is impossible, given the complicated life cycle of the parasite. But chipping away at the disease is possible, and DDT has proved itself to be a valuable tool.

“The big picture is bad, but there are examples out there of what works,” Bate said. “We need every tool in the arsenal!” **CS**



A brave entomology graduate student at the University of Florida offers her hand to hungry mosquitoes, hoping to learn more about the bugs' behavior.

KILLER GENES

Scientists have tried for decades to develop a vaccine to prevent malaria, without success.

Dozens of different species of mosquito carry the parasite inside them, infecting people with their blood-sucking bites. To complicate things further, four different *Plasmodium* parasites cause malaria in humans. Because so many different species of mosquito and parasite are involved, and because *Plasmodium's* life cycle is so complex, a vaccine has so far been impossible to produce.

Still, researchers haven't given up. Many are looking for solutions in modern biotechnology. In 2002, scientists sequenced the genomes of the most common malaria parasite, *Plasmodium falciparum*, and one of its most common carriers, the mosquito *Anopheles gambiae*. A genome is the total genetic information in an organism.

Theoretically, scientists could use that genetic knowledge to tinker with the genome of the mosquito to make its immune system kill the parasite. Or researchers could tweak the genome of the parasite itself to render it less infectious or less deadly. Such tasks would take years to accomplish, if they can be achieved at all. But the genomes offer one more target in the fight against malaria.



Children in a Kenyan slum play near a river of sewage—a perfect breeding ground for mosquitoes. Malaria-infected children living in poverty often cannot afford treatment.

Top right: AP/Wide World Photos; Bottom: Landov