Electromagnetic pulsed waves can kill locust swarms

Once locusts swarm, while they can still be attacked by chemicals, bioelectromagnetics is faster, cheaper, and ecologically superior. Warren J. Hamerman reports.

Imagine that as a one-mile square swarm of tens of millions of locusts, reaching several thousands of feet in elevation, comes over the horizon foraging everything in sight, teams of helicopters equipped with low-cost electromagnetic radiation generators move into position. When the flying swarm is only three miles away—perhaps over a low-foliage desert or crossing a river—the magnetrons on the helicopters emit specially-tuned microwave pulses several times per second, which sweep out and destroy a square mile of locusts in approximately two to three minutes.

"Zapping" flying locust swarms with pulsed radar is neither a dream nor science fiction but a scientific capability which has been proven feasible in the research laboratory, but which our government declined to scale up and develop last year and the year before.

Research on the scientific frontiers of biophysics has discovered an effective and low-cost means to eliminate large swarms of locusts with pulses of electromagnetic radiation. The fundamental science underlying the work touches upon an advanced area variously known as "optical biophysics" or "bioelectromagnetics" and involves a multi-disciplinary integration of discoveries in biology, physics, chemistry, and geometry.

During the summer of 1986, various scientists who were participating in a series of scientific seminar discussions in the United States and Western Europe hosted by this journal and an associated scientific foundation (the Fusion Energy Foundation), began a project at the request of several African nations to pursue the feasibility of utilizing advanced scientific principles to knock out large swarms of locusts. By employing electromagnetic methods at the frontiers of biophysics, the international scientific team which participated in the project succeeded in conducting a "Proof of Principle" experiment in a biophysics laboratory in the United States and working out a feasible approach for taking the method into the field.

The "proof of principle" experiment demonstrated that electromagnetic pulsed waves could generate killing acoustical shockwaves in large swarms of locusts and other biological organisms.

We had great hopes and optimism that the successful laboratory results of a low-cost, pulsed electromagnetic system would be immediately scaled up and deployed in Africa. Therefore, with the aim of saving lives in Africa, throughout the fall of 1986, I and others associated with the project intensively "cross-fired" the results to various government, scientific, and military policy circles. After further discussions, we decided to press the proposal in formal terms, since we were convinced that the advanced scientific approach would help to prevent a biological holocaust.

On behalf of those scientists involved in the project, during late 1986 and the first half of 1987 we circulated a proposal through every relevant policy agency in the U.S. government, from scientific laboratories to the White House and Department of Agriculture to the Defense Advance Research Projects Agency (DARPA) and Defense Science Board (DSB). The proposal had wide circulation in private research universities, private industry and military research areas, as well as the cabinet departments of the government. It also was later reviewed at the highest scientific levels among other nations.

After initial universal scientific enthusiasm for the approach, encouragement and interest in the project was dashed and shut down by the U.S. government on budgetary grounds. During the course of the project, of course, it was apparent to certain agencies concerned with national security that the

FAO (Photo by Studios du Souissi, Rabat)

Swarms of locusts invading Morocco, during a past epidemic. Locusts squashed by cars are immediately preyed on by the survivors.

new physical principles employed could have applications beyond merely neutralizing vast locust swarms, and they initially seemed as excited as we.

Our focus, however, was not any military application, but immediately stopping the needless murder of hundreds of millions of Africans from the direct and indirect effects of the locust swarms. While there was much encouragement for our work, through the early months of 1987, the highest levels of policy determination abruptly turned off their interest and "disappeared" in the spring of 1987.

We were shocked to discover that the highest levels of scientific policy assessment in our nation were excited about the work and its military applications, knew that it could stop the slaughter of millions of Africans, but were unwilling to back the relatively low costs of the final phase of the work, even though Africa desperately needed the technology.

It is still not too late to revive this project, which can save millions of African lives and help to prevent the onset of an irreversible "biological holocaust."

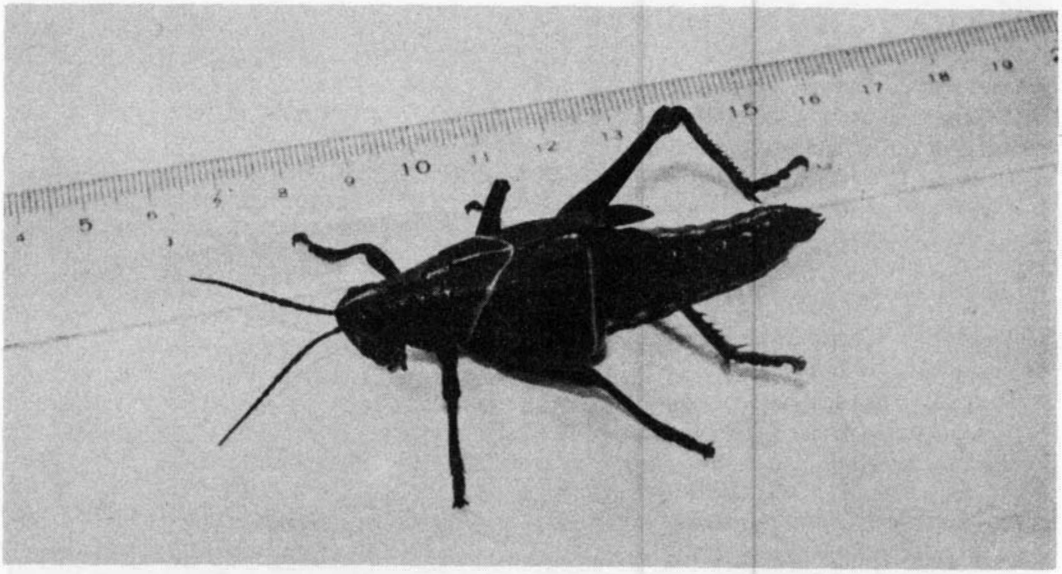
Scope of the project

When it first became apparent that an uncontrolled locust problem of catastrophic proportions was developing, representatives of several African nations approached us to ask if there were any advanced scientific methods which could be utilized to eliminate vast locust swarms, even were the traditional opportunities of egg-spraying missed. A locust can eat two to three grams—two to three times its weight—each day. A one-mile square swarm of 150 million locusts, up to 5,000 feet in elevation, can go through 200 to 600 tons of vegetation daily. Once in the swarm stage, locusts can travel up to 3,000 miles per generation. They have a double set of wings, about 5 inches across, and they fly where the winds take them, averaging about 10 miles per hour. In one 1958 locust plague in Somalia alone, a swarm of 40 billion locusts ate 80,000 tons a day—enough corn to feed 400,000 people for one year!

Once locusts swarm, while they can still be attacked by chemicals, the advanced technology of bioelectromagnetics is faster, cheaper, and ecologically superior. Indeed, the advanced scientific principles of electromagnetics and biophysics were demonstrated to work beautifully in generating acoustical shockwaves in the organism.

The instrument used, a Japan Electric Company head inactivator, was intentionally "tuned" to the magnetic mode at the locus of the insect. The instrument was intentionally constructed for basic neurochemical research to rapidly inactivate mouse brains in very short times so that rapid turnover intermediates of brain metabolism could be studied in anatomically specific regions of the brain. Scientists using the device in basic research have caused a quantum leap in our knowledge of the way in which signals are transmitted in the brain. The instrument was originally developed in a research laboratory in the United States, but further commercial development proceeded in Japan because of the refusal by U.S. corporations to participate. It is now the acknowledged technique for neurochemical preparations.

The unique feature of the design of the machine is neither its maximum power nor its "tunability," but the fact that it alters the ratio between the magnetic and electrical field strength. Normally the electrical to magnetic field strength is 377 to 1. In the experimental configuration it is much closer

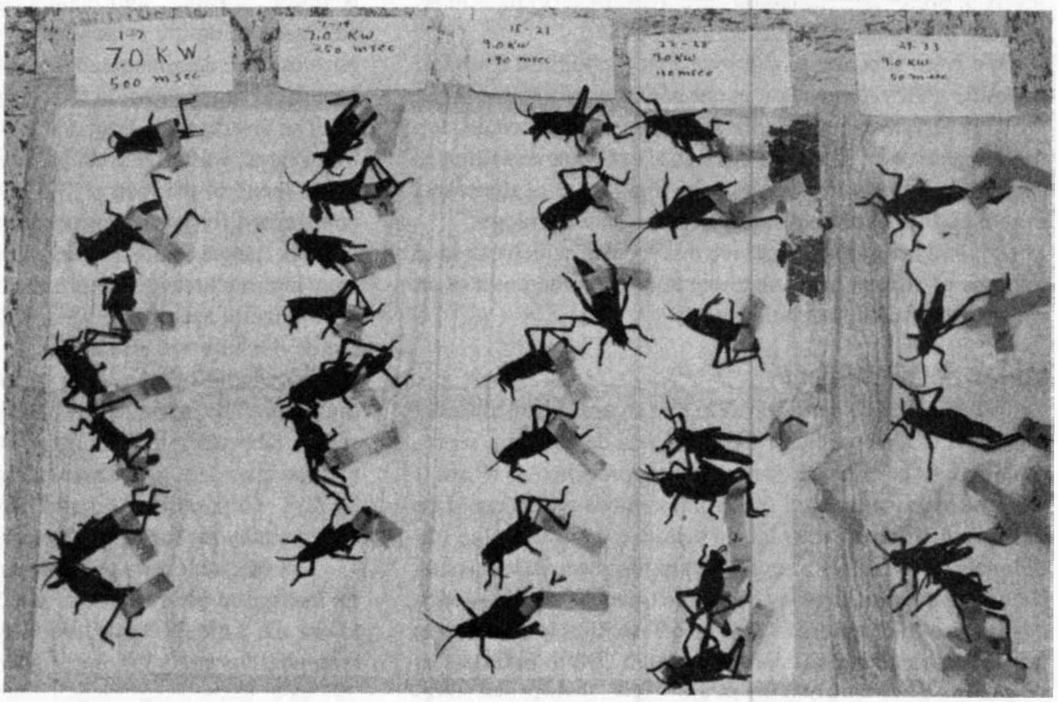


In the experiments Lubber grasshoppers were used because their biophysical characteristics and dimensions resemble those of their "cousins," the African locusts. The electromagnetic radiation's wavelength approximated the size of the grasshoppers.

to 1 to 1. The magnetic field intensity creates special sorts of "eddy currents" in the organism such that the energy is intensified or focused at certain points.

In a series of experiments, insects were exposed in the "head inactivator" to specially "tuned" pulses of radiation whose wavelengths were approximately the length of the bug. The experiments were conducted with Lubber Grasshoppers obtained from a biological supply house; the grasshoppers are of the necessary size and have the appropriate dielectric constant to simulate their close cousins, the African locusts.

In essence, the grasshoppers became receiving antenna which were tuned in on. Various combinations of power were tested and the time period of the pulse varied between a short 50 milliseconds to a long 500 milliseconds (half a second). Even at 50 milliseconds the bugs were woozy and "out of it." The threshold for rapid kill was at 100 milliseconds (one-tenth of a second). Temperature probes at the core of the dead bugs revealed a temperature rise from 26 to 48 degrees Centigrade.



The photograph shows that the electromagnetic pulses with a wavelength approximating the length of the insect worked beautifully in knocking out the 33 grasshoppers used in the experiment. The various combinations of power (7.0 to 9.0 kW) and time periods (500 msec to 50 msec) are indicated at the top of each column. The number of bugs in each regime is also indicated at the head of each column. Even at 50 msec the grasshoppers were very out of it. The threshold for rapid kill was at 100 msec.

Non-thermal acoustical shockwaves

It was firmly established that the effect was due to the pulsed nature of the wave and not merely "cooking" or "heating." This principle was checked in a contrasting "control" experiment. Insect "controls" were put in a research microwave oven at 60°C which is the higher end of the pulse power. The oven reached 60° in 10 minutes. It took one hour and 55 minutes to kill the insects this way. In the first 20 minutes the insects were hyperactive.

Thus, what was critical about the "proof of principle" experiment was the *pulsed* nature of the power delivered. As the microwave oven control demonstrated, the effect was non-thermal. The electromagnetic pulses coupled into the physiologic frequencies. Temperature probes indicated that there was uneven heating in various parts of the bug.

The insect's exoskeleton, a very strong insulator (dielectric), can be polarized back and forth through wave-mixing. The surface area soaks up energy like a sponge, which facilitates the uneven absorption of energy in several focal points under the exoskeleton.

In field situations, of course, one needs a means to deliver the electromagnetic pulses other than by the head inactivator. One could use a 100 kilowatt continuous wave capacity magnetron, pulsed at 5-10 per second and mounted on helicopters. At three miles distance, the focal area would be approximately 4-5 meters. The weight of the special apparatus in the helicopter would mostly be the power generator, which would be between one and two tons. The major cost for the generator scales linearly with the kilowatt output size. At approximately $1,000 per kilowatt, a 100 kilowatt device would cost only $100,000.

Several helicopters—positioned in phased array—could sweep out one square mile in approximately 2-3 minutes from a distance of 2-3 miles. If the source of radiation were non-polarized, the helicopters would have to hit the swarm head-on. However, with a circularly polarized source, the bugs wouldn't have to be linearly lined up with the helicopters only in a head-on firing position.

In the field situation, without control of the "wave guide" field structure inside the head inactivator, the coupling efficiency into the insects will drop unless a very specific use of several transmitting antennae is employed to produced maximum magnetic fields inside the swarms to increase the coupling efficiency.

There would be little or no effect on animals or people, since there would be no penetration through the skin which is a poor conductor at the frequency used against the locusts.

Steam generation inside the locust

In the words of the senior biophysicist on the project:

"This work demonstrates that if electromagnetic energy sufficient to cause a temperature rise to around 50°C is applied to insects such as grasshoppers or locusts, irreversible damage resulting in death occurs. Energy absorbed is about 100 joules/gram in times less than a second. If this power is applied at a rate allowing cavitation—around 200 joules/gram in time less than 0.1 second, preferably in times approaching 0.1 msec or less—acoustic shockwave generation will occur and a nonlinear decrease in energy is required to produce death as a result (steam generation, if you will)."

In the "proof of principle" experiment the grasshoppers were placed inside the "head inactivator" pictured above. Such devices were developed by researchers who wished to rapidly inactivate the chemical processes going on in the brains of small research animals such as mice in order to study the metabolism of neurological reactions in anatomically specific areas of the brain. Some of the specific features of the instrument are described in the text.

In the "proof of principle" experiment, such energies could not be applied because of the limitations on peak pulse power of the 10 KW magnetron used, and because of the relatively low coupling of applied power to the insect. The frequency used was not near the resonant frequency of the insect.

We have hypothesized that it is more than feasible to couple into biologic or physiologic frequencies. Future experimental work could determine the species-specific and tissue-specific resonances which are most efficient. While the power is absorbed on a total surface area, it may be concentrated on specific focal points in the biological organism.