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Rev. Daniel J. Sullivan, S.J., Ph.D.

Father Sullivan, an associate professor in the department of biological sciences at Fordham University, received his doctorate in entomology from the University of California—Berkeley in 1969. He returned there on a sabbatical last year as a research associate in the department of entomological sciences.

"No witchcraft, no enemy action had silenced the rebirth of new life in this stricken world. The people had done it themselves."[1] When Rachel Carson wrote this in her book, *Silent Spring*, in 1962, ecology suddenly became a household word. It was not, of course, the beginning of this science by any means, for it had long been recognized as an important biological discipline. But it did usher in an era of public awareness, helping us to appreciate the complexity of the ecosystem which exists around us. As a result, hardly a day passes without environmentalists reminding us of the intricate interrelationships between nuclear reactors and human health, between chemical pesticides and living organisms.

The Insect Problem

The most recent prediction by demographers indicates that by the year 2000, there will be a 50 per cent rise in the world population to 6.3 billion. Increased food production, then, remains a major concern facing *homo sapiens.* One hoped-for solution was the "green revolution" which involved the breeding of miracle strains of major crops. Unfortunately, because of its heavy reliances on synthetic fertilizers and other problems, this approach has not lived up to expectations. In addition, the ever-present insects remain as man's chief competitor for his food, attacking not only crops growing in the field, but also the seeds before and after they are planted, and grains and foods in storage.

The insects are a remarkably adaptable group of animals and comprise about 80 per cent (almost 900,000) of the described animal species in the world. Hence, they have taken advantage of most ecological niches during their more than 350 million years of evolution on this planet. It should be pointed out, however, that not all insects eat plants. Over half of them eat other insects, and so, from man's point of view, most are beneficial.

The Wrong Solution

Beginning in the 1940's, DDT came into wide use as a synthetic chemical insecticide which was hailed as the answer to our insect problems. Initially, crop production was indeed increased, and a whole host of other chlorinated hydrocarbons was introduced: aldrin, dieldrin, endrin, heptachlor, chlordane, etc. Economic dependence on such insecticides involved not merely the farmers, but also related agricultural services and satellite industries such as farm advisers and salesmen, marketing and advertising, spraying operators and airplane pilots, crop transportation and food processing plants.

It was soon realized, however, that chemical insecticides were a short-sighted solution. Indeed, a Pandora's box had been opened, for as early as 1946 resistance to DDT was reported, and today upwards of 200 insect pests have developed similar tolerance to insecticides. This should have come as no surprise to entomologists, for insects have short life cycles and are very adaptive. Hence, it was inevitable that insects would evolve resistance very rapidly due to typical Darwinian natural selection of a population under stress. As a result, the phenomenon of "resurgence" of the insect pest soon followed, often higher than before the chemical application which was supposed to cause extinction. This was due not merely to resistance on the part of the pest, but also because these broad-spectrum insecticides killed instead the natural enemies (insect predators and parasitoids) of the pest. In fact, as a result of widespread mortality of such normally occurring natural enemies, even other insects which had been kept under control suddenly increased in abundance and became "traded-pests."

Ironically, the reaction of agriculture to the triple threat of resistance, resurgence and traded-pests was not to re-evaluate the entire insecticide philosophy, but rather to increase the use of chemicals.

This was done by more frequent applications and greater dosages, as well as by marketing two new generations of synthetic chemical insecticides: organophosphates (parathion) and carbamates (carbaryl). This further attempt at complete eradication of insect pests was doomed to failure from the outset because the same three problems eventually arose again. The farmer was helplessly locked onto the "pesticide treadmill" resulting in reduced yield at increased cost.[2]

Through the writings of Rachel Carson and others, however, a fourth problem quite unexpectedly emerged with the increased use of chemical insecticides — environmental contamination. Not only were some of these chemicals, especially DDT, residual or long-lasting in the ecosystem, but they had even spread via wind and water far from the target sites of original application. Furthermore, these chemicals were not merely insecticides for the killing of insects, but also zooicides, i.e., they killed directly or indirectly other animals besides insects. Both by direct kill and through "biological magnification" in the food chain, fish were affected as well as fish-eating birds that could not produce viable eggs with strong-enough shells. Even mammals such as cows had dangerously high levels of these chemicals in their milk. Hence, we inevitably return to man as the ultimate consumer — the recipient of decades of careless use of these dangerous chemicals.

Medical Aspect of Agriculture

Because so many agricultural workers are involved in planting, cultivating and harvesting crops, they themselves also become part of the ecosystem that is affected by chemical insecticides. As a result, the medical aspect of agriculture has assumed a more important role, and the new term "agromedicine" has been introduced into the biomedical literature. Dr. Ray F. Smith of the University of California at Berkeley has been one of the leaders in promoting concern for this aspect of the impact of pesticides on agriculture. As part of a joint project with the U.S. Agency for International Development (UC/AID)), he and his colleagues define agromedicine as "the integrated interdisciplinary application of the skills and knowledge of agriculture, applied chemistry and medicine to the production of an adequate and wholesome food supply for the welfare of man."[3]

Depending on the degree of contact with these pesticides, the UC/AID researchers list three levels of exposure: acute, high chronic (occupational) and low chronic (incidental).[4] Acute exposure occurs when field workers are involved either with mixing, loading and applying pesticides or with harvesting crops having persistent chemical residues. The usual route of acute poisoning is by dermal contact, but respiratory and even digestive poisonings are not uncommon. Results vary, but epidemiological studies reveal systemic illness, convulsions.

dermatitis and eye lesions. Endrin, for instance, is one of the most toxic chlorinated hydrocarbons, yet the organophosphates "are implicated in more human poisonings than any other class of pesticides." [5] The latter were introduced because they were less residual or shorter acting, but they were a greater danger to field workers because their mode of action as cholinesterase inhibitors produces cholinergic effects.

High chronic or occupational exposure does not produce such immediate and dramatic symptoms. For that very reason, however, it may go unnoticed and untreated until enough workers show the effects of a neurological disorder, liver disease, personality changes, etc. Finally, low chronic or incidental exposure is probably of greater interest to the general public. Low residues on or in food, as well as trace elements in the air, water, household dust, etc. may have an adverse effect on people via passive contamination. According to Davies, agromedical research is being concentrated in three areas: "1) human monitoring programs, 2) microsomal enzyme induction effects, and 3) carcinogenesis, teratogenesis and mutagenesis." [6]

Alternatives to Chemicals

It has been known for a long time that insect pests have their own natural enemies, viz., other insects that are their predators and parasitoids. Since these natural enemies are limited to eating only insects as food, they pose no danger to humans or their crops. This method is called "biological control" of insect pests and is an ecologically safer method than using chemical insecticides. Although Rachel Carson emphasized biological control in her book, the trend in recent years has been for an even broader approach. We speak today of "Integrated Pest Management" which includes not only biological control, but also other techniques and methods which are ecologically safe: insect genetics, plant breeding of resistant varieties, insect pheromones, microbial pathogens, insect sterilization, cultural methods, and even selective use of chemical insecticides.[7] This has involved the collaboration not merely of ecologists and entomologists, but medical personnel and specialists in many other scientific disciplines. It is of special importance for the developing nations, and is being supported by the Food and Agricultural Organization (FAO).[8]

Although chemicals to kill insects are the main topic in this presentation of the importance of agromedicine, it should be pointed out that insecticides are only one aspect of the overall pesticide problem. There are many other animal and even plant pests besides insects, and these in turn are the targets of a whole range of chemicals having such generic names as: miticides, fungicides, rodenticides and herbicides. Fundamentally, however, our ethical concern for the ecological ramifications of their use should not be neglected. Integrated Pest Management is a philosophy which is also applicable in these cases and provides a safer medical alternative to complete reliance on chemicals. Even when selective use of pesticides is deemed necessary, preventive medicine might indicate that farm workers should be better protected by improvements in packaging, application methods and clothing. At least we have an ethical imperative to be concerned.

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