

DDT and *Silent Spring*: Fifty Years After

Cristóbal S. Berry-Cabán PHD

The impact of DDT on human health received worldwide attention from the general public, political and scientific communities, with the publication of Rachel Carson's *Silent Spring*.¹ In *Silent Spring*, Carson described a series of harmful effects on the environment and wildlife resulting from the use of DDT and other similar compounds. Fifty years later the book and the issues raised remain controversial. DDT, which had been effectively used to eradicate malaria carrying mosquitoes, continues to be a major public health problem and effective treatment and prevention efforts are still necessary.

One day in January, 1958, Rachel Carson received a long, angry letter from her friend Olga Huckins, describing the deadly effect of DDT spraying for mosquito control over the Huckins' private two-acre bird sanctuary at Powder Point, in Duxbury, Massachusetts. Not long afterward Carson was a house guest at Powder Point when, late in the afternoon, a spraying plane flew over. The next morning she went through the estuary with the Huckins in their boat. She was sickened by what she saw — dead and dying fish everywhere, crayfish and crabs dead or staggering as their nervous systems appeared destroyed. She then realized she would write about DDT.¹

Dichlorodiphenyltrichloroethane, DDT, is one of the most effective and best known of all of the synthetic insecticides. While DDT was first synthesized in 1874, it was not until the 1930s that scientist Paul Hermann Müller, working for a Swiss chemical company, discovered its insecticidal properties. Though he held no medical degree and had never engaged in medical research, Dr. Müller was awarded the Nobel Prize in Medicine in 1948 “for his discovery of the high efficiency of DDT as a contact poison against several arthropods.”²

A chemist, Dr. Müller worked for J. R. Geigy as a laboratory technologist, where he developed synthetic tanning substances. In 1936 Müller turned his attention to pesticide research. He was looking for an insecticide to protect woollens against moths. In 1939 Müller synthesized the chlorinated hydrocarbon dichlorodiphenyltrichloroethane.

Müller's research technique was to coat the inside of a glass box with whatever chemical he was testing and fill it with houseflies. He took some DDT home with him one day and powdered a small amount into

a container and noted that it killed flies. He wiped the container clean with an acetone solvent and added more flies; these also died. Müller soon realized he had a powerful insecticide.

As World War II began in Europe, DDT was successfully tested in Switzerland initially as a dusting powder against potato beetles and later against lice and fleas. These successes, however, convinced Geigy that DDT was a powerful synthetic insecticide — fatal on contact in extremely minute quantities to a wide range of insects, yet apparently wholly nontoxic to humans. In 1940, Geigy patented the formula as a general insecticide and began marketing the substance in two forms: Gesarol, a spray insecticide principally for use against potato beetles and Neocid a dust insecticide for use as a lousicide.³

A U.S. Military Attaché at Berne, Major A. R. W. de Jonge, noticed that Neocid shipments were going to Germany. He persuaded Geigy to send samples to the United States and England and these were received by the Geigy offices in New York and London in November 1942.

British and American entomologists reviewed the patents with a mixture of hope and some scepticism. Of immediate concern to them, because of the millions of Allied army and navy personnel deployed around the world, was the possible use of DDT for the control of several insect borne diseases: malaria (carried by *Anopheles* mosquitoes), typhus (carried by body lice) and dysentery and typhoid fever (both carried by houseflies). With growing desperation they had been searching for a substitute for pyrethrum, a contact insecticide extracted from *Chrysanthemum* flowers that was imported chiefly from Japan. War with Japan had cut off the major source of supply just as the demand for pyrethrum soared.⁴

Studies conducted by U.S. Department of Agriculture entomologists demonstrated beyond question that this new insecticide had tremendous possibilities not only against lice but also against several other noxious insects, such as mosquitoes and houseflies.⁵ With the help of the War Production Board, DDT was quickly put into large scale production. It seemed a panacea. It was easy to produce and safe to handle. Soon DDT production was approaching three million pounds a month by the time it was placed on Army supply lists in May 1943, and on Navy lists in January 1944.⁶ All

DDT was allocated to the armed services save a few hundred thousand pounds used for further research. Among research tests conducted were field tests in which powered DDT was successfully used to arrest several small typhus epidemics in Mexico, Algeria and Egypt.

Egyptian research was supervised by Brigadier General Leon Fox, a field director of the Typhus Commission. Several months later General Fox was summoned to newly captured, refugee-swollen Naples where, in the wake of the German army, Allied medical authorities identified a potential typhus epidemic. New typhus cases in the city approached sixty a day and people were dying by the score. In mid-December Fox began systematically dusting the entire Neapolitan population with DDT. Dusting involved having people tie their garments at the ankles and wrists, and then using a dust gun similar to that used in gardening, the DDT powder was blown down the collar, creating a balloon effect. While a tedious procedure, Neapolitans were dusted as they exited the railway stations and dusted in the grottoes that served as bomb shelters beneath the streets.⁷

New cases began declining; by mid-February there were no new cases at all. For the first time in history, typhus, which thrives in cold, filthy, overcrowded conditions, was not only arrested but totally eliminated.⁸ This was but the beginning of DDT's march to glory.

In August 1943, DDT was first tried against mosquitoes that carried malaria.⁹ Malaria, a parasitic disease, has plagued humans for perhaps 50,000 years. Almost half of the world's population lives in areas where they are exposed to risk of malaria. Until the 1950s, malaria was widespread in Europe and North America, and epidemics were even recorded above the Arctic Circle.

In 1898, Ronald Ross, a physician stationed with the British army in India, discovered that mosquitoes transmit malaria. For this discovery Ross was awarded the Nobel Prize in Medicine in 1902. Elsewhere, Giovanni Battista Grassi, a leading Italian zoologist, identified the specific genus of mosquito (*Anopheles*) responsible for transmitting the malaria-causing parasite. Soon public health officials were targeting mosquitoes.

The principal methods of eradicating mosquitoes that carry malaria have been drainage — especially when followed by cultivation — and insecticides. Insecticides, notably pyrethrum, had been used in malaria control prior to DDT. This was sprayed on the inside walls of houses where the *Anopheles* mosquito rests after feeding. The mosquito takes up the insecticide while resting on walls and its toxicity kills her.

In August 1943, the Army began spraying the interior of buildings and found the procedure effective. DDT lasted for over six months and as a result a malaria control team could cover many more houses and protect far more people. In the spring of 1944, they began spraying in the town of Castel Volturno, north of Naples and later in the Tiber River Delta area.¹⁰ These highly successful efforts proved the practical usefulness of DDT in malaria control.

Soon, soldiers and sailors by the millions were carrying small cans of DDT powder to protect themselves from bedbugs, lice and mosquitoes. They came to love the stuff, especially in the tropics. Millions of DDT aerosol bombs were used to spray the interiors of tents, barracks and mess halls. Throughout European refugee camps, along the span of the Burma Road, across jungle battlefields of Southeast Asia, on Saipan and dozens of South Sea islands infested by stinging, biting insects, DDT spread its beneficent mist.

As DDT supplies became more abundant, other clinical trials were conducted in 1944 and 1945. These trials led directly to the concept in the United States of a “nationwide malaria eradication” campaign. While DDT no doubt would eventually have found its place in malaria control, war requirements greatly accelerated its acceptance and use.

Even before the war and the advent of DDT, malaria had been declining in the United States because of improved standards of living, proliferation of window screens and other methods of protection from mosquitoes. In urban areas, better drainage and larviciding improved mosquito control that in turn led to fewer cases of malaria.

With the war's end, the U.S. Public Health Service (PHS), along with the Tennessee Valley Authority and the Rockefeller Foundation, began funding the large scale use of DDT for malaria control. Mosquito control officers in the United States used DDT in two ways: as a residual insecticide on the walls of houses and as a larvicide. The results were dramatic. By 1952, there were only 437 cases of malaria transmitted domestically, in contrast to the million of cases just a few years earlier.¹¹

In the early 1950's the World Health Organization launched the Global Malaria Eradication Program.^{7,11} South Africa was one of the first countries to use the insecticide in 1946 and within several years, malarial areas had decreased.¹² India's malaria control program saw similar decreases. Between 1953 and 1957, morbidity was more than halved from 10.8 percent to 5.3 percent of the total population, and malaria deaths were reduced almost to zero.¹³ After DDT was introduced in Ceylon (now Sri Lanka), the number of malaria cases fell from 2.8 million in 1946 to just

110 in 1961.¹⁴ Taiwan also adopted DDT for malaria control shortly after World War II; in 1945, there were over 1 million cases of malaria on the island; by 1969, however, there were only nine cases, and shortly thereafter the disease was permanently eradicated from the country. Similarly spectacular decreases in malaria cases and deaths were seen everywhere DDT was used.¹⁵

By the 1950s DDT had become the most publicised synthetic chemical in the world. One American newspaper clipping service accumulated nearly 21,000 items about it in an eighteen-month period between 1944 and 1945.¹⁶ Most were glowingly enthusiastic; only a few questioned the mixed blessings of this new miracle compound. Dr. Clarence Cottam, Director of the Fish and Wildlife Service urged forethought in 1945 when he stated “caution in its use is essential because of our incomplete knowledge of its action on many living things, both harmful and beneficial.”¹⁷

Other cautionary direction came from Fred Bishop who reported the following year in the *American Journal of Public Health* that “DDT must not be allowed to get into foods or to be ingested accidentally”¹⁸ and American naturalist Edwin Way Teale who warned, “a spray as indiscriminate as DDT can upset the economy of nature as much as a revolution upsets social economy. Ninety percent of all insects are good, and if they are killed, things go out of kilter right away.” Rachel Carson wrote to *Reader's Digest* in 1945 proposing an article about a series of tests on DDT being conducted not far from home outside the nation's capital in Silver Spring, Maryland.¹⁸ The magazine rejected the idea.

Carson's interest in DDT did not wane and DDT's demise began with the publication of her 1962 book *Silent Spring*.¹ By the time *Silent Spring* was published she was a renowned nature author and a former marine biologist with the U.S. Fish and Wildlife Service. A native of rural Pennsylvania, she had grown up with an enthusiasm for nature matched only by her love of writing. In 1936, the Bureau of Fisheries (now the U.S. Fish and Wildlife Service) hired her as a full-time biologist and over the next 15 years, she rose in the ranks, becoming chief editor for all publications. The educational brochures she wrote for the Fish and Wildlife Service, as well as her published books and magazine articles, were characterised by meticulous research and a poetic evocation of her subject.¹⁹⁻²¹

Silent Spring took Carson four years to complete. In it she detailed how DDT entered the food chain. A single application on a crop, she wrote, killed insects for weeks and months, not only the targeted insects but countless more, and remained toxic in the environment even after it was diluted by rainwater. Carson concluded that DDT had irrevocably harmed birds and animals and was contaminating the entire

world's food supply. The book's most haunting and famous first chapter, “A Fable for Tomorrow,” depicts a nameless American town where all life - from fish to birds to apple blossoms to children - have been “silenced” by the insidious effects of DDT.

Carson recognized that the direct kills were by no means the worst effect of DDT. More widespread and disastrous by far, were the delayed kills, coupled with the inhibition of reproductive processes. Entire species of birds were threatened with extinction. *Silent Spring* describes an early instance that occurred on the campus of Michigan State University. Annual spraying of elm trees with DDT began there in 1954 to control the beetle that spreads Dutch Elm disease. For the first year or so, there were little visible side effects, but people began noticing that robins had disappeared from the campus. The cyclic silencing that Carson had described was occurring: earthworms feeding on elm leaves contaminated with tiny amounts of DDT accumulated the chemical in their body fat until a level toxic to robins was reached. Robins that ate contaminated worms died, even robins unfortunate enough to visit the campus two years after spraying ceased.

“Like the robin, another American bird seems to be on the verge of extinction. This is the national symbol, the eagle,” Carson wrote. She suggests that DDT's increasingly massive invasion of the food chain was largely responsible for the fact that bald eagles were ceasing to breed on the East Coast (large concentrations of DDT residues were found in the brains of prematurely dead eagles) and that eagles in the Great Lakes region faced extinction because their egg shells were growing too thin (the physiological mechanism by which DDT inhibits calcium production had yet to be discovered).

Carson never argued that all pesticides should be banned entirely, but that “control must be geared to realities, not to mythical situations, and that the methods employed must be such that they do not destroy us along with the insects.”²¹ Neither did she call for DDT to be banned for the purpose of fighting malaria (nor indeed has it been banned for that purpose by the United States or the World Health Organization). Carson argued that the widespread use of DDT as an agricultural pesticide was harmful for three reasons:

First, its indiscriminate application had repercussions on the ecosystems that range far beyond the intended effect, resulting in the death of fish and birds, and population drops in species that depend on specific insects. Additionally, the deaths of predators cause population explosions in other pests. Carson cites the example of the spider mite that “has become practically a worldwide pest as DDT and other insecticides have

killed off its enemies.” Widespread DDT spraying in Montana and Idaho in 1956 caused “the most extensive and spectacular infestation of spider mites in history.”¹

Second, allowing DDT to soak into the soil, the drinking water and the skin has health repercussions for humans. Carson sounded an initial alarm in *Silent Spring*, but at that time little was known about cancer, its causes and its relationship with DDT and other similar pesticides.²²

Third, overuse of DDT in agriculture allows malaria-spreading mosquitoes to develop resistance to DDT and other pesticides. Once this happens, small-scale malaria spraying becomes useless and the problem worsens, forcing public health officials to resort to more dangerous pesticides that often have worse health effects on humans and their ecosystems.

Resistance to insecticides by mosquitoes...has surged upward at an astounding rate, being created by the thoroughness of the very house-spraying programs designed to eliminate malaria. In 1956, only 5 species of these mosquitoes displayed resistance; by early 1960 the number had risen from 5 to 28! The number includes very dangerous malaria vectors in West Africa, the Middle East, Central America, Indonesia, and the Eastern European region.... Agencies concerned with vector-borne disease are at present coping with their problems by switching from one insecticide to another as resistance develops. But this cannot go on indefinitely.¹

She began the book with the working title — “The Control of Nature,” but changed to “Man Against the Earth,” then “Dissent in Favor of Man.” It was her editor Paul Brooks that suggested using “*Silent Spring*.” Carson’s work first appeared as a series of three articles in the *New Yorker* magazine.

Even before publication, Carson was violently assailed by threats of lawsuits and derision, including suggestions that she was a “hysterical woman” unqualified to write such a book. A huge counterattack was led by Monsanto, Velsicol, and American Cyanamid, supported by her former employer the U.S. Department of Agriculture. In their heated campaign to silence Carson, the chemical industry only increased public awareness. *Silent Spring* soon became a runaway best seller.

Silent Spring was on the New York Times bestseller list for 31 weeks. Subsequently it appeared on The Modern Library’s “Best 100 Non-fiction Books of the Century” (#5); Boston Public Library’s “100 Most Influential Books of the Century”; and New York Public Library’s 100 “Books of the Century.” Rachel Carson was one of only twenty “scientists and thinkers” recognised in Time’s 100 most important persons of the 20th century.

Two years after her best seller was published— in April, 1964 — Rachel Carson, aged fifty-six, died of cancer. (Dr. Paul Müller died in October of the following year, at the age of sixty-six.)

The most important legacy of *Silent Spring* was a public awareness that nature was vulnerable to human intervention. Carson had made a radical proposal — that, sometimes, technological progress is fundamentally at odds with the natural processes and it must be curtailed. The threats Carson had outlined — the contamination of the food chain, cancer, genetic damage, the deaths of entire species — were too frightening to ignore. For the first time, the need to regulate industry in order to protect the environment became widely accepted and environmentalism was born.

Many believe that DDT was banned after 1972. In fact it continued to be used for pest control, for which exemptions were granted by the federal government and it is still available for public health use today. In January 1979, DDT was used to suppress fleas that carried typhus in Louisiana. That same year, the California Department of Health Services used DDT to suppress fleas that carried bubonic plague. Texas got an exemption to control rabid bats in October 1979. Between 1972 and 1979, DDT was used to combat the pea leaf weevil and the Douglas-fir tussock moth in the Pacific Northwest; rabid bats in the Northeast, Wyoming, and Texas; and plague-carrying fleas in Colorado, New Mexico, and Nevada. State governments, with the permission of the federal government, continued to use DDT to protect public health and agriculture.²³

Malaria continues to threaten military forces. In 1993, over 200 US Marines and Soldiers participating in Operation Restore Hope in Somalia developed malaria. Noncompliance with personal protective measures and chemoprophylaxis contributed to this largest outbreak of malaria in US military personnel since the Vietnam conflict.^{24, 25}

DDT is neither a panacea nor a super villain. In many places DDT failed to eradicate malaria not because of environmentalist restrictions on its use but because it simply stopped working. Carson showed that insects have a phenomenal capacity to adapt to new poisons; anything that kills a large proportion of a population ends up changing the insects’ genetic composition so as to favour those few individuals that manage to survive due to random mutation. In the continued presence of the insecticide, susceptible populations can be rapidly replaced by resistant ones.

By 1972, when the DDT controls went into effect in the United States, nineteen species of mosquitoes capable of transmitting malaria, including some in Africa, were resistant to DDT. Genes for DDT resistance can

persist in populations for decades. Spraying DDT on the interior walls of houses led to the evolution of resistance half a century ago. In fact, pockets of resistance to DDT in some mosquito species in Africa are already well documented. There are strains of mosquitoes that can metabolize DDT into harmless by-products and other mosquitoes have evolved whose nervous systems are immune to DDT.²⁶ There are even mosquitoes that avoid the toxic effects of DDT by resting between meals not on the interior walls of houses, where chemicals are sprayed, but on the exterior walls, where they don't encounter the chemical at all.²⁷

And if public health officials have learnt anything since the rise and demise of DDT about the million-plus species of insects in the world, it's that there is no such thing as an all-purpose weapon when it comes to pest management. DDT may be useful in controlling malaria in some places, but it's essential to determine whether target populations are resistant; if they are, then no amount of DDT will be effective.

Silent Spring is credited for the fact that public, governmental, and scientific attention was focused on the threat of DDT. In 1963, in direct response to the public concern aroused by *Silent Spring*, President

John F Kennedy's Science Advisory Committee recommended an immediate reduction of DDT use with a view to its total elimination as quickly as possible, along with other "hard" pesticides. In November 1969, acting on the recommendation of a special study commission on pesticides, Robert H. Finch, Secretary of Health, Education, and Welfare, announced that the federal government would "phase out" all but "essential uses" of DDT within two years.

Silent Spring, both as a work of literature and a clarion for the scientific scrutiny of the use of pesticides, shows every evidence of enduring as one of the most read and most revered books on science addressed to a general audience.

Acknowledgments

I would like to acknowledge the editorial help of CPT Brook A. Danboise in preparation of this article.

Author's affiliation: Womack Army Medical Center, Fort Bragg, NC. Contact author: Cristóbal S Berry-Cabán, PhD, Clinical Researcher/Epidemiologist, Womack Army Medical, Center Department of Research, Fort Bragg, NC 28310-5000, USA Email: cris.berrycaban@us.army.mil

References

1. Carson R. *The Silent Spring*. New York: Houghton Mifflin; 1962.
2. The Nobel Prize in Physiology or Medicine 1948: Paul Müller. In: Grandin K, ed. *Les Prix Nobel*. Oslo 1948.
3. Hoff EC, ed *Communicable Diseases: Malaria*. Washington, DC: US Department of the Army; 1963. Coates JB, ed; No. 6.
4. Casida JE. Pyrethrum Flowers and Pyrethroid Insecticides. *Environmental Health Perspectives*. 1980;34:189-202.
5. Knipling EF. The Development and Use of DDT for the Control of Mosquitoes. *The Journal of the National Malaria Society*. June 1945;4(2):77-92.
6. Bishopp FC. Present Position of DDT in the Control of Insects of Medical Importance. *American Journal of Public Health*. June 1946;36(6):593-606.
7. Gladwell F. The Mosquito Killer. *The New Yorker*. July 2 2001.
8. Stapleton DH. A lost chapter in the early history of DDT: The development of anti-typhus technologies by the rockefeller foundation's louse laboratory, 1942-1944. *Technology and Culture*. 2005;46(3):513-540.
9. Gahan JB, Travis BV, Morton PA, Lindquist AW. DDT as a Residual-Type Treatment to Control *Anopheles quadrimaculatus*: Practical Tests. *Journal of Economic Entomology*. April 1945;38(2):251-235.
10. Soper FL, Knipe FW, Casini G, Riehl LA, Rubino A. Reduction of *Anopheles* Density Effected by the Pre-season Spraying of Building Interiors with DDT in Kerosene: At Castel Volturno, Italy in 1944-45, and in the Tiber Delta in 1945. *American Journal of Tropical Medicine*. March 1947;27:177-200.
11. Andrews JM, Grant JS, Fritz RF. Effects of suspended residual spraying and of imported malaria on malaria control in the USA. *Bulletin of the World Health Organization*. 1954;11(4-5):839-848.
12. Tren R, Bate R. South Africa's War against Malaria Lessons for the Developing World. *Policy Analysis*. 2004(513):1-20.

13. Cohn EJ. Assessing the costs and benefits of anti-malaria programs: the Indian experience. *American Journal of Public Health*. 1973;63(12):1086-1096.
14. Gray RH. The decline of mortality in Ceylon and the demographic effects of malaria control. *Population Studies*. 1974;28(2):205-229.
15. Wright JW, Fritz RF, Haworth J. Changing concepts of vector control in malaria eradication. *Annual Review of Entomology*. January 1972;17(1):75-102.
16. Davis KS. The Deadly Dust: The Unhappy History Of DDT. *American Heritage*. 1971;22(2).
17. Fish and Wildlife Service. Press Release. August 22, 1945.
18. Carson RL. Letter to Reader's Digest. 1945; <http://www.cgfi.org/wp-content/uploads/2010/06/DDT-Rachel-Carson-Letter-to-Readers-Digest-001.jpg>. Accessed June 15, 2011.
19. Carson RL. *Under the Sea: A Naturalist's Picture of Ocean Life*. New York: Simon & Schuster; 1941.
20. Carson RL. *The Sea Around Us*. New York: Oxford University Press; 1951.
21. Carson RL. *The Edge of the Sea*. New York: Houghton, Mifflin and Co.; 1955.
22. Mendonça Guimarães R, Rodrigues Fróes Asmus CI, Meyer A. DDT Reintroduction for Malaria Control: the Cost-benefit Debate for Public Health. *Cadernos de Saúde Pública*. December 2007;23(12):2835-2844.
23. Bate R. The Rise, Fall, Rise, and Imminent Fall of DDT. *American Enterprise Institute for Public Policy Research*. 2007(14):1-9.
24. Newton JA, Schnepf GA, Wallace MR, Lobel HO, Kennedy CA, Oldfield EC. Malaria in US Marines returning from Somalia. *The Journal of the American Medical Association*. 1994;272(5):397-399.
25. Wallace MR, Sharp TW, Smoak B, et al. Malaria among United States troops in Somalia* 1. *The American Journal of Medicine*. January 1996;100(1):49-55.
26. Chiu TL, Wen Z, Rupasinghe SG, Schuler MA. Comparative molecular modeling of *Anopheles gambiae* CYP6Z1, a mosquito P450 capable of metabolizing DDT. *Proceedings of the National Academy of Sciences*. 2008;105(26):8855.
27. Georghiou G. Parasitological review. Genetics of resistance to insecticides in houseflies and mosquitoes. *Experimental parasitology*. 1969;26(2):224.